Visual hallucinations in Parkinson's disease: a review and phenomenological survey

J Barnes, A S David

Abstract

Objectives—Between 8% and 40% of patients with Parkinson's disease undergoing long term treatment will have visual hallucinations during the course of their illness. There were two main objectives: firstly, to review the literature on Parkinson's disease and summarise those factors most often associated with hallucinations; secondly, to carry out a clinical comparison of ambulant patients with Parkinson's disease with and without visual hallucinations, and provide a detailed phenomenological analysis of the hallucinations.

Methods—A systematic literature search using standard electronic databases of published surveys and case-control studies was undertaken. In parallel, a two stage questionnaire survey was carried out based on members of a local branch of the Parkinson's Disease Society and followed up with a clinical interview.

Results—The review disclosed common factors associated with visual hallucinations in Parkinson's disease including greater age and duration of illness, cognitive impairment, and depression and sleep disturbances. The survey comprised 21 patients with visual hallucinations and 23 without. The hallucinators had a longer duration and a greater severity of illness, and tended to show more depressed mood and cognitive impairment. The typical visual hallucination in these patients is a complex visual image experienced while they are alert and have their eyes open. The image appears without any known trigger or voluntary effort, is somewhat blurred, and commonly moves. It stays present for a period of "seconds" or "minutes". The content can be variable within and between hallucinators, and includes such entities as people, animals, buildings, or scenery. These features resemble those highlighted in hallucinations in the visually impaired (Charles Bonnet's syndrome).

Conclusion—A consistent set of factors are associated with visual hallucinations in Parkinson's disease. The results of the phenomenological survey and those of visual hallucinations carried out in other settings suggest a common physiological substrate for visual hallucinations but with cognitive factors playing an as yet unspecified role.

(J Neurol Neurosurg Psychiatry 2001;70:727-733)

Keywords: visual hallucinations; Parkinson's disease; phenomenology

According to the DSM IV criteria,¹ a hallucination is "a sensory perception without external stimulation of the relevant sensory organ" distinguishing it from an illusion, in which an external stimulus is perceived but then misinterpreted. Although separate, the phenomena often overlap, with illusions leading to hallucinations and vice versa. One of the commonest neurological conditions associated with visual hallucinations is Parkinson's disease. Although there are reports of visual hallucinations in Parkinson's disease before the dopamine era,² the phenomena have only been noted as a frequent complication of the disorder since levodopa treatment was introduced.³

One categorisation of visual hallucinations is "simple" versus "complex". Simple hallucinations are characterised by the absence of form, and are often photopsias such as flashes of light or colour. Occasionally, geometric shapes are described which move around in space. Complex visual hallucinations are characterised by visions that are clearly defined, have specific form, and can include animals, objects, and humans. These two types tend to be seen as having localisation value: simple, pointing to occipital pathology⁴⁻⁵ whereas the complex type are presumed to involve the temporal cortex,⁶⁻⁷ either directly or indirectly through modulatory connections (as in peduncular hallucinosis).⁹⁻¹⁰

In a recent review¹¹ it was proposed that there were three basic mechanisms, which, alone or in combination, underlie complex visual hallucinations with widely differing causes: irritative processes acting on higher visual centres or pathways; defective visual processing (both peripheral and central); and brainstem modulation of thalamocortical connections.

In this article we review surveys of visual hallucinations in patients with Parkinson's disease and contribute a survey of our own. The objectives were firstly, to characterise the typical features of the hallucinations in Parkinson's disease and summarise their associations; and secondly, to compare these findings to those derived from descriptions of visual hallucinations in other disorders. The aim was to examine whether the phenomena in different settings have characteristics in common despite varied causes and whether inferences about their pathophysiology can be made on this basis.

Literature review

A systematic literature search using MEDLINE and EMBASE databases was carried out on papers published in English

Department of
Psychology, Oxford
Brookes University,
Gipsy Lane,
Headington, Oxford
OX3 0BP, UK
J Barnes
A S David

Division of
Psychological
Medicine, Section of
Cognitive
Neuropsychiatry, GKT
School of Medicine
and Institute of
Psychiatry, London
SE5 8AF, UK
J Barnes

Correspondence to:
Professor A S David
a.david@iop.kcl.ac.uk

Received 15 May 2000 and
in final form
6 November 2000
Accepted 22 November 2000

between 1966 and December 1999. Search terms were Parkinson(s) and hallucination(s)/and "visual". Case series, surveys, and case-control studies were included, but not case reports and reviews. The minimum quality criterion was some information on how the diagnosis of Parkinson's disease was reached and qualitative information on abnormal visual phenomena. These criteria excluded most studies including those before 1990 (thoroughly reviewed by Cummings.³ Table 1 summarizes the results of included studies published after 1991.

Prevalence

Prevalence rates of 11/89 (12.3%) for visual illusions plus hallucinations,¹² or 23/189 (11.6%) for hallucinations¹³ are typical of samples of chronically treated patients. Recent surveys give prevalence estimates of visual hallucinations between 8.8% and 44%.¹⁴⁻¹⁹ The visual phenomena range from bizarre, complex, and frightening "visions", through distortions of real percepts (illusions) to vague feelings of a "presence". Aarsland *et al*²⁰ carried out a community based study of 235 patients in Norway with Parkinson's disease. Of these, 23 patients (9.8%) had hallucinations with retained insight, and another 14 patients (6%) had more severe hallucinations and delusions. Under-reporting is a possible problem,¹⁵ even in interview studies, possibly because patients may fear being labelled as "mad".

Risk factors

The review—based on a total of 316 hallucinators and 806 comparison subjects—showed consistent results in terms of risk factors for visual hallucinations (table 1). Some features such as visual impairment have been found to be associated with visual hallucinations in general²¹ and in other neurological disorders.²² Primary deficits in visual processing are associated with Parkinson's disease and have been exhaustively reviewed elsewhere.²³ The possible link with sleep disturbances has also been discussed at length.^{11, 24}

MEDICATION

Comparisons of hallucinators and non-hallucinators have seldom shown major differences in drug history.¹⁶ Anticholinergic agents may be responsible for confusion in elderly people²⁵ and cholinergic²⁶ and serotonergic systems together have been implicated in hallucinations.²⁷ Some authors noted increased use of anticholinergic drugs (and primary dopamine agonists) but the results are inconsistent. Goetz *et al*²⁸ studied five non-demented patients with Parkinson's disease with daily hallucinations who were given high dose levodopa infusions in a placebo controlled trial. No hallucinations were provoked. Fernandez *et al*²⁹ found that when there was an apparent link between hallucinations and medication or clinical state it was more likely to be in periods of immobility. Hence visual hallucinations do not simply relate to high levels of dopaminergic

Table 1 Summary of studies of visual hallucinations in Parkinson's patients with disease showing clinical associations

Study	No of patients	Controls/ comparison group	Sample	Association with visual hallucinations							Comments
				Age	Duration	Medication dose	Cognitive impairment	Disease severity/ disability	Depression	Sleep disturbance	
Fernandez <i>et al</i> 1992 ²⁹	30	20	Random clinical	+	-	-	+	-	-	-	8 patients' VHs associated with off periods
Haeske-Dewick 1995 ¹⁵	16	20	Clinic survey: initial mailing	+	-	-	+	+	- (when adjusted for age)	?	Not premorbid IQ
Klein <i>et al</i> 1997 ³¹	29	58	Prospective clinical	*	*	-	-	+	-	+	*Matched for age/duration. MMSE fell over follow up; CT measures not different
Sanchez-Ramos <i>et al</i> 1996 ¹⁶	55	214	Consecutive clinical	+	-	+	+	+	+	+	Higher anticholinergic and bromocriptine in VH+ve group
Graham <i>et al</i> 1997 ¹⁷	32	97	Clinic survey	?	Trend	+ dopamine agonists + (lifetime)	+ late onset only	+ motor disorder in early onset	Less in late onset	?	Main analysis early/late onset of hallucinations matched controls
Inzelberg <i>et al</i> 1998 ³³	35	76	Consecutive clinical	-	-	-	+	-	+	?	Emphasis on combined auditory and visual hallucinations
Aarsland <i>et al</i> 1999 ²⁰	23	212	Population based	+	-	-	+	+	+	+	First population based study
Fenelon <i>et al</i> 2000 ¹⁹	86	109	Consecutive clinical	+	+	+/-	+	+	+	+	21 had auditory (not included here). Formed VH occurred in 48 (22% of whole sample)

+ = Definite association; - = no association; ? = not reported or data not available.

stimulation but clearly dopaminergic drugs interact with Parkinson's disease in some way to produce visual hallucinations.

COGNITIVE IMPAIRMENT

Although some studies excluded patients with significant dementia,²⁴ all samples with a range of cognitive impairment related to Parkinson's disease have shown a significant correlation with visual hallucinations (more impairment in hallucinators; table 1). Several mechanisms could account for the association, excluding potential confounders such as medication dose, duration of illness, and depression:

(1) Cognitive impairment may be a marker of diffuse brain disease or more severe basal ganglia pathology. However, a recent study reported that despite having more severe disease, hallucinating patients with Parkinson's disease did not show more evidence of white matter lesions on MRI³⁰ and this concurs with earlier CT findings.³¹

(2) Cognitive impairment could also be a marker of a general degradation in information processing. A range of cognitive functions are impaired in Parkinson's disease.³² Visual hallucinations occur in many neuropsychiatric conditions as though at the end of a final common path.^{11 33 34} This could occur through combined neurological and psychological mechanisms.

(3) Finally, the impairment (or pattern of spared and compromised functions) may include abnormalities in, for example, reality testing, source monitoring, visual cognition etc, which are necessary to produce visual hallucinations. Waterfall and Crowe³⁵ systematically reviewed the neuropsychological literature on visual cognition in Parkinson's disease and concluded that complex visuospatial functions were compromised.³⁶ Whether there is a pattern of cognitive deficits specific to visual hallucinators awaits further research.

AGE AND DURATION OF ILLNESS

Increased age has been associated with the presence of hallucinations.^{37 38} This might be explained by accelerated sensory loss^{39 40} or age related side effects of medication.⁴¹ One of the main confounders with age is duration of illness; when the non-independence of these variables was controlled, Fénelon *et al*⁹ found that duration of illness was the crucial factor. Graham *et al*¹⁷ identified two subgroups of patients with Parkinson's disease experiencing hallucinosis: in those with disease duration of 5 years or less, visual hallucinations were associated with rapid progression of the motor but not the cognitive component of the disease. In the remainder with longer histories, visual hallucinations were associated with postural instability, global cognitive impairment, and the lack of depression. Goetz *et al*¹² contrasted patients with Parkinson's disease who experienced hallucinations (visual and auditory) within 3 months of levodopa therapy with those who experienced hallucinations after 1 year of treatment. Diagnoses in the early onset group more often changed to Lewy body or Alzheimer's disease. Lewy bodies are present to a greater or lesser degree in all cases of Parkinson's

disease⁴³ and are known to be associated with visual hallucinations.^{44 45}

Age of onset, duration, or speed of progression of illness, cognitive decline, and suboptimal response to medication are all proxy measures for disease severity. Most authors who recorded disease stage using the Hoehn and Yahr classification⁴⁶ found a relation between severity and presence of visual hallucinations.

Finally, personality profiles as measured by the Minnesota multiphasic personality inventory (MMPI) have been implicated in hallucinations in patients with Parkinson's disease.^{47 48} A recent study controlled for cognitive impairment and found an MMPI pattern specific for hallucinations.¹⁴

After this review, we screened a community sample of patients with Parkinson's disease for the presence of current hallucinatory experiences. Patients who consented were then interviewed to gather more detailed information about their disorder and the characteristics of the hallucinations.

Methods

PATIENTS

Respondents were recruited through a questionnaire study carried out at the University of Reading via local branches of the United Kingdom Parkinson's Disease Society, and at a neurology clinic at the King's College Hospital. All patients had a presumptive clinical diagnosis of Parkinson's disease, made by a hospital consultant, and all had been or were currently treated with compounds containing dopa. Patients were assigned to groups according to whether they had experienced visual hallucinations in the past 3 months, and those who had never experienced visual hallucinations. No patient in the population sampled had a clinical diagnosis of either Alzheimer's disease or Lewy body dementia.

QUESTIONNAIRE

We compiled an initial questionnaire, which was either mailed to patients or distributed at local Parkinson's disease Society meetings. The questionnaire was a typed A4 booklet and investigated general visual changes in Parkinson's disease. The front page contained information about the general nature of the study. The first section was used to record details of age and sex of respondents. The existence of comorbid diseases and use of medication, including dosage, were recorded. A total of 182 questionnaires were returned out of about 250 (because some questionnaires were distributed at meetings, it was not possible to be precise about how many were received by patients). Those indicating the presence of visual hallucinations in the past 3 months ($n=31$ (17.2%)) were asked to complete a second questionnaire and were invited to attend a clinical and neuropsychological assessment. Of these, 24 agreed to participate. A control group was derived from non-hallucinators who indicated a willingness to participate in research and could travel ($n=27$). The second questionnaire comprised items covering the nature and properties of the patients' visual hallucinations. These

Table 2 Demographics: patients with Parkinson's disease with and without visual hallucinations (mean(SD))

	Hallucinators (n=21)	Non-hallucinators (n=23)
Sex:		
Male	7	9
Female	14	14
Age (y)	67.62 (6.52)	63.23 (10.82)
Duration of illness (y)*	11.76 (5.42)	8.30 (4.38)
Daily levodopa (mg)	578 (163)	670 (159)
Hoeft and Yahr ¹⁶ *	3.47 (0.63)	2.95 (0.57)
Beck depression inventory	18.24 (4.5)	16.60 (5.4)
MMSE	26.7 (1.4)	27.6 (1.1)
Recognition memory:		
Words	29.2 (5.5)	31.5 (6.7)
Faces*	28.5 (4.6)	32.2 (5.4)

*p<0.05.

†Hallucinators (n=17); non-hallucinators (n=20).

derived from four broad "dimensions," 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 was to determine the experiential properties of these hallucinatory episodes. In addition, a short cognitive screen including the mini mental state examination (MMSE), and the Beck depression inventory (BDI) were administered.

DEMOGRAPHICS

There were 24 patients (10 men) with, and 27 (12 men) without visual disturbances of any type. Those who reported frequent migraines and ongoing eye disease (hallucinators=1, non-hallucinators=2) were excluded. This left 21 questionnaires from hallucinators (seven men) and 23 from non-hallucinators (nine men). The non-hallucinator group had a mean age of 63.2 years (SD 0.8) and the hallucinator group had a mean age of 67.6 years (SD 6.5) (table 2).

Results

The two groups differed significantly on duration of illness ($t(42)=2.34$, $p<0.05$), but did not differ in age ($t(42)=-1.615$, $p>0.05$), or levodopa medication ($t(42)=1.887$, $p>0.05$). A brief cognitive screening was performed which showed generally poorer performance in the hallucinators with a significant difference

on a recognition memory test for faces. The hallucinators had greater disease severity (as assessed by the Hoehn and Yahr scale¹⁶) but did not differ on the MMSE. Hence, the clinical profile of this group was similar to others in which visual hallucinations have been studied. Brief details of hallucinatory experiences are given for each patient in table 3. Most described complex biological forms (animals, children etc) sometimes smaller than in real life and distorted. More fragmentary formless precepts were also noted.

The percentages of each group who reported the presence of problems or symptoms are shown in table 4. A χ^2 test was used to investigate whether the distribution differed from chance (table 4).

FREQUENCY AND DURATION

Just over three quarters had five or less visual hallucinations a week (76.2%). All patients had their eyes open while experiencing the hallucinations. The duration of the experiences reported varied according to the time of day, with the longer episodes either in the morning or evening. In one patient, visual hallucinations lasted several hours and manifested gradually through the day. The remainder claimed that their hallucinations generally lasted for a few seconds up to 30 minutes and most (15 (76%)) experienced a sudden onset.

APPEARANCE

Seven patients experienced black and white images whereas 14 had single colour or multiple colour hallucinations. The clarity was blurred in 11 (52.4%) of the patients; only five patients (14.3%) described their hallucinations as sharp, although few reported distorted images. In these five patients the hallucinations were of meaningful content, pets or loved ones now dead, where perhaps familiarity may have contributed to the clarity. Thirteen patients (61%) claimed that their hallucination "seemed real" which could be taken as a measure of lack of insight into their hallucinatory nature. Sixteen (76%) reported having hallucinations that had form. Often the content was mundane such as an animal or unfamiliar person but ranged to the bizarre (faces made of

Table 3 Description of content of hallucinations associated with Parkinson's disease in 21 patients

Patient No	Sex	Age	Description of hallucinations
1	M	75	Dead relatives walking about the house. Sees his dead dog by his bed
2	F	64	People, in old style dresses. Some disembodied figures. Bright circle that changes into small children
3	F	65	Egg shapes that move around. Sees dogs and cats on the sofa
4	M	75	Humans sitting in lounge. Children playing in garden
5	F	76	Shadows of figures approaching from behind. "Molecular structure" of materials. Small girls looking in through the window
6	F	55	Spiders in her bed
7	F	65	People sitting in kitchen
8	M	64	People in garage. Big heads. Small girls and soldiers
9	F	66	Blackbirds sitting on shoulder
10	F	72	A flight of stairs appears in the garden. Spiders in her tea cups
11	F	64	Shadows, not very clear. Sees animal and birds when turning head
12	M	68	Spiders and piles of hairs around the house
13	F	77	Dog's face and people walking around the house
14	M	61	Brick red images of faces. Patterns covering buildings. Birds flying about
15	F	68	Small insect running around on the table. People in rooms as she walks past and looks in.
16	M	68	Vague human forms which he sees over her shoulder. Disappear when he looks around
17	F	71	Insect and spiders on duvet. Patterns on walls, which move in and out of the wall. Waterfall coming out of wall
18	F	69	Signposts change into men. Holes appear in carpet which go into the earth. Children's faces with distorted features.
19	F	73	Legs underneath trees in the garden. Small dogs and cats chasing each other around the house.
20	M	52	Black shadows moving around, sometimes change into human forms
21	F	72	Children by television set late at night. Small girls messing around in kitchen cupboards. Bleeding face on wall

Table 4 Characteristics of visual hallucinations in 21 patients with Parkinson's disease

Variable	Hallucinators	
	Number	Percentage
Frequency of hallucinations		
>5/week	5	23.8
1 to 5/week	8	38.1
<1/ week	8	38.1
Form:		
Yes	16	76.2*
No	5	23.8
Onset:		
Sudden	16	76.2*
Gradual	5	23.8
Duration:		
Hours	1	4.8
Minutes	7	33.3
Seconds	13	61.9*
Movement:		
Present	18	85.7*
Absent	3	14.3
Number of images:		
One	15	71.5*
One to five	4	19
More than five	2	9.5
Clarity:		
Sharp	3	14.3
Blurry	11	52.4*
Transparent	2	9.5
Variable	5	23.8
Perceived control:		
Have control	7	33.3
No control	14	66.7
Colour:		
Black and white	7	33.3
Single colour	6	28.6
Multiple colours	8	38.1
Eyelids:		
Open	21	100*
Closed	0	0
Reality:		
Seemed real	13	61.9
Seemed unreal	8	38.1
Lighting:		
Bright	5	23.8
Dim	11	52.4*
Dark	3	14.3
All conditions	2	9.5
Trigger:		
Starts with percept	12	57.1
Starts independently	9	42.9
Medication related:		
Yes	5	23.8
No	16	76.2
Content:		
Stereotyped	7	33.3
Different	14	66.6
Field of vision:		
Complete	2	9.5
Partial	19	90.5*
Distortion of image:		
Present	8	38.1
Absent	13	61.9

* χ^2 ; significant difference in distribution of responses from chance, $p < 0.05$.

brick). visual hallucinations involving people consisted of relatives, soldiers, and "strange people", mainly involving children. Many of the hallucinations were dynamic with 18 patients (85.7%) reporting movement. Seven patients (33.3%), however, had recurrent hallucinations generally in the same surroundings; as one patient put it "like a video recording of an event, which replays every day".

PRECIPITANTS AND CONTROLS

The hallucinations showed a clear relation with medication in only five patients (23.8%), who reported onset or aggravation of the symptoms in relation to consuming medication. The seven of 16 patients who claimed that their hallucinations were not linked to medication,

experienced them in their immobile periods, usually at night or first thing in the morning. Ambient lighting was an important factor individually, with the largest group (52.4%) reporting visual hallucinations only in dim lighting. Fourteen (66.6%) described their experiences as involuntary. The seven patients (33.3%) who had control of their hallucinations were only able to terminate the image. The most common way of interacting with the hallucination was either by walking towards it or by trying to touch it. Twelve patients (57%) reported that the hallucination started with a percept that slowly changed into another image, and the remainder stated that the images appeared independently. Emotional responses at interview were varied, often in line with the severity of the hallucinations experienced: frustration, anger, fear, and in a few patients, indifference.

Discussion

Our sample may not be wholly representative of patients with Parkinson's disease and our case ascertainment methods may have resulted in selection biases for both hallucinators and non-hallucinators. Nevertheless, we were able to recruit a group of patients with hallucinations who were willing and able to describe their experiences, which was large enough to discern some general patterns. Previous studies based on hospital clinic attenders may be biased toward patients with more complex needs. Those patients with hallucinations differed from non-hallucinators for duration and severity of illness, as anticipated from the review of the literature. There was some evidence of cognitive impairment although the groups did not differ on the MMSE, probably because we sought only patients who could give a good account of hallucinations. More details of the neuropsychological assessment will be presented elsewhere.

This investigation indicated that hallucinations associated with Parkinson's disease possess a common set of characteristics. The typical hallucinator's experience occurs while alert and with eyes open, generally in dim surroundings. It involves having a blurry image appear suddenly without voluntary effort, filling an area of the visual field. The hallucination is present for a few seconds, typically moves while present, and then suddenly vanishes. The findings from this study concur with previous investigations. The visual hallucinations most often reported were complex, usually containing animate or inanimate objects or persons¹⁵ although more transient and less clearly perceptual phenomena also occurred.¹⁹ Usually they contained five or less images, which were sometimes meaningful to the patient. For example, one man regularly saw his dog, which had died 5 years earlier, lying by the bed. In addition, most reported that their hallucinations often occurred in dim surroundings, were non-threatening, and were sometimes recurrent.²⁴ These characteristics are very similar to those documented in neurologically normal people with visual impairment (Charles Bonnet's syndrome⁴⁹). A survey of 60 such patients

showed that frequent meaningful complex hallucinations were the most common type and lasted seconds or minutes. As in the patients with Parkinson's disease, most occurred with the eyes open and in dim light, and were not stereotyped. Some slight differences also emerged in that the patients in this sample only experienced hallucinations with eyes open (as did most visually impaired people) and more often described the images as blurry and moving. Different patterns have been described in the visually impaired in relation to colour, duration, motion, and eye opening.⁵⁰ Nevertheless, the similarities seemed to outweigh differences. In fact visual hallucinations in elderly people,²¹ those with Alzheimer's disease, and those with late paraphrenia⁵¹ or even typical schizophrenic psychoses⁵² also tend to be complex, brief, and associated with some sensory impairment and variable insight. Patients with Lewy body dementia show a divergence, with more auditory or multimodal experiences, and less insight.⁴⁵⁻⁵³

Looking at how the properties of hallucinations found in this study differ from those of normal visual perception, the most obvious is that visual hallucinations are only present for a brief time and are generally indistinct. The hallucinations also seem particularly susceptible to being identified as hallucinations when they are actively examined, at which point they tend to disappear. Even though some of the images appeared real, seemed to occur externally, and were not under voluntary control, most patients "knew" that they were hallucinating. Again, a similar pattern is seen in Charles Bonnet's syndrome.⁴⁹⁻⁵⁴ Consistent triggering and stereotyped form may have aided this judgement but were not frequent enough to provide a reliable basis for reality testing. The fact that some patients attempted to interact with the hallucination suggests that they were regarded with some suspicion. Hence insight tends to be preserved in the sense that the perceptual experience is relabelled as pathological,⁵⁵ which contrasts with patients—not present in this sample—who develop delusions revolving around their experiences. The precise cognitive basis for accurate judgements of this type requires further study.

Visual hallucinations in the patient with Parkinson's disease probably result from a complex interaction of many variables, including cognitive, affective, medication, sensory, and even personality and environmental factors. The fact that these experiences can occur with little or no visual information from the environment (or none in the case of the blind) argues strongly for endogenous processes playing a part in the production of the hallucinations. These may be understood mechanistically as the manifestation of aberrant possibly disinhibited discharges from neural systems involved in processing or generating visual images.³⁴⁻⁵⁴⁻⁵⁶ Indeed the apparent overlap in the phenomenology of hallucinations regardless of cause supports this idea. Similarly, some hitherto mysterious features such as micropsia and "tessellation" (brick-like patterns as seen in patients 7, 14, and 21) may be explained

given a complex understanding of visual physiology.⁵⁴ The predominance of human faces and dynamic forms may reflect the survival implications of these stimuli and subsequent evolution of specialised neural substrates for their processing.⁵⁷⁻⁵⁹ However, certain aspects of the content—the predominance of remembered people or animals, some of emotional significance—suggests that higher level "top down" cognitive factors may also play a part. Neisser⁶⁰ argues convincingly that perception is a cyclic process involving receiving information from the environment through cognitive schemata, which in turn direct exploration for new information. Nevertheless the commonalities between the form of hallucinations described in treated patients with Parkinson's disease and other conditions suggest that visual hallucinations represent a restricted set of such schemata that are played out on a dysfunctional physiological system.

We acknowledge the help and advice of Drs Chris Clough, Rob Howard, and John Harris, plus the cooperation of the Parkinson's Disease Society.

- 1 American Psychiatric Association. *Diagnostic and statistical manual of mental disorders*. 4th ed. Washington, DC: APA, 1990.
- 2 Rabins PV. Psychopathology of Parkinson's disease. *Comprehensive Psychiatry* 1982;23:421-9.
- 3 Cummings JL. Behavioral complications of drug treatment of Parkinson's disease. *J Am Geriatr Soc* 1991;39:708-16.
- 4 Weinberger LM, Grant FC. Visual hallucinations and their neuro-optical correlates. *Arch Ophthalmol* 1940;23:169-99.
- 5 Anderson SW, Rizzo M. Hallucinations following occipital lobe damage: the pathological activation of visual representations. *J Clin Exp Neuropsychol* 1994;16:651-63.
- 6 Horrax G. Visual hallucinations as a cerebral localizing phenomenon with special reference to their occurrence in tumors of the temporal lobe. *Arch Neurol Psychiatry* 1922;10:532-47.
- 7 Penfield W, Perot P. The brain's record of auditory and visual experience: a final summary and conclusion. *Brain* 1963;86:568-93.
- 8 Withdrawn.
- 9 Feinberg W, Rapcsak S. Peduncular hallucinosis following paramedian thalamic infarction. *Neurology* 1989;39:1535-6.
- 10 Gellar TJ, Bellur SN. Peduncular hallucinosis: magnetic resonance imaging confirmation of mesencephalic infarction during life. *Ann Neurol* 1987;21:602-4.
- 11 Manford M, Andermann F. Complex visual hallucinations. Clinical and neurobiological insights. *Brain* 1998;121:1819-40.
- 12 Mindham RHS. Psychiatric symptoms in parkinsonism. *J Neurol Neurosurg Psychiatry* 1970;33:188-91.
- 13 Friedman A, Sienkiewicz J. Psychotic complications of long-term levodopa treatment of Parkinson's disease. *Acta Neurol Scand* 1991;84:111-13.
- 14 Meo G, Bonifati V, Cusimano G, et al. Hallucinations in Parkinson's disease: neuropsychological study. *Ital J Neurosci* 1990;11:733-9.
- 15 Haeske-Dewick HC. Hallucinations in Parkinson's disease: characteristics and associated clinical features. *Int J Geriatr Psychiatry* 1995;10:487-95.
- 16 Sanchez-Ramos JR, Ortoll R, et al. Visual hallucinations associated with Parkinson's disease. *Arch Neurol* 1996;53:1265-8.
- 17 Graham JM, Grunewald RA, Sagar HJ. Hallucinosis. *J Neurol Neurosurg Psychiatry* 1967;63:434-40.
- 18 McDowell SA, Harris JP. Visual problems in Parkinson's disease: a questionnaire survey. *Behav Neurol* 1997;10:77-81.
- 19 Fénelon G, Mahieux F, Huon R, et al. Hallucinations in Parkinson's disease. Prevalence, phenomenology and risk factors. *Brain* 2000;123:733-45.
- 20 Aarsland D, Larsen JP, Cumming JL, et al. Prevalence and clinical correlates of psychotic symptoms in Parkinson's disease. *Arch Neurol* 1999;56:595-601.
- 21 Holroyd S. Visual hallucinations in a geriatric psychiatry clinic: prevalence and associated diagnoses. *J Geriatr Psychiatry Neurol* 1996;9:171-5.
- 22 Chapman FM, Dickinson J, McKeith I, et al. Association among visual hallucinations, visual acuity, and specific eye pathologies in Alzheimer's disease: treatment implications. *Am J Psychiatry* 1999;156:1983-5.
- 23 Harris J. Vision in Parkinson's disease: what are the deficits and what are their origins? *Neuroophthalmology* 1998;19:113-5.
- 24 Moskowitz C, Moses H, Klawans HL. Levodopa induced psychosis: a kindling phenomenon. *Am J Psychiatry* 1978;135:669-75.

- 25 de Smet Y, Ruberg M, Serdaru M, *et al.* Confusion, dementia and anticholinergics in Parkinson's disease. *J Neurol Neurosurg Psychiatry* 1982;45:1161-4.
- 26 Perry EK, Kerwin J, Perry RH, *et al.* Cerebral cholinergic activity is related to the incidence of visual hallucinations in senile dementia of the Lewy body type. *Dementia* 1990;1:2-4.
- 27 Steckler T, Sahgal A. The role of serotonergic-cholinergic interactions in the mediation of cognitive behaviour. *Behav Brain Res* 1995;67:165-99.
- 28 Goetz CG, Pappert EJ, Blasucci LM, *et al.* Intravenous levodopa in hallucinating Parkinson's disease patients: high dose challenge does not precipitate hallucinations. *Neurology* 1998;50:515-17.
- 29 Fernandez W, Stern G, Lees A. Hallucinations and parkinsonian motor fluctuations. *Behav Neurol* 1992;5:83-6.
- 30 Kraft E, Winkelmann J, Trenkwalder C, *et al.* Visual hallucinations, white matter lesions and disease severity in Parkinson's disease. *Acta Neurol Scand* 1999;99:362-7.
- 31 Klein C, Kompf D, Pulkowski U, *et al.* A study of visual hallucinations in patients with Parkinson's disease. *J Neurol* 1997;244:371-7.
- 32 Savage CR. Neuropsychology of subcortical dementias. *Psychiatr Clin North Am* 1997;20:911-31.
- 33 Lishman WA. *Organic psychiatry. The psychological consequences of cerebral disorder*. 3rd ed. Oxford: Blackwell, 1998.
- 34 David AS, Busatto G. The hallucinations: a disorder of brain and mind. In: Ron MA, David AS, eds. *Disorders of brain and mind*. Cambridge: Cambridge University Press, 1998:336-62.
- 35 Waterfall ML, Crowe SF. Meta-analytic comparison of the components of visual cognition in Parkinson's disease. *J Clin Exp Neuropsychol* 1995;17:759-72.
- 36 Cronin-Golomb A, Braun AE. Visuospatial dysfunction and problem solving in Parkinson's disease. *Neuropsychology* 1997;11:44-52.
- 37 Nagano O, Takauchi S, Nishitani H, *et al.* Hallucinatory symptoms in Parkinson's disease treatment with anti-parkinsonian drugs. *Clin Neurol* 1986;26:464-70.
- 38 Tanner CM, Vogel C, Goetz CG, *et al.* Hallucinations in Parkinson's disease: a population study [abstract]. *Ann Neurol* 1983;14:136.
- 39 Berrios GE, Brook P. Visual hallucinations and sensory delusions in the elderly. *Br J Psychiatry* 1984;144:662-4.
- 40 Holroyd S, Rabins PV, Finkelstein D, *et al.* Visual hallucinations in patients with macular degeneration. *Am J Psychiatry* 1992;149:1701-6.
- 41 Pederzoli M, Girotti F, Scigliano G, *et al.* L-dopa long term treatment in Parkinson's disease: age related side effects. *Neurology* 1983;40:259-69.
- 42 Goetz CG, Vogel C, Tanner CM, *et al.* Early dopaminergic drug-induced hallucinations in parkinsonian patients. *Neurology* 1998;51:811-4.
- 43 Hughes AJ, Daniel SE, Lee AJ. Parkinsonism: onset, progression and mortality. *Arch Neurol* 1992.
- 44 Gibb WRG, Esiri MM, Lees AJ. Clinical and pathological features of diffuse cortical Lewy body disease (Lewy body dementia). *Brain* 1987;110:1131-53.
- 45 Ballard C, McKeith I, Harrison R, *et al.* A detailed phenomenological comparison of complex visual hallucinations in dementia with Lewy bodies and Alzheimer's disease. *Int Psychogeriatr* 1997;9:381-8.
- 46 Hoehn MM, Yahr MD. Parkinsonism: onset, progression, and mortality. *Neurology* 1967;17:427-42.
- 47 Glanz RH, Bieliauskas L, Paleologos N. Behavioral indicators of hallucinosis in levodopa-treated Parkinson's disease. *Adv Neurol* 1986;45:417-20.
- 48 Todes CJ, Lees AJ. The premorbid personality of patients with Parkinson's disease. *J Neurol Neurosurg Psychiatry* 1985;48:97-100.
- 49 Teunisse RJ, Cruysberg JR, Hoefnagels WH, *et al.* Visual hallucinations in psychologically normal people: Charles Bonnet's syndrome. *Lancet* 1996;347:794-7.
- 50 Schultz G, Needham W, Taylor R, *et al.* Properties of complex hallucinations associated with deficits in vision. *Perception* 1996;25:715-26.
- 51 Howard T, Levy R. Charles Bonnet syndrome plus: complex visual hallucinations of Charles Bonnet syndrome type in late paraphrenia. *Int J Geriatr Psychiatry* 1994;9:399-404.
- 52 Frieske DA, Wilson WP. Formal qualities of hallucinations: a comparative study of visual hallucinations in patients with schizophrenic, organic and affective psychoses. *Proceedings of the Annual Meeting of the American Psychopathological Association* 1966;54:49-62.
- 53 Inzelberg R, Kipervasser S, Korczyn AD. Auditory hallucinations in Parkinson's disease. *J Neurol Neurosurg Psychiatry* 1998;64:533-5.
- 54 ffytche DH, Howard RJ. The perceptual consequences of visual loss: positive pathologies of vision. *Brain* 1999;122:1247-60.
- 55 David AS. The clinical importance of insight. In: Amador XF, David AS, eds. *Insight and Psychosis*. New York: Oxford University Press, 1998:332-51.
- 56 Schultz G, Melzack R. The Charles Bonnet syndrome: phantom visual images. *Perception* 1991;20:809-25.
- 57 Kanwisher NJ, Chun MM. The fusiform face area: a module in human extrastriate cortex specialised for face perception. *J Neurosci* 1997;17:4302-11.
- 58 Howard R, Brammer M, Wright I, *et al.* A direct demonstration of functional specialisation within motion-related visual and auditory cortex of the human brain. *Curr Biol* 1996;6:1015-19.
- 59 Senior C, Barnes J, Giampietro V, *et al.* The functional neuroanatomy of implicit motion perception or representational momentum. *Curr Biol* 2000;10:16-22.
- 60 Neisser U. *Cognition and reality*. San Francisco, CA: WH Freeman, 1976.