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Complex Visual Hallucinations Associated With Deficits In Vision: The Charles Bonnet Syndrome

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"... During the fall of 1843, as I was sitting by the stove in the evening, I saw a lady sitting by me with an infant child in her arms asleep. In two or three minutes she disappeared. Near the same time I saw a small child standing by me and looking me in the face. The appearance was so familiar that I inadvertently put out my hand, although I knew it to be an illusion, for there was no child in the room."

"... On the evening of the 23rd of March, after a severe trial with much of my company during that day and evening, I was threatened to be run over about 10 o'clock by a drove of oxen; but having my presence of mind, I sat quiet, and with much crowding they all passed without touching me."

"... What I have here stated must appear incredible to those unacquainted with the history of illusive visions. Yet it is not only strictly true, but is only a mere sketch of what I saw during fifteen weeks; neither have I language to describe many of the most interesting particulars. How far my blindness contributed to produce such a result, I am not able to say."

"Never before have I been able to realize the ancient comparison of the human mind to a microcosm, or universe in miniature."

T.W. Abell, 1845

[from a letter written to The Boston Medical and Surgical Journal, 33, 409 - 413]

ABSTRACT

The Charles Bonnet syndrome is characterized by complex visual hallucinations in people without psychopathology or disturbance of normal consciousness. This thesis highlights the association of visual deficits with the syndrome, and proposes that it is analogous to the perception of phantom limbs; both conditions arise when normal sensory input to the brain is severely reduced. The five studies that comprise this thesis systematically gather information on the syndrome to answer three basic questions: how can the hallucinations be classified, what are the clinical implications for individuals who experience them, and what might cause the hallucinations. Study 1 examines 64 cases described in the literature. Demographic information on the hallucinators, properties of the hallucinations, initiating factors, as well as etiological mechanisms are reviewed. Study 2 examines the properties of the hallucinations in a sample of 60 subjects and reveals, by statistical analysis, a dimension of the hallucinatory experience that ranges from discrete, singular perceptual experiences to multiple changing experiences. Studies 3 and 4 examine the mental status of hallucinators. It was found that the majority of hallucinators score within the normal range on tests of anxiety, depression, and psychological symptomatology and exhibit no evidence of gross cognitive impairment. A detailed analysis of results show that a small proportion of hallucinators endorse comparatively more symptom-oriented items than the remainder of hallucinators, as well as more items than non-hallucinators (in Study 4). Finally, Study 5 examines the performance of two hallucinating groups as well as a group of visually impaired non-hallucinators on threshold estimation and signal detection tasks. The results of the combined studies indicate that both groups of

hallucinators adopt a more liberal criterion in the threshold detection task for reporting the stimulus. The relevance of the hallucinations for understanding the processes involved in visual perception is discussed together with possible areas for future research.

RESUME

Le syndrome Charles Bonnet est charactérisé par des hallucinations visuelles complexes chez les personnes sans psychopathologie ou troubles normaux de conscience. Cette thèse souligne l'association des déficits visuels au syndrome, et suggère que ce syndrome est analogue à la perception des membres phantôme; les deux conditions surviennent lorsque les données sensorielles normales acheminées au cerveau sont gravement diminuées. Les cinq études qui composent cette thèse, unissent systématiquement des informations sur le syndrome afin de répondre à trois questions fondamentales: comment les hallucinations peuvent-elles être classifiées, quelles sont les conséquences cliniques chez les individus qui en font l'expérience, et quelles pourraient-être les causes des hallucinations. La première étude examine 64 cas décrits dans la littérature. Des informations démographiques sur les hallucinateurs, des charactéristiques des hallucinations, les facteurs initiaux, ainsi que les mécanismes étiologiques sont revus. La deuxième étude examine les charactéristiques des hallucinations avec un échantillon de 60 sujets et révèle, par des analyses statistiques, une dimension de l'expérience hallucinatoire qui varie d'une expérience perceptuelle singulière et discrète à des expériences multiples et changeantes. Les études 3 et 4 examinent la condition mentale des hallucinateurs. Les resultats révèlent que la majorité des hallucinateurs sont dans la moyenne de l'échelle des tests d'anxiété, de dépression, ainsi que de la symptomatologie psychologique et ne démontrent aucun signe de détérioration cognitive générale. Une analyse détaillée des résultats démontre qu'une faible porportion des hallucinateurs endosse comparativement plus d'items qui sont reliés à des symptomes que le reste

des hallucinateurs, ainsi que plus d'items que les non-hallucinateurs (dans l'étude 4). Et pour terminer, l'étude 5 examine la performance de deux groupes d'hallucinateurs ainsi qu'un groupe de non-hallucinateurs, non-voyants, face à des tâches d'estimation de seuils et de détection de signaux. Les résultats des études combinées indiquent que les deux groupes d'hallucinateurs adoptent un critère plus large en rapportant le stimulus dans la tâche d'estimation de seuils. La pertinence des hallucinations afin de comprendre le processus impliqué dans la perception visuelle est discutée et des avenues pour des recherches futures sont aussi suggérées.

ACKNOWLEDGMENTS

Throughout my graduate training I have had the pleasure of working with my primary supervisor and mentor, Professor Ronald Melzack. His broad range of knowledge in the field psychology has stimulated me to explore problems that have proved to be fruitful and exciting. He has, by example, taught me to ask difficult questions and pursue challenging research interests. For this, I am very grateful. It is my sincere hope that we will continue to share ideas.

I also wish to express my deep gratitude to Dr. Walter Needham. His willingness to collaborate in research has enabled much of the work that constitutes this thesis to take place. Over the past four years I have come to know Walt as a dedicated, caring clinician, truly concerned about the impact that the visual hallucinations have on his patients' lives. In his quiet and understated manner he has made important contributions to my clinical appreciation of this hallucinatory phenomenon.

Many others have given me valuable assistance with this thesis. My thanks to Dr. Robert Taylor of the Birmingham AL Veterans Affairs Medical Center for gathering together and providing portions of the data for Study 2. It is also a pleasure to thank Dr. John Simms, Mr. Bill Rudkin and the Montreal Association for the Blind for their help in making Study 3 possible, and my thanks to Marlyne Israelian for collecting data for one of the cases in the study. Thanks to Dr. Diane Kampen and Rhonda Amsel for reading Study 5 and giving their helpful comments; to Rhonda Amsel also for her statistical consultations; and to Chantale Bousquet for the French translation of the thesis abstract. Finally, I am grateful to all the subjects for contributing their time and sharing their experiences.

Thanks to my parents, Bob and Dorothy, for the support and encouragement through so many years of university.

I cannot complete my acknowledgments without mention of my son Brandon. Though he is much too young to understand the effect that he has had on me, his arrival during this last year has allowed me to maintain my perspective on life during the rather stressful process of writing this dissertation.

Finally, I wish to acknowledge my wife, Lori-Anne. A few words cannot possibly express my gratitude and appreciation for the unending patience, support, and encouragement she has given me over the years. Thank you.

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Professor Ronald Melzack has, in general, provided fertile intellectual ground for my ideas to grow. This was provided through discussion and reading his published theories of brain function. More specific delineation of my contributions to this thesis, as well as those by others, are presented below.

Study 1, the literature review and analysis of cases, was carried out by myself. The manuscript was written by myself, with organizational and editorial guidance from my co-author, Dr. Melzack. This review, to my knowledge, is still the most comprehensive evaluation the Charles Bonnet syndrome and, except for Bartlet's (1951) paper, was the first to highlight the relationship between the Charles Bonnet syndrome and phantom limb phenomena.

Study 2, is the product of a joint effort by a number of people. The original questionnaire data were collected by the co-authors who are, or were at the time, located at the Veterans Affairs hospitals in West Haven CT, Birmingham AL, and Palo Alto CA. Data were also collected by those individuals acknowledged in Study 2. It was my idea -- knowing that this sample of hallucinators was the largest ever taken -- to analyze the data using more sophisticated statistical techniques than frequency counts for each hallucinatory variable examined. I was responsible for coding the data, analyzing it, graphing it and interpreting the results. I wrote the manuscript for Study 2, again with some organizational and editorial guidance from Dr. Melzack, and to a lesser extent from Dr. Needham. This study is the only one on the Charles Bonnet syndrome to focus entirely on the properties of the hallucinations, and further, to relate the findings on the properties to recent theories of how hallucinations may occur.

Study 3 was conceived of, and carried out by myself, with the exception that subject data for one case was obtained by an undergraduate honors student, Marlyne Isrealian. I analyzed the data and wrote the manuscript with helpful guidance from Dr. Melzack. This study extends the knowledge on the mental status of hallucinators by first obtaining data from a sample of community-based hallucinators rather than from hallucinators who report to

a hospital. Secondly, it reports scores on tests of mental status never previously reported together in the same subjects.

Study 4 was a joint effort of myself, Dr. Needham and Dr. Melzack. The original data were collected by Dr. Needham and constituted an unpublished paper presentation at the Annual Meeting of the American Psychological Association in 1991. Dr. Needham was kind enough to lend me the original data to answer the specific question that I had posed after reviewing the results of Study 3 and examining his 1991 paper. I was responsible for coding the data, analyzing and interpreting the results. Some helpful suggestions regarding the statistical analysis were made by Rhonda Amsel. The manuscript was the result of my effort with guidance from Dr. Melzack. This study supports results from the previous investigation.

The final study is a joint effort by myself, Dr. Needham, and Dr. Melzack. I conceived of the idea for the study, wrote the computer programs for stimuli presentation, tested most subjects, analyzed and interpreted the results, and wrote the manuscript. Helpful suggestions from Dr. Needham, especially with regard to the use of the Marlowe-Crowne questionnaire, were incorporated into the study. Dr. Needham also tested subjects. Rhonda Amsel was considerably helpful in clarifying my ideas with regard to the data analysis and interpretation of the results. Dr. Melzack, as always, helped me clarify my ideas during the writing stage of this manuscript. Rhonda Amsel and Dr. Diane Kampen also made valuable suggestions to help readers, unfamiliar with signal detection theory, understand some of its more technical aspects. This study is unique in that it is the only signal detection study with Charles Bonnet hallucinators.

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INTRODUCTION

Many people who have lost a significant portion of their visual capacity report that they experience complex visual hallucinations. People, animals, buildings, or scenery may all sporadically inhabit their perceptual landscape. Like those who experience a phantom limb following an amputation, these perceptions are usually vivid and realistic. In 1769, the Swiss philosopher and naturalist Charles Bonnet wrote a treatise on the hallucinations experienced by his visually impaired but otherwise healthy grandfather. Since that time, medical journals in several fields including psychiatry, ophthalmology, neurology, and psychology have published many case reports. The eponym "Charles Bonnet syndrome" has come to represent complex visual hallucinations that occur mostly in elderly individuals with visual problems and without any obvious mental abnormalities (Asaad, 1990).

Thesis Overview

This thesis comprises five studies on complex visual hallucinations that occur in the Charles Bonnet syndrome. Study 1, a published review article, examines the phenomenon by analyzing 64 cases that appeared in the literature up to 1990. Common to all hallucinators is some form of lesion within the visual processing system. We find that the syndrome occurs predominantly in the elderly, and occurs with greater frequency in women. The hallucinatory experiences may occur over the course of years with individual episodes lasting for periods that range from seconds to hours. The images may be of a variety of objects, and may or may not be familiar to the

hallucinator. Study 1 also discusses various theories as to why the hallucinations occur and emphasizes the similarities between the Charles Bonnet syndrome and the perception of phantom limbs.

A limitation inherent in the analysis of cases reported by other investigators is that the same information is usually not collected and thus the syndrome cannot be systematically investigated. Further, specific information regarding the hallucinators' mental status --namely, the tests that were used, and the hallucinators' scores on those tests -- is also frequently unavailable. Studies 2, 3 and 4 strive to improve upon these weaknesses in the literature.

Study 2 examines the properties of the visual hallucinations utilizing questionnaire data from 60 people who report complex visual hallucinations. This sample, the largest ever reported, demonstrates that the "clinical lore" with regard to the properties of the hallucinations is largely accurate; however, some discrepancies were noted. In the course of the statistical analysis, a previously unreported dimension was revealed. Speculation about the meaning of this dimension, particularly with respect to perceptual and hallucinatory processes, is discussed.

Study 3, published in 1993, examines the mental status of 14 hallucinators using 4 standard psychological testing instruments. The results show that three of the 14 subjects endorsed more items (relative to the remainder of subjects) on scales measuring depression, anxiety and other psychological symptoms. However, as a group, this sample of community-based hallucinators were not suffering from psychological problems nor were they suffering from gross cognitive impairment. Results clearly imply that an abnormal mental status, in either the emotional and/or cognitive spheres, is not a necessary condition for these hallucinations to occur.

Study 4 is a brief follow-up to Study 3. Since a previous report (Needham et al., 1991) found that hallucinators endorsed more symptom-oriented items on an MMPI short-form than did non-hallucinators, Study 4 sought to determine if a similar pattern of results would be found upon a more detailed re-examination of Needham et al's MMPI data. Simply put, is it possible that a small subgroup of hallucinators could elevate the mean of the entire hallucinating group above that of the non-hallucinating group? Statistical analysis shows this to be the case. Like the group of Montreal-based hallucinators, the U.S.-based hallucinators -- as a group -- did not show psychopathology in the range that would be expected in individuals who are hallucinating due to a psychosis. Instead results show that differences between hallucinators and non-hallucinators were due to a small proportion of hallucinators with significant MMPI elevations. In Study 4, suggestions are made to screen all subjects for emotional distress since labeling a person as a "Charles Bonnet hallucinator" may result in the failure to evaluate the psychological status of a person. Unrelated, but nevertheless clinically relevant, psychological problems could go undetected.

The final study in the thesis examined the performance of 15 hallucinators and 15 non-hallucinators on two visual tasks. During a threshold estimation procedure, subjects were asked to report the detection of faint visual stimuli presented briefly on a computer screen. During a signal detection task, subjects were again asked to report the detection of visual stimuli, but the presentation of the stimuli were intermixed with trials in which no stimuli were displayed. Results from the two tasks, taken together, show that hallucinators exhibited a more liberal criterion for reporting the experience of the stimuli in the threshold estimation procedure.

Intriguing and sometimes frightening to those who experience them, unusual and puzzling to those who study them, these hallucinations have evoked interest for over 200 years. Systematic research on Charles Bonnet hallucinations, however, has only just begun.

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The Charles Bonnet syndrome: 'phantom visual images'

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Abstract. The Charles Bonnet syndrome is a condition in which individuals experience complex visual hallucinations without demonstrable psychopathology or disturbance of normal consciousness. An analysis of the sixty-four cases described in the literature reveals that the syndrome can occur at any age though it is more common in elderly people. Reduction in vision, due to peripheral eye pathology as well as pathology within the brain, is associated with the syndrome. Individual hallucinatory episodes can last from a few seconds to most of the day. Episodes can occur for periods of time ranging from days to years, with the hallucinations changing both in frequency and in complexity during this time. The hallucinations may be triggered or stopped by a number of factors which may exert their effect through a general arousal mechanism. People, animals, buildings, and scenery are reported most often. These images may appear static, moving in the visual field, or animated. Emotional reaction to the hallucinations may be positive or negative. Several theories have been proposed to account for the hallucinations. This paper highlights the sensory deprivation framework, with particular emphasis on the activity in the visual system after sensory loss that produces patterns of nerve impulses that, in turn, give rise to visual experience.

1 Introduction

Visual hallucinations are usually associated with psychiatric disorders, drug ingestion, or metabolic and endocrine disorders (Asaad and Shapiro 1986). They may also occur in association with epilepsy, tumours, or other pathology in several brain areas, and during electrical stimulation of structures such as the amygdala (Gloor et al 1982) and the temporal cortex (Penfield and Perot 1963). However, hallucinations may also occur in the absence of any known brain pathology or psychopathology. There is a growing body of literature which indicates that the loss of visual input to the brain as a result of pathology of the eye can be a sufficient cause of visual hallucinations. This paper examines visual hallucinations that occur in the absence of any known cognitive or emotional impairment. We propose that they represent a visual analogue of the phantom limb phenomenon—that is, experience generated by brain activity in the absence of sensory input.

2 The Charles Bonnet syndrome

In 1769 Charles Bonnet reported that his grandfather, Charles Lullin, experienced well-formed visual hallucinations in the absence of any known psychopathology or cognitive impairment. The full account can be found in Bonnet's *Essai Analytique sur les Facultés de l'Âme* (1769) and is reviewed by Fluornoy (1902), and by de Morsier (1967). Briefly, Monsieur Lullin, at the age of 89 (eleven years after cataract surgery), began to see astonishing images of men, women, carriages, and buildings. The figures appeared in movement: approaching, receding, becoming larger or smaller, disappearing then reappearing. Buildings would rise in front of his eyes, showing their exterior construction. Tapestries in his apartment would change and become those of a "richer taste". At other times the tapestries would be covered in paintings of scenic views. These visual images appeared with his full knowledge that they were not

actually physically present. Since Bonnet's initial description of the phenomenon, numerous similar case reports have appeared.

The characteristics described by Ernest Naville (de Morsier 1967) have become established as the core features of the Charles Bonnet syndrome. These visual experiences (i) occur while the person is in a state of clear consciousness and do not deceive the subject, (ii) coexist with normal perception, (iii) are exclusively visual (the hallucinations do not make any noise), (iv) are not accompanied by any bizarre sensations, (v) come and go without the person knowing why, (vi) are not distressing but rather are interesting, and finally (vii) disappear when the eyes are closed. An important feature that should be added to this list is that the hallucinations are almost always associated with some form of reduction in vision.

We here analyze sixty-four cases from various journal articles (see table 1). The majority of these cases exhibited some type of pathology of the eye or of the visual projection system from the retina up to the cortex. Many of these cases had cerebral infarctions or tumours involving the visual system. However, none of them showed any significant cognitive or emotional impairment. That is, the feature that best characterizes these patients is that they had visual hallucinations in the context of reduced vision. Cases were not included when the patient had obvious clouding of consciousness, dementia, or psychiatric illness. Only patients who had well-formed visual hallucinations in the context of reduced vision were included in the analysis.

Table 1. List of references and the cases from each that were used in the analysis.

References	Case(s)	References	Case(s)
Adair and Keshavan (1988)	1	Lance (1976)	3, 5–13
Alroe and McIntyre (1983)	1, 2, 3	Levine (1980)	1, 2
Bartlet (1951)	1	McNamara et al (1982)	1
Benson and Rennie (1989)	1	de Morsier (1967)	Mr Lullin
Berrios and Brook (1982)	2	Olbrich et al (1987)	1–5
Damas-Mora et al (1982)	1, 2	Patel et al (1987)	1
Feinberg and Rapcsak (1989)	1	Podoll et al (1989)	46
Flynn (1962)	1	Raschka and Schlager (1982)	1
Gold and Rabins (1989)	C, D, F	Rosenbaum et al (1987)	1, 2
Hart (1967)	1, 2	Weinberger and Grant (1940)	7–10, 16
Kölmel (1985)	1–16	White (1980)	1, 2, 3

3 Properties of the hallucinations

3.1 *Content*

Hallucinations of the Charles Bonnet syndrome are usually colourful, well-formed images that are detailed and sharply in focus even when they appear at a distance. The variety of objects seen by different people is unlimited, although the variation seen by an individual is usually more restricted (Olbrich et al 1987). Images of people are common. In a review of forty-six cases, Podoll et al (1989) found that 83% reported seeing images of people. Usually these figures are in proper proportions, although distorted human figures are sometimes seen. Lance (1976) describes a 60-year-old woman who saw two people with "big heads and discoloured brown skin with black spots". Isolated body parts such as heads (Olbrich et al 1987, cases 4 and 5) or hands (Kölmel 1985, case 3; Lance 1976, case 6) are infrequent.

Other objects frequently seen are animals such as dogs, cats, birds, and horses. Podoll et al (1989) found that 50% of people report hallucinations of animals. Not all the animals were common. Lance (1976) reports the case of a women who saw tiny giraffes and hippopotamuses. Finally, plants, landscapes, and inanimate objects such as furniture and buildings make up the remainder of the objects frequently seen.

This summary of images does not do justice to the elaborate and sometimes unusual content of the hallucinations in some people. Hallucinators report experiences such as having "a brightly coloured circus troupe burst through the window" (White 1980), or seeing "an old fashioned charabanc made of wire netting with men wearing mushroom hats sitting on it" (Bartlet 1951). Flynn (1962) reports on a 72-year-old woman who would see large chickens wearing shoes. Lilliputian-sized figures may sometimes appear, often to the delight of the hallucinator (Damas-Mora et al 1982).

3.2 *Movement*

Descriptions of the hallucinated images lend themselves to categorization by type of movement. Images during the hallucinatory experience can be static, moving, or dynamic. Static hallucinations are those in which an image will simply appear in a person's visual field and remain fixed in that position. A moving hallucination is one in which the image moves within a person's visual field yet the image itself is not animated. Dynamic hallucinations are those in which the hallucinatory image is animated. The cases, where possible, were categorized on the basis of these types of movement. If, within a case, more than one type of movement was present, the case was classified according to the example that described the greatest degree of movement (eg a case describing both static images and moving images would be categorized as 'moving'). Thus, of the forty-eight categorizable cases, sixteen were static, sixteen were moving, and sixteen were dynamic. Cases within each of these groups do not appear to be associated with any single type of pathology which might be implicated in causing the reduction in vision. For any given category of movement, various implicated pathologies were found.

When dynamic hallucinations do occur, the action performed by the figure is often stereotyped, but not exclusively so. As Lance (1976) notes with regard to his cases, the movements did not tell any story. Quite often the figures, when animated, are simply walking or head-nodding (Lance 1976), trying on clothes (Rosenbaum et al 1987), or marching in procession (Feinberg and Rapcsak 1989). Kölmel (1985) suggests that the hallucinations which move may involve "stimulation of [a brain] area in which movement is codified".

3.3 *Relationship to memory*

The relationship between these visual images and an individual's memory remains unclear. Are the hallucinations a simple 'playback' of memory traces or are they new experiences? Our review revealed cases in which patients could remember the hallucinated object from past experience (two cases), cases in which the hallucinated object was not at all familiar to the patient (five cases), as well as cases in which some of the hallucinated objects were familiar and others were not (five cases) (see table 2). Interpretation of this information is difficult. Although remembering a hallucinated object from experience suggests that some of the hallucinations are simply a playback, failure to remember a hallucinated object from experience does necessarily indicate that they are 'newly created'. Given that the average age of the patients is 66.3 years (with some patients as old as 89), it is possible that an isolated memory of an object, if triggered, may not be recognized as having been previously experienced. This, however, becomes increasingly unlikely in cases in which the hallucinating individual is young. In fact, as can be seen from table 2, there were two cases in which the hallucinated object was not familiar even though the patients were in their early twenties. It is also unlikely that the hallucinated objects represent an averaged combination of prior memories of an object—that is, a prototype. The hallucinated object may be very specific as in the case (Olbrich et al 1987) of a 69-year-old woman who hallucinated a dachshund.

Table 2. List of cases and ages of the patients in which it was possible to classify the hallucinations on the basis of familiarity to the individual.

Reference	Case	Familiarity	Age
Adair and Keshavan (1988)	1	familiar	85
Alroe and McIntyre (1983)	1	mixed	75
Bartlet (1951)	1	mixed	84
Benson and Rennie (1989)	1	not familiar	64
Lance (1976)	9	mixed	62
Lance (1976)	10	mixed	65
Podoll et al (1989)	46	not familiar	71
Rosenbaum et al (1987)	2	mixed	66
Weinberger and Grant (1940)	7	not familiar	23
Weinberger and Grant (1940)	9	familiar	17
Weinberger and Grant (1940)	10	not familiar	20
Weinberger and Grant (1940)	16	not familiar	59

3.4 *Interaction with the hallucinations*

Occasionally, hallucinators report that the hallucinations (usually people) may react to activities being performed by the hallucinators. For example, Flynn's (1962) subject reported that the hallucinated people covered their faces when she was using the washroom. There are a few reports of the subject touching, moving, or otherwise interacting with their hallucinations. Alroe and McIntyre (1983) document a case in which a 75-year-old woman, in clear consciousness and showing no evidence of mental deterioration, threatened her hallucinated figure of a man, to which he responded by exposing a sword hidden in his coat.

3.5 *Emotional reaction*

It seems surprising that people's emotional reactions to the suddenly appearing, well-formed hallucinations are described as pleasant or positive in nature. Yet beginning with Bonnet's initial description of his grandfather's case, this type of emotional reaction is predominant. Damas-Mora et al (1982) state that the most frequent reaction to the hallucinations is one of delight. In the present review it was found that the patients were pleased by them (Adair and Keshaven 1988), expressed curiosity, amazement, and delight (Damas-Mora et al 1982), found them not unpleasant (Alroe and McIntyre 1983), were pleasantly surprised by their presence (Patel et al 1987), and took an amused impersonal interest (Bartlet 1951).

However, some people regard the hallucinations as an annoyance (Flynn 1962), particularly when they are present for long continuous periods of time (Damas-Mora et al 1982). Berrios and Brooks (1982) present a case of a man whose hallucinations took the form of men with ugly faces. The man took "strong objection to their presence ... and on one occasion, tried to strangle one of them". Others, however, are simply distressed by the visual images (McNamara et al 1982; Raschka and Schlager 1982). Some people report mixed emotions, finding some images beautiful and pleasing, while others are threatening and frightening (Levine 1980).

3.6 *The effects of drugs on the hallucinations*

The administration of drugs to abolish the hallucinations is occasionally reported. Most attempts were unsuccessful. White (1980, case 1) found that phenothiazines had no effect, and Alroe and McIntyre (1983) report no effect with an anxiolyic. Nevertheless, a few positive results have been reported. Hart (1967) successfully abolished a patient's hallucinations with corticosteroid therapy, and Lance (1976) also reports that anticonvulsant medication reduced or abolished the hallucinations in two of the

cases examined here. The only case reported in which the hallucinations were purposely exacerbated by drugs is Bartlet's (1951) patient, whose hallucinations were enhanced by sodium amytal, mescaline, or alcohol.

3.7 *Hallucination lateralization*

In seventeen cases it was possible to classify the hallucinations according to the field of vision. They appeared in the left visual field in six cases, in the right visual field in six, and in both visual fields in three cases. In addition, two cases were found in which the hallucinations only appeared in one eye—the left eye in one case and the right eye in the other (cf Alroe and McIntyre 1983). In all cases the field(s) of vision in which the hallucinations were seen corresponded to the side(s) in which the pathology was present. It was also found that all those cases in whom hallucinations were lateralized had pathology within the brain. Conversely, the three cases in whom the hallucinations occurred in both visual fields, had eye pathology.

4 Demographic factors

4.1 *Incidence*

Although most papers on the Charles Bonnet syndrome are individual case reports, there are a few studies on the frequency of occurrence. Kölmel (1985) found that sixteen out of one hundred and twenty patients with hemionopia (13.3%) had complex visual hallucinations. Olbrich et al (1987) found five out of forty-three patients with bilateral eye-disease (11.6%) could be classified as cases of the Charles Bonnet syndrome. Fitzgerald (1970, 1971) followed a group of sixty-six recently blind adults, of whom 24% had "continuous waking visual experiences" which included visual disesthesiae, described as "changing, flashing, or kaleidoscope effects", and 10% were reported to experience "visual hallucinations". It is unclear whether these subjects met the criteria for the Charles Bonnet syndrome. Recently, Needham and Taylor (1990) reported that 30.6% of a sample of one hundred and twenty-four blinded veterans acknowledged experiencing complex hallucinations. From this small amount of information, it appears that the incidence is anywhere from 10%–30% in people with deficits in vision. In reviews, such as those of Podoll et al (1989) and of Olbrich et al (1987), it is stated that the incidence may be considerably higher because patients may be reluctant to talk about these experiences for fear of being labelled as emotionally disturbed.

4.2 *Sex distribution*

Information on the gender distribution of the syndrome is equivocal. A review by Damas-Mora et al (1982) cites Trillot and Carlet-Soulages (1937) as reporting that the syndrome occurs almost exclusively in females. However, Damas-Mora et al (1982) also cite de Mosier's (1967) and Patry's (1937) findings which indicate that males outnumber females. Further, in the current review by Podoll et al (1989) a female to male ratio of 1.1 was found which suggests that the syndrome is almost equally distributed between males and females. The discrepancies among findings may be due to the small number of cases seen by earlier investigators [for example, de Mosier's (1967) review was based on eighteen cases, whereas the review by Podoll et al (1989) was based on forty-six cases]. The present review of sixty-four cases found that males were significantly outnumbered by females at a ratio of 1.7 ($\chi^2 = 4.00$, $p < 0.05$).

4.3 *Age distribution*

It is generally believed that well-formed visual hallucinations of the type seen in the Charles Bonnet syndrome occur only in elderly individuals, so that age has almost come to be part of the definition of the syndrome. While the majority of cases reviewed here involve subjects over the age of 60, figure 1 shows that these types of

hallucinations can occur in a substantially younger population: almost 20% of the cases were under the age of 60 years. The average age of the patients reviewed here was 66.3 years, and the aged ranged from 10 to 89 years. The nature of the pathology that contributes to the reduction in vision appears to be a factor in determining at what age the hallucinations occur. It appears that individuals who have had brain tumours may experience the hallucinations at a relatively young age (cf Weinberger and Grant 1940). Cataracts appear to be largely involved in those cases in which the patients are elderly.

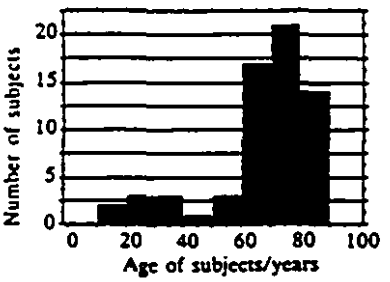

Figure 1. Age distribution of the cases analysed.

4.4 *Ethnic and cultural background*

Information on the ethnic background of the cases is almost nonexistent. This variable may potentially be relevant, given that some cultures perceive 'visions' as an accepted part of their cultural milieu.

5 Initiating factors

5.1 *Reduction of vision*

Visual hallucinations of the type seen in the Charles Bonnet syndrome are associated, almost without exception, with some type of reduction in vision. In some cases this reduction in vision may take the form of a hemianopsia, with normal visual acuity in the spared visual field; while in other cases visual acuity is impaired. The degree of loss in visual acuity ranges from slight reduction to total blindness (see figure 2). Interestingly, there are a few cases in which the formed visual hallucinations occur despite complete blindness. Flynn (1962) documents a case in which a 72-year-old woman experienced hallucinations of "various inanimate objects, such as figured wallpaper, tapestries, trees, and pretty dresses" for seven and a half years after becoming blind owing to glaucoma. In addition, Weinberger and Grant (1940) present a case (their case 16) of a 59-year-old man who became blind following the

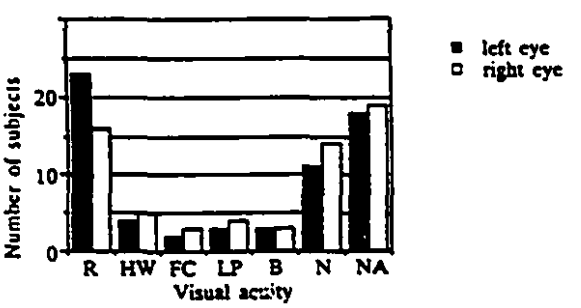

Figure 2. Visual acuity of the individuals in the analysis classified as reduced (R), hand wave (HW), finger count (FC), light perception (LP), blind (B), normal (N), and not applicable (NA). Note that cases classified as 'normal' are those in which visual acuity is not reduced, although some form of reduction in vision is present (ie a hemianopia).

excision of a tumour near the left optic nerve. Simple images appeared initially and evolved during the next few days into more detailed formed images of landscapes, buildings, and people.

A wide range of disorders are implicated in causing the reduction in vision (see figure 3). In the sixty-four cases under study, 93.8% specified a disorder. The most frequent cause cited was cerebral infarction (31.6%). Other disorders involving the brain make up an additional 21.6%, including tumours (13.3%), cranial arteritis (3.3%), haemorrhages (3.3%), and viral encephalitis (1.7%). As can be seen in table 3, most of the brain disorders involve areas associated with visual processing. Peripheral eye pathology was implicated in twenty-one cases (35.0%), with cataracts comprising the largest portion (thirteen) of these cases. The remaining 11.7% of the cases specified more than one of the categories listed in figure 3.

Unfortunately, there is no information on the degree of visual impairment present at the time of the appearance of hallucinations. When the visual images arise during a progressive eye disease, there is often a varying length of time between the patients' first hallucinatory experience and their reporting of the experience to a health professional. During the intervening time, vision may have decreased substantially or only slightly. When the hallucinations arise in the context of a sudden decrease in vision, such as in the case of a cerebral infarction, the amount of visual loss at the time of the onset may be determined more readily.

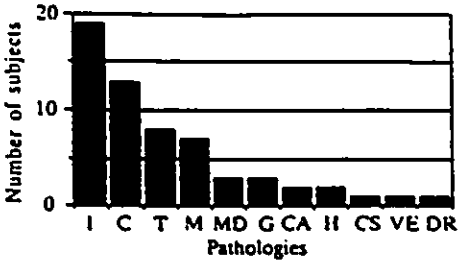

Figure 3. Frequency of the pathologies implicated in causing the reduction in vision. The pathologies implicated were infarction (I), cataract (C), tumour (T), multiple (M), macular degeneration (MD), glaucoma (G), cranial arteritis (CA), haemorrhage (H), corneal scarring (CS), viral encephalitis (VE), and diabetic retinopathy (DR).

5.2 *Triggers and stoppers*

Although hallucinations generally occur in the context of visual reduction, little is known about why, or under what conditions, individual episodes are triggered. For some people, a low level of illumination is needed to trigger the hallucinations (eg Raschka and Schlager 1982; Rosenbaum et al 1987). Levine (1980) suggests that they may take place under conditions of general sensory reduction such as when "sitting in a chair with no radio or television on, or just before retiring for the evening".

Low-level illumination is not always necessary; White (1980) presents two cases in which the hallucinations were triggered by light. Other authors have reported that the hallucinations may appear when the patient is fatigued (Olbrich et al 1987, case 1). However, they may also occur when the person goes to bed but cannot sleep (Olbrich et al 1987, case 3; Raschka and Schlager 1982). Interestingly, Lance (1976) presents a case (his case 12) in which a 73-year-old woman's hallucinations initially happened at times when she was wide awake but subsequently occurred when she was drowsy. Kölmel (1985) describes a person whose hallucinations, after abating, would reappear in stressful situations. Lance (1976, case 9) describes a 62-year-old woman who experienced hallucinations, which were subsiding in frequency, when she received stimulation of the nonvisual senses such as the smell of food or the sound of a siren.

Once the hallucinatory episode has begun, the procession of visual images may disappear without apparent cause, or alternatively, after some action performed by the hallucinator. Closing the eyes will, for some individuals, stop the images (eg Bartlet 1951), but for others, this action has no effect (eg Weinberger and Grant 1940, case 10). Movement of the eye itself has been reported to abolish the hallucinations.

Table 3. Cases with documented brain pathology.

Reference	Case	Neurological findings
Benson and Rennie (1989)	1	no neurological symptoms other than photopsias; very localized infarction of the medial aspect of the left occipital lobe
Feinberg and Rapcsak (1989)	1	episode of vertigo CT and MRI; increased T2 signal in the right dorsomedial thalamus, bilateral deep white matter, and third ventricle; no abnormality in cerebral peduncles or midbrain
Hart (1967)	1	cranial arteritis
Hart (1967)	2	cranial arteritis
Kölmel (1985)	1	occipital infarction
Kölmel (1985)	2	occipital infarction
Kölmel (1985)	3	occipital/parietal infarction
Kölmel (1985)	4	occipital/parietal infarction
Kölmel (1985)	5	occipital/other infarction
Kölmel (1985)	6	occipital/parietal infarction
Kölmel (1985)	7	occipital/temporal infarction
Kölmel (1985)	8	occipital infarction
Kölmel (1985)	9	occipital/parietal/temporal infarction
Kölmel (1985)	10	occipital/temporal infarction
Kölmel (1985)	11	occipital/other infarction
Kölmel (1985)	12	occipital infarction
Kölmel (1985)	13	occipital/temporal infarction
Kölmel (1985)	14	occipital/temporal infarction
Kölmel (1985)	15	occipital/parietal infarction
Kölmel (1985)	16	occipital infarction
Lance (1976)	3	EEG showed bilateral slow activity which was maximal over the left hemisphere; brain scan and angiogram were normal; viral encephalitis
Lance (1976)	5	left calcarine infarction
Lance (1976)	6	left occipital infarction
Lance (1976)	7	right occipital infarction (vertebrobasilar insufficiency)
Lance (1976)	8	right parietal infarction
Lance (1976)	9	right occipital infarction (vertebrobasilar insufficiency)
Lance (1976)	10	right occipital infarction
Lance (1976)	11	right occipito-parietal infarction
Lance (1976)	12	right occipital infarction
Lance (1976)	13	left then right occipital infarction (vertebrobasilar insufficiency)
McNamara et al (1982)	1	panhypopituitarism; large suprasellar enhancing lesion; EEG showed generalized delta slowing and no evidence of paroxysmal activity
Weinberger and Grant (1940)	7	tumour under the optic chiasm extending between the arms of the optic nerves
Weinberger and Grant (1940)	8	tumour lying behind and stretching the left optic nerve
Weinberger and Grant (1940)	9	tumour beneath the right optic nerve
Weinberger and Grant (1940)	10	tumour on the posterior edge of the optic chiasm
Weinberger and Grant (1940)	16	tumour by the left optic nerve.

Benson and Rennie (1989) state that "the images disappeared with saccades but were unaffected by smooth pursuit movements". This phenomenon was also seen in all of Kölmel's (1985) patients. Similarly, Kölmel documents a case (his case 4) in which fixation on the hallucinated image caused its disappearance; this was also seen in Weinberger and Grant's (1940) case 10. Hallucinations have been reported to disappear when the individual attempts to approach them (Patel et al 1987; Rosenbaum et al 1987), and Lance (1976) documents that a hallucination of a "Chinese lad" disappeared when the patient tried to speak to it.

It is evident that there are a limited number of factors which may trigger or stop the hallucinations. It is unknown whether these reports of isolated cases represent a more general phenomenon. However, these variables clearly need to be investigated systematically since they are of theoretical importance and, potentially, of importance in clinical management of the hallucinations.

5.3 *Temporal factors*

Temporal factors can be classified into variables that can be examined within a single hallucinatory episode and variables that can be studied across episodes.

5.3.1 *Episodic factors.* Specific variables included under the heading of episodic factors include duration of each hallucinatory episode and the time of day when they occur. Information on the duration of episodes is inconsistent. McNamara et al (1982) state that individuals "experience them continuously rather than episodically" and Gold and Rabins (1982) state that "the visions tend to be prolonged if not continuous". However, Damas-Mora et al (1982) in their review report that the hallucinations can be episodic, periodic, or almost continual, which draws attention to the transitory nature of some hallucinations. Some hallucinations may last for a few seconds (Benson and Rennie 1989), about one minute (Bartlet 1951; Rosenbaum et al 1987), or up to several minutes (Olbrich et al 1987), while other hallucinatory episodes last a good part of the day (McNamara et al 1982; Weinberger and Grant 1940, case 16).

The time of day when the hallucinations appear varies among cases. For some individuals, the hallucinations appear at any time of day, while for others they tend to occur at night.

5.3.2 *Changes as a function of time.* For some people, the visual hallucinations comprise only a few isolated episodes, while others report many episodes over a period of years. Kölmel's (1985) study of a group of sixteen patients found that the hallucinations were experienced for an average of 11.5 days, ranging from 1 to 45 days. Much longer periods of time have been documented. Damas-Mora et al (1982) provide a case (their case 1) of an elderly man who reported visions for a period of 4–5 years. Similarly, case 5 of Olbrich et al (1987), a 69-year-old woman, had a history of hallucinations lasting 5 years. Notably, these hallucinations can increase or decrease in frequency over the period during which they are experienced. These changes may be associated with progressive visual loss (White 1980). For example, Rosenbaum et al (1987) describe a 66-year-old man who hallucinated during progressive macular degeneration. The hallucinations initially increased in frequency, and later decreased in frequency (and finally ceased) when his condition worsened.

Hallucinations can also vary in complexity during the period in which they are experienced. They can be initially experienced as fully formed images, as in the case of an 83-year-old man who reported that flying birds, dogs, and military marching men appeared one afternoon at his bedside (Feinberg and Rapcsak 1989). Alternatively, the hallucinations may progress from simple to complex. Weinberger and Grant (1940) describe a 59-year-old man who became blind owing to a tumour

impinging on the left optic nerve. Following craniotomy and tumour removal, the patient remained blind. Shortly thereafter, the man began to experience simple visual images such as "stars shining in the sky", and "clouds moving before his eyes". Later, the hallucinations became much more complex. Landscapes, buildings, people, and animals "passed before him in panoramic procession". Less frequently, the hallucinations regress from complex to simple as they gradually disappear. For example, Lance (1976) reports a case of a 72-year-old man who, following a right occipito-parietal infarction, began to experience "purple kidney-shaped blobs" floating in front of his eyes. Later, fully formed animals were seen, including dogs, goats, and birds. Lance continues, "the formed visions persisted during his waking hours for about one month when they regressed in form to the purple blobs he had noticed first".

6 Etiological mechanisms and theoretical implications

In this section, theories on the etiology of the Charles Bonnet syndrome will be reviewed and discussed. One of the earliest peripheral theories [Hoppe (1887) as cited by Klüver (1942)] suggested that some hallucinatory phenomena arise from the elaboration of rudimentary images provided by the eye itself. Horowitz, in 1964, reconsidered this idea by using drawings and descriptions of hallucinations from a variety of sources. He noted that the drawings and descriptions tended to be similar, and in most cases, reducible to simple forms such as wavy lines, moving sets of dots, radiating lines, etc. The actual stimuli for these experiences, he proposed, are the retinal ganglionic network and elements composing the eyeball itself (blood vessels, the optic disc, layers of rods and cones, 'floaters' in the vitreous humour). Further, Horowitz contends that these simple images are always present but "under conditions of an increased need to see", a facilitation or loss of inhibition could result in these images being transmitted to higher centres in the brain, where they are elaborated and experienced.

While this 'entopic theory' may be applicable to other types of hallucinations, it does not appear to be relevant to the Charles Bonnet syndrome. First, the sharp, well-formed and detailed nature of the hallucinations are much more complex than simple lines, spirals, and moving sets of dots. It does not seem plausible, even if it is postulated that a psychological mechanism were to elaborate these rudimentary images, that the visual hallucinations in the Charles Bonnet syndrome are derived from elements within the eye. Second, this theory seems to require that the hallucinator be in a lighted environment in order to be able to use that light in the formation of the images. The fact that the hallucinations may occur in situations of reduced lighting, together with the fact that totally blind people have these hallucinations, presents difficulties for this theory.

Flynn (1962) has proposed an explanation purely at the psychological level. In the psychoanalytic tradition, he suggests that conditions of sensory deprivation (such as a reduction of vision) lead to "feelings of depersonalization and regressive disturbances in thinking". Accordingly, the patient, having withdrawn affective investment from external objects, creates a substitute reality through regressive wish fulfillment (Flynn 1962). Fitzgerald (1970, 1971) has similarly focused on the "psychic distress" of subjects in his studies on recently blind adults. He regards continuing visual experiences such as daydreams, dreams, and visual hallucinations as a denial of the loss of sight. This view has not gone unchallenged. An empirical study by Needham and Taylor (1990) found that hallucinating blind subjects did not have severe psychological impairment, though they did experience more emotional distress than nonhallucinating blind subjects. They emphasize that the visual hallucinations are not indicative of psychopathology but are benign in nature. The present review supports this view.

Severe psychopathology was not documented in any of the cases reviewed (see table 4).

Furthermore, the Charles Bonnet syndrome differs from Anton's syndrome in which blind patients deny the loss of their sight and frequently experience disorientation together with attentional and memory deficits (Hecaen and Albert 1978). In contrast, individuals with Charles Bonnet syndrome represent clinical cases in which there are known pathologies of the visual system without impairment of other mental abilities.

Another author, Fischer (1969), proposes that a high ratio of sensory input to motor output is important in the formation of hallucinations, or more precisely, that this ratio defines the state in which hallucinations appear. Fischer garners evidence from drug-induced hallucinatory states as well as from REM sleep to support his claim that hallucinations are a particular type of perception that is not consensually verifiable to ourselves (or to others) through voluntary motor behaviour. In not being able to verify the perception of what Fischer calls the 'substructure' of an object, through voluntary motor behaviour, an object may appear real—that is, appear as a hallucination. Fischer's hypothesis to account for hallucinations in general is consistent with some of the data. If a high ratio of sensory input to motor output is crucial for the appearance of hallucinations, decreasing this ratio, through some type of action (increasing motor output), should stop the hallucinations. Fischer (1969) himself reports that hallucinating schizophrenics may rid themselves of their hallucinations by making noises themselves. As to the hallucinations of the Charles Bonnet syndrome, it has been previously noted that various types of movement, including eyelid closure, ocular movement, as well as body movement may stop the hallucinations.

Hughlings Jackson's early work on epilepsy, as well as the brain stimulation studies performed by Penfield, have led investigators to discuss another theoretical possibility: that the hallucinations seen in the Charles Bonnet syndrome may be caused by a focal irritive centre within the brain (cf Berrios and Brook 1982; Raschka and Schlager 1982; Rosenbaum et al 1987). In a review of their stimulation studies conducted on patients with temporal-lobe epilepsy, Penfield and Perot (1963) reported that seizure activity, as well as stimulation of the temporal lobes, would in some cases lead to complex, well-formed visual hallucinations. Further, Penfield and Perot note that it is not uncommon for epileptic patients to "have an abortive attack that may consist of the experiential hallucination alone", rather than the seizures being accompanied by usual epigastric sensations or by other abnormal sensations. While this hypothesis appears to have some merit, failure to pinpoint an irritive focus, or any abnormal electrical brain activity for that matter, presents a challenge to this view. Bartlet (1951) describes a man who maintained a normal EEG while experiencing hallucinations of faces and people. Other investigators have also noted normal EEGs in their patients who hallucinated, although it is unclear if the normal EEG was maintained while they were actually experiencing the visual images [for examples see Flynn (1962); Patel (1987); Rosenbaum et al (1987); and White (1980)]. Of course the possibility still exists that the abnormal irritive focus is highly localized and is therefore masked by other brain activity. Even though a large area of brain tissue is presumably required for a complex integrated hallucination (ie one that involves bodily sensations, feelings of familiarity, distinct emotions, as well as the visual component), the ictal hypothesis may still be tenable if it is assumed that the largely visual nature of the Charles Bonnet hallucinations may be triggered by a very small focus.

In contrast to the 'irritive' hypothesis—which holds that a distinct locus initiates the hallucinations—it has also been suggested that the hallucinations are the experiential sequelae of a functional lack of visual input to the brain. Perhaps the most widely

Table 4. List of cases and the results of examination for psychopathology, cognitive deficits, or neurological deficits.

Reference*	Psychological and cognitive findings	Neurological findings
Adair and Keshavan (1988) [1]	no previous contact with a psychiatrist; cognitive functioning remarkably intact	not applicable
Alroe and McIntyre (1983) [1]	no abnormalities on psychological testing; was taking oxazapam; conscious and oriented; no signs of either acute confusion or dementia	not applicable
Alroe and McIntyre (1983) [2]	clearly conscious and no signs of dementia	not applicable
Alroe and McIntyre (1983) [3]	no previous psychiatric treatment; mild chronic anxiety; was taking oxazapam; clearly conscious and no signs of dementia	not applicable
Bartlet (1951) [1]	no mood change or memory impairment; without mental deterioration	EEG was almost arrhythmic, showing some normal alpha rhythm after eye closure; EEG recorded while hallucinating showed no change from previous record
Berrios and Brook (1982) [2]	some memory failure	not applicable
Damas-Mora et al (1982) [1]	mildly euphoric and spoke quickly; well oriented for time, place, and person; memory for recent past and remote past was fine	not applicable
Damas-Mora et al (1982) [2]	no signs of psychotic or affective disorders; no signs of intellectual deterioration	not applicable
Flynn (1962) [1]	deficit in abstract thinking	EEG was essentially normal; no evidence of CNS disease or brain damage
Gold and Rabins (1989) [C]	not applicable	normal CT or MRI scans
Gold and Rabins (1989) [D]	not applicable	normal CT or MRI scans
Gold and Rabins (1989) [F]	not applicable	CT or MRI scan showed frontal ischemia
Levine (1980) [1]	no common defects noted in organic mental syndrome	not applicable
Levine (1980) [2]	oriented to time, place and person; answers to questions were pertinent and reasonable	not applicable
de Morsier (1967) [Mr Lullin]	no abnormalities	not applicable
Olbrich et al (1987) [1]	psychiatric examinations revealed no abnormalities	no abnormalities in the neurologic examination; in EEG, runs of bilateral delta waves accentuated over the frontal regions and trains of focal delta waves over the anterior temporal areas, chiefly on the left

Table 4 (continued)

Reference*	Psychological and cognitive findings	Neurological findings
Olbrich et al (1987) [2]	psychiatric examinations revealed no abnormalities	no abnormalities in the neurologic examination; in EEG, alteration in the lower alpha range over the anterior temporal regions, more on the right
Olbrich et al (1987) [3]	psychiatric examinations revealed no abnormalities	no abnormalities in the neurologic examination; EEG showed an alpha rhythm of 8 cps
Olbrich et al (1987) [4]	psychiatric examinations revealed no abnormalities	no abnormalities in the neurologic examination EEG showed an alpha rhythm of 8 cps
Olbrich et al (1987) [5]	light to moderate impairment of attention and concentration	EEG showed slowing of alpha rhythm to 7.5 cps
Patel et al (1987) [1]	delusions of being watched by the devil; clear sensorium; attention, concentration, memory, and orientation were within normal limits	normal EEG; mild frontal atrophy
Podoll et al (1989) [46]	mild depression	EEG was normal for age; CT was normal
Raschka and Schlager (1982) [1]	well oriented; appropriate affect; normal thinking; intact cognitive functions	EEG showed synchronous slow waves over the temporo-occipital cortex with left predominance
Rosenbaum et al (1987) [1]	no previous psychiatric disease; mental status was intact; no cognitive dysfunction	unremarkable CT scan and EEG
Rosenbaum et al (1987) [2]	no evidence of dementia or psychiatric disease	mild cerebellar atrophy; EEG was normal
White (1980) [1]	not applicable	no abnormal neurological signs; skull X-rays, brain scan, and EEG were normal; CT showed mild atrophic changes
White (1980) [2]	not applicable	skull X-rays, brain scan, and EEG were normal
White (1980) [3]	not applicable	skull X-rays, brain scan, and EEG were normal; CT showed moderate cerebral atrophy

* The case is shown in square brackets.

accepted theoretical formulation in the sensory deprivation framework has been proposed by West (1962). Drawing on concepts from Hughlings Jackson and Evarts, West (1975) has proposed that hallucinations are a 'release' of perceptual traces, as a result of the disinhibition of processes normally held in check by sensory input. Specifically, he proposes that input from sensory pathways maintains a mechanism that screens out unimportant information and scans for important information, in addition to generally arousing the reticular activating system (and thus supporting normal awareness). Normally, when sensory input is decreased, the scanning and screening processes are disrupted and awareness is reduced. However, under some conditions of reduced sensory input, arousal may be at a sufficient level to support awareness, but the scanning and screening process fails to inhibit perceptual traces. If these released perceptual traces are present under conditions in which "perception-bearing circuits ... reverberate sufficiently" they may be reexperienced (West 1975).

While West's perceptual release theory is a general theory of hallucinations, Cogan (1973) has specifically drawn attention to its applicability to hallucinations of the type seen in the Charles Bonnet syndrome. In his view, there is a sharp distinction between irritive hallucinations and release hallucinations. Irritive hallucinations, he writes, are "brief, intermittent, repetitively stereotype[d], and sometimes associated with other discharge activity in the motor (convulsions) or sensory (aura) systems", whereas the release hallucinations are "relatively continuous over long periods, variable in their patterns from time to time, and not characteristically associated with other motor or sensory discharges". The cases reviewed here suggest that temporal factors and the stereotypical nature of the hallucinations may not be the best criteria for differentiating between these two types of hallucinations. Other factors discussed by Cogan, such as the absence of aberrant sensory or motor phenomena and concomitant visual problems, appear to be better criteria for distinguishing irritive hallucinations from release hallucinations.

Further examination of the release hypothesis suggests that an individual's level of arousal may be a factor in determining whether released perceptual traces enter awareness. The observations that hallucinations are not constant in duration for all people but may appear for varying lengths of time, that they may be triggered by particular circumstances, and that their frequency and duration may change as time passes, suggest that (i) released perceptual traces do not automatically impinge upon awareness with the cessation of visual input but must reach a certain threshold in order to be experienced, and (ii) this threshold for stimuli to enter awareness may be conceived of as increasing with time since the onset of the hallucinations.

The relation between level of arousal and the experience of released perceptual traces has been discussed by West (1962, 1975, and Duke-Elder and Scott (1971). Scheibel and Scheibel (1962) have suggested that the widespread connections of the brainstem reticular formation and its function in general arousal make it a likely structure to bias 'internal elaborations' selectively over incoming sensory information. When little or no visual input reaches the visual processing centres of the brain, as with the Charles Bonnet syndrome, it can be postulated that reticular formation activity either enhances the activity of the released perceptual traces beyond threshold level, or lowers the threshold itself, allowing the released perceptual traces to enter awareness. Cases in which the hallucinations appear when the person is in stressful situations, and those in which nonvisual sensory stimulation, such as sounds and smells, triggers visual hallucinations support this view if it is assumed that the stimuli exert their influence through an arousal mechanism. The fact that the majority of individuals with the Charles Bonnet syndrome are not totally blind and that the hallucinations, in some cases, can be triggered by bright light (eg White 1980) may also be explained if it is assumed that the visual input serves to heighten arousal rather than to convey specific information. It has been noted that the hallucinations tend to stop or decrease in frequency after a period of time. This occurs despite persistent reduction in vision. It may be useful to speculate that the role played by the arousal level in triggering the hallucination experience becomes smaller as time passes. That is, arousal may no longer enhance the activity of the released perceptual traces, or the threshold may no longer be sensitive to arousal levels.

Descriptively, the patients' hallucinations bear some resemblance to objects that appear in dreams. In the dream state, some objects may be familiar, yet others are not. Additionally, the unusual content of some of the hallucinations lend support to West's (1962) idea that a dream-like process is impinging on awareness. Finally, there are rare cases in which the hallucinator can interact with a hallucinated object. From these ideas it may be fruitful to entertain the possibility that the hallucinations may lie

anywhere on a continuum between a static playback of a previous perception, and a fluid, spontaneous construction of a dream-like sequence within the bounds of normal wakeful awareness.

Visual hallucinations due to the ingestion of drugs such as lysergic acid diethylamide (LSD) may, at times, bear some resemblance to the hallucinations that occur in the Charles Bonnet syndrome. These hallucinations may be well-formed and may have no basis in physical reality. However, on other occasions they may be less complex, consisting of lattices, cobwebs, tunnels, etc, as noted by Klüver (1942), or alternatively, they may represent distortions of objects that have a physical basis. Though Slade and Bentall (1988) conclude that the cause of LSD hallucinations is not known, they point to the disrupting effect that this drug has on visual processing in the lateral geniculate nucleus (Evarts 1957; Horn and McKay 1973). This effect is consistent with the sensory deprivation framework.

It has also been noted that there is a similarity between the hallucinations of the Charles Bonnet syndrome type and phantom limb phenomena (Bartlet 1951). Both experiences arise in the context of the lack of input from their respective sensory domains. In the case of the phantom limb, this lack of input can be due to amputation of a body part, section of a sensory nerve, or an anaesthetic block of the brachial plexus or the spinal cord (Bromage and Melzack 1974; Melzack and Bromage 1973). With visual hallucinations, the loss of input may be due to the disruption of visual impulses anywhere along the visual pathways. The analogy holds for more descriptive phenomena: both phenomena appear to have a rather ill-defined set of manipulations that may trigger or stop the experience, and both can have similar temporal parameters (ie the experiences tend to decrease in frequency after a period of time and may reappear after periods of absence).

Recently Melzack (1989) has proposed a new conceptual framework to explain phantom limb phenomena. He notes that phantoms occur in virtually all cases in which somatosensory impulses are blocked, and that the phantom does not appear to be generated by peripheral nerve fibres. His theory proposed that nerve-impulse patterns flowing through widely distributed neural networks in the brain—the 'neuromatrix' that he hypothesizes to be the substrate for somatic experience—produce the phantom experience (Melzack 1989, 1990). 'Experience' is not evoked by 'stimulation' according to this idea, but is generated by the brain.

Similarly, it is hypothesized that the complex visual experiences of the Charles Bonnet syndrome are generated by neural-impulse patterns, originating in those brain areas subserving vision. These patterns of neural impulses may be initiated by nonspecific input of the ascending reticular formation, activity of intact visual receptors, or hyperactivity of cells central to damaged visual areas. This theory emphasizes the inherent capacity of the brain to generate, or constuct, meaningful experience without direct correspondence to sensory stimuli. In addition, it counters the view that a single locus is responsible for the hallucinatory experiences.

In this review it is shown that the Charles Bonnet syndrome is an extremely complex experiential phenomenon. The use of one theoretical framework rather than another must be based on its ability to account for the diversity of descriptive information. We propose that the recently developed neuromatrix theory is a useful framework. While allowing for comparisons between Charles Bonnet syndrome hallucinations and phantom limb phenomena, it is also flexible enough to support specific hypotheses such as the role of an arousal mechanism in hallucination formation. This hypothesis rejects the explanation that people who experience the syndrome are "going crazy". These people must be assured that their experiences are a natural consequence of their deteriorating eyesight.

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Bridge between Study 1 and Study 2

Numerous journal articles concerning the Charles Bonnet syndrome have appeared in print since the publication of the above review. The majority of these reports involve a single case, or two-to-three cases. Since most of these articles with small sample sizes do not add significantly to knowledge on the Charles Bonnet syndrome, they will not be addressed individually at this point. However, they will be discussed within the ensuing studies of the thesis.

The single exception that merits discussion at this point is an article by White and Jan (1992), who report on complex visual hallucinations in a four-year-old child. Briefly, White and Jan (1992) describe a case of a boy with visual difficulties beginning at age 11-months due to a tumor located along the optic radians. A combination of radiation therapy and surgery delayed blindness until age four. Shortly after the onset of total blindness, the child began to see people, animals and familiar objects. Aside from the hallucinations, the child's mental and neurological status were unremarkable. Further medical evaluation also revealed no abnormalities.

Not only is this the youngest case ever reported, but it also adds to the strength of a finding in Study 1 -- that even though the Charles Bonnet syndrome occurs most frequently in older people, it can also occur in much younger individuals, particularly those with tumours in the visual processing areas. Thus, the general consensus that these hallucinations occur predominantly in older persons is, at least in part, due to an increase in the frequency of visual problems in older individuals. Epidemiological studies, both world-wide (Thylefors et al., 1995) and those conducted in North America (Kahn et al, 1977; Tielsch et al., 1990; Klein et al, 1991), show that the

prevalence of visual disorders increases as a function of increasing age. Clearly, future studies that assess the risk for these hallucinations should take into account the change in base rates of visual disorders across the age spectrum.

This case also raises an interesting question concerning the amount of visual experience that is necessary in order for a person to have the hallucinations. This child had visual difficulties from the time he was an infant and was blind by the age of four. He clearly had not enjoyed 65 - 70 years of sight that the average hallucinator has experienced. In the phantom limb literature, there are reports of individuals who experience a phantom despite being born without a limb (Vetter and Weinstein, 1967; Saadah and Melzack, 1994). There are no reports of complex hallucinatory experiences in congenitally blind individuals. However, in a true case of total blindness from birth it would be difficult (if not impossible) for the blind person to assess whether he or she were hallucinating. The reports of a phantom limb in cases of congenital aplasia are credible because the person with the phantom has experience with "what it is like" to feel other parts of their body; they have a reference experience by which to judge the reality of the phantom experience. The congenitally blind person has the entire sensory domain abolished, and thus would have no reference experience with which to compare a hallucinatory visual experience, if one were to occur.

In summary, Study 1 of the thesis provides an overview of the syndrome through an examination of cases in the literature. This approach plays an important role in the development of ideas about the syndrome, but a systematic study is necessary to validate those ideas. Different kinds of information are usually collected by different investigators. The advantages of having the same information collected from a comparatively large number

of subjects are obvious; generalizations to the entire population are more likely to be accurate; the strength of association between properties of the hallucinations can be determined; statistical dimension-reduction techniques can also be utilized to determine underlying factors. The next study in the thesis systematically examines the properties of the hallucinations.

Properties of Complex Hallucinations Associated with Deficits in Vision

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Abstract

Complex visual hallucinations are known to occur in individuals with visual deficits whose emotional and intellectual functioning are within the normal range. These hallucinations, which were first reported by Charles Bonnet, have been reported in many case studies, but have not been analyzed empirically to determine their major properties. In the present study, sixty "Charles Bonnet" hallucinators were administered a questionnaire to determine the properties of their hallucinations. Combined use of multiple correspondence analysis and hierarchical cluster analysis reveal a core set of features, some of which are similar to those proposed by Naville in the early 1900's. Typically, the hallucinator's experience occurs while he is alert and with the eyelids open. Moreover, a sharply focused image appears suddenly, without any apparent trigger or voluntary effort. The hallucination is present for a few seconds, does not move during this time, then suddenly vanishes. The results also uncover a previously unreported "dimension" of hallucinatory/perceptual experience, which ranges from discrete, singular perceptual experiences to multiple, changing experiences. Possible brain mechanisms that underlie the Charles Bonnet hallucinations are discussed.

Introduction

Complex visual hallucinations are known to occur in individuals with visual deficits whose emotional and intellectual functioning are within a normal range. These hallucinations, called "Charles Bonnet" hallucinations, have been the subject of single case studies and small collections of case reports since 1760, when the phenomenon was first described by Charles Bonnet. Despite the fact that information collected in case reports usually varies from case to case, knowledge has gradually accumulated on the properties of these hallucinations. However, there has never been a large scale empirical study to substantiate (or refute) the "clinical lore."

It is important to establish the properties of Charles Bonnet hallucinations in order to determine how the hallucinations associated with deficits in vision are similar to or different from normal visual perception, other visual hallucinations, and other quasi-visual experiences such as imagery and dreaming. This knowledge, in turn, may shed light on the cause of the hallucinations as well as provide clues about the nature of visual perception in general. Recently, Walter et al. (1990) have attempted to classify hallucinations by looking for differences in activity in various brain regions when a group of hallucinating psychiatric patients was compared to a group of hypnotically induced "hallucinating" healthy subjects. Using a brain imaging technique, they found differences in nine brain areas, including thalamic and hippocampal regions and propose that these differences provide the basis for a classification of hallucinatory phenomena. However, the investigator who pursues a phenomenological approach to classifying hallucinations, which historically is the most common approach, generally recognizes that knowledge of the cause or causes of hallucinations does not

follow so directly from the data. Here, speculation on etiology depends upon the ability to create links between observed regularities in hallucinatory properties and theoretical models based on known brain physiology.

When the phenomenological method is utilized, it is important to note that the final classification structure depends upon the questions asked of the subject. When an inquiry is made with regard to a particular hallucination property, such as whether the hallucination contains colour, that question creates a "dimension" on which the hallucinators may be placed. This in turn raises the issue of what are the relevant dimensions; what questions should be asked of hallucinators in order to characterize them? The answer is not simple. In fact, a body of literature has accrued in which aspects of a wide variety of quasi-visual experiences, including hallucinations, are examined (see Galton, 1883; Jaspers, 1923; Sarbin, 1967). A review of these largely philosophical and anecdotal explorations is beyond the scope of this paper and will not be addressed here. We will start, however, by noting how the Charles Bonnet hallucinations have previously been characterized.

Ernest Naville, as documented by de Morsier (1967), summarized his own personal experience with the Charles Bonnet syndrome in the early 1900's. He stated that the following properties characterize the syndrome: 1) the subject is alert and realizes that the hallucinations are not real, 2) normal visual perception and the hallucinations co-exist, 3) the hallucinations are exclusively visual, 4) no other special sensations accompany the hallucinations, 5) the hallucinations come and go without the person knowing why, 6) the hallucinations are not distressing but, rather, are interesting (de Morsier, 1967). Based on their review of cases, Damas-Mora, Skelton-Robinson and Jenner (1982) note that the hallucinations may vary

from being highly organized at the onset to gradually forming before the hallucinator. They further note that the duration of the hallucinations is variable, that the hallucinations are localized in external space at varying apparent distances, that the images can be bright and multi-coloured or black and white, and that they are usually animated.

In a review of the Charles Bonnet literature, Schultz and Melzack (1991) found that a number of hallucinators did not find the experience positive, and further that other features such as the conditions under which an episode arises, the duration of the images, and movement of the images, were varied among the different hallucinators. On rare occasion, sound may accompany the visual hallucinations; Patel et al (1987) document a case in which music accompanied circus acts seen by a woman with losses in both vision and hearing. The extent to which the variability of the hallucinatory experiences, as described in the review papers, is due to the fact that their information came from a wide variety of sources is unknown.

The present analysis was undertaken to establish whether a set of properties common to Charles Bonnet hallucinators exist, and if so, to clarify the nature of the properties. This was done with the assumption that if the hallucinations can be found to exhibit a common set of properties, then those properties may in turn shed light on the the processes that create the hallucinations. The questions asked about the hallucinations derive from four broad "dimensions." The dimensions examined do not represent an exhaustive set, but sample a wide variety of properties, including temporal factors (frequency, duration, onset), content (quantity, colour, clarity, movement), subjective concomitants (affect, arousal level, perceived control), and external factors (triggers, state of eyelids). The aim of the analysis is to determine the experiential properties of these hallucinatory perceptions.

Methods

Subjects

Sixty subjects who reported complex visual hallucinations were investigated. The subjects were inpatients at the Blind Rehabilitation Services of the Veterans Affairs Medical Centers at West Haven Connecticut, Birmingham Alabama, and Palo Alto California from 1986 to 1992. These subjects were included among the group studied by Needham (1992) and Taylor et al. (1988) as part of their larger studies on unusual visual events. All subjects, whose eye condition met the criterion of legal blindness, were enrolled in a 10 to 12 week program on adjustment to blindness. The mean age of the group was 62.3 years (SD of 12.2).

Procedure

As part of a routine clinical interview and assessment shortly after admission, the subjects were asked if they have experienced any unusual visual phenomena. If a subject acknowledged such experiences, a visual hallucination questionnaire was administered to that person.

Visual hallucination questionnaire

Information on twelve properties of visual hallucinations was developed for statistical analysis. Table 1 shows the properties or variables examined along with the levels within their respective variable. These properties derive from a questionnaire (Taylor et al, 1988) that contained 18 variables. For three variables used in the present study ("Frequency", "Duration" and "Affect"), levels within that variable were collapsed from the original questionnaire to increase the frequency count within the formed levels. For an additional three variables, a level within each variable was

1. Onset
    - sudden
    - gradual
2. Variety
    - single image
    - two-to-five images
    - greater than five images
3. Frequency
    - frequent
    - infrequent
4. Duration
    - seconds
    - minutes
    - hours
5. Clarity
    - sharp
    - blurry
    - variable
6. Arousal level
    - alert
    - drowsy
7. Trigger
    - has trigger
    - does not have trigger
8. Perceived Control
    - has control of hallucination
    - does not have control
9. Hue
    - achromatic
    - single colours
    - multiple colours
10. Associated Affect
    - positive
    - negative
11. Movement
    - hallucinations move
    - hallucinations do not move
12. Eyelids
    - open
    - closed
    - either open or closed

Table 1. Hallucination properties used for the analysis.

dropped from the original questionnaire. For the variable "Perceived Control" a response of "not attempted" was coded as missing data. For the variable "Clarity" the response category of "barely discernible" was dropped as no responses fell into this category and further it was felt that the "blurry" response category subsumed this category. Finally, for the variable "Arousal" the category of "dreamlike or dreaming" was dropped along with any subjects who chose only this category. If a subject has the experiences only in a state close to dreaming it is unclear whether they are hallucinating and not, in fact, dreaming. In total there were 29 categories analyzed from the 12 variables.

The six variables of the original questionnaire which were not included in the modified questionnaire are related to the following: the apparent size of the hallucinations (larger, smaller or normal sized); their appearance in the usable field; whether the environment could be seen in front of or behind the hallucinated object; the eye or eyes that the hallucinations appeared in; concomitant sensations in other sensory modalities; and a question on their understanding of the cause of the hallucinations. The question on size was dropped as there was not enough variation to include it in the type of analysis performed. Most hallucinators reported that the size appeared normal. The remaining questions were not included because there were too many missing data points.

Data Analysis

A 60 by 29 (subjects by levels of variables) indicator matrix was formed. Missing values or responses in which more than one level within a variable was endorsed were "fuzzy coded." For example, a hallucinator who endorses that his eyelids are "open" rather than "closed" or "open or closed" will have that response coded as "1,0,0" for those levels within the "Eyelids" variable. If data were missing for that subject for that question it would have been coded

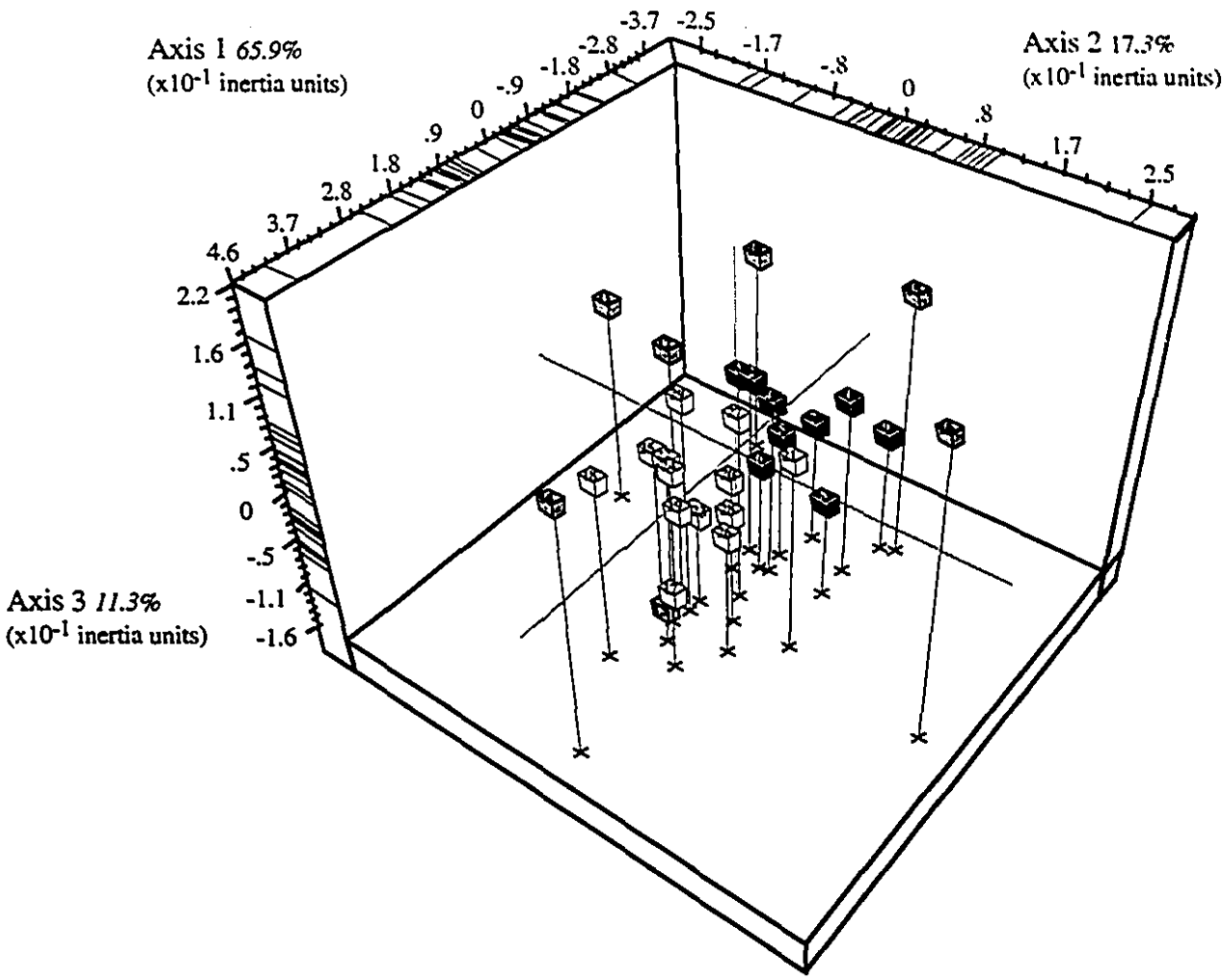
as ".3333, .3333, .3333", effectively splitting the certainty of the response among the possible choices. Missing or ambiguous data (fuzzy coded) comprised 10.1 % of the indicator matrix. The computed indicator matrix was the starting point for two complementary analysis methods -- multiple correspondence analysis and hierarchical cluster analysis.

Multiple correspondence analysis (MCA) is a descriptive multivariate technique that provides a graphical display of cross-tabular data along with associated statistics (Greenacre, 1993; Greenacre and Blasius, 1994). This graphical display allows for an easy identification of associated categories because the degree of association between categories is represented by the proximity of the points in the display. For the present analysis, the MCA was computed by using a so-called "Burt" table of all possible cross-tabulations between the categories (see Greenacre, 1993 for a precise definition and description of the make-up of the Burt table). MCA, like principle component analysis, yields a set of "factors" on which the original categories are given a projected value. As well, a "principal inertia" (eigenvalue) is found for each of the factors. The value of a principal inertia, when expressed as a percentage of the sum of all the principle inertias, is analogous to the percentage of variance that can be explained by that factor associated with the principle inertia. In order to improve the accuracy of those projected values (i.e., in order to have the first few factors account for a greater percentage of the variance), a procedure introduced by Benzécri in 1979 (Rovan, 1994) was carried out and resulted in a set of "modified" values for the factors (see Rovan 1994 for a rationale for, and details on, the modification procedure). (Thesis readers please refer to Appendix A for a description of a "Burt" table and a rationale for the use of modified factor scores.) A plot of the categories using the modified factor scores for the first three factors was made.

Where the MCA plot allows for a global inspection of the association between categories, it is often helpful to further summarize the configuration of points using cluster analysis (Lebart , 1994). For example, it may at times be difficult to determine where bounds should be drawn around categories that appear to cluster together. A clustering procedure provides this information. A hierarchical clustering procedure was performed using Ward's method to join groups, and based on a dissimilarity matrix calculated from the original indicator matrix.

Results

Figure 1 shows the plot of the hallucination categories using the first three dimensions defined by the modified factor scores. It can be noted that these first three dimensions accurately reflect the position of the categories relative to each other. Combined, they represent 94.5 percent of the total modified inertia. Figure 1 also shows the how the categories cluster when they are partitioned into three groups. Figure 2 shows the more complete result of the cluster analysis in the form of a dendrogram. Inspection of the dendrogram demonstrates that the categories fall into three clusters. Cluster 1 appears to be a "main" cluster. Cluster 3 is largely (but not exclusively) comprised of the opposite categories of cluster 1, and cluster 2 composed of those categories that do not fit into cluster 1 or 3. For the purposes of most agglomerative cluster analyses, however, the number of clusters discussed also depends upon the "usefulness", or "how interesting" a particular set of clusters are within the context of the exploratory analysis. It can be seen that cluster 1 contains members that correspond fairly closely to Naville's "core" features of the Charles Bonnet syndrome. Namely, that the hallucinations



Cluster 1

1. Occur infrequently
2. Hallucinations occur for seconds
3. Eyes are open
4. Hallucinations have no trigger
5. Not under voluntary control
6. Occur while alert
7. Occur Suddenly
8. Hallucinations are sharply focused
9. Hallucinations do not move

Cluster 2

10. Single image
11. Hallucinations are blurry
12. Hallucinations are achromatic
13. Hallucinations occur for hours
14. Hallucinations have variable sharpness
15. One colour
16. Eyes are closed

Cluster 3

17. Eyes can be open or closed
18. Hallucinations have a gradual onset
19. Hallucinations have a trigger
20. Associated with negative emotions
21. Greater than five different images
22. Under voluntary control
23. Two-to-five images
24. Occur frequently
25. Hallucinations move
26. Multiple colours
27. Associated with positive emotions
28. Hallucinations occur for minutes
29. Occur while drowsy

Figure 1. Plot of hallucination properties cross-classified by clusters.

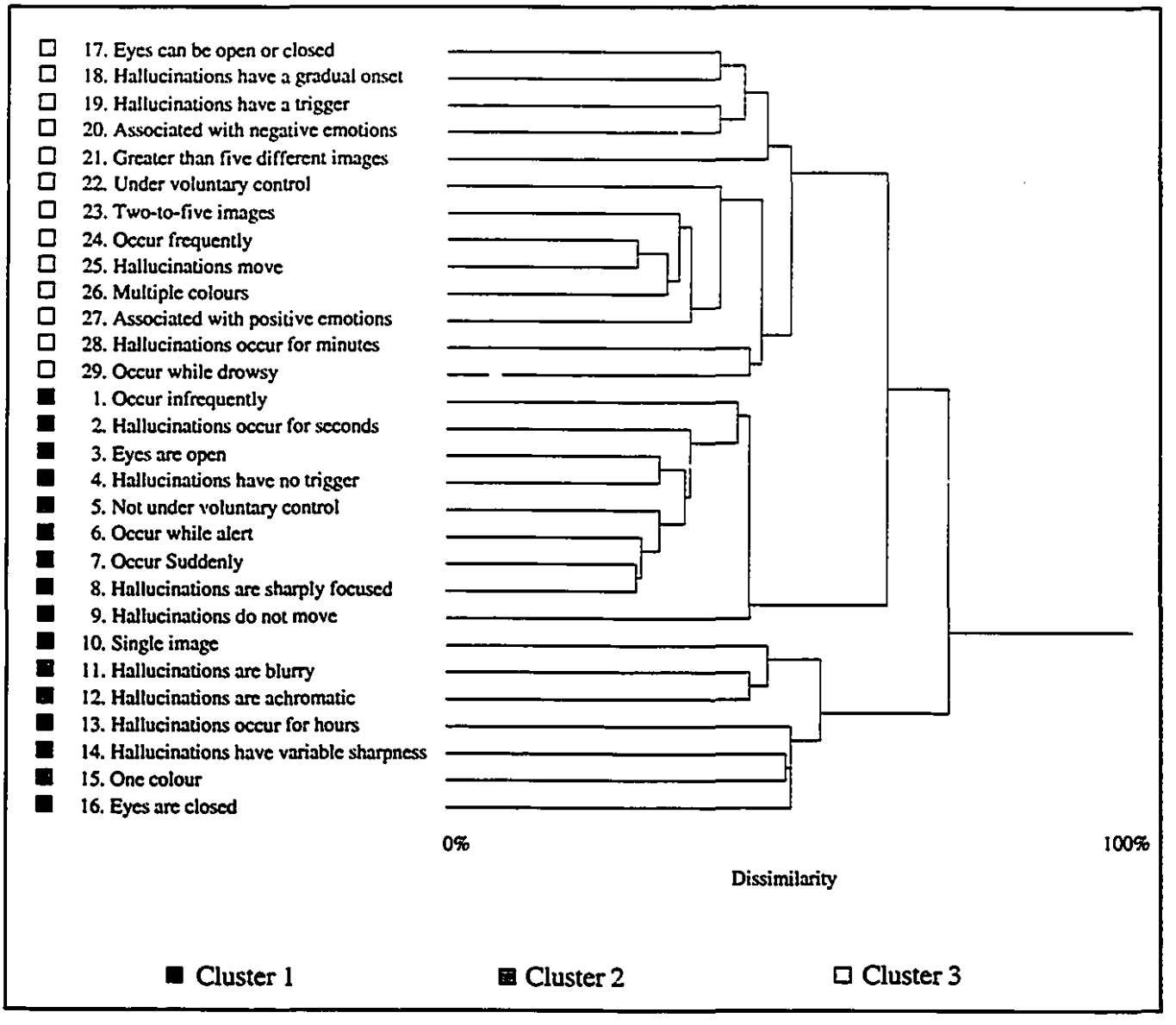


Figure 2. Cluster analysis dendrogram.

occur while the person is alert (Naville's feature 1), that the hallucinator's eyes are open (Naville's feature 2) they have no trigger and are not under voluntary control (Naville's feature 5). Interestingly, the fact that the positive emotion category (or negative emotion) was not found within the main cluster suggests that Naville's feature 6 is not an essential part of the core constellation of features. (Information on whether the hallucinations are exclusively visual was not available therefore features 3 and 4 described by Naville could not be compared to our data).

Since the agglomerative cluster analysis, by its nature, forced the categories into groups, it was of interest to determine the extent to which the members of the main cluster, cluster 1, were associated. In other words, how strong is the association between those categories that constitute cluster 1? It was reasoned that if a set of categories was strongly associated, then at least most of those categories that constitute cluster 1 should be present *together* when being endorsed by a hallucinator. To determine if this was in fact what happened, the indicator matrix was further analyzed. Fuzzy data points were first converted to zeros so that the indicator matrix was composed only of 1's (to indicate the definite presence of a category) and 0's. For each of the 60 hallucinators a score from 0-9 was found that indicated how many of the 9 categories of cluster 1 were present. A frequency count of each of those bins from 0-9 was computed. In order to compare the observed frequency distribution to a standard, a frequency distribution based upon the average of randomly chosen sets of 9 categories was constructed. From probability theory it can be found that there are 540,720 different combinations of 9 categories given the constraint that only one category from a variable can be used in any group of 9 (taken from the 12 variables). As it is computationaliy unwieldy to find the average of all possible combinations, the average of a smaller, but

still sizable number (10,000 groups of 9) was computed. Each of the sets was formed by first randomly choosing 9 of the 12 variables, then randomly choosing one of the categories from each of the variables. Figure 3 shows the frequency distribution of the number of categories present in cluster 1, as well as the frequency distribution for the randomly generated combinations. Descriptively, it can be seen that for bins indicating a high degree of association, the set of categories found in cluster 1, were far more frequent than what could be expected from chance groupings of 9 categories (refer to Figure 3, bins 6, 7, and 8). Conversely, random combinations of categories show greater numbers for the bins indicating lower association (see Figure 3, bins 2, 3, and 4). Chi-square analysis confirms the difference between the observed distribution of the cluster 1 and the expected distribution formed from the averaged data $\chi^2_9 = 74.24, p < .001$).

The MCA results can also be approached from a "factor" perspective. That is, it can be assumed that the categories investigated on the questionnaire measure, to a greater or lesser extent, underlying dimensions of perceptual/psychological space. The results from the MCA show that a single factor (axis 1, Figure 1) accounts for 2/3 (65.9%) of the total modified inertia. Figure 4 shows that factor along with the projections of the categories on that factor. Inspection of the relative positions of the categories along this axis reveal that this dimension appears to encompass an aspect of hallucination perception that we call "multiplicity/discreteness." That is, this dimension appears to represent discrete and singular perceptual experiences at the one end, and multiple and changing perceptual experiences at the other end. Charles Bonnet hallucinations, as defined by Cluster 1, are found exclusively on the negative pole of this dimension (underlined type on Figure 4).

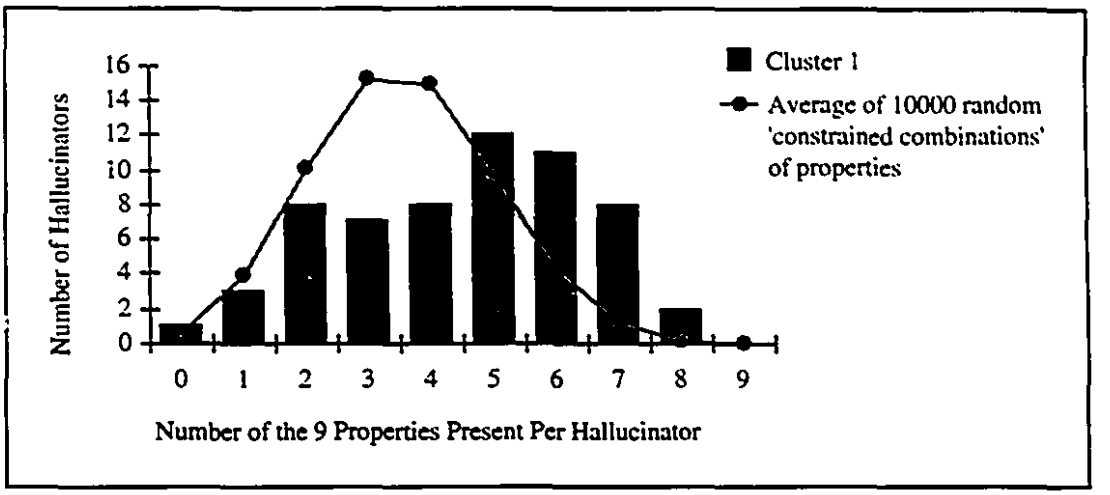


Figure 3. Distribution of the number of properties present in cluster 1 compared to a randomly generated distribution.

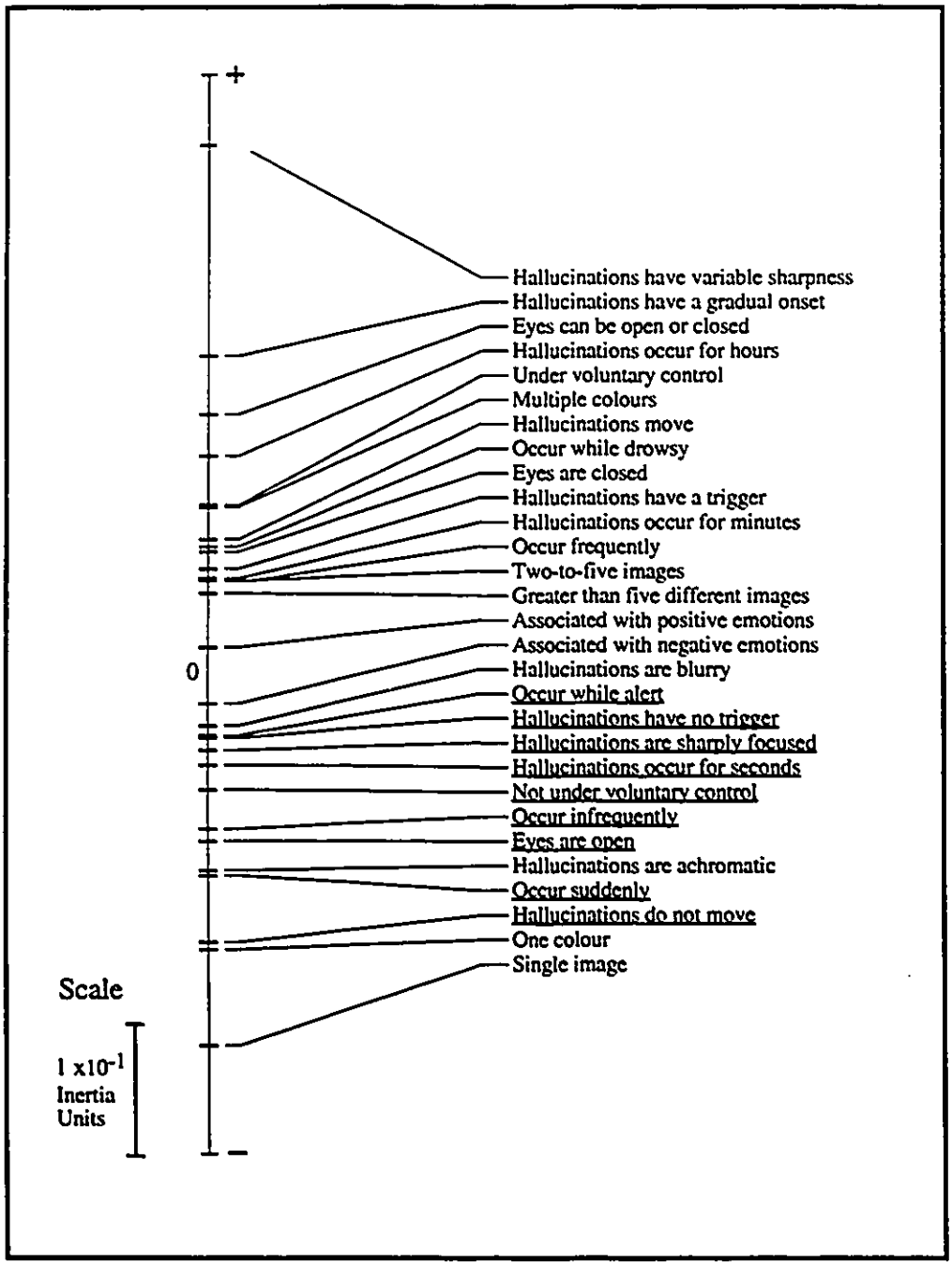


Figure 4. "Multiplicity/discreteness" dimension.

Discussion

The results show that Charles Bonnet hallucinators exhibit a common set of characteristics. The typical hallucinator's experience occurs while alert and with his/her eyelids open. It involves having a sharply focused image appear suddenly, without any apparent trigger or voluntary effort. The hallucination is present for a few seconds, does not move while present, then suddenly vanishes. While Naville, over eighty years ago, described the properties of Charles Bonnet hallucinators, this paper reports on the first larger sample, empirical study to document their properties. In contrast to Naville and reports by authors such as Damas-Mora et al (1982), it was found that the representative or typical experience is not necessarily pleasant for the hallucinator. In fact, as Needham and Taylor (1992) have observed, some hallucinators fear that the 'phantom visions' are a harbinger of psychoses, when in fact they are not (Schultz and Melzack, 1993; Needham and Taylor, 1992; Taylor et al., 1988). Additionally, the results from this study, in contrast to Damas-Mora et al (1982), indicate that the typical hallucinated image does not move.

The results also reveal a dimension of the hallucinatory experience which has not been previously recognized. We have labeled it as the "multiplicity/discreteness" dimension. The utility of this dimension still needs to be demonstrated. The knowledge that the Charles Bonnet type of hallucination clusters on one pole of the dimension could potentially be used to discriminate between Charles Bonnet hallucinations and other types of hallucinations. For this to occur, visual hallucinations which arise during other circumstances, such as during an acute psychotic episode in

schizophrenia, would have to show a different distribution of properties along this dimension.

This dimension is also relevant to speculation on the processes that underlie hallucinations [and perceptual experience itself]. According to Dennett (1991) the hallucinatory process (and perhaps the normal perceptual process) involves sating "epistemic hunger" with a mechanism that reports on information gathered from the environment. That is, the brain generates hypotheses, then has them "accepted" or "refuted" on the basis of information from the environment. The multiplicity/discreteness dimension suggests that the negative pole, relative to the positive pole, represents properties that would require less information from the environment to generate (or sustain) it.

Further evidence related to Dennett's idea may come from looking at how the properties of hallucinations found in this study differ from those of normal visual perception. Jaspers (1923) wrote that normal perceptions have the characteristic of "objectivity", appear in external objective space, are clearly delineated, have sensory elements that are full and fresh, are constant, and are independent of our will. Given the results from this study, we can see that the hallucinations are unlike normal perception in that the hallucinations are only present for a brief time and generally do not move. In light of the ideas proposed by Dennett and developed here, it is predicted that the hallucinations would be particularly susceptible to being disconfirmed when they are actively examined. As time passes during examination, the likelihood that degraded (or random) peripheral input would conform precisely to what is anticipated, becomes increasingly small. Thus, the hallucinations are present for only brief periods. Anecdotal evidence is consistent with this account. As noted by Schultz and Melzack (1991), Charles

Bonnet hallucinations have been reported to disappear when the hallucinator approaches the hallucination or attempts to interact with the hallucinated object.

The fact that these experiences can occur with little or no information from the environment argues strongly for "top-down" processes playing a role in the production of the hallucinations. Dennett's idea of hypothesis generation has already been mentioned, but we speculate further on the nature of a "hypothesis." Neisser (1976) argues convincingly that perception is a cyclical process involving receiving information from the environment through cognitive schemata which in turn direct exploration for new information. Most relevant here is Neisser's notion of anticipatory schemata. Anticipatory schemata are "[cognitive structures] that prepare the perceiver to accept certain kinds of information rather than others and thus control the activity of looking." More recently, Melzack (1989, 1990) has elaborated this concept of schema which he calls a "neuromatrix." The neuromatrix is conceptualized as a template, which is genetically determined but modified by experience, that generates the pattern of nerve impulses (or "neurosignature") that subserves perception on the basis of the synaptic architecture of the neuromatrix and the raw sensory input. Accordingly, Charles Bonnet hallucinations may occur when an anticipatory schema, or a certain neuromatrix, is activated and a minimal input from the peripheral visual areas confirms or sustains the schema or neuromatrix.

It is paradoxical that phenomenology is both a strength and weakness of psychological research, for it seeks to classify "what it's like" to have uniquely human experiences, but also denies the objective verification of its data. When combined with the fact that language can, in some instances, fail to adequately describe our experiences, confusion may arise as

to what a word or phrase means in experiential terms. Researchers (Aggernaes 1972; Aggernaes and Nyeborg, 1972), for example, have attempted to determine how realistic schizophrenic hallucinations are by having schizophrenics rate their hallucinations along seven rather similar dimensions such as: sensation vs. ideation, publicness vs. privateness, objectivity vs. subjectivity, existence vs. non-existence. How can we be sure that we are not asking questions about the same aspect of a mental representation?

The consequence of this may be to create undue nosological confusion. For example, the distinction between Jasper's (1923) "characteristic of objectivity" and "appears in objective space" appears to have added to the confusion surrounding the term "pseudo-hallucination" (Taylor, 1981). Jaspers, following Kadanski (1885 pp. 49 -50, as translated in Taylor, 1981), thought that a visual event could seem to take place external to an individual, still have the "phenomenological feel" of one's own mental processes, yet not be under volitional control. And it is this phenomenon that was termed a "pseudo-hallucination." Since the visual experience is very vivid and non-controllable (as is normal visual perception) yet can be distinguished from normal visual perception in that it occurs in an imaginal space, a secondary judgment can be made that the experience is not real . This, in turn, may have contributed to the evolution of an alternate definition of "pseudo-hallucination" where the term is used to describe any hallucination experience in which the person retains insight into the fact he or she has had an hallucination (as is the case with Charles Bonnet hallucinations).

Despite these potential shortcomings, there are some heuristic procedures that can aid phenomenological research. As Lowe (1973, p. 626-

627) notes, "phenomenological research, in so far as it is hypothesis-finding, requires broad initial definitions of the subject for study, and multi-dimensional parameters of variation. The only limiting factor is one of practical convenience." In the present study attempts were made to query a wide variety of properties of the hallucinations. Subjects, by their inability to answer questions, pared down the initial set of variables to select the final set. Additionally, the ability to "fuzzy code" data allowed for analysis to proceed without creating "dummy" variables for missing points (and thus increasing the dimensionality of the analysis), or throwing out that subject's data entirely.

As the principal method of data analysis in this study is still relatively unknown, a comment will be made on multiple correspondence analysis. Developed in the 1960's by Benzécri, this method has only within the last ten years become known as an alternative to more traditional methods of analyzing categorical data, such as performing many chi-square analyses. The advantages over chi-square are immediately evident. This approach can handle multiple categorical variables simultaneously, results can be displayed in plots that convey large amounts of information, and because analysis involves eigenvalue decomposition, "interesting" dimensions can be discovered that were not immediately apparent from the initial data. Computation is obviously more complex than with chi-square, though both methods have conceptual similarities in their analysis of contingency tables.

The Charles Bonnet syndrome, like all higher-order perceptual phenomena, is obviously very complex. While, on the one hand, it may be disheartening to see that we are still investigating topics that are hundreds of years old, on the other hand this is not new for psychology because it seeks to understand very complicated systems. As well, answers to these questions are

slowly accumulating. In this study, efforts were directed towards classifying these hallucinations by using a sample size much larger than has been previously employed as well as utilizing statistical methods permitted by that sample size.

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Bridge between Study 2 and Study 3

The next two studies address a second question posed by the review of the literature, namely, what is the mental status of the hallucinators? The term mental (or psychological) status is used to refer to a individual's emotional and cognitive functioning. Specifically, to the extent that a person experiences symptoms of emotional disregulation, that person would be regarded as not functioning well, and it is expected that distress would be reflected in scores on psychological questionnaires that measure those symptoms. Likewise, impaired cognitive functioning, broadly defined as "a diminished capacity to know the world" (Folstein et al., 1985), was tested with an instrument that screens for obvious deficits in orientation, memory, attention, calculation, and language functions.

With regard to the mental status of the hallucinators, the general consensus based on case reports has been that the hallucinators are not psychotic, nor are they, by and large, cognitively impaired. Nevertheless, as was mentioned before, the psychological status issue has not been addressed systematically using formal psychological tests. At the outset of this study, there were no published reports documenting test results on psychological measures and cognitive status measures taken together. There were two unpublished studies (Taylor et al., 1988, Needham et al., 1991), not reported in Study 3 because they were unpublished at the time. Both of these studies were based on inpatients in a blindness rehabilitation program offered at selected veterans affairs (VA) medical centers in the United States.

There are many differences between the VA studies and Study 3 of the thesis. As stated before, their subject population was hospital based, and involved an "adjustment to blindness" program which may have influenced

baseline measures of psychological functioning. Emotional distress could have been higher than normal, given that the subjects were enrolled in a program where they focus on their disability. Alternately, it could be argued that emotional distress could have been lower than normal, since subjects have the immediate support of others with visual problems, as well as the availability of psychological services. It was therefore important to determine mental status in a community-based population. Other differences include the choice of measures of psychological symptomatology. Study 3 of the thesis included a general measure of psychological symptoms (the Mini-Mult), and two specific measures for depression and anxiety (the Beck depression Inventory and the Spielberger anxiety inventory, respectively). Additionally, Study 3 employed a widely-used objective cognitive screen (the Mini-Mental State Examination).

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Visual Hallucinations and Mental State

A Study of 14 Charles Bonnet Syndrome Hallucinators

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Complex visual hallucinations are usually a sign of acute psychopathology or gross cognitive impairment, but may also occur in people with visual deficits—the Charles Bonnet Syndrome. The mental state of 14 Charles Bonnet hallucinators was assessed using four psychological tests: the Beck Depression Inventory, the State-Trait Anxiety Inventory, the Mini-Mult, and the Mini-Mental State Examination. Results are consistent with earlier reports suggesting that these hallucinations are not due to psychopathology or compromised cognitive functioning. It is proposed that these complex visual hallucinations represent ongoing neural activity in the visual system following eye damage.

—*J Nerv Ment Dis* 181:639–643, 1993

Hallucinations occupy a cardinal place among the numerous signs and symptoms of severe mental disturbance. This perception of events that have no physical basis seems to indicate a malfunctioning brain. However, if it is believed that the brain not only registers sensory events, but contains the neural matrix in which both externally and internally generated information flows, then it is conceivable that hallucinations can occur in a neuropsychiatrically normal individual. A recent conceptual theory of brain functioning (Melzack, 1989, 1990) proposes that the reduction of normal sensory input to the brain is the basis of hallucinatory phenomena such as phantom limbs. This concept is consistent with current ideas in cognitive psychology, which hold that sensory inputs arrive at an active brain that is the repository of past experiences, meaning, expectations, and other cognitive abilities.

The Charles Bonnet Syndrome is a condition in which individuals experience visual hallucinations within the context of a decrease in vision (Schultz and Melzack, 1991). The original case published by Bonnet in 1769 (Morsier, 1967) suggests that his subject exhibited no gross mental abnormalities. This clinical feature has also been reported by others (*e.g.*, Adair and Keshaven, 1988; Alroe and McIntyre, 1983; Rosenbaum et al., 1987). Since most cases have been reported in an ophthalmological or neurological setting, clinical judgments on the subjects' mental state have not been substantiated by formal psychological testing. This study used four standard psychological tests to evaluate the mental state of 14 hallucinators who were labeled as having the Bonnet syndrome.

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Method

Subjects

Fourteen subjects (five men and nine women) were recruited for the study. The mean age of the group was 74.6 years (range, 43 to 87 years). In all cases, visual acuity was 20/200 or less in the better eye, as determined from optometry records. Table 1 presents the subjects' age, sex, visual status, and a summary of their principal hallucinatory content. To further illustrate the nature of the hallucinations, description is provided in greater detail for two cases.

Case Examples

Subject 5. Subject 5 states that his hallucinations began in April 1990 and have occurred daily since that time. He describes seeing frequently changing images of people that appear predominantly on a "light background" but sometimes on a "dark background" as well. He reports that the images are mostly of heads and faces but may also include the torso of the person. They appear life-like and have natural colors. He further states that he sees very few women; his images consist mainly of children's faces. He reports that he has, on occasion, seen an image of a grandchild, his wife, and his daughters at a younger age, but for the most part, he does not recognize the faces. While being interviewed, subject 5 began to hallucinate and described seeing the head and face of a young boy. He described the boy as having short, curly hair and a straight nose. Interestingly, he reported that the young boy's eyes and head turned to follow the subject's hand movement when he

TABLE 1
List of Cases in the Study

Case	Age	Sex	Visual Acuity* (left eye, right eye)	Principal Hallucinatory Content
1	73	F	10/600, 10/700	Images of animals; faces and entire people
2	81	F	5/600, 5/300	A large rock; a lilac-covered building; flying birds
3	82	F	5/100, 1/500	A winter snow scene; a red-brick building
4	79	F	10/140, 5/3500	A mask-like face; two different images of the mouth area of a face
5	72	M	NLP, NLP	Images of children; faces of people
6	49	F	10/140, NLP	A sharp, realistic-looking eye
7	76	F	CF, CF	Images of two different dogs across television screen
8	78	M	HM, 10/200	Faint images of a cathedral, faint images of a billboard
9	82	F	10/225, 3/600	Red and black checkerboard; images of people across television screen; floral pattern in visual field
10	87	M	CF, CF	Wild animals; images of people; large black circles
11	83	F	LP, 20/600	Black and white images of people that resemble portraits
12	79	F	5/300, 5/250	Circular design; shrubs and bushes; horse-drawn carriages
13	83	M	10/100, 5/250	Wire-net fence; vertical bars "like in a jail"; red brick wall; schematic silhouette of 3 people
14	43	M	NLP, NLP	Animated scene of room being lit on fire by a woman

*By convention, when visual acuity is too poor to be quantified using standard eye charts, it is designated by using the terms counting fingers (CF), hand movement (HM), light perception (LP), or no light perception (NLP).

stretched out his arm. This type of interaction between the hallucinator and the hallucinated object is rarely reported. Further questioning revealed that another type of "interaction" may also occur. While hallucinating, when subject 5 moved his eyes downward, he reported that the hallucinated image shrank in size (as if he were now looking down at the image), and conversely, when he moved his eyes upward the hallucinated image became larger (as if he were looking up at the image). He reports that the images do not disappear when he closes his eyes and may be present for as long as 15 minutes. Subject 5 also reports that he has seen numerous other images, such as a van on the street, or a person in front of him while walking. He reports seeing a large window on a solid wall in his living room; through this window he can see tall trees in a park in which the ground is covered with snow. Subject 5 reports that all these images appear during times when he is not concentrating on anything in particular. He expresses curiosity about the images and regards them as a remembrance of what he has seen in the past. One year later, the subject reports that the images of the faces have become less vivid. He states that the images now do not appear as real as they had previously; he likens them now to plaster casts.

Subject 12. Three months after the start of her visual problems, subject 12 began to experience various hallucinatory images on an infrequent basis. The first hallucination occurred during a bus trip. The subject noticed a circular design (about 5 inches in diameter) on the back of the seat in front of her, where moments before there was none. At times the circular design appeared to come closer to her. Although the subject was unable to remember details of the design, she stated that the image remained for over an hour. The subject also reported that she sees fairly distinct images of green-colored shrubs and bushes periodically when she looks out the window at work as well as when she looks at the front part of the church when she is sitting during church services. Since the interview was carried out at work, the experimenter could verify that there were no shrubs or bushes in view when looking out the window. Subject 12 further added that she has seen different images of horse-drawn carriages on several occasions. She stated in a follow-up interview that the horses sometimes appear miniature in size (about the size of a large dog). Interestingly, the subject reported, while being interviewed, that she saw a floral pattern on the interviewer's solid white shirt.

Subject recruitment. Subjects were recruited from a database of clients served by the Montreal Association for the Blind. Subjects were initially contacted by telephone and told that a study was being conducted on particular types of visual experiences some people have during the course of their visual problems. During the conversation, subjects were asked whether they had had any unusual visual experiences, including seeing objects or things that appeared "like a mirage." If a subject reported having such experiences, then an interview was set up, usually at the client's home.

Exclusion of cases. During the subject recruitment phase of the study, eight cases were seen and excluded from the study. One individual refused to be seen a second time for testing, one was hospitalized, and one could not be re-contacted for the testing session. Upon interviewing one individual, it was found that his hallucinations were due to epilepsy. Another person's visual experiences were so vague that it was unclear whether

he was actually hallucinating. Three additional subjects, all at least 90 years of age, were interviewed. They were not followed up because they could not furnish specific information due to memory failure, were vague about their experiences, or had obvious global cognitive impairment.

Procedure

During the initial meeting, information about the subject's hallucinations was recorded during the course of a semistructured interview. Approximately 9 to 12 months later, the subjects were re-contacted, informed consent was obtained, and the psychological testing took place. In four cases, testing took place at the initial meeting. All but one subject reported a hallucination during the 2 weeks before testing. During the testing session, subjects were administered the Mini-Mult (Kincannon, 1968), a 71-item short-form version of the Minnesota Multiphasic Personality Inventory (MMPI), the 21-item Beck Depression Inventory (Beck et al., 1961), the trait form of the State-Trait Anxiety Inventory (Spielberger et al., 1970), and the Mini-Mental State Examination cognitive screen (Folstein et al., 1975). Because the subjects were unable to read normal-sized print, given their visual problems, items from each of the tests were read to the subject by the investigator. On the Beck Depression Inventory, if a subject endorsed the first statement in the group of statements comprising one question, that statement was checked and the next question was asked. If the subject did not endorse the first statement to a question, all the remaining statements to a question were read to the subject. Since two items on the Mini-Mental State Examination require an individual to use his or her sight to receive credit for the item, modifications to this test were made. A special sign was made using large upper case letters (18 mm in height) for an item in which subjects were asked to read and obey a sign ("Close Your Eyes"). Another item, which requires the subject to copy a geometric figure of two overlapping pentagons, was made larger than normal. Subjects who were still unable to see these items received a prorated scored based upon those tasks that do not require normal vision.

Results

Results from the Beck Depression Inventory (BDI), State-Trait Anxiety Inventory (STAI), and the Mini-Mental State Examination are summarized in Table 2. The mean score for the BDI indicates that the group as a whole can be categorized as having a minimal level of depression, using cutoff scores for categories of depression suggested by Beck et al. (1988). When individual scores were categorized by level of depression, nine subjects fell within the least depressive category (none or minimal depression). Three of the individuals indicated mild to moderate levels of depression, and one individual had a moderate to severe level. No individual's score fell within the severe category.

TABLE 2
Mean Test Scores and Standard Deviations

Test[a]	Mean ± SD	*N*
Beck Depression Inventory	7.69 ± 7.28	13[a]
State-Trait Anxiety Inventory (trait form)	34.92 ± 10.51	13
Mini-Mental State Examination	28.56 ± 1.67	14

[a]Data for the Beck Depression Inventory and the State-Trait Anxiety Inventory were not collected for one subject (case 11) as it was believed that, after being interviewed and administered the Mini-Mult, and the Mini-Mental State examination, she was too tired to continue.

Table 2 also reveals that the anxiety level of the group was generally low. For comparison, it can be noted that Spielberger et al. (1970) found an average STAI score of 46.62 (SD = 12.41) in a group of neuropsychiatric patients. Finally, Table 2 also shows an intact cognitive status of the group as measured by the Mini-Mental State Examination (28.6 out of a possible 30).

Since the MMPI is one of the primary tools used today to determine psychopathology, results from the projected full-scale MMPI profiles will be examined in more detail. Figure 1 shows the group's K-corrected MMPI profile projected from the 71-item Mini-Mult. As can be seen from the figure, the group's mean T-score did not exceed 70 for each of the scales.

For the 14 subjects, there was a total of 23 elevated scales (of a possible 154). The average number of ele-

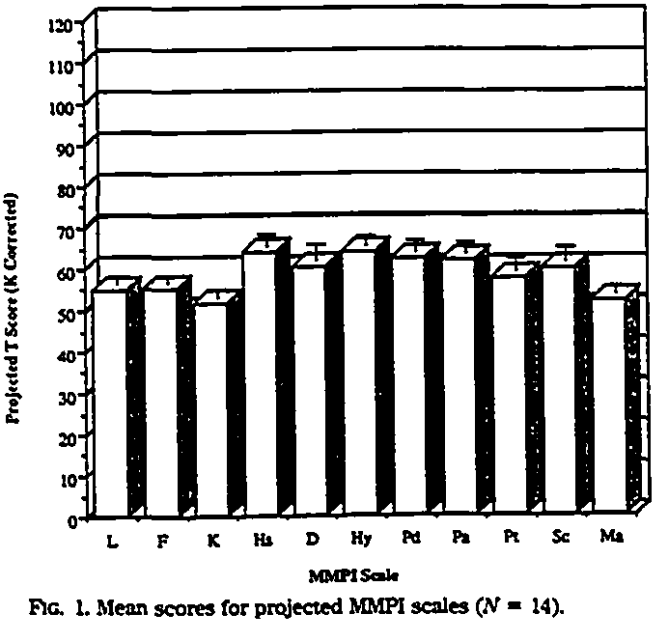

FIG. 1. Mean scores for projected MMPI scales (N = 14).

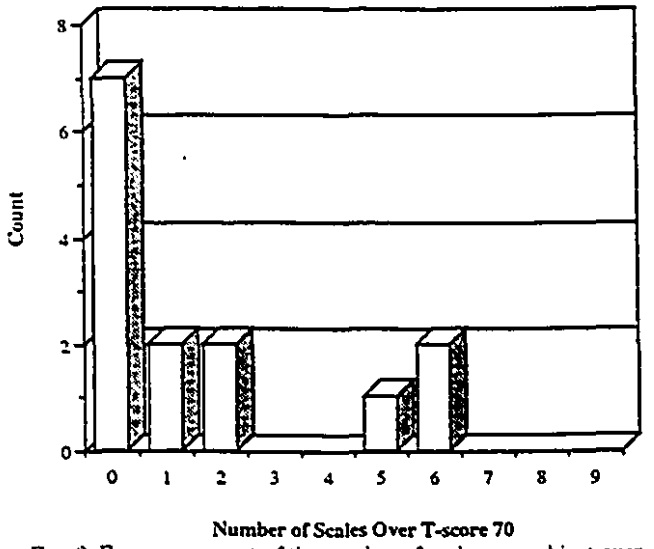

FIG. 2. Frequency count of the number of scales per subject over a T-score of 70.

vated scales per person was 1.64, with a standard deviation of 2.31. Figure 2 shows that when subjects are distributed along a continuum according to the number of scales per person over T-score 70, it can be seen that half of the individuals had no elevated scales, and an additional four had only one or two elevated scales. Three people contributed about 74% of the 23 elevated scales, with one individual having five elevated scales and two subjects having six elevated scales. Since these three cases appear to be exhibiting some psychological distress, they will be analyzed further below.

In addition to analyzing the subjects' Mini-Mult responses using the MMPI scale, subjects' responses were also analyzed using individual questions as the unit of analysis. In this manner, it was possible to determine which questions represent a belief or experience common to the group and, further, which of those shared beliefs or experiences were deviant. A belief or experience was regarded as common or shared by the group if 12 or more of the subjects responded to the question in the same (yes or no) direction.[2] The response to a question was regarded as deviant if it contributed to the score on one or more of the MMPI scales. When such an analysis was performed on the Mini-Mult items, it was found that the group's response pattern was significant for 29 questions. That is, almost 41% of the questions could be considered as representing shared or common beliefs or experiences. More importantly, though, it was found that of the 29 questions, only four were in the deviant direction. The four questions were as follows: "Do you find it hard to make talk when you meet new people?" (13 no responses), "Do you wish you were not so shy?" (12 no responses), "Do you, at times, feel that you can make up your mind with unusually great ease?" (13 yes responses), and "Is your eyesight as good as it has been for years" (13 no responses).

A final analysis of the group's Mini-Mult responses examined the so-called critical-item questions. This method flags certain questions that are assumed to be of greater clinical importance than other questions, and is regarded by Butcher (1990) as one of the most direct methods of assessing specific problems. Of the 73 MMPI items that appear on the Koss-Butcher critical items list (Koss and Butcher, 1973), 18 are also found on the Mini-Mult. Nine of these 18 Mini-Mult questions were also questions that were responded to in the same direction by 12 or more of the subjects. None of these nine questions were responded to in the deviant direction.

The critical-item responses of the three cases whose projected MMPI profiles showed five or six elevated scales (cases 1, 6, and 10) were also examined. Case 1 and case 6 both answered nine of the 18 critical items in the deviant direction, while case 10 answered six of the 18 critical items in the deviant direction. Finally, a further analysis of these three subjects shows that they also represent the three highest scorers on both the BDI and on the STAI.

Discussion

Although visual hallucinations are generally associated with acute psychopathology or gross impairment in cognitive functioning, it is clear from the results of this study that they may also occur in visually impaired people who do not have psychological disturbances. The results of the four tests, taken together, demonstrate that the majority of the hallucinators did not exhibit emotional distress or cognitive abnormalities. While three of the 14 hallucinators in this study did have moderate depression and some anxiety as indicated by scores on the BDI, STAI, and on the Mini-Mult, an appeal to psychopathology as an explanatory mechanism for the hallucinations does not appear warranted.

In the absence of emotional distress and global cognitive impairment, it is suggested that the hallucinations experienced by the subjects represent normal neural activity generated by the brain. We have noted previously (Schultz and Melzack, 1991) that an analogous condition exists within the somatosensory perceptual domain: the experience of phantom limbs. Both conditions involve the persistence of perceptual experiences despite a major decrease or complete disruption of peripheral sensory impulses. Melzack's (1989) neuro-

[2]Chi-square analysis shows that for 14 cases, the response pattern for a question is significantly different from chance (at an alpha level ≤.01) when a question is responded in the same direction by 12 or more of the individuals.

matrix theory posits that a widely distributed neural network continues to generate patterned activity that gives rise to perception and cognition in the absence of sensory input. We propose that it is this activity, in those brain areas that process visual information, that results in the visual hallucinatory experience.

It is possible that psychological distress could play a role in explaining the content of the hallucinations, if it is present, rather than explaining why the hallucinations actually occur. For example, one of the three people who scored highest on the measures of distress related that the content of her hallucinations—an eye—reflects that she has not accepted the loss of her sight. For the majority of the hallucinators, however, who showed no evidence of emotional distress, the content of the hallucinations appeared to be random, involving buildings and boulders, as well as people and animals.

Complex visual hallucinations are known to occur with Alzheimer's dementia and multi-infarct dementia (Cummings et al., 1987). It has even been documented that the hallucinations may occur before the onset of cognitive impairment (Crystal et al., 1988). However, as Burns et al. (1990) note, patients with Alzheimer's who also experience hallucinations (auditory or visual) show a faster decline in cognitive functioning than those without hallucinations. Given that the subjects had been experiencing the hallucinations up to years before the first interview and were tested on the Mini-Mental State Examination 9 to 12 months after that time, the fact that the group demonstrated intact cognitive functioning rules out the hypothesis that the hallucinations were caused by dementia.

The use of the Mini-Mult as a short-form of the MMPI has been somewhat controversial since its inception. Critics of this tool point to the poor congruence between the configural codes on it and on the full-length MMPI. However, as a gross measure of pathology and as a measure of group means, the test appears to be accurate (Faschingbaur and Newmark, 1978). Needham et al. (1986) further examined the effectiveness of the Mini-Mult using a group of blind subjects. These researchers compared the results on separate administrations of the Mini-Mult and the MMPI and found that the Mini-Mult successfully predicted the absence pathology in 87.5% of normal MMPIs, and successfully predicted the presence pathology in 77.8% of abnormal MMPIs. To obtain an index of the severity of pathology on the Mini-Mult, one of the methods used in the present study examined the number of scales with a T-score greater than 70. This method, as noted by Faschingbauer and Newmark (1978), "compare[s] favorably with test and retest MMPIs." While full length MMPI tests were not administered here, this method does appear to be valid as an index of severity of psychopathology. The three individuals who obtained the greatest number of elevated scales were the three highest scorers on the BDI and STAI.

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Bridge between Study 3 and Study 4

In the last bridge section it was stated that there were two unpublished studies that also examined the mental status of Charles Bonnet hallucinators. Since one of those studies (Needham et al., 1991) also used the Mini-Mult short-form of the MMPI, it was of interest to compare their results on this measure to those in Study 3. The next study of the thesis, Study 4, forms the basis of that comparison. Of particular interest in Study 4 was the extent to which the Needham et al. (1991) findings -- namely that hallucinators endorsed more items than non-hallucinators on four of the scales of the Mini-Mult -- could be due to a relatively small number of hallucinators who exhibited extreme scores, and thus skewed their results.

A Focused Re-examination of the Mental State of Charles Bonnet Hallucinators

Geoffrey Schultz

Walter Needham

Ronald Melzack

Introduction

In an unpublished paper presented at the Annual Meeting of the American Psychological Association, Needham et al. (1991) reported on the mental status of U.S. veterans enrolled in an "adjustment to blindness" program offered by the VA Medical Center in West Haven Connecticut. In the paper it was reported that visually impaired hallucinators endorsed more symptom-oriented items than visually impaired non-hallucinators on a short-form of the Minnesota Multiphasic Personality Inventory (MMPI), the Mini-Mult, and on a checklist of symptoms, the SCL-90. The authors go on to say that the extent of the emotional distress is unlikely to account for the hallucinations, but instead may be a consequence of the experiences.

While it is true that the typical hallucinator does not find the experiences pleasant, and may therefore be disturbed by them, the results reported by Needham et al. (1991) may not be due to an overall increase in emotional distress by the entire hallucinating group. If the hallucinating group were composed of two sub-groups -- one essentially identical to non-hallucinators with respect to level of psychopathology, and another whose scores reflect comparatively much greater distress -- then those two sub-groups, when combined, may appear to be only slightly more distressed than non-hallucinators. This was the composition found within the group of hallucinators in Schultz and Melzack (1993). On the basis of these results (Schultz and Melzack, 1993), and the fact that standard deviations in the data of Needham et al. (1991) were larger for hallucinators than non-hallucinators on all Mini-Mult scales -- a result to be expected if the above hypothesis were true -- the following analysis was performed to determine if the results

reported by Needham et al. (1991) were essentially due to a small sub-group of outliers.

Method

Subjects

In the Needham et al. (199i) study, U.S. Veterans Administration Medical Center clients served as subjects. On the basis of their response to a question about "unusual" visual events, "hallucinating" and "non-hallucinating groups were formed. The hallucinating group (n=44) experienced complex visual hallucinations, while the non-hallucinators (n=89) did not experience hallucinations. Subjects, whose unusual visual events consisted of elementary forms or events judged to be of entoptic origin, were eliminated from their study. Since the present study is a further examination of their subjects' data, 40 of the 42 hallucinators in this study were among the hallucinating group reported by Needham et al. (1991). An additional two hallucinators were added to increase the number of subjects. The mean age of the hallucinators was 59.8 years (SD = 13.2 years, range 27 to 81 years).

Since it has been shown that MMPI response patterns change as a function of age (Colligan and Offord, 1992), and given that the age of hallucinators spanned 54 years, an attempt was made to match each hallucinator with a same-age non-hallucinator. This constitutes a difference between the Needham et al. (1991) study and the present one. If possible, the non-hallucinator was also culled from among the 89 non-hallucinators in the Needham et al. (1991) study. When a non-hallucinator of same, or very similar age, could not be found in this group, a non-hallucinator was chosen

at random (subject to the age constraint) from client records. This occurred for six subjects. The mean age of the non-hallucinators was 59.8 years (SD = 12.8 years). Thirty-three pairs of subjects had an age difference of one year or less, five pairs had an age difference of two years, three pairs had an age difference of three years and one pair had an age difference of four years.

Procedure

Subjects in the study were administered the Mini-Mult as part of the clinical evaluation during an "adjustment to blindness program" offered by the West Haven Connecticut VA Medical Center. The Mini-Mult is a 71-item short-form of the Minnesota Multiphasic Personality Inventory (MMPI). It has been shown to be a valid tool for estimating full-length MMPI pathology in the visually impaired (Needham et al., 1986).

Results

1) A comparison of MMPI profiles

Subjects' responses on the 71-item Mini-Mult were tabulated and estimated MMPI profiles were constructed for each of the groups. Figure 1 shows a side-by-side comparison of hallucinators and non-hallucinators for each of the scales. Inspection of the clinical scales (Hs, hypochondriasis; D, depression; Hy, hysteria; Pd, psychopathic deviance; Pa, paranoia; Pt, psychasthenia; Sc, schizophrenia; Ma, mania) shows that hallucinators as a group score consistently higher than non-hallucinators ($p=.0186$, using the Wilcoxon matched-pairs signed-ranks test, including the validity scales, L, F,

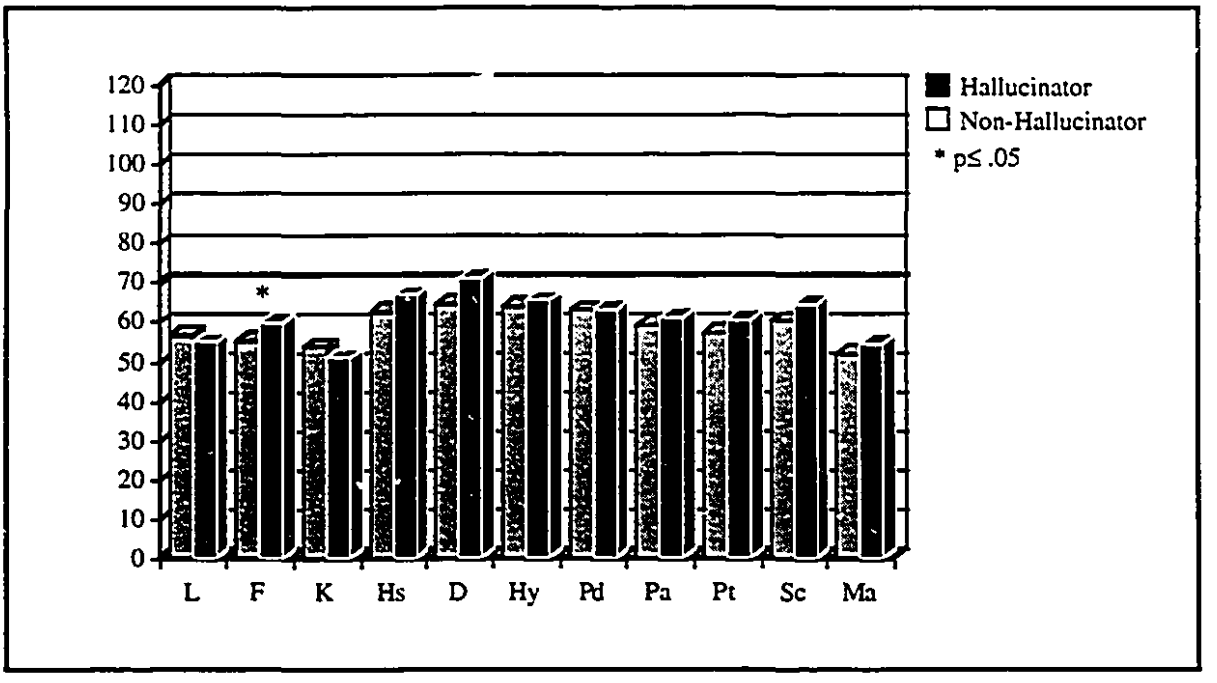

Figure 1. Hallucinator and non-hallucinator group MMPI scores.

and K). Analyses of T-score differences for each of the scales using paired t-tests for each, found only one scale, the F scale, in which the difference was significant; $p \leq .05$ using Dunn's table of t' critical values (Howell, 1982, p. 528) to control for experimentwise type I error. Thus the analysis shows that there are small but consistent differences between the groups[1]. These statistical results, together with the fact that variance within the group of hallucinators is greater than the variance within the group of non-hallucinators for all MMPI scales, provide indirect evidence for the hypothesis that there is a sub-group of "distressed" hallucinators.

2) Determination of the sub-group

In order to directly identify potential outliers, a plot of subjects based upon the similarity of their responses to the 71-item Mini-Mult was constructed utilizing multiple correspondence analysis (MCA). Since this procedure requires a data matrix with no missing values, it was first necessary to estimate responses for missing answers.

2.1. Estimation of responses for missing answers.

Of the 84 subjects, 19 had missing answers for one or more questions. In total, 27 questions were not answered, representing .45% of the total number of questions. In order to have a complete data matrix for the subsequent analysis, responses for these 27 questions were estimated. Subject's responses on the Mini-Mult were first coded as 1 if the subject responded "True", or 0 if the subject responded "False", resulting in a rectangular matrix (71 questions wide by 84 subjects long). From this matrix,

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[1] In the Needham et al. (1991) paper, data were analysed by comparing group scale-scores (not T-scores) using multiple one-way anovas. They report significant differences on four scales (L, F, D, and Sc). Differences between their results and those reported here may be due to 1) the smaller number of non-hallucinators used in the present analysis, 2) the slightly different composition of subjects in the hallucinating group, and/or 3) type I error.

association scores for all the questions taken pairwise were computed using the following formula (Gower, 1985):

$$S4 = \frac{a+d}{a+b+c+d}$$

where,

S4 is the measure of association,
a is the frequency of responses in which both questions (i and j) are answered "True",
d is the frequency of responses in which both questions (i and j) are answered "False",
b is the frequency of responses in which question$_i$ is answered "True" and question$_j$ answered "False",
c is the frequency of responses in which question$_i$ is answered "False" and question$_j$ answered "True."

S4 is defined as the "proportion of pairs in which both values agree" (Wilkinson et al., 1992, p.54). Subjects who had missing values were removed from this procedure. Therefore the similarity matrix was computed based upon 65 subjects. Next, for each of the 29 questions that were not completed, the question that associates strongest to it was found. Finally, the subject's response on that highly associated question was found and used as the estimated response for the question not completed.

2.2. A multiple correspondence analysis plot of subjects.

Following completion of the rectangular data matrix, a two-dimensional plot of the subjects was constructed using modified factor scores following multiple correspondence analysis (MCA). Figure 2 shows the results of the procedure. It can be seen that the first dimension accounts for 78.2 % of total inertia, while the second dimension accounts for 5.8%. Inspection of this plot shows the majority of subjects (both hallucinators and non-hallucinators) clustered together to the left of the plot with sporadic

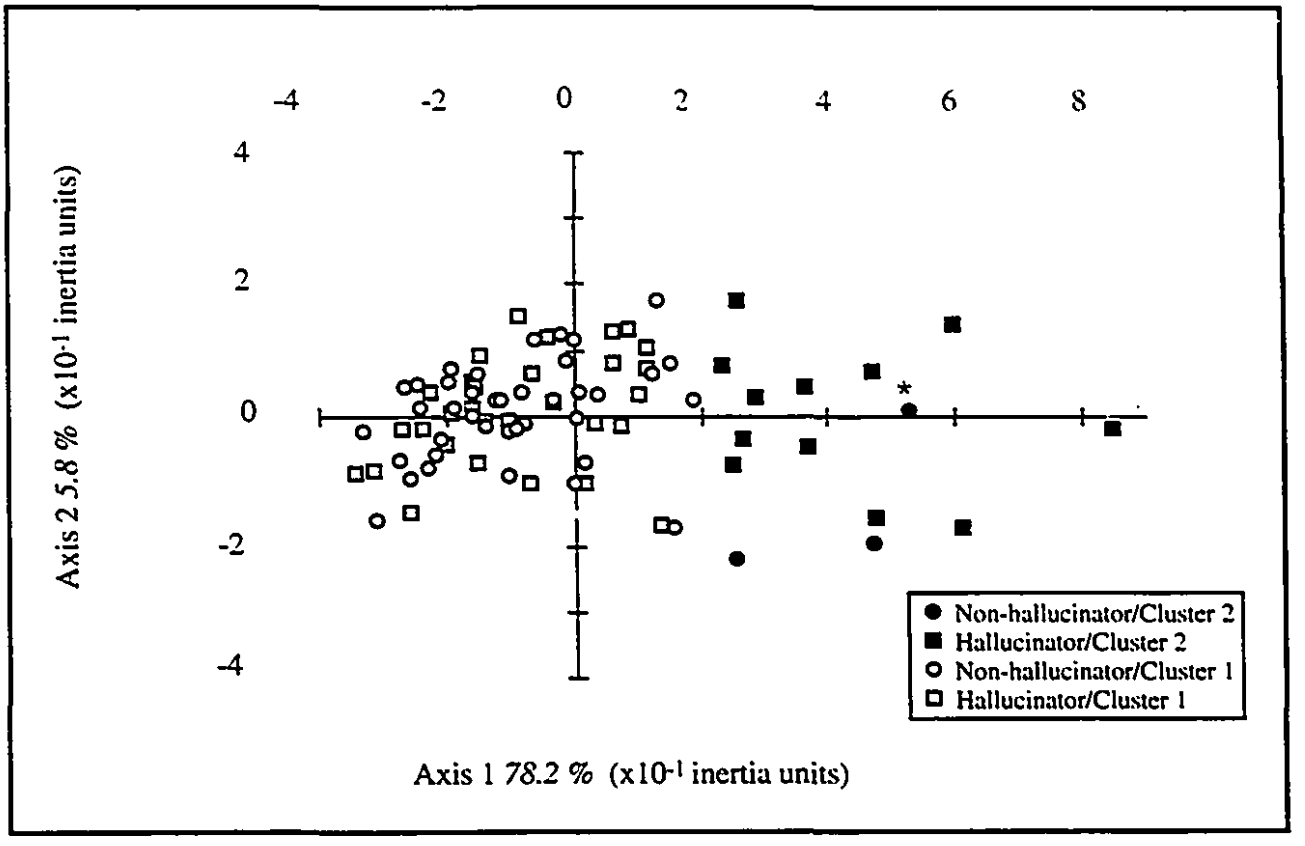

Figure 2. Plot of subjects cross-classified by group (hallucinator/non-hallucinator) and by results of cluster analysis (cluster 1/cluster 2).

outliers populating the right side of the plot.

2.3. A two group partition of subjects.

In order to determine which subjects belong to the main or "outlier" cluster, subjects were divided into two groups using a partitioning cluster analysis procedure (Thioulouse, 1995). A typical member of the outlying sub-group was chosen to start the partitioning procedure. This subject is identified on Figure 2 by an asterisk above the point. Results from the partitioning procedure are also shown on Figure 2. Fifteen members, identified as cluster 2 in Figure 2, formed the outlying group while the remainder of subjects, identified as cluster 1 on Figure 2 formed the main group. Hallucinators were disproportionately represented in the outlying group ($p=.0102$ using Fisher's Exact test). Twelve of the 15 members in cluster 2 were hallucinators .

3) Cluster 1 and cluster 2 MMPI plots

Following the determination of the two clusters, MMPI plots were constructed based upon a subject's membership in cluster 1 or cluster 2. As can be seen in Figure 3, the outlying group, cluster 2, had significantly higher scores than cluster 1, for each of the clinical scales (significance was, as before, determined by using Dunn's t' critical values to control for experimentwise type I error).

4) Hallucinator and non-hallucinator MMPI plots following removal of subjects in cluster 2

A final MMPI plot was constructed to compare hallucinators and non-hallucinators in cluster 1. As can be seen from Figure 4, hallucinators and non-hallucinators mean scores for the scales are not different from one another ($p> .05$ for all individual t-tests).

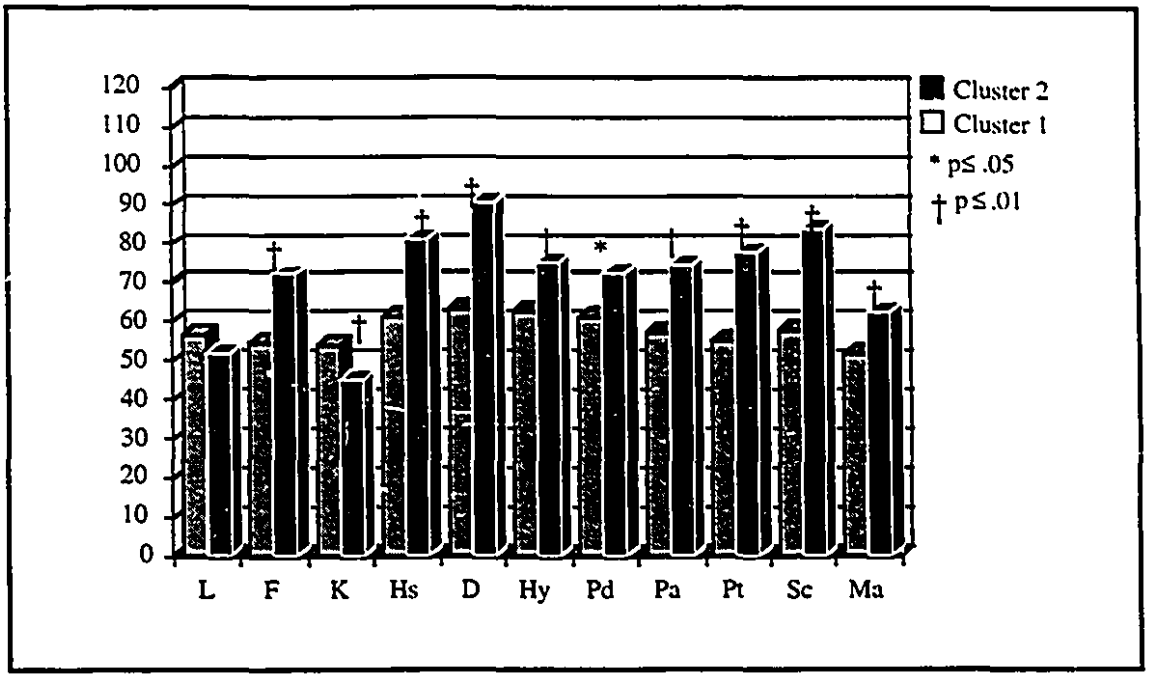

Figure 3. MMPI scores for members in cluster 1 and cluster 2.

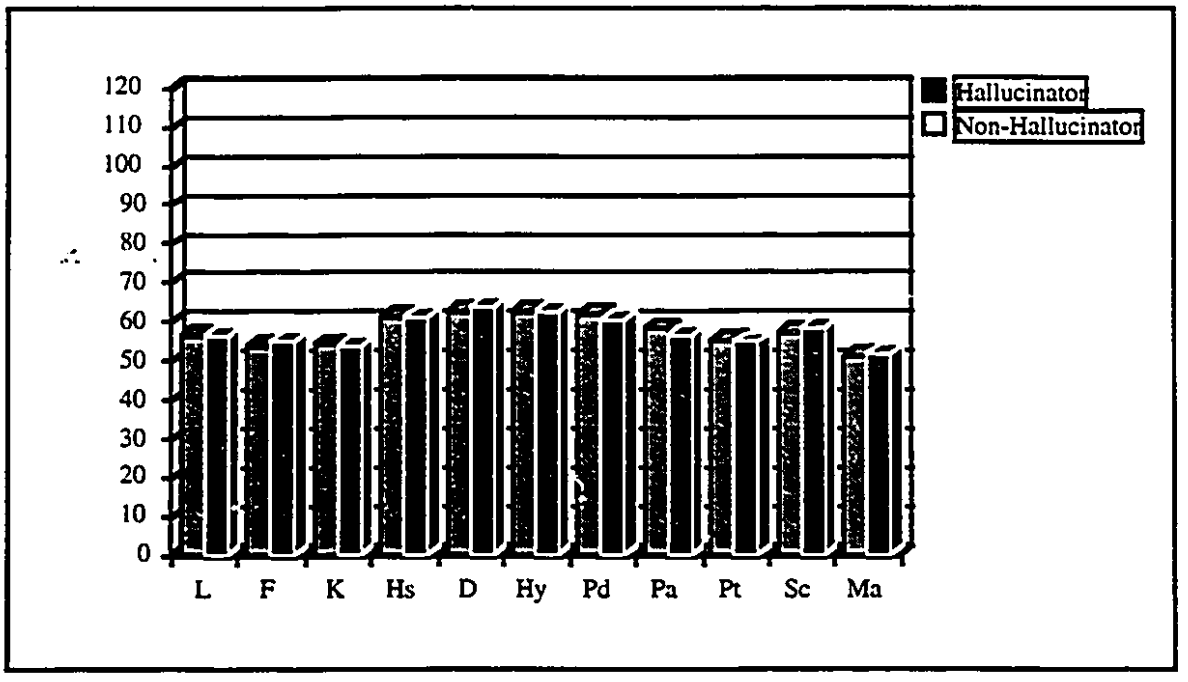

Figure 4. Group MMPI scores following removal of members in cluster 2.

Discussion

The results of this study show that a cluster of outliers can be found whose scores indicate significantly more psychological distress than non-outliers. Since this outlying cluster is composed of hallucinators -- by a large majority -- it can be stated that the hypothesis of the study was supported. These results therefore suggest that differences between hallucinators and non-hallucinators scores on scales of the Mini-Mult, in the Needham et al. (1991) study, are due to a relatively small number of hallucinators who endorse more symptom-oriented items.

The results are also consistent with those of Schultz and Melzack (1993). Both studies show a similar ratio of hallucinators who can be considered outliers. (i.e. 3/14 in the Schultz and Melzack study and 12/42 in this study, p=.442 using Fisher's Exact test for differences in proportions). Thus we can state, based upon the results of Schultz and Melzack (1993) and the present study, that between 21% and 29% of hallucinators do endorse items that indicate the experience of some psychological problems. The clinical implications of this finding are clear. Health professionals cannot assume that an individual with the Charles Bonnet syndrome is immune to psychological distress. They should, as a matter of course, screen all patients with Charles Bonnet syndrome for psychological symptoms.

While the focus of this study was to detect psychological symptoms, this orientation should not be unduly emphasized. The results of the study also show that the majority of hallucinators cannot be distinguished from non-hallucinators based upon a test of psychological symptoms. Thus it is clear that psychopathogy is not a necessary agent in the process that causes Charles Bonnet hallucinations. It is proposed that the relationship among

visual hallucinations, visual impairment, and psychological symptoms may be conceptualized as overlapping, as depicted in the Venn diagram of Figure 5.

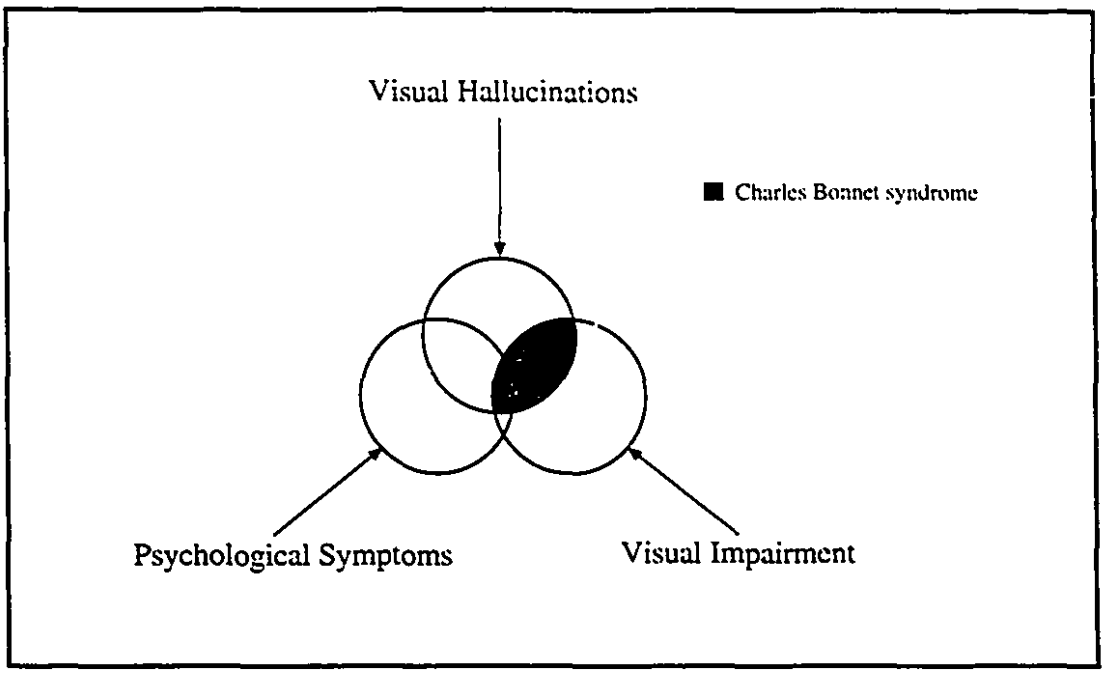

Figure 5. Proposed relationship between visual hallucinations, visual impairment, and psychological symptoms.

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Bridge between Study 4 and Study 5

The previous two studies documented the mental status of Charles Bonnet syndrome hallucinators. While the results of these studies are clear -- these hallucinations occur in individuals predominately free from psychopathology or cognitive impairment -- it must be stated that not all investigators draw their subjects from a blind or visually impaired community. To the extent that other investigators draw on other populations, the results of their testing may be different. For example, Howard and Levy (1994) have recently written a paper entitled "Charles Bonnet syndrome plus" in reference to complex visual hallucinations of the "Charles Bonnet syndrome type" that co-occur in individuals with late paraphrenia (a late-onset schizophrenic-like psychiatric disorder characterized by delusions [Kaplan and Sadock, 1985]). These authors began their investigation using a population that had obvious psychological abnormalities and found that "Charles Bonnet plus" hallucinators scored slightly (but significantly) lower on the Mini-Mental State Examination than other late paraphrenics (26.18 vs. 27.25, respectively). Other recent investigations that report on the cognitive status of their subjects have obtained those subjects from a variety of sources including psychiatry and geriatric medicine departments (Teunisse et al., 1994), a psychiatric emergency department (Lalla and Primeau, 1993), referrals to geriatric psychiatry (Cole, 1992), a low vision clinic (Holroyd et al., 1992) as well as a low vision clinic and general medicine department (Holroyd et al., 1994). Two of these studies report little or no cognitive impairment in their subjects (Teunisse et al., 1994; Lalla and Primeau, 1993). A third (Cole, 1992), found mixed results: some hallucinators were cognitively intact and others showed either minimal

cognitive impairment or mild dementia. The Holroyd studies (Holroyd et al., 1992 and Holroyd et al., 1994) are particularly noteworthy because these investigators also gathered a control group of non-hallucinators. They found that hallucinators had a significantly lower score on a brief cognitive test -- the telephone interview cognitive screen, or TICS (Brandt et al., 1988). Closer examination of these results (Holroyd et al., 1992) shows 13 hallucinators scored an average of 30.4 and 39 non-hallucinators scored 32. 8 (of a possible 41). The authors question whether a mild cortical disinhibition could have contributed to both the slightly lower scores on the TICS and the production of the hallucinations. The exact mechanism by which "mild cortical disinhibition" could cause the lowered TICS scores was not discussed. Interestingly, in both studies by Holroyd et al. (1992, 1994), hallucinators were either "nearly" significantly older than non-hallucinators (in the 1992 study), or significantly older (in the 1994 study). Given that older age is associated with increasing rates of mild cognitive deficits (cf. Folstein et al., 1985), as well as increasing rates of visual deficits (Kahn et al., 1977), the possibility also exists that the hallucinations are related to the vision problems but unrelated to cognitive deficits.

While these authors speculate about a possible contributory role played by cognitive deficits, they clearly endorse the view that visual deficits play the main causal role in the hallucinations. The next and final study in the thesis explores the role of the visual system, after visual loss, in the production of the hallucinations.

Hallucinator and Non-Hallucinator Performance on Detection Tasks: Evidence for a Liberal Criterion Contributing to the Production of Complex and Simple Hallucinations Associated With Deficits in Vision

Geoffrey Schultz
Ronald Melzack
Walter Needham

Abstract

The role of the visual system in the production of simple and complex visual hallucinations was assessed using a signal detection paradigm. Fifteen hallucinators (nine complex hallucinators and six simple hallucinators) and 15 non-hallucinators initially underwent a procedure to establish a threshold stimulus suited to each subject's visual capacity at the time of testing. Subsequently, the threshold stimulus was used in a signal detection task. Subjects were asked to report the detection of the stimulus on "stimulus trials", intermixed with trials in which the stimulus was not displayed. Results from the two tasks show that hallucinators exhibited a more liberal criterion for reporting the experience of the stimulus than non-hallucinators during the threshold estimation procedure. Relevance of the results to possible differences between the state of hallucinators' and non-hallucinators' visual systems are discussed.

Introduction

Individuals who have severe deficits in vision often report hallucinatory experiences. That is, they report the experience of visual events that do not correspond to events that originate externally to them. For most of these people, the hallucinatory experiences consist of flashes of light, "starbursts" and spots of indistinct shape in front of their eyes (Freiberg and Rapuano, 1990). For others, the hallucinatory experiences are much more complex; the hallucinated images definitely "look like something" such as a person, an animal, or scenery. These complex hallucinations, when they occur in clear consciousness without obvious cognitive deterioration, are called Charles Bonnet hallucinations (Asaad, 1990).

In the search for a cause of visual hallucinations associated with deficits in vision, a distinction can be made between explanations that account for simple hallucinations and those that attempt to explain the complex Charles Bonnet hallucinations. A quite reasonable and satisfactory account of simple hallucinations is that they are caused by the discharge of peripheral retinal cells, as well as the firing of cells in low-level visual processing areas such as in area V1. In fact, ophthalmology texts (e.g. Roy, 1993) enumerate a number of peripheral eye conditions including glaucoma, impending retinal detachment, traction of the vitreous on the retina, or retinal microembolism that may give rise to simple flashes of light. However, the attempt to explain the Charles Bonnet hallucinations by direct application of this idea is clearly insufficient for the simple reason that Charles Bonnet hallucinations are usually highly formed. It is very unlikely that a presumably random discharge of retinal cells could be the basis of any experience other than that of a light flash or an indistinct shape. Perhaps for

this reason, a number of alternate ideas have been forwarded. Most of these proposals can be grouped under the rubric "sensory deprivation."

Charles Bonnet hallucinations and sensory deprivation

The term sensory deprivation, used in its widest sense as an explanation for Charles Bonnet hallucinations, implies an isolated or under-stimulating environment. Accordingly, Charles Bonnet hallucinations arise because the hallucinators live in rather monotonous environments. Cole (1992), for example, noted that nine of his thirteen cases of Charles Bonnet syndrome were living alone and, by implication, in an under-stimulating environment. He further noted that the hallucinations abated for five people after they received attention and stimulation during their stay in hospital. Likewise Hosty (1990) found that the hallucinations experienced by one of two cases stopped during the person's hospital admission. He also suggested that the change in sensory – that is, social/environmental – stimulation is of "causal importance in the syndrome." Finally, Teunisse et al. (1994) use the term "social isolation" when discussing the cause of the Charles Bonnet syndrome. They note that eleven of their fourteen cases were living alone.

A well-known, controversial experimental analog of sensory deprivation was documented in a number of laboratories in the 1950's and 1960's (e.g., Bexton et al., 1954; Zubek et al, 1961). Typically, undergraduate subjects lived in specially constructed sensory isolation rooms for periods of time that ranged from 1 day to 1 week. Complex visual hallucinations were reported by a number of subjects. In a review of 32 such studies (Zuckerman, 1969), the evidence for hallucinations (both simple and complex) was established. However, the failure of other laboratories to reproduce these findings has lead at least one investigator (e.g., Suedfeld and Coren, 1989) to question the earlier reported data.

Despite the research into environmental sensory deprivation, studies on Charles Bonnet syndrome that suggest a causal role for an "under-stimulating environment" do not propose a specific mechanism -- psychological or physiological -- by which the under-stimulating environment could give rise to the hallucinations. Instead, some authors (eg., Cole, 1992; Holroyd, 1992) have proposed visual deficits and environmental monotony in combination with non-specific cognitive/CNS abnormalities as all contributing to the production of the hallucinations. The exact mechanism by which those contributing factors actually produce the hallucinations remains unknown.

In a narrower sense, the term "sensory deprivation" is used to mean the disruption of normal sensory functioning, so that central neural processing is deprived of information from the environment regardless of the content of that environmental information. The disruption can occur in peripheral processing areas including the sensory transducing cells of the retina, or it can occur along the optic nerve and optic tract, up to and including early, low-level, visual processing areas. There have been a number of theories within this framework as to why this disruption would cause hallucinations.

The most widely cited of these is West's general theory of visual hallucinations -- the "perceptual release" theory (West, 1975). Briefly, the theory posits that normal sensory input engenders both a stimulating effect on the reticular activating system as well as an organizing effect on a mechanism that screens out irrelevant internally and externally generated information. When sensory input diminishes, awareness is normally reduced. However, hallucinations may occur when input is reduced yet the reticular activating system is sufficiently active to maintain normal

awareness. The organizing function, now compromised, allows internally generated information that is normally screened out, to enter awareness.

Schultz and Melzack (1991) and Schultz et al. (1995) have compared the visual hallucinations of the Charles Bonnet syndrome with the somatosensory/kinesthetic hallucinations that occur in people who have an amputated limb or a disruption of normal somatosensory processing -- the so-called "phantom limb" phenomena (Melzack, 1992). They have proposed that these experiences reflect patterned activity within distributed neural networks in their respective sensory domains. Further, this patterned activity, which resembles a schema (c.f. Neisser, 1976), may be triggered and/or sustained by hyperactive cells immediately central to the processing disruption. Similarly, Rabins (1994) has also recently discussed the parallels between phantom limb phenomena and phantom hallucinations. He proposes that spontaneous discharge from deenervated cells or cells involved in cortical reorganization following peripheral eye damage are responsible for the hallucinations.

Halligan et al. (1994) have recently proposed that the hallucinations may be caused when higher visual processing areas such as V4 drive lower areas (e.g. V1, dorsal LGN) via feedback connections between the areas. They cite evidence from a study with cats (Minard and Malpeli, 1991) that shows the ability of feedback connections from V2 to drive cells in V1. They argue that, in general, information found at higher levels of visual processing can influence and contribute to information processing at lower levels.

In sum, a number of proposals have been forwarded regarding the cause of Charles Bonnet hallucinations. Differences between theories stem from both the importance ascribed to conditions outside the visual system (i.e., a monotonous environment or the role of mild cognitive deficits, if

present), as well as differences in the specific mechanism by which complex visual events enter awareness. Note, however, that the "release" theory, "phantom vision" theory, as well as the mechanism proposed by Halligan et al. (1994) all hold, as a reasonable but untested assumption, that the complex experiences employ the visual system's "hardware." Establishing that this is indeed the case may in turn be a starting point for a more exact determination of the underlying mechanisms of these hallucinations.

The idea that these hallucinations are a product of activity within the visual system makes intuitive sense because the hallucinations have a similar phenomenology to normal vision (Schultz et al., 1995). That is, the hallucinations "feel" like normal vision in a number of respects. For example, the hallucinations appear external to a person. They are sharply focused and become visible suddenly without any voluntary effort while the hallucinator is alert and has his eyes open. In contrast, the everyday experience of thinking about an object is quite different. As well, there is evidence that another quasi-visual process, namely mental imagery, shares a common neural substrate with visual functions (Finke, 1985; Farah et al. 1988). If mental imagery utilizes visual processing areas, then it is even more likely that visual hallucinations have a common neural substrate with normal visual processes. Hallucinations simply share more with vision than do mental images.

The signal detection methodology: a visual system probe

To test the idea that the hallucinations are a product of activity within the visual system, a signal detection paradigm was used. In a standard signal detection experiment a stimulus is chosen which is within the threshold range for subjects in the experiment. A stimulus within threshold range is defined as one in which an individual detects some proportion of stimulus

presentations greater than zero but less than one. According to signal detection theory, if the same threshold stimulus were repeatedly presented and rated according to perceived intensity, the ratings should be distributed along the normal curve. Similarly, signal detection theory asserts that background noise intensity, during trials in which the stimulus is not presented, is also normally distributed. The more detectable a stimulus is from background noise, the farther apart the centers of the two distributions are from one another. A subject in a given experimental situation chooses a criterion point along the "perceived intensity" dimension whereby stimuli that fall past that criterion are responded to as being perceived and stimuli that fall before the criterion are responded to as not perceived. Any criterion chosen will intersect both distributions, yielding a portion of the respective distribution above and below the criterion point (see Figure 1, panel A). That portion of the "noise" distribution falling past the criterion point corresponds to the proportion of trials in which no stimulus was presented but the subject responded by reporting as seeing something and is called the "false alarm" proportion (Figure 1, panel B1).

The proportion of the noise distribution that falls before the criterion corresponds to the proportion of "correct rejections"; in these trials, nothing is presented and the subject responds that he does not perceive anything (Figure 1, panel B2). Designations can also be given to the portions of the signal+noise distribution above and below the criterion. Above the criterion, the proportion corresponds to "hits", in which a stimulus is presented and the subject reports perceiving it (Figure 1, panel B3). Below the criterion, the proportion corresponds to "misses", or the proportion of stimulus

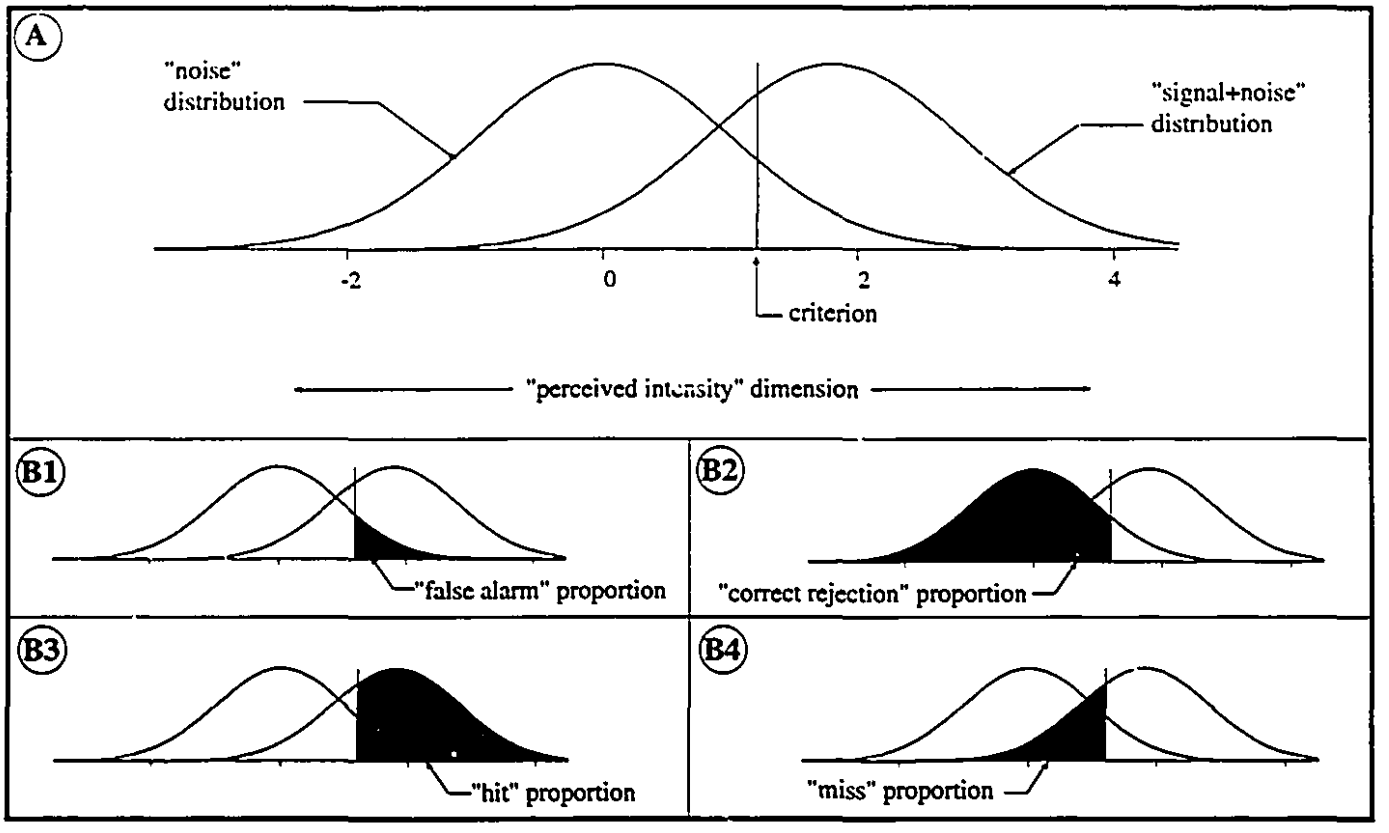

Figure 1. A) graphic representaion of the relationships between a hypothetical "noise" distribution, "signal+noise" distribution, and criterion on the perceived intensity dimension., B1-B4) names given to selective portions of one of the distributions (see text for details).

presentations responded to as not being perceived (Figure 1, panel B4).

The signal detection paradigm has been utilized by a number of investigators to make inferences about the state of the visual system. For example, Segal and colleagues (Segal and Gordon, 1969; Segal and Fusella, 1970, Reeves and Segal, 1973) and, more recently, Farah (1985, 1989) have used signal detection methods to make inferences about the interaction between mental imagery and visual processing. Likewise, Perlini et al (1993) employed signal detection methodology to investigate the effect of hypnotically induced hallucinations on the ability to perform a lexical decision task. The authors also sought corroborating evidence from visual evoked potentials from a number of brain areas. The only signal detection study to compare true hallucinators and non-hallucinators was reported by Bental and Slade (1985). These authors found that schizophrenics who have auditory hallucinations are more likely to report that they heard a faintly spoken word on a background of white noise, regardless of whether the word was actually present, than schizophrenics who do not hallucinate (i.e. different biases). No signal detection studies have compared Charles Bonnet hallucinators to non-hallucinating visually impaired individuals. The absence of such studies may be the result of several factors. First, systematic investigation of this topic is just beginning. As well, the visual capacity of Charles Bonnet hallucinators can be considerably different from one another. This precludes the application of a straight-forward signal detection experiment because a stimulus that is within the required threshold range for one subject may be completely detectable for another subject, and totally undetectable for yet another subject. In order to work around this fact, a threshold stimulus can be found for each subject prior to the detection experiment by adjusting the size of the presenting stimulus until it is within threshold range. This

procedure, however, invalidates a between-group comparison on a measure of the sensitivity of the visual system to the stimulus, simply because the measure, called d', is affected by the size of the presenting stimulus (in addition to the sensory capacity of the visual system). The criterion point -- that is, the point along a dimension of perceived intensity beyond which a subject will respond that he or she saw the stimulus -- can be compared, because a criterion point is chosen independently of the stimulus size.

Despite this limitation, the available measure -- the criterion -- has considerable theoretical importance. For example, in her studies of mental imagery, Farah (1989) found that a mental image imagined to be seen on a target screen, consistently and systematically lowers the criterion for detection of a stimulus in the same region of the visual field. Farah argues that the lowered criterion may reflect a type of attentional mechanism. That is , when a mental image is formed, attention is deployed to that region of the visual field, effectively lowering an individual's threshold for perceiving any activity within that region. Both physiological (e.g., Moran and Desimone, 1985; Chelazzi et al., 1993) and psychophysical (Ramachandran and Cobb, 1995) evidence support the notion that changes in attention can alter the responses of cells in the visual system and the perception of stimuli presumed to be processed very early in a "bottom-up" processing stream. Given that normal visual perception also frequently involves active attending to a portion of the visual field -- that is, it involves an attentional mechanism -- it is of interest to determine whether hallucinators differ from non-hallucinators on the criterion measure.

The criterion measure is also of interest for another reason. It can reveal a difference in background activity, or "noise", between hallucinators and non-hallucinators. The value of the criterion can be obtained by finding

the distance between it and the mid-point of the noise distribution. The distance is calculated from the "correct rejection" proportion and is expressed as a z-score. If it is assumed that spontaneous cell firing or background "noise" levels within the visual system are distributed along a normal curve, in accordance with signal detection theory, then it is possible that the entire noise distribution is shifted in hallucinators compared to non-hallucinators, and thus is reflected by a smaller criterion value (smaller z-scores for hallucinators compared to non-hallucinators).

The following experiment, therefore, was performed to determine if hallucinators and non-hallucinators do, in fact , show criterion differences. Specifically, it is hypothesized that hallucinators show a more liberal (smaller) criterion relative to non-hallucinating visually impaired people.

Method

Subjects

Thirty male subjects participated in the study. Twenty-nine were visually impaired U.S. veterans who were currently participating, or had in the past participated, in a 10 to 12 week program on adjustment to blindness at the Veterans Affairs Medical Center in West Haven Connecticut. One subject was a visually impaired staff member. Of the 30 subjects, half were hallucinators (mean age = 65.1 years, SD 11. 4) and half non-hallucinators (mean age = 60.1 years, SD 12.0). Of the hallucinating group, 9 experienced complex hallucinations and 6 experienced simple hallucinations. All but one complex hallucinator reported seeing an image within the two weeks prior to the experiment. Examples of hallucinations seen by complex hallucinators include: a compellingly realistic red-and-white striped basketball in the corner

of a room, faces of people, realistic plant life, figures of men or women, landscape, rag-dolls wearing hats. Subjects in the simple hallucinator group included people who acknowledged that they experience unusual visual phenomena but whose description lacked clarity and/or complexity characteristic of Charles Bonnet hallucinators. The simple hallucinators reported seeing unusual visual phenomena of various shapes and colours that "look like" an object, or were "reminiscent" of an object as opposed to the complex hallucinator's description of "seeing" an object. Examples of objects hallucinated by subjects in this group include a brightly coloured geometric pattern, a wave against a nondescript part of the hull of a boat, an image that looks like a skull and cross-bones, a box or car at a distance. Non-hallucinators fit into neither of these groups.

Procedure

The experiment consisted of two phases: 1) finding a stimulus that is within the subject's threshold range, and 2) presenting the threshold stimulus over trials that are randomly interspersed with blank trials.

Phase 1: Determining the threshold stimulus

After informed consent was obtained, the subject was seated and ambient lighting was reduced to near dark conditions. During an interval of approximately 15 minutes whereby the subject's eyes were allowed to adapt to the lighting conditions, a 51-item social desirability scale (Marlowe and Crowne, 1964) that also contained filler items from the Minnesota Multiphasic Personality Inventory (MMPI) was administered. After completing the questionnaire, the subject was instructed to place his chin on a chin rest and a nine-inch computer screen was moved directly in front of the subject at a distance of four feet from the edge of the chin rest. Subjects with

deficits in the central portion of their visual field (13 hallucinators, 5 non-hallucinators) were instructed to fix their attention on a large black cross on a white sheet of paper that was fixed at a distance of 25 inches from the center of the computer screen. In this manner, these subjects viewed the screen at an eccentricity of 27.5 degrees. Alternately, subjects with peripheral visual deficits were instructed to fix their attention directly at the center of the computer screen (1 hallucinator, 10 non-hallucinators[1]). Subjects were then instructed that they would hear two tones. In the interval between the two tones, a circle would be briefly presented to them. They were informed that sometimes they would see the circle and sometimes they would not. The size would change depending on their answer.

The stimulus for each of the trials was a circle composed of fine alternations of black and white pixels (72 pixels = 1 inch), so that for practical purposes it was gray when viewed at four feet. The stimulus was presented on a black background. A single trial consisted of the following events in sequence: a 200Hz tone of .5 seconds duration served to warn that a stimulus is forthcoming; a 1.5 second interval; presentation of the stimulus for .5 second; another 1.5 second interval; a 400Hz tone of .25 seconds duration to signal the end of the stimulus interval; a period of at least 4 seconds in which the subject's response was keyed in; and a 3 second interval following the keyed response before the subsequent trial. Subject's verbal responses were keyed into a file during the course of the experiment.

Stimulus size was changed after every trial. A "yes" response led to a decrease in the stimulus size of the subsequent trial. A "no" response led to an increase in the subsequent stimulus size. The amount of change was determined using the "parameter estimation by sequential testing", or PEST,

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[1]The testing angle (straight or side) was not recorded for one subject, due to an oversight.

algorithm (MacMillan and Creelman, 1991, p. 196 - 197). Initial stimulus size was 70 pixels in diameter (72 pixels = 1 inch). Initial "step" size -- that is, the amount by which the subsequent stimulus was changed -- was 40 pixels. Following the PEST rules, each step in the opposite direction from the previous step, called a reversal (i.e., an increase in size following a decrease), called for a halving of the step size, with the exception that the smallest step size allowed was one pixel. Two changes in the same direction did not change step size but a third doubled the step size. Finally, if a reversal followed a doubling of step size then three changes in the same direction had to take place before doubling began again. This sequence of stimulus presentation and size adjustment continued until there were a total of 14 reversals in direction. Calculation of the threshold was based on the average size of the last eight stimuli. The entire threshold estimation phase was performed twice for each subject. The threshold estimation that was smaller was used for the second phase of the experiment.

Due to the range of visual abilities of the subjects, brightness of the stimulus was adjusted for some subjects prior to the start of threshold phase. As previously stated, the specific goal of this first phase was to find a stimulus that was within threshold range for that subject. In fact, the procedure as described should converge upon that stimulus size to which the subject would respond "yes" 50% of the time.

Phase 2: The detection experiment

Once the threshold stimulus was established, the subject was instructed that the task was now different from the previous one. The subject was told that half the time there would be a circle presented, as before, and half the time there would actually be nothing presented between the two tones. The subject was also told that the order of presentation would be random, so that

on any given trial he would not be able to anticipate whether a circle would be presented. One-hundred trials were administered: 50 trials in which a stimulus was presented and 50 "blank" trials. Stimulus and blank trials were alternated on a fixed, pseudorandom basis. Stimulus trials in which subjects responded "yes" (i.e., hits) were sporadically provided with feedback to ensure that subjects maintained an internal reference for the stimulus. All other aspects of phase two were identical to phase one. That is, timing conditions were the same, lighting conditions were also identical, and responses were written to a file during administration. An opportunity for rest was given every 20 trials. At the conclusion of the experiment a measurement of background illumination was taken.

Results

Pooling subject responses

Each of the 100 trials was categorized as a "hit", "miss" ,"correct rejection", or "false alarm." For each subject, a hit rate (total hits/50), false alarm rate (total false alarms/50), was calculated. Since more than one subject in all groups completed phase two without a giving a false alarm response (6 non-hallucinators, 4 complex hallucinators, 2 simple hallucinators), and thus had a false alarm rate of zero, subject's responses were pooled within their respective group. Pooling data from subjects is one method of dealing with a proportion of zero, if, as noted by MacMillan and Creelman (1991, p. 276), the observed proportion is the result of "...sampling variability associated with [a] small number of trial[s]..." Pooled hit rate and false alarm rate for the groups were as follows: complex hallucinators, .449 and .027; simple hallucinators,

.473 and .030 ; combined (simple and complex) hallucinators, .459 and .028; non-hallucinators, .597 and 024.

Measure of interest -- the criterion

It may be noted that each phase of the experiment has an associated criterion by virtue of the fact that in both phases, subjects were required to make a decision whether or not they saw a stimulus during the presentation interval between the two tones. According to signal detection theory, the act of making a decision implies the use of a criterion. We will designate the criterion used in the threshold phase as C_1 , and the criterion used in the detection phase as C_2. As stated previously, the value of the criterion can usually be obtained by finding its distance from the mid-point of the noise distribution. The distance is calculated from the "correct rejection" proportion and is expressed as a z-score. A statistical comparison can be made between two z-scores (MacMillan and Creelman, 1991 pp. 271 - 274), since it is known that a z-score corresponding to a correct rejection proportion p has a variance of

$$\text{var}\,[\,z(p)\,] = p(1-p) \,/\, N\,[\,\phi\,(p)\,]^{2}$$

where N is the number of trials, and $\phi\,(p)$ is the height of the normal density function at z(p). Using the calculated variances, a 95% confidence interval can be found for a score that is the difference between the two z-scores. If the confidence interval does not include zero, then there is a significant difference between the criteria.

Since the threshold phase of the experiment did not include "blank" trials (and thus there was no possibility of obtaining "correct rejections"), calculation of the criterion C_1 could not be determined in the standard

manner. Instead, the value of C_1 was calculated using the following method. Because it is known that the threshold procedure finds the stimulus size to which the subject should respond "yes" 50% of the time -- and given that the same "50% yes stimulus" is used in the second phase -- it follows that C_1 can be obtained from the point along the intensity dimension in phase two where the combined percentage of false alarm area and hit area equals 50.

Table 1 shows the values of C_1 for each of the hallucinating groups (separately and combined) and non-hallucinators represented as distance from the center of their respective noise distributions. From this table it can be seen that combined complex and simple hallucinators , as well as complex hallucinators alone, had criteria significantly different from non-hallucinators during phase one of the experiment. The criteria utilized by the hallucinating groups is one which allows for a greater percentage of false alarms.

The criterion C_2 is calculated in a more straight forward manner by finding the z-score corresponding to the correct rejection proportion in the detection phase. Comparisons between hallucinators and non-hallucinators, again by finding confidence intervals for the difference scores, showed no significant differences for this phase.

To further test the significant differences between the hallucinator's and non-hallucinator's criteria in the first phase, two additional data analysis procedures were carried out. Since pooling subjects' data is one of a number of methods of dealing with an observed proportion of zero, it was of interest to determine if significant differences would also be found using other methods. Significant differences between hallucinators and non-

	Criterion Score (C_1)	95% Confidence Interval for difference score	Significance ($p < .05$)
Group			
complex halucinators	1.879	$.375 \pm .340$	*
simple hallucinators	1.887	$.367 \pm .378$	
combined hallucinators	1.882	$.372 \pm .307$	*
non-hallucinators	2.254	—	

Table 1. Criterion scores and 95% confidence intervals for difference scores. Difference scores are calculated by subtracting the relevant hallucinators' group score from the non-hallucinators' group score.

hallucinators were still found when C_1 scores (found for each of the subjects individually, using the procedure described for the data analysis of phase one) were subjected to a t-test. Subjects with a proportion of zero were eliminated from this test. (This approach was also used by Farah, 1989). Using a third data analysis technique, that is, computing individual criteria (as above) after adding a small value (.01) to zero false alarm proportions, did not yield significant differences between the groups.

There were no significant differences between hallucinators and non-hallucinators on the Marlowe-Crowne measure of social desirability.

Discussion

The results show that during phase one of the experiment, complex hallucinators, as well as combined (simple and complex) hallucinators, utilized a significantly more "liberal" criterion than non-hallucinators. "Liberal" is used in the sense that the criterion was one that allowed for a greater number of false alarms. This difference, however, was not evident during the second signal detection phase of the experiment.

It is important to note that the above differences in criterion location can arise from at least two different sets of circumstances. Figure 2 shows two alternate interpretations for the observed criterion differences. Accordingly, the comparison labeled 1 shows the criterion differences between hallucinators and non-hallucinators arising from true (or absolute) differences between the groups' criterion points. The comparison labeled 2 shows the criterion differences arising from a relative increase in the background noise for the hallucinating group.

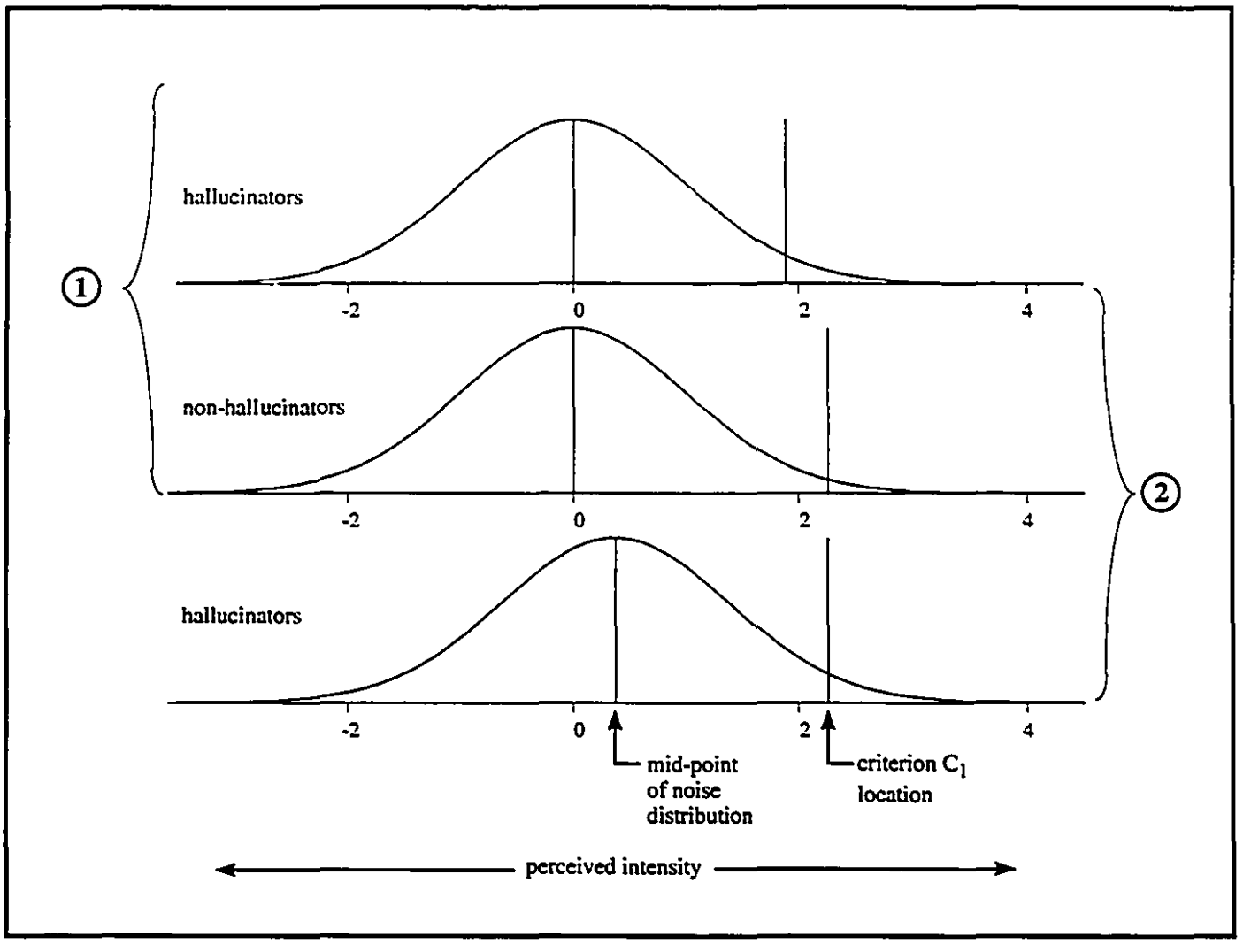

Figure 2. Alternate interpretations for criteria differences. 1) A graphic representation of the criterion location relative to the noise distribution for hallucinators (top) and non-hallucinators (middle). The comparison labelled 1 shows the criteria difference due to an absolute difference along the perceived intensity dimension. 2) The comparison labelled 2 shows the criteria difference due to a shift in the noise distribution of the hallucinators (bottom).

A clue as to why there was a significant difference between groups in phase one and not in phase two of the experiment is apparent from examining Figure 3. This figure accurately depicts the noise distributions and criteria for the threshold phase, as before, but additionally, the signal+noise distribution and the criteria from phase two (dotted lines) are added. It can be seen that the difference observed between the groups in phase 1 is the result of a shift in criteria by the non-hallucinators. The hallucinators as a group did not change criteria across phases. Since the hallucinators -- by virtue of their membership in the "hallucinating" group -- are different from the norm, this lack of criterion shift could play a role in the production of the hallucinations.

Criterion shifts can be due to a number of factors. In addition to the previously described and hypothesized attentional mechanism, motivational factors and information gleaned from instructions can also be said to affect the criterion used by a subject. The fact that hallucinators and non-hallucinators did not significantly differ from one another on the social desirability scale makes an explanation based upon an approval motive unlikely (i.e., trying to do or say what they believe the investigators want of them). Perhaps subjects, though they received the same instructions, responded differentially to them. Why this might occur is unknown at present. One possibility is that the lack of criterion shift for the hallucinators reflects a "ceiling effect" for this group. Specifically, it can be speculated that knowledge that stimuli would not be presented on all trials in the second phase made subjects in both groups more vigilant for occasions in which the stimulus was presented, and thus produced an impetus for a criterion shift

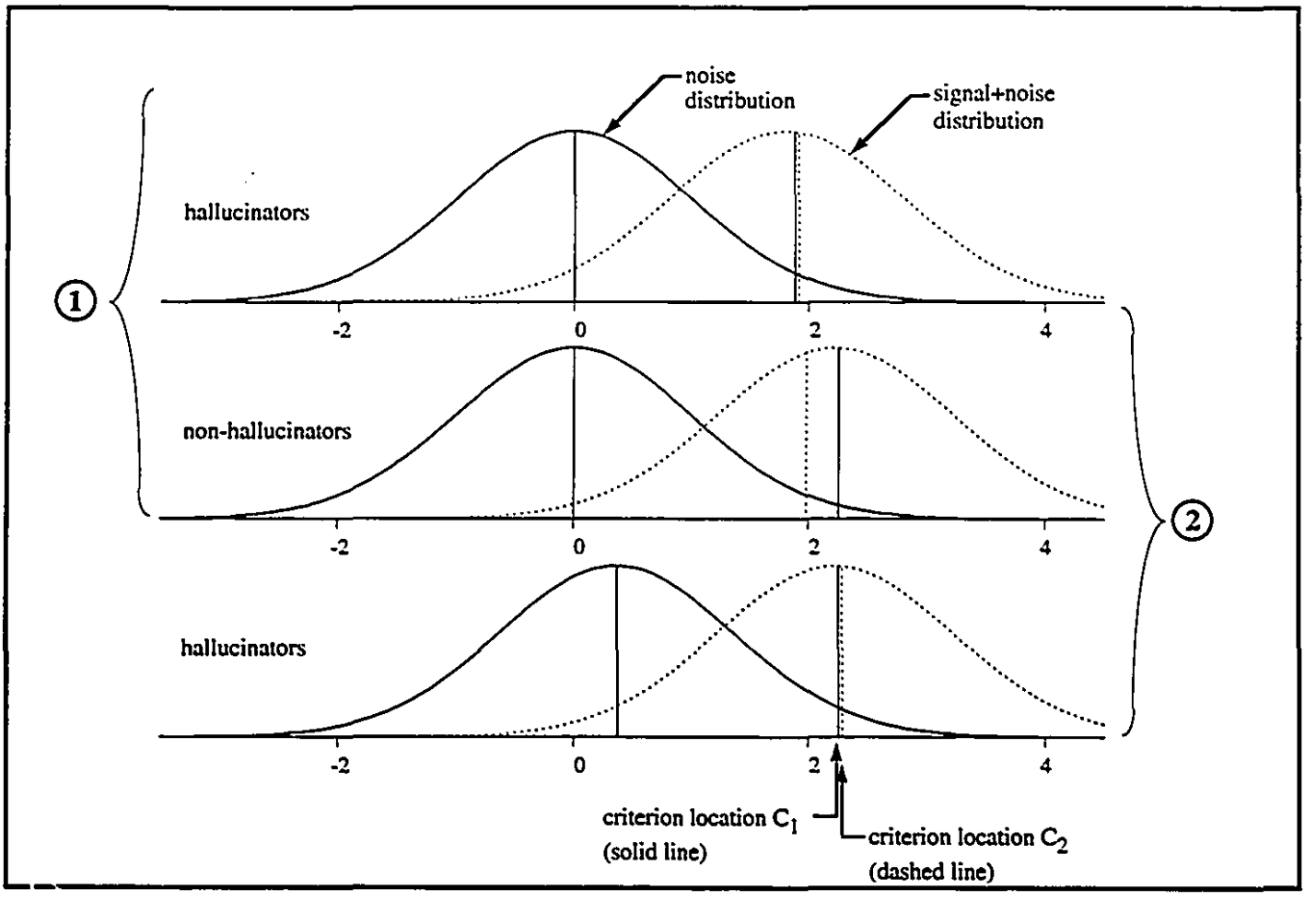

Figure 3. Criterion placement for hallucinators and non-hallucinators in both phases of the experiment.

(i.e., more attentional resources allocated to detecting any activity within the attended portion of their visual field.) If it is further hypothesized that all individuals have an upper limit for the proportion of times that they are willing to say "yes" under conditions of uncertainty, then perhaps the hallucinators were already at that limit due to an increase in background noise (spontaneous activity within the lower level visual system). The non-hallucinators' criterion still had "room for movement." This situation would be represented by the comparison labeled 2 on Figure 3.

The above speculative explanation cannot fully account for the mechanism by which Charles Bonnet hallucinations occur. In this study simple hallucinators responded to the stimuli in a similar fashion to the complex hallucinators. It appears that it was only by virtue of the smaller number of subjects in the "simple hallucinators" group that the criterion difference between this group and the non-hallucinations was not significant. The reason why one of the hallucinating groups would have complex hallucinations and the other group simple hallucination is unknown. Thus while the above proposed mechanism of an increase in background noise modulated by attentional resources may account for the *occurrence* of what might be called a "stock visual hallucinatory experience", how that visual experience gets incorporated into an individual's ongoing neuromatrix for visual experience may vary from one individual to another.

The results from this study show that hallucinators and non-hallucinators can, at times, significantly differ in their relative criterion location during visual tasks. This result is consistent with a true absolute criterion difference between the groups. It is also consistent with a relative increase in background activity (or noise) for the hallucinators. Or alternately, the differences could arise from some combination of both

circumstances. Future research may be directed towards studies that differentially assess these hypotheses.

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GENERAL DISCUSSION

In this last section of the thesis, the major findings of the studies are summarized, explanations for the hallucinations are explored, and finally, future directions for research are offered.

Major Findings

1) A strong association exists between the reduction of normal visual capacity and the complex visual hallucinations seen in the Charles Bonnet syndrome. The visual reduction may be due to peripheral eye conditions such as macular degeneration, cataract, glaucoma, and diabetic retinopathy as well as central conditions such as tumors and infarcts of the visual processing areas. The hallucinations appear to be more prevalent in woman and in older individuals, although no prevalence studies have been conducted which control for base rates of eye disorders in the sexes and across the age spectrum. The content of the hallucinations can be variable within an individual hallucinator and between hallucinators, and may include such entities as people, animals, buildings or scenery. The images may or may not be familiar to the hallucinator. Like phantom limb experiences, the visual hallucinations tend to fade over time.

2) A set of properties common to hallucinators can be established, despite the fact that not all hallucinators have identical experiences. The results from study 2 show that Charles Bonnet hallucinators typically experience an image that appears while they are alert and have their eyelids open. The image suddenly becomes visible without any known trigger or voluntary effort. The

image itself is sharply focused, and commonly does not move while seen. The hallucinated image stays present for a period of time best characterized by hallucinators as "seconds" rather than "minutes" or "hours."

3) A dimension of hallucinatory/perceptual experience was revealed through statistical analysis of the hallucinatory properties of Study 2. The dimension, which accounts for 65.9% of modified inertia, ranges from discrete, brief and singular experiences at one pole, to multiple, lengthy and changing experiences at the other pole. Hallucinations experienced in the Charles Bonnet syndrome are found at the discrete, brief, and singular pole of the dimension.

4) The results of psychological testing demonstrate that the mental status of Charles Bonnet hallucinators can be characterized as intact. On tests that measure psychological symptoms, and thus indicate emotional distress, the hallucinators score on average within the normal range. Similarly, on a test that screens for cognitive impairment, hallucinators scored within the normal range. A detailed study of hallucinators' and non-hallucinators' responses on one test of psychological symptoms, the Mini-Mult, reveals that higher hallucinator scores on the clinical scales are the result of a small cluster of outliers (largely composed of hallucinators). These outliers score significantly higher in the pathological direction than the non-outlying cluster. The remaining majority of hallucinators could not be distinguished from non-hallucinators on this measure.

5) The results of Study 5 show that on visual tasks that require a subject to report the detection of threshold-level stimuli, hallucinators compared to

non-hallucinators can have significantly smaller values that measure the distance between a subject's criterion location and the center of the background noise distribution. These results are consistent with the hypothesis that the level of background activity is greater in hallucinators than in non-hallucinators. The results are also consistent with differences between the groups in absolute criterion location.

Final Speculation on the Cause of the Visual Hallucinations and Directions for Future Research

It has been asserted throughout this thesis that Charles Bonnet hallucinations can be considered analogous to phantom limb experiences. The most compelling justification for this idea is that both experiences are associated with a large reduction of normal sensory input in their respective sensory domains. The simple fact that these parallel phenomena exist -- and further , that musical and formed auditory hallucinations can be experienced following hearing impairment (Miller and Crosby, 1979; Hammeke et al., 1983; Asaad, 1990; Berrios, 1990) -- suggests the inference that hallucinations subsequent to sensory loss reveal a general property of both normal and hallucinatory perceptual processes. More specifically, the fact that individuals may experience complex well-formed perceptual experiences when peripheral sensory input, at best, provides a degraded and sporadic stream of information about the world -- and at worst, no information whatsoever -- is a persuasive argument that higher level processes in the perceptual processing hierarchy can at times dominate over lower level processes involved in the various domain-specific perceptual experiences. In short, "top-down" influences appear to be important.

This idea has appeared throughout the thesis. For example, in Study 2 the hypothesized role of top-down processes in the production of Charles Bonnet hallucinations was discussed. In this regard, Dennett's (1991) idea of a hypothesis generation mechanism was described. While Dennett is certainly not the first to propose the analogy between perception and hypothesis generation -- apparently that idea follows from the writings of Helmholtz in 1866 (Gregory, 1987, pp. 608 - 611) -- he extends the analogy to hallucinatory perception as seen in the following passage:

> "All we need suppose must happen for an otherwise normal perceptual system to be thrown into a hallucinatory mode is for the hypothesis-generation side of the cycle (the expectation-driven side) to operate normally, while the data driven side of the cycle (the confirmation side) goes into a disordered or random or arbitrary round of confirmation and disconfirmation ..." (Dennett, 1991, p.12)

Similarly, in Study 2, Neisser's (1976) idea of an anticipatory schema as well as Melzack's (1989) schema-like concept of the "neuromatrix" were also discussed. In Study 5, an "attentional" mechanism proposed by Farah (1989) was discussed. And even the review paper, Study 1, proposed that the hallucinations occurred within the context of a general arousal mechanism. Clearly, all these phrases do not refer to identical concepts. However, insofar as they do refer, in part, to larger, more general, widespread brain processes which can exert an influence on the operation of the visual system, they can be said to have a common function. In the present discussion, the phrases "attentional mechanism", "hypothesis", and "anticipatory schema" are used interchangeably.

If the general idea of a top-down process and the specific idea of a hypothesis generation mechanism are valid, then it would be reasonable to

conjecture that all people who have severe visual deficits should hallucinate. These accounts of the hallucinatory experience regard the hallucinations as the product of processes involved in normal visual perception and presumably operate in all people who, at one time, had relatively normal vision. The fact is, not all visually impaired people hallucinate. A puzzling discrepancy exists between the proportion of people who report phantom limb phenomena and the proportion who report Charles Bonnet hallucinations. Within groups of people who are visually impaired, the prevalence rate for these hallucinations is estimated at 10 to 30 percent (based upon a review of the literature), whereas it is commonly estimated that 80 to 100 percent of amputees experience phantoms (Katz, 1989).

One possible explanation for the discrepancy is that Charles Bonnet hallucinators simply report the experiences at a much lower rate than they actually occur. There is a considerably greater stigma associated with the admission of visual hallucinations, which occur commonly in patients with severe mental disorders, compared to the report of phantom limb experiences. Even with an allowance for different rates of admission, however, it is not likely that the visual hallucinations are as ubiquitous as phantom limb experiences. The question, then, is why all people with severe visual impairment do not hallucinate.

Perhaps a key to the answer lies in the joint consideration of "top-down" and "bottom-up" contributions. While top-down accounts of the hallucinations have been emphasized, we must not disregard the role of spontaneous and random activity, or noise, in the low-level visual processing areas of the visual system. In fact, the "neuromatrix" explanation as well as the hypothesis-generation account as proposed by Dennett both postulate a role for spontaneous, random activity in the visual system. A neuromatrix

hypothesis for the hallucinations holds that the spontaneous activity in low-level visual processing areas triggers more complex and patterned activity in higher-level visual processing areas. A hypothesis-generation account holds that the random activity potentially confirms a "perceptual hypothesis." Presumably this mechanism is analogous to the common phenomenon of erroneously hearing the telephone ring while in the shower, when one is expecting an important call.

Study 5 of the thesis was an attempt to determine the reason why hallucinations occur in some people and not in others. This study measured the proportion of trials in which subjects report a threshold-level visual stimulus when it was and was not actually present. Unfortunately, because of limitations of the design of the study, the results cannot be interpreted unambiguously with regard to the relative contribution of top-down and bottom-up influences. From the results, an argument can be made that both are necessary. If the observed difference between hallucinators and non-hallucinators were due only to a difference in background noise, then an additional (top-down?) mechanism must be proposed to account for the reason why some of the hallucinators had complex hallucinations while others experienced only simple hallucinations. The results showed that complex hallucinators do not differ from simple hallucinators, though both differ from non-hallucinators. On the other hand, if the results are assumed to be due entirely to top-down attentional or expectancy effects (reflected in absolute criterion differences between the groups), then the question still remains as to why some visually impaired subjects hallucinate and others do not, since presumably all people have expectancies.

The above discussion leads to a number of ideas for future studies. The most direct assessment of top-down and bottom-up contributions could be

conducted using a functional brain imaging technique such as positron emission tomography (PET). Hallucinators and non-hallucinators could be pre-trained in a classical conditioning paradigm to expect a visual stimulus when a specific tone is heard. Measures of baseline activity in the visual system could quantify bottom-up contributions, and expectancy, or top-down, contributions could be assessed by measuring the effect of the tone presentation on visual system activity (assuming that the tone does indeed create an expectancy for a visual event).

Short of conducting a PET study, a slightly more complicated signal detection study may also differentially assess the role of both top-down and bottom-up contributions. In general terms, these could be assessed by directly manipulating subjects' expectancy for a visual stimulus and also manipulating the degree to which the actual stimulus matches the expected stimulus within the same experiment.

Another area for future research is in the development of effective approaches to manage the hallucinations. Regardless of whether an individual is incessantly hounded by visual images, or the person experiences the occasional hallucination, these experiences can both be frightening and annoying. In the literature review, Study 1, it was noted that there are reports of individuals who were able to stop the hallucinations by closing their eyes (Bartlet, 1951), moving their eyes (e.g. Benson and Rennie 1989), or simply fixating on the hallucinated object (e.g. Kolmel, 1985). Similarly, approaching the hallucination (e.g. Patel et al., 1987) or talking to it (Lance, 1976) was also reported to stop the hallucinations. In Study 5, it was also mentioned that an increase in social/environmental stimulation appeared to stop the hallucinations in some individuals (e.g. Hosty, 1990). Clearly these reports must be followed up and investigated systematically. In addition to the

potential relief for individuals disturbed by the hallucinations, the development of effective management techniques may hasten the understanding of the cause of the hallucinations.

It is usually the case in scientific exploration that description precedes explanation. Only after careful, systematic examination of descriptive phenomena do patterns begin to emerge, and it is only after linking these patterns to testable hypotheses that causes can be assessed. Studies on the Charles Bonnet syndrome have for the last 230 years, by and large, been descriptive. It is time that researchers move beyond description and work toward explanation.

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APPENDICES

Appendix A

A Description of the "Burt" Table and a Rationale for Using Modified Factor Scores

As noted within the text of Study 2, the multiple correspondence analysis (MCA) solution is based upon the analysis of a "Burt" table which is the cross-tabulations of all possible pairs of variables, *including* a variable with itself. The Burt table, therefore, is itself composed of a number of contingency tables. The small example provided shows two variables, A and B. Variable A has three levels while variable B has two levels. This Burt table based on these variables contains four contingency tables, each outlined by double lines. A value in each of the cells, A1B2 for example (in boldface type), represents the number of subjects who endorsed both level one of the A

	A1	A2	A3	B1	B2
A1	A1A1	A1A2	A1A3	A1B1	**A1B2**
A2	A2A1	A2A2	A2A3	A2B1	A2B2
A3	A3A1	A3A2	A3A3	A3B1	A3B2
B1	B1A1	B1A2	B1A3	B1B1	B1B2
B2	B2A1	B2A2	B2A3	B2B1	B2B2

variable and level two of the B variable. Two of the four sub-tables in this example represent variables crossed with themselves (i.e. the sub-table in the upper left is A crossed with A; the sub-table in the lower right is B crossed with B). If the amount of "inertia" is roughly equated to the distribution of subjects within the sub-tables; sub-tables in which the subjects are evenly distributed amongst the cells have a low quantity of inertia. Sub-tables in which subjects are unevenly distributed contain a high level of inertia. (Technically, inertia it is equal to the chi-square value for the entire table divided by the number of data points). Note that sub-tables in which variables are crossed with themselves contain a large amount of inertia simply because of the contrived nature of crossing a variable with itself. The total inertia for the entire Burt table is therefore vastly over estimated, and conversely the quality of the MCA solution is underestimated. In simple

terms, the modification procedure corrects for this by eliminating the inertia contribution made by the sub-tables where a variable is crossed with itself. This is accomplished by scaling the principle inertias accordingly (Rovan, 1994):

$$\tilde{\lambda}_k = \left[\frac{Q}{Q\text{-}1}\left(\lambda_k - \frac{1}{Q}\right)\right]^2 \quad \text{for } k=1,2,\ldots,$$

where $\tilde{\lambda}_k$ is the kth modified principle inertia (eigenvalue), Q is the number of variables from which the categories came, λ_k the kth principle inertia. The square-root of the first modified inertia is multiplied with the coordinate points of the first axis to yield the final values for the modified factor score of the first axis. A similar procedure is used to find the points for the second and third dimensions, etc.

Appendix B

Study 3 Case Reports

Case 01

Female: Born 1917

This 73-year-old woman reports that she woke up one morning in January 1983 to find a sudden decrease in her visual perception. Optometry notes from the Montreal Association for the Blind (MAB) confirm macular degeneration in both eyes, with a visual acuity of 10/600 in her left eye and 10/700 in her right eye. Subject 01 reports experiencing different visual phenomena, ranging in complexity and apparent type. From the simplest to the most complex, she states that she sees flashes of light shoot across her visual fields on a daily basis. She also reports seeing "sparkles" around a street lamps at night and that, in general, any light bothers her. Intermittently, since the onset of her visual problems, she sees a mass of moving "spaghetti" or "intestine" against a white hazy background. Out of the centre of this moving mass, images of faces and sometimes images of an animal such as a dog may appear. She reports that this whole scene occurs for a few minutes in duration and appears only at night before she goes to bed. When questioned explicitly whether she is asleep, the subject reports that she is awake. She states that her eyes are open and that the images appear on the wall of her bedroom, or on her closet door. The subject reports an irregular sleeping pattern, waking in the middle of the night, or at an early morning hour. At these times the subject reports getting out of bed and having a cup of tea before going back to bed. One of the complex, well-formed images that

she has experienced is that of a figure of a man. She describes the image as tall, thin, and very beautiful to look at. The figure was not in colour and was further described being very neatly dressed in a black suit with a grey shirt. He had long black hair with grey streaks in it. The subject reports not being able to see his face. This hallucination was estimated to last for 3 minutes. When she attempted to wake her husband, the figure rose slightly in the air and receded back through the wall of their bedroom. She said that she saw this figure again, on a separate occasion, from the torso up as if it was kneeling. She further reported that a couple of years later, again at night, she saw a very clear image of her mother by her bed. This image occurred for approximately 5 minutes.

It is apparent that some of the visual phenomena that this subject experiences can be accounted for without recourse to central explanatory mechanisms. The flashes of light may be due to the spontaneous discharge of retinal cells, and the sparkles around street lamps may be due to refractive glare of the light. Even the mass of moving "spaghetti" can be accounted for if it is proposed that blood vessels in front of the macular region are casting shadows on the retina, however, this is unlikely since the subject reports that she in a dark environment when the "mass" appears. The faces of people, figures of animals, and especially the life-size figures of people appear to be true hallucinatory experiences like those seen in Charles Bonnet syndrome.

Case 02

Female: Born 1909

Subject 02, an 81-year-old woman, reports a sudden onset of visual difficulties in December 1988 due to retinal hemorrhage and subsequent

macular degeneration that has left her with little central vision. Optometry records from the MAB show that her visual acuity was 5/600 and 5/300 in the left and right eyes respectively.

Subject 02 reports that her hallucinations started approximately 16 months after the onset of her visual deficits. Since that time they have occurred almost daily. Her principal hallucination consists of seeing a huge rock when she looks out her front window. Upon looking out her window the interviewer saw houses, trees, and grass; in short, nothing that resembled a rock. Subject 02 can describe the rock in some detail, stating that its outline describes a jagged arch. She says that it looks three-dimensional with protuberances and appears to be made of grey granite with bluish veins. She reported that her initial reaction was one of amazement; now, however, she finds the image annoying as she wants to see behind the rock. She has developed a technique for making the rock disappear, which consists of turning her head and using her peripheral vision. This image of the rock appears only when she looks out her front window and not at other times.

In addition to seeing the rock, Subject 02 reports three other unusual visual experiences. When outside, subject 02 sees one particular building covered in what looks like small lilacs, though she knows that it is not. This covering "appears thicker than moss" and is greyish-brown in colour. Other buildings in her neighbourhood do not have this appearance. Subject 02 also reports that when she mixes porridge in the morning she sees a brownish granular substance in the pot. This often makes her think that the porridge is contaminated, although her husband, upon inspection of the breakfast, finds nothing. Finally, at the second interview, the subject amusingly related a recent hallucinatory experience when she and her husband attended a play. At a point during the play the subject noticed black coloured birds come out of

the stage and fly out into the audience. The subject, not realizing that the birds were hallucinatory, marveled at the "special effects" provided during the play. It was only later, in taking to her husband, that she discovered that the birds were not real.

Case 03

Female: Born 1908

Subject 03 is an 82-year-old woman. In addition to a cataract in her left eye and pseudophakia in her right eye, subject 03's visual difficulties include macular degeneration in both eyes resulting in a central scotomas. Records from the MAB indicate that visual acuity was 5/100 in both eyes.

The subject reports that her first hallucinatory experience occurred in December 1987 following a rapid decline in her sight. While watching a hockey game one evening, she looked up and saw a winter snow scene. The scene appeared normal in size, complete with a winter pond and water running in woods composed of pine trees. When questioned, the subject reports that the scene reminds her of a place where she used to live, approximately 35 years ago. Subject 03 also recurrently hallucinates an image of a tall, red-brick building. The image is very clear to her, and she can discern the steps leading up to the double doors on the building as well as the dormir windows on the front face. This image also usually appears in the evening while watching television. In addition to these complex hallucinations the subject also sees two images in silhouette: one that is shaped "like Elsie the cow" and one that is shaped like a Christmas tree bell. These images are black in colour and may to be related to the shape of the degeneration on the macula of her eye.

Case 04

Female: Born 1911

Subject 04, a lively 79-year-old woman reports that she has had problems with her vision since the age of 21. Between the years 1970 and 1980, subject 04 noticed a significant drop in her vision due to macular degeneration. It was during the later half of this decade, specifically in 1977, that she experienced the beginning of her hallucinatory episodes. A recent eye examination at the MAB found her visual acuity to be 10/140 in her left eye and 5/3500 in her right eye.

Subject 04 states that, for a couple of months in 1977, she saw a brick-red image of a face. The face did not look real but more mask-like with the eyes closed. The image appeared almost everyday with each hallucinatory episode lasting between 10 and 15 minutes. Further details of this hallucination could not be obtained due to the length of time that has passed since she has seen this image. The subject's most recent hallucinatory episodes consist of seeing the mouth area of a face. The image always appears in the late afternoon when she attempts to relax but is emotionally upset. She describes two versions of the mouth, one being pleasant to look at and the other unpleasant. The "nicer" image is composed of a pair of thin lips with the mouth closed. The nose cannot be seen but part of the chin is present. The image appears in natural copper-colored flesh tones. In contrast, the unpleasant mouth is larger and has a deeper copper colour. The lips are thicker and slightly parted almost in a grin, exposing three teeth. She sees more of the cheek area in this image with the creases off the nose being visible.

Case 05

Case is described within text of Study 3.

Case 06

Female: Born 1942

Subject 06 is a 49-year-old woman. Subject 06 reports that her visual problems began at the age of 7, shortly after contracting a series of childhood diseases (measles, chicken pox, whooping cough, and ring worm). At that time she began to wear glasses, noticing a slow gradual decline in her vision until she was 30. At 30, subject 06 experienced a retinal detachment in her right eye leaving her with no light perception in the right eye and only poor vision in the left. Vision in the left eye stabilized until the last three years, when Subject 06 experienced retinal hemorrhages compounding the visual problems caused by myopic degeneration. She reports that she has no central vision in her left eye now. Charts from the MAB show visual acuity at no light perception (right eye) and 10/140 (left eye). Subject 06 states her first hallucination occurred after the retinal detachment at age 30. She reports that it occurred a few times during the first year, then stopped for approximately 15 years until the vision in her left eye began decreasing. With decreasing vision in her left eye, the hallucinations have become more frequent and vivid. The subject reports that the hallucinations occur almost exclusively when she is meditating or when she is in a relaxed mental state, not focusing her attention on anything in particular. She further adds that they appear almost every time she attempts to meditate now. The subject reports that the hallucination usually consists of a single eye, though at times there is more

than one eye. The typical episode consists of the eye appearing at an apparent distance of about 12 feet in front of her, then gradually moves toward her so that it appears to be right in front of her face. At this point she estimates the image to have a long diameter of about 1.5 feet. The eye is sharply in focus, and has a blue iris with a black pupil. She does not see eyelashes, nor an eyelid. She states that it does not look spherical since she can only see the front part of the eye. When the eye comes fairly close, it starts to 'disintegrate', 'distort', or 'melt', which causes her considerable distress. At this point she usually stops the image by shaking her head and cringing. The subject has adopted a psychological explanation for the phenomenon, stating that the eye represents her own eye and it is her subconscious letting her know about her eye problems.

Case 07

Female: Born 1915

Subject 07 is an 76-year-old woman who reports that her eye problems began in June 1988, with a sudden decrease in vision in her left eye. About a year later she again experienced a sudden decrease in her vision, this time in her right eye. Eye charts from the MAB have determined her visual acuity to be counting fingers in both eyes, owing to macular degeneration. In February 1990, subject 07 began to experience very realistic-looking hallucinations of two dogs, when she watches television. The subject notes that the images. when they appear, gradually form on the television screen after watching it for 15 to 30 minutes. Each dog's eyes appear first, then its nose, mouth and the remainder of its head. She reports that both images, one a beige-coloured spaniel and the other an Airedale with a dark patch on its back, look as if they

are alive. Eye movement causes the images to disappear, though they return periodically while she watches the television.

Case 08

Male: Born 1912

This 78-year-old widowed man reported that his visual problems began in 1987 with a "sparkling" in his left eye. He was seen by a an ophthalmologist in Montreal who told him that he had cataract in both eyes. After the removal of the right cataract, he reported that vision in his right eye improved greatly . During the same period of time he was found to have mild diabetes, now controlled by pills taken prior to meals. Charts from the MAB show that subject 08 still has a posterior cataract of the left eye and a lens implant (pseudophakia) in the right eye, in addition to an underlying retinopathy condition in both eyes. Testing for visual acuity in June 1990 showed hand movements for his left eye, and 10/200 right eye. Subject 08 reports that his vision varies on a day to day basis.

During the course of the first interview in August 1990, subject 08 revealed that about three months earlier he saw for the first time an image of a grey stone coloured cathedral. He reported that the image was transparent. Though he could not describe details of the building, he knew it to be a cathedral. He also reported seeing a large rectangular object which he described as a billboard, again not very distinctly. He knew that the objects were not in fact present. These same objects appeared approximately 6 times in the period of time between their first appearance and the first interview. He stated that the images lasted for approximately 1/2 minute and generally appeared in the afternoon when being driven in a car. He reported seeing the

images matter-of-factly and stated that he neither enjoyed them nor did they bother him.

Case 09

Female: Born 1908

Subject 09 is an 82-year-old woman whose visual problems include macular degeneration (both eyes) and open-angle glaucoma. This subject reports a gradual loss in sight since before 1985. Visual acuity tested at the MAB found 10/225+ in her left eye, and 3/600 in her right.

Subject 09 reports that her first hallucinatory experience occurred in 1985 while being driven in a car at night. She saw a distinct checkerboard, with red and black squares, in front of her . This image appeared a few times during this initial period of time and remained present for variable periods of up to two hours. The image was not seen for some time until about May 1990. She reports that the image is much more "fleeting" now and the squares have changed colour to a grid of alternating fawn and darker brown.

Subject 09 also reports that she has seen images of people move across her screen while watching television (apart from the content of the program). In October 1990 she reported that this had occurred three times in the previous three months. The figures, miniature in size, were not animated but crossed her visual field from the left corner of the television screen to the right. She reported that the figures did not look like "cut-outs" but more natural in appearance. She said that she could see the back of the figures' heads which were flesh coloured, and the shoulders of an orange suit. The first of the repeating figures was most prominent, with the second and third being smaller and less vivid. Finally, during a second interview with this

subject, she reported having seen the floral pattern of her bedspread in her visual field. This hallucination remained present for approximately 2 hours one evening.

Case 10

Male: Born 1903

Subject 10 is an 87-year-old man whose macular degeneration in both eyes has left him with a visual acuity of counting fingers at 8 feet in the left eye and counting fingers at 5 feet in the right eye. He reports that he wore glasses since he was in his forties but did not have significant visual problems until 10-15 years ago when he experienced a detached retina in his left eye. Subject 10 has also experienced a retinal hemorrhage in his right eye.

The subject reports three types of unusual visual phenomena. The first type is described by the subject as seeing afterimages. The subject, for example, sees multiple copies, in different colours, of the skirt of a woman who passes by him. This palinopsia may also occur, at times, when the subject looks at plants. While these images may occur at anytime during the day, subject 10 states that he may see images of people, and less frequently, images of wild animals during the night only. In contrast to the coloured afterimages, the figures are reported to appear only in black against a white background. He notes that the figures move with his eyes and eye closure stops the images. Finally, this subject reports seeing large black circles in his visual field. The circles appear in different sizes, ranging from 6 to 12 feet in diameter, by his estimate.

Case 11

Female: Born 1908

Subject 11 is an 83-year-old woman. Macular degeneration in both eyes has left this woman with light projection in her left eye and a visual acuity of 20/600 in her right eye. Approximately one and a half months before being interviewed in September 1991, this woman began to experience her hallucinations. She reported that she sees images of people when she looks at the door in her room. The images are described as looking like a portrait or a black and white photograph. She notes that they are mostly of women, though no particular woman. She does remember seeing one image that looked like Abraham Lincoln. The images do not move and may be stopped by eyelid closure.

During testing, this woman displayed some mild mind wandering, spontaneously recounting stories of her childhood, youth, and middle age. She was, however, able to orient to the present when being tested on the Mini-Mental State Examination. Although, she was not administered the BDI or the STAI, since it was felt that she was growing weary after being interviewed, it appeared that she was mildly depressed. She further alluded to being bored, stating that there is nothing for her to do during the day.

Case 12

Case is described within text of Study 3.

Case 13

Male: Born 1906

Subject 13 is an 83-year-old man. Macular degeneration in both eyes, beginning between 1979 and 1980 has left this subject with a scotoma in the centre of his visual fields. Optometry records from the MAB indicate a left-eye visual acuity of 10/100 and a right eye acuity of 5/250.

Between 1987 and 1988 Subject 13 began to have various hallucinations. These hallucination occur on average 1-2 times per week and persist for about 10 seconds. The hallucinations occur more frequently on the television screen than on an open wall. Subject 13 reports that his most vivid hallucinations are of a wire-netting fence (perhaps green in colour by his recollection) and of vertical bars "like in a jail". The bars are finger width and dark grey or black in colour. The subject further described a red brick wall that took up part of the television screen, and a blue diamond shaped "swatch of cloth with no visible texture". He reports having seen the faint outline or silhouette of three people, all the same shape and very schematic in character. On the second interview the subject reported seeing an addition hallucination of a skyline in silhouette on the television screen. He reported that the skyline looked as if it were composed of blocks like "cubism".

Case 14

Male: Born 1949

Approximately five years prior to being interviewed, this subject experienced a sudden failure of his eyesight following laser surgery performed in the attempt to halt retinal deterioration. Subject 14 is now totally blind.

Subject 14 describes three hallucinations. The first hallucination occurred only once, approximately 2 and 1/2 years prior to the interview date.

While lying on his bed one evening, listening to the television, he saw a clear image of a woman dressed in brown-coloured clothing bend over a fireplace with a rolled piece of paper in her hand. The figure proceeded to light the paper on fire then set his room ablaze. The subject noted the red and yellow flames in his room. Interestingly, the hallucination was accompanied by both the sound and smell of fire. Initially bewildered by these events, the subject leapt to his feet and rushed towards the flames before remembering that he was blind. At this realization, the hallucination vanished. The subject reported that he had never previously been afraid of fire. He did not appear paranoid during the interview. The subject further reports seeing, on a periodic basis, what he described as shadows of people in movement. The figures, usually seen in the afternoon, appear for a few seconds walking or dancing about. Finally, subject 14 reported seeing a framed picture of his father on occasion, when he thinks of him. The picture appears quite detailed to him and is composed of greys and blues. The subject clearly makes the distinction between imaging his father and "seeing" this picture, as the latter appears projected in space while the former is not.

Appendix C

Tests and Consent Forms for Study 3 and Study 5

McGill

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Consent Form

Many people who suffer from a loss in vision sometimes experience vivid, well-formed visual images despite their decrease in sight. The reason we are conducting this research project, is to find out more about this phenomenon, including what may trigger or stop the images. We are also interested in finding out how personality characteristics as well as your mood may be related to the occurrence of the images.

If you consent to participate in the study, Mr. Geoffrey Schultz will ask you some questions about your mood and your personality. The information that you provide will remain strictly confidential and will be used anonymously for the purposes of research and publication. Your participation would be greatly appreciated.

Consent Signature

I have understood the above information and agree to participate in the research project as described above. I also understand that I am free to not answer any question, and am free to withdraw from the study at any time I choose.

Date _____ Participant's signature _____

Witness' signature _____

Investigator's signature _____

Mini-Mental State Examination

Name:_____

Examiner:_____

Date:_____

Maximum Score	*Score*	
		Orientation
5	( )	What is the (year) (season) (date) (day) (month) ?
5	( )	Where are we: (province) (country) (city) (hospital) (floor)
		Registration
3	( )	Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them. Give 1 point for each correct answer. Then repeat them until he learns all 3. Count trials and record. Trials:_____
		Attention and Calculation
5	( )	Serial 7's: 1 point for each correct. Stop after 5 answers. Alternatively, spell "world" backwards.
		Recall
3	( )	Ask for the 3 objects repeated above. Give 1 point for each.
		Language
9	( )	Name a pencil, and watch. (2 points) Repeat the following, **"No ifs ands or buts."** (1 point). Follow a 3-stage command: **"Take a paper in your right hand, fold it in half, and put it on the floor."** (3 points). Read and obey the following: **Close Your Eyes** (1 point).

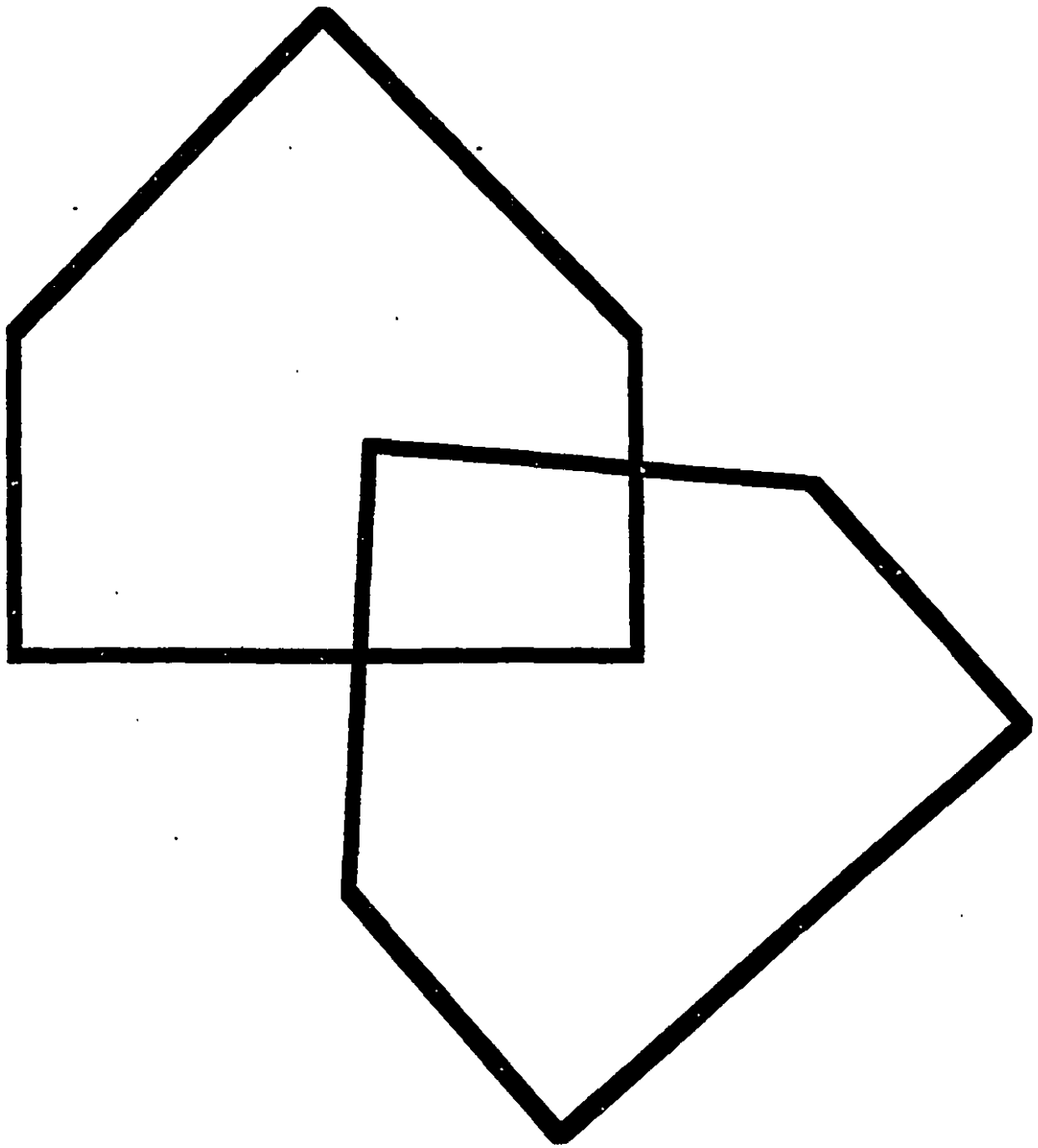
Write a sentence. (1 point)
Copy a design. (1 point)

_____ **Total Score**

Assess level of consciousness along a continuum:

Alert Drowsy Stupor Coma

CLOSE YOUR EYES



Instructions to the subject are:

MINI-MULT

"Please answer the following questions Yes or No as they apply to you now" (the examiner must make every effort to let the subjects decide their choices for themselves). Many subjects will seek advice, etc., from the examiner. Try to just reread the question and repeat the instructions, e.g. "answer the question Yes or No as it applies to you now." Be careful in reading the items so that your voice inflection or presentation does not influence the subject's answer. Record by circling subject's choice, either Yes or No.

	M.M.P.I.											
Booklet Number	Mini Mult											
		A	L	F	K	1	2	3	4	6	7	8	9
2 - 1.	Do you have a good appetite?	Y				N	N	N					
3 - 2.	Do you wake up fresh and rested most mornings?	Y				N		N			N		
8 - 3.	Is your daily life full of things that keep you interested?	Y					N	N	N		N	N	
13 - 4.	Do you work under a great deal of tension?	N					Y						Y
15 - 5.	Once in a while, do you thing of things too bad to talk about?		N							Y	Y	Y	
18 - 6.	Are you troubled by constipation?	N				Y	Y						
21 - 7.	Have you, at times, very much wanted to leave home?	N							Y			Y	Y
22 - 8.	At times, do you have fits of laughing and crying that you cannot control?	N								Y	Y	Y	Y
23 - 9.	Are you troubled by attacks of nausea and vomiting?	N		Y		Y	Y	Y					
24 - 10.	Does it seem that no one understands you?	N							Y	Y		Y	
30 - 11.	At times, do you feel like swearing?	Y	N		N		N	N					
31 - 12.	Do you have nightmares every few nights?	N		Y									
32 - 13.	Do you find it hard to keep your mind on a task or job?	N					Y	Y	Y		Y	Y	
33 - 14.	Have you had very peculiar and strange experiences?	N							Y			Y	
35 - 15.	Would you have been much more successful if people had not had it in for you?	N		Y					Y	Y		Y	
38 - 16.	During one period when you were a youngster, did you engage in petty thievery?	N							Y			Y	
41 - 17.	Have you had periods of days, weeks or months when you couldn't take care of things because you could not "get going"?	N					Y				Y	Y	
43 - 18.	Is your sleep fitful and disturbed?	N				Y	Y	Y					
48 - 19.	When you are with people are you bothered by hearing very queer things?	N		Y									
54 - 20.	Are you liked by most people who know you?	Y		N									

		A	L	F	K	1	2	3	4	5	7	8	9
58 - 21.	Have you often had to take orders from someone who did not know as much as you did?	N											Y
67 - 22.	Do you wish you could be as happy as others seem to be?	N					Y		Y		Y		
71 - 23.	Do you think a great many people exaggerate their misfortunes to gain the sympathy and help of others?	Y			N			N					
75 - 24.	Do you sometimes get angry?	Y	N	N									
86 - 25.	Are you definitely lacking in self-confidence?	N					Y				Y		
103 - 26.	Are you troubled with your muscles twitching or jumping?	N				Y		Y				Y	
106 - 27.	Much of the time, do you feel as if you have done something wrong or evil?	N							Y		Y		
107 - 28.	Are you happy most of the time?	Y					N	N	N	N			
109 - 29.	Are some people so bossy that you feel like doing the opposite of what they request, even though you know they are right?							N		N			Y
121 - 30.	Are you being plotted against?	N		Y						Y		Y	
124 - 31.	Will some people use somewhat unfair means to gain profit or advantage rather than lose it?	Y			N			N		N			
125 - 32.	Do you have a great deal of stomach trouble?	N				Y							
129 - 32.	Have you often been cross or grouchy without understanding why?	Y			N			N					
134 - 34.	At times, have your thoughts raced ahead faster than you could speak them?				N				N				Y
137 - 35.	Is your home life as pleasant as that of most people you know?	Y						N	N				
142 - 36.	Do you certainly feel useless at times?				N		Y				Y		
153 - 37.	During the past few years, have you been well most of the time?	Y				N	N	N					
156 - 38.	Have you had periods in which you carried on activities without later knowing what you had been doing?	N		Y								Y	Y
157 - 39.	Do you feel you have been punished without cause?	N								Y		Y	Y
160 - 40.	Have you ever felt better in your life than you do now?	N			Y		Y	Y					
170 - 41.	Are you bothered by what others think of you?	N			Y			Y	Y				
178 - 42.	Is your memory all right?	Y					N				N	N	
180 - 43.	Do you find it hard to make talk when you meet new people?	Y			N			N	N				
189 - 44.	Do you feel weak all over much of the time?	N				Y	Y	Y			Y		
190 - 45.	Are you troubled by headaches?	N				Y		Y					

		A	L	F	K	1	2	3	4	6	7	8	9
192 - 46.	Have you had difficulty in keeping your balance in walking?	N				Y		Y				Y	
- 47.	Do you like everyone you know?	N	Y										
200 - 48.	Is anyone trying to steal your thoughts and ideas?	N		Y									
201 - 49.	Do you wish you were not so shy?	Y						N	N				
209 - 50.	Do you believe your sins are unpardonable?	N		Y									
217 - 51.	Do you frequently find yourself worrying about something?				N						Y		
224 - 52.	Have your parents often objected to the kind of people you went around with?	N							Y				
225 - 53.	Do you gossip a little at times?	Y	N										
228 - 54.	Do you, at times, feel that you can make up your mind with unusually great ease?	N											Y
230 - 55.	Are you troubled by your heart pounding and by a shortness of breath?	N				Y		Y					
234 - 56.	Do you get mad easily and then get over it soon?	Y			N			N					
238 - 57.	Do you have periods of such great restlessness that you cannot sit long in a chair?	N						Y			Y	Y	Y
245 - 58.	Do your parents and family find more fault with you than they should?	N		Y					Y				
252 - 59.	Does anyone care much what happens to you?	Y		N									
271 - 60.	Do you blame a person for taking advantage of someone who lays himself open to it?						Y						N
272 - 61.	Are you full of energy at times?	Y		N	N		N						
274 - 62.	Is your eyesight as good as it has been for years?	Y				N		N					
281 - 63.	Do you often notice your ears ringing or buzzing?	N				Y				Y		Y	
291 - 64.	Have you ever felt that someone was making you do things by hypnotizing you?	N		Y						Y		Y	
296 - 65.	Have you had periods in which you felt unusually cheerful without any special reason?	Y			N		N		N				
305 - 66.	Even when you are with people, do you feel lonely much of the time?	N								Y	Y	Y	
316 - 67.	Do you think nearly anyone would tell a lie to keep out of trouble?	Y			N					N			
3 68.	Are you more sensitive than most other people?	N								Y	Y		
374 - 69.	Does your mind seem to work more slowly than usual, at times?	Y			N								
383 - 70.	Do people often disappoint you?	Y			N								
215 - 71.	Have you used alcohol excessively?	N		Y					Y				

Name _____ Date _____

For each of the following groups of statements please place a check (✓) beside the one statement that best describes how you presently feel.

A. ___ I do not feel sad.
___ I feel sad or blue.
___ I am blue or sad all the time and I can't snap out of it
___ I am so sad or unhappy that it is very painful.
___ I am so sad or unhappy that I can't stand it.

B. ___ I am not particularly pessimistic or discouraged about the future.
___ I feel discouraged about the future.
___ I feel I have nothing to look forward to.
___ I feel that I won't ever get over my troubles.
___ I feel that the future is hopeless and that things cannot improve.

C. ___ I do not feel like a failure.
___ I feel I have failed more than the average person.
___ I feel I have accomplished very little that is worthwhile or that means anything.
___ As I look back on my life all I can see is a lot of failures.
___ I feel I am a complete failure as a person (parent, husband, wife).

D. ___ I am not particularly dissatisfied.
___ I feel bored most of the time.
___ I don't enjoy things the way I used to.
___ I don't get satisfaction out of anything anymore.
___ I am dissatisfied with everything.

E. ___ I don't feel particularly guilty.
___ I feel bad or unworthy a good part of the time.
___ I feel quite guilty.
___ I feel bad or unworthy practically all the time now.
___ I feel as though I am very bad or worthless.

F. ___ I don't feel that I am being punished.
___ I have a feeling that something bad may happen to me.
___ I feel that I am being punished or will be punished.
___ I feel I deserve to be punished.
___ I want to be punished.

G. ___ I don't feel disappointed in myself.
___ I am disappointed in myself.
___ I don't like myself
___ I am disgusted with myself.
___ I hate myself.

H. ___ I don't feel that I am any worse than anybody else.
___ I am very critical of myself for my weaknesses or mistakes.
___ I blame myself for everything that goes wrong.
___ I feel I have many bad faults.

I. ___ I don't have any thoughts of harming myself.
___ I have thoughts of harming myself but I would not carry them out.
___ I feel I would be better off dead.
___ I have definite plans about committing suicide.
___ I feel my family would be better off if I were dead.
___ I would kill myself if I could.

J. ___ I don't cry anymore than usual.
___ I cry more than I used to.
___ I cry all the time now. I can't stop.
___ I used to be able to cry but now I can't cry at all even though I want to.

K. ___ I am no more irritated now than I ever am.
___ I get annoyed or irritated more easily than I used to.
___ I feel irritated all the time.
___ I don't get irritated at all at the things that used to irritate me.

L. ___ I have not lost interest in other people.
___ I am less interested in other people now than I used to be.
___ I have lost most of my interest in other people and have little feeling for them.
___ I have lost all my interest in other people and don't care about them at all.

M. ___ I make decisions about as well as ever.
___ I try to put off making decisions.
___ I have great difficulty in making decisions.
___ I can't make decisions at all anymore.

N. ___ I don't feel I look any worse than I used to.
___ I am worried that I am looking old or unattractive.
___ I feel that there are permanent changes in my appearance and they make me look unattractive.
___ I feel that I am ugly or repulsive looking.

O. ___ I can work about as well as before.
___ It takes extra effort to get started at doing something.
___ I don't work as well as I used to.
___ I have to push myself very hard to do anything.
___ I can't do any work at all.

P. ___ I can sleep as well as ever.
___ I wake up more tired in the morning than I used to.
___ I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
___ I wake up early every day and can't get more than 5 hours sleep.

Q. ___ I don't get any more tired than usual.
___ I get tired more easily than I used to.
___ I get tired from doing anything.
___ I get too tired to do anything.

R. ___ My appetite is no worse than usual.
___ My appetite is not as good as it used to be.
___ My appetite is much worse now.
___ I have no appetite at all anymore.

S. ___ I haven't lost much weight, if any, lately.
___ I have lost more than 5 pounds.
___ I have lost more than 10 pounds.
___ I have lost more than 15 pounds.

T. ___ I am no more concerned about my health than usual.
___ I am concerned about aches and pains *or* upset stomach *or* constipation *or* other unpleasant feelings in my body.
___ I am so concerned with how I feel or what I feel that it's hard to think of much else.
___ I am completely absorbed in what I feel.

U. ___ I have not noticed any recent change in my interest in sex.
___ I am less interested in sex than I used to be.
___ I am much less interested in sex now.
___ I have lost interest in sex completely.

Spielberger Trait Anxiety Inventory

SELF-EVALUATION QUESTIONNAIRE

STAI FORM X-2

NAME _____ DATE _____

DIRECTIONS: A number of statements which people have used to describe themselves are given below. Read each statement and then blacken in the appropriate circle to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	①	②	③	④
22. I tire quickly	①	②	③	④
23. I feel like crying	①	②	③	④
24. I wish I could be as happy as others seem to be	①	②	③	④
25. I am losing out on things because I can't make up my mind soon enough	①	②	③	④
26. I feel rested	①	②	③	④
27. I am "calm, cool, and collected"	①	②	③	④
28. I feel that difficulties are piling up so that I cannot overcome them	①	②	③	④
29. I worry too much over something that really doesn't matter	①	②	③	④
30. I am happy	①	②	③	④
31. I am inclined to take things hard	①	②	③	④
32. I lack self-confidence	①	②	③	④
33. I feel secure	①	②	③	④
34. I try to avoid facing a crisis or difficulty	①	②	③	④
35. I feel blue	①	②	③	④
36. I am content	①	②	③	④
37. Some unimportant thought runs through my mind and bothers me	①	②	③	④
38. I take disappointments so keenly that I can't put them out of my mind	①	②	③	④
39. I am a steady person	①	②	③	④
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	①	②	③	④

Department of Veterans Affairs

VA RESEARCH CONSENT FORM

Subject Name: _____ **Date** _____

Title of Study: Signal Detection Sensitivity and Response Bias Measures of Charles Bonnet Hallucinators

Principal Investigator: Walter E. Needham, Ph.D. **VAMC:** West Haven, CT

DESCRIPTION OF RESEARCH BY INVESTIGATOR

You are invited to participate in a research study designed to investigate how the visual system may be related to visual images that people with visual deficits sometimes see. You have been invited to participate in the study because you have been admitted to the Eastern Blind Rehabilitation Service and although you have a visual loss, you have some residual sight. Your participation in this study will last for one 30 to 45 minute period.

If you consent to participate, the investigator will ask you to sit in front of a computer screen, and tell him or her if you can see a series of circles that will be briefly presented to you. There will be several rest periods during this time.

It is anticipated that there will be no discomfort during the procedure. It will involve scheduling you at some time during the day as a medical appointment is normally done.

There are no known risks to your health or psychological well-being associated with this. You may drop out of the study at any time.

There are no direct benefits to you. It is believed that the results, however, will lead to a better understanding of the visual systems of those persons who experience visual images. This hopefully will eventually lead to treatment of such images for persons who find them distressing.

If you choose not to participate in this proposal, you will continue in your present program.

_____
Initials

SUBJECT'S IDENTIFCATION (I.D. plate or give name-last, first, middle)

Subject Name: _____ **Date** _____

Title of Study: Signal Detection Sensitivity and Response Bias Measures of Charles Bonnet Hallucinators

Principal Investigator: Walter E. Needham, Ph.D. **VAMC:** West Haven, CT

If you are physically injured as a result of taking part in this study, all necessary medical and appropriate care will be provided if you are eligible for medical care as a veteran. Humanitarian emergency care will be provided if you are not eligible as a veteran. Compensation may or may not be payable under federal law. Further information regarding eligibility for medical care and compensation under federal law in the event of injury may be obtained from the Chief of the Medical Information Service at telephone extension 3701. You may also contact the Medical Center's Patient Representative at telephone extension 3877.

_____
Initials

Department of Veterans Affairs

VA RESEARCH CONSENT FORM

(Continuation Page 3 of 3)

157

Subject Name: _____ **Date** _____

Title of Study: Signal Detection Sensitivity and Response Bias Measures of ~~Charles Bonnet Hallucinators~~

Principal Investigator: Walter E. Needham, Ph.D. **VAMC:** West Haven, CT

RESEARCH SUBJECTS' RIGHTS: I have read or have had read to me all of the above. _____ has explained the study to me and answered all of my questions. I have been told of the risks or discomforts and possible benefits of the study. I have been told of other choices of treatment available to me.

I understand that I do not have to take part in this study, and my refusal to participate will involve no penalty or loss of rights to which I am entitled. I may withdraw from this study at any time without penalty or loss of VA or other benefits to which I am entitled.

The results of this study may be published, but my records will not be revealed unless required by law.

In case there are medical problems or questions, I have been told I can call Dr. Rita Louard at 2-157 during the day and Dr. _____ at Call main hospital number and ask for _____ after hours. If any medical problems occur in connection with this study the VA will provide emergency care. The Blind Service physician on call after hours.

I understand my rights as a research subject, and I voluntarily consent to participate in this study. I understand what the study is about and how and why it is being done. I will receive a signed copy of this consent form.

_____ Subject's Signature	_____ Date
_____ Signature of Subject's Representative*	_____ Subject's Representatives
_____ Signature of Witness	_____ Witness (print)
_____ Signature of Principal Investigator	_____ Signature of Person Obtaining Consent
*Only required if subject not competent.	_____ Person Obtaining Consent (print)

IF MORE THAN ONE PAGE IS USED, EACH PAGE (VAF 10-1086A) MUST BE CONSECUTIVELY NUMBERED AND SIGNED.

The Marlowe-Crowne Social Desireability Scale
(with MMPI filler items indicated by boldface numbers)

Please read each statement and decide whether you feel in general that it is mostly true as applied to you or mostly false. Please circle the appropriate letter (T-true F-false) directly to the right of each statement. Answer 'True' to positively stated questions if they are true as often or more often as stated. For example, answer 'True' to "Occasionally, I play poker" if you play occasionally of more often.

1. I find it hard to keep my mind on a task or job.	T	F
2. I am sometimes irritated by people who ask favors of me.	T	F
3. I am happy most of the time.	T	F
4. Before voting, I thoroughly investigate the qualifications of all the candidates.	T	F
5. I believe I am no more nervous than most others.	T	F
6. I sometimes think that when people have a misfortune they only got what they deserved.	T	F
7. I am more sensitive than most other people.	T	F
8. I like to gossip at times.	T	F
9. On occasion I have had doubts about my ability to succeed in life.	T	F
10. There have been occasions when I took advantage of someone.	T	F
11. I am a high-strung person.	T	F
12. I have never intensely disliked anyone.	T	F
13. I cannot keep my mind on one thing.	T	F
14. I never make a long trip without checking the safety of my car.	T	F
15. I have periods of such great restlessness that I cannot sit long in a chair.	T	F
16. I am always courteous, even to people who are disagreeable.	T	F
17. On a few occasions, I have given up doing something because I though too little of my ability.	T	F
18. I am always careful about the manner of my dress.	T	F
19. At times I think I am no good at all.	T	F
20. I have never felt that I was punished without cause.	T	F

21. When I don't know something, I don't at all mind admitting it.	T	F
22. I am usually calm and not easily upset.	T	F
23. I never resent being asked to return a favour.	T	F
24. I am not unusually self-conscious.	T	F
25. I sometimes try to get even, rather than forgive and forget.	T	F
26. If I could get into a movie without paying and be sure I was not seen, I would probably do it.	T	F
27. I work under a great deal of tension.	T	F
28. I have never deliberately said something that hurt someone's feelings.	T	F
29. I can remember "playing sick" to get out of something.	T	F
30. I am inclined to take things hard.	T	F
31. I sometimes feel resentful when I don't get my way.	T	F
32. Life is a strain for me much of the time.	T	F
33. No matter who I'm talking to, I'm always a good listener.	T	F
34. I certainly feel useless at times.	T	F
35. I always try to practice what I preach.	T	F
36. There have been times when I was quite jealous of the good fortune of others.	T	F
37. I sometimes feel that I am about to go to pieces.	T	F
38. I have never been irked when people expressed ideas very different from my own.	T	F
39. My table manners at home are as good as when I eat out in a restaurant.	T	F
40. There have been occasions when I feel like smashing things.	T	F
41. I have sometimes felt that difficulties were piling up so high that I could not overcome them.	T	F
42. I never hesitate to go out of my way to help someone in trouble.	T	F
43. It is sometimes hard for me to go on with my work if I am not encouraged.	T	F
44. At times I have really insisted on having things my own way.	T	F
45. I feel anxiety about something or someone almost all of the time.	T	F
46. I'm always willing to admit it when I make a mistake.	T	F

47. There have been times when I felt like rebelling against people in authority even though I knew they were right. T F

48. I frequently find myself worrying about something. T F

49. I have almost never felt the urge to tell someone off. T F

50. I shrink from facing a crisis or difficulty. T F

51. I don't find it particularly difficult to get along with loud-mouthed, obnoxious people. T F

52. I am certainly laking in self-confidence. T F

53. I would never think of letting someone else be punished for my wrong-doings. T F