

Musical alexia with recovery: a personal account

Ian McDonald

Institute of Neurology, University College London, Queen Square, London, UK

Correspondence to: Ian McDonald, Institute of Neurology, University College London, Queen Square, London, UK, WC1N 3BG

E-mail: ian.mcdonald@rcplondon.ac.uk

I describe the experience of an acute loss of ability to read music and play the piano accurately and expressively following an embolic infarct of the right angular and supramarginal gyri in a setting of chronic migraine. Other parietal deficits included a small visual field defect, visual hallucinations, prosopagnosia, topographical disorientation, disturbance of perception of velocity of moving objects and dyscalculia. Recovery began within a month of the ictus after instituting a regular practice routine. The ability to read and play polyphony recovered before the ability to read homophonic music. A substantial degree of recovery of musical function occurred within 6 months and of the other parietal deficits over a year. Failure to maintain regular practice led to marked though recoverable deterioration. An increased frequency of migraine persisted for some 18 months.

Keywords: cerebral infarction; parietal lobe; angular gyrus; supramarginal gyrus; prosopagnosia; dyscalculia; spatial disorientation; extracampine hallucinations

Received and Accepted August 2, 2006. Advance Access publication September 7, 2006.

Introduction

The literature on acquired musical alexia is small and does not include an account of what it is like to experience this disorder. The reported cases have been associated with rather large or diffuse cerebral lesions (*see* Brust, 1980; Judd *et al.*, 1983; Horikoshi *et al.*, 1997; Beversdorf and Heilman, 1998; Cappelletti *et al.*, 2000; Midorikawa *et al.*, 2003 for references). Therefore, I thought it might be of interest to record my own experience following a small cerebral infarction at the end of October 2004, that was identified on MRI some 6 weeks after the presumed date of the ictus. To put the account in context, I provide some information about my musical and professional backgrounds and the stroke itself.

First, the music. I studied the piano from about the age of 7 to 17 and again from ~40 to 60. Playing the piano has been throughout my life my chief recreation. I could be described as of about average competence, being able to sight-read well enough to be a useful accompanist in lieder and chamber music from the baroque/classical and easier romantic repertoires. I can read a musical score well enough to get some idea in my head of how it should sound in performance.

Professionally, I have been an academic neurologist with particular interests in multiple sclerosis and its pathophysiology, and in neuro-ophthalmology. Although I have seen a broad spectrum of clinical neurology in the clinic, and have spent 9 months as Senior House Physician to

Macdonald Critchley in 1963–64 (when I saw a good many cases of disorders of higher cerebral function), I have no special skills in cognitive neurology. Whilst the relationship between music and the brain has always interested me, I have not made a study of it. Thus, I come to the experience of musical alexia with a broad though not specifically relevant neurological background and an enthusiastic if modest practical experience of music. I kept a diary of my experience without going back to the neurological literature until writing up the episode, so as to avoid contaminating experience with expectation.

It is also appropriate to say something about my medical history. I have had migraine since adolescence but on only two or three occasions ever did it interfere with work. It chiefly manifested as episodic lethargy, fatigue and malaise (especially on Saturdays). In adolescence, and for a brief period in my late 20s and early 30s and again in my late 50s and early 60s (and after the stroke), I occasionally had fortification spectra with or without systemic symptoms. Headache has rarely been severe. The only risk factors for migraine have been disturbance of sleep pattern and the consumption of brandy, which I have therefore avoided.

The neurological illness

It is important at the outset to state that there was no sudden event of which I was aware. The deficits gradually

became apparent from the end of October 2004, at first to my partner and friends and later to myself. My realization that there was a particular deficit was in some cases delayed for several months until a specific challenge made me aware that I was unable to perform some long-familiar action. Thus, some symptoms had resolved by the time I recognized others. Early in the illness especially, I tended to provide for myself or others facile (and often ridiculous) explanations for the obvious problems. The course of events was as follows.

In the autumn of 2004, when I was 72, I was busy as a co-author completing several chapters for the 4th edition of *McAlpine's Multiple Sclerosis* and working on a major historical lecture for the Royal College of Physicians, the Fitzpatrick Lecture for 2004. In such circumstances I tend to sleep poorly, and this was the case at that time. In mid-October, I began to have daily migraine that made work somewhat difficult, but never impossible. From October 31st it was apparent to friends and colleagues—but not to me—that something had happened. On that day, I seated a lunch guest at an unset place at the circular dining table and served a barely cooked salmon.

On November 1st I lectured in Cambridge, having had a worrying journey because I had difficulty telling the time from my watch (not digital), and was anxious that I might be late. When the first slide was projected (my migration to Powerpoint was not fully accomplished at that time) I knew there was something peculiar about it but could not tell what; the chairman later told me it was upside down (an unusual mistake for me). During the lecture I became aware that I was having difficulty keeping the sequence of points in my head, although with my brief notes I managed well enough for it evidently not to be apparent to most people to whom I spoke subsequently that there was a problem. During this and the following few weeks there was dressing apraxia, which included coming down to breakfast one morning with my trousers inside-out (this I attempted to explain away by saying that they were my gardening trousers) and wearing my cardigan incorrectly buttoned.

During the next few weeks I had considerable difficulty keeping track of my working papers, notes, books and reprints while writing, but none in the acts of reading and writing themselves. Comprehension was normal. I had difficulty telling the time from my wrist watch unless the hands were exactly on the numbers. I also found it difficult to imagine how long it was before I had to give the Fitzpatrick Lecture, and would frequently go back to my diary and count the weeks until its date. At the time I attributed these difficulties to poor concentration as a result of daily migraine. I used the same explanation to myself when I attempted to accompany a violinist friend in the Vitali Chaconne, a work I had played many years before but now found impossible: there were many wrong notes and I was unable to get the rhythm right.

Shortly after this I found it impossible to play with my regular piano duo partner a two-piano transcription of a Schubert symphony that was well within my range. There

were no problems of dexterity but the sounds I heard as I played bore little resemblance to the piece that I knew well in its original form. It didn't sound right. It was obvious to me that there were many wrong notes and I could not play even short sections correctly.

It was, however, only on November 29th that I realized there was a specific deficit in reading music. I had been asked to turn the pages for a performance of the Schubert F minor Fantasy for piano duet, a work I know well, having at various times played both parts. I was quite unable to do so. The notes on the page bore no relationship to the sounds I heard. Again I explained away the difficulty by poor concentration due to migraine.

A few days later I gave the Fitzpatrick Lecture: colleagues were complimentary, but it was clear to them that there were some problems, if not in content, then in delivery. I lacked my customary fluency. There were frequent rather long pauses. In the discussion, I was only able to identify a questioner, well known to me as a close friend of 30 years standing, by his voice since I could not find him in the auditorium; he was in fact low down on the left. Visual field examination 2 weeks later revealed a small left lower homonymous quadrantanopia, detectable only with the 1/3 isopter on the Goldman perimeter (Mr James Acheson; Fig. 1). It is possible that small though the defect was it contributed to the difficulty in locating the questioner. Neglect and prosopagnosia may also have played a part for although I was easily able to recognize the questioner's face during a conversation a few minutes later prosopagnosia had undoubtedly been present a few days earlier when I had been quite unable to recognize a fairly new acquaintance with whom I had had several long conversations in the previous few weeks; I had even asked my secretary twice within half an hour to point this person out to me but on neither occasion did her face register as in any way familiar.

In the early part of December I was aware on several occasions whilst sitting on a couch watching television of a 'presence' on my left side. There was a vague, silent, dark shape in my left visual field that I interpreted as human but when I looked in its direction there was no one there. It was unthreatening, and I was not concerned about it. It was only a few days later that I interpreted this as an hallucination. My colleague Dr Christopher Earl subsequently reminded me that Dr Macdonald Critchley used to teach that patients with field defects due to a parietal lesion could often be observed looking over their shoulder, presumably in the direction of visual hallucinations. He (Critchley, 1943) described such 'extracampine' hallucinations in mountaineers and shipwreck survivors but not after parietal lobe lesions (Critchley, 1953). They have been reported recently in neurodegenerative disorders (Chan and Rossor, 2002). This symptom disappeared early in the New Year. Another that was obvious to others and had appeared about the same time lasted a few weeks longer. It consisted of intermittent fiddly movements of the left hand when I was not paying attention to it. Professor Jurg Kesselring told me that he is

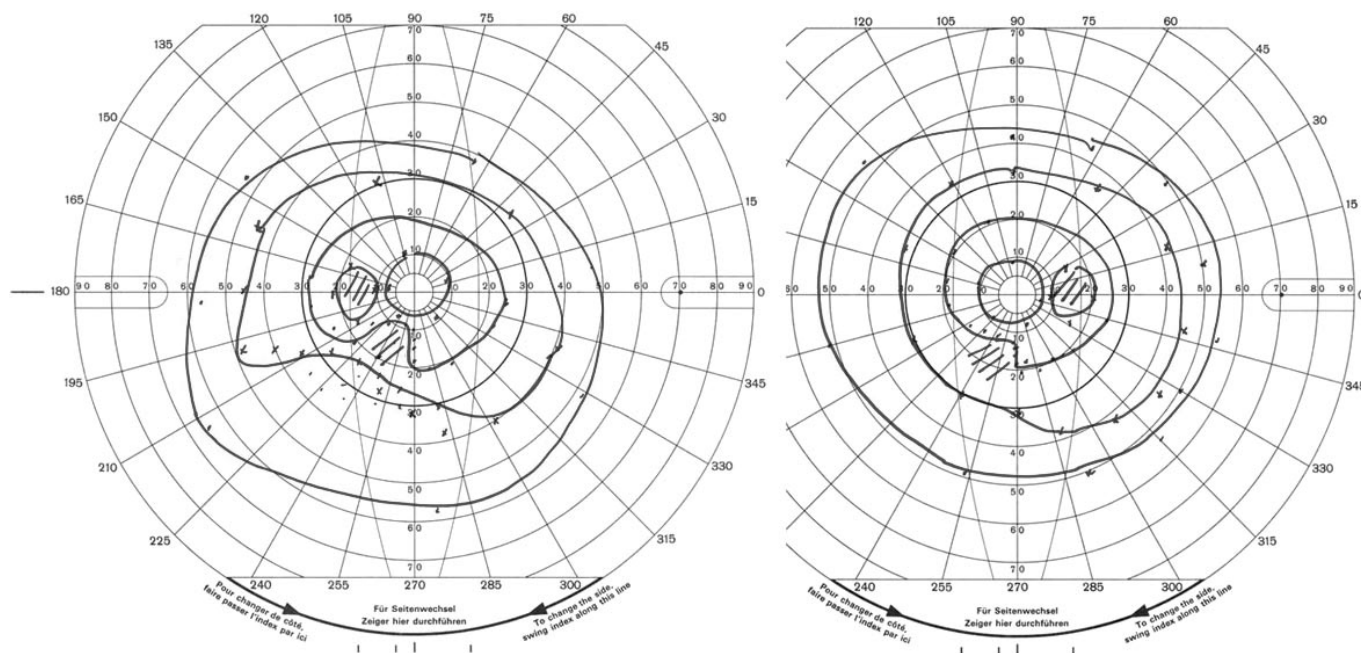


Fig. 1 Visual field defect showing non-congruous left lower quadrantanopia.

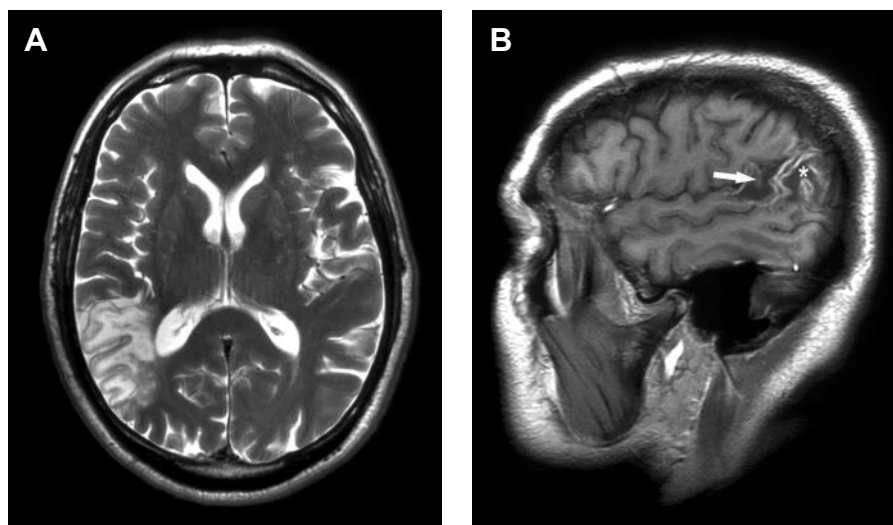


Fig. 2 Cerebral MRI showing an area of infarction involving the right supramarginal and angular gyri with surrounding oedema. **(A)** T₂-weighted fast spin echo sequence, axial slice. **(B)** T₁-weighted parasagittal slice. The hyperdensity of the cortex indicating cortical laminar necrosis (arrow) may be noted.

familiar with such movements in patients with neglect and interprets it as a form of reassurance strategy.

Anatomy of the lesion

Because of the persistence of symptoms including daily migraine I consulted my colleagues, Professors Martin Brown and Peter Goadsby. Professor Brown found that I was unable to recognize letters traced on the palm of either hand and was slow to demonstrate individual fingers. An MRI scan was performed on December 15, which revealed an area

of infarction involving the right (non-dominant—I am right-handed for everything) supramarginal and angular gyri with surrounding oedema (Fig. 2). The only other abnormalities were a few small white matter lesions. Magnetic resonance angiography revealed no abnormality in the carotid or vertebral systems. Professors Goadsby and Brown agreed with the neuroradiologist (Professor Tarek Yousry) that the parietal lobe lesion was characteristic of embolism. They did not think that it was attributable to migraine. The probable source of the embolus was subsequently thought to be a small patch of atheroma in

the ascending aorta identified by transoesophageal echocardiography (Dr Diana Holdright).

Other neurological deficits

It is obvious from this brief account of the early evolution of the symptoms that despite my neurological background, I did not at first identify these as specific deficits attributable to cerebral dysfunction: in short, I did not realize that I had had a stroke. Some examples of what I subsequently realized was topographical disorientation will serve to illustrate the point further.

In January 2005 I had to correct proofs of a short piece I had written for *Practical Neurology*, which involved a description of the field defect produced by compression of the junction of one optic nerve with the optic chiasm. It has been my practice for over 30 years to teach the explanation of this common defect by drawing a diagram showing the inversion of the image on the retina by the lens, the crossing of the optic nerve fibres in the chiasm and the projection to the occipital cortex. But I was quite incapable of working out what the deficit should be, in the case I was reporting. I solved the problem by modifying the text so as to avoid mentioning a specific side and running the risk of getting the field defect wrong. Two related examples of delayed recognition of parietal deficits occurred in April 2005 when I visited Taipei en route for New Zealand. At home, and in my local area, I had had no difficulty finding my way about. However, soon after my arrival in Taipei, I became aware when I went for a walk that I was very uneasy about letting the hotel out of my sight lest I should be unable to find it again. The next day I was incapable of finding a nearby restaurant that had been marked on a map. I could not make the streets and the map correspond. That I had topographical disorientation was confirmed a few weeks later when going to see the newly restored façade of the Scuola Grande di S Marco and the Basilica dei SS Giovanni e Paolo in Venice, which, being well signposted, was easy to find. On looking at the map, I noticed that a small church I had long wanted to see was in a nearby campo. I was, however, quite unable to get there using the map or even by walking out of each exit in turn from the large campo I was in and exploring the surrounding calles. Finally, I abandoned the attempt and returned to the hotel by retracing my steps, following the signs in reverse.

In retrospect, I realized that I had been experiencing a related deficit from early in 2005: I had been distinctly uneasy when walking even in familiar streets close to home. Analysing the reason, I realized that I was often unsure where moving traffic was coming from, or should be coming from, and that I had difficulty in estimating whether I had sufficient time to cross a road when I saw a car coming.

Another difficulty that became apparent on the Taipei trip was dyscalculia. I wanted to work out the sterling equivalent of the Taiwanese currency that I had with me. It was only after about half an hour of struggling unsuccessfully to make

the conversion (52.785 to the pound) that I recognized experience of the same affective state I had when fearing to let the hotel out of my sight. I was not even able to make the conversion using a rate of 50 to the pound and writing the numbers down.

The most troublesome symptoms on a day-to-day basis were lethargy, abnormal fatigability and malaise with or without nausea and headache, the characteristic manifestations of migraine as it affects me. In the first few months these symptoms occurred several times each week, and I was warned by Professor Goadsby that migraineurs who suffer a cerebrovascular accident may expect to have a markedly increased frequency of attacks for a year or so after the event. And so it proved. Although the frequency had declined somewhat by January 2006, it was not until May that I could reliably expect to be able to fulfil an engagement without the risk of having to cancel because of migraine. For much of the first year after the stroke I lacked the energy for sustained work. Intellectual effort was unusually tiring, much as Brodal (1973) had found after his presumed right capsular lesion that led to a left hemiparesis. He also noticed changes in handwriting, including omissions, duplication of letters and reversal of numbers. None is evident in mine in the diary of my illness although I fancy there may be more frequent reversals of letters in typing than there used to be; but of this I cannot be sure. During 2005 I had quite a lot of unfocused anxiety not consciously related to concerns about my health. By the beginning of June 2006 these symptoms had subsided and I had sufficient energy to return to regular reading and writing on medical historical topics.

During the year and a half following the stroke, I have been much more susceptible to jet-lag than previously. The journey of ~24 h between London and New Zealand resulted in daily migraine for ~2 weeks; previously migraine occurred but rarely after these flights. At no stage were I, my colleagues or my friends aware that I had any difficulty with speech or in reading or writing words.

The musical deficit

From late December 2004 I played the piano every day and from the beginning of January 2005 I kept detailed notes of difficulties and progress. The following account is derived from these notes, often with direct quotation.

Having recognized that I was unable to play even relatively straight-forward pieces I decided only to attempt simple music that I had been able to play effortlessly in the past. I started with a collection of Bach chorales. Even playing slowly there were many errors in playing the notes, which I recognized by the sound. I seemed to have lost the ability to follow from one chord to the next. The music did not seem to ‘make sense’, that is, there did not seem to be the necessary or implied connection between one chord and the next of which anyone familiar with this music is aware. This was so even when slowly and laboriously I worked out exactly what the notes should be by giving each its

alphabetical designation. This I seemed to be able to do accurately in spite of the great difficulty I had in playing the correct notes on the piano when reading directly from the score. Thus, written musical notes that convey information about pitch through their placement on the stave meant little, whereas letters designating tones did.

Even a single melodic line presented great difficulty. For example, I tried to play the treble melody from the slow movement of Bach's Italian Concerto, a piece I have played for over 50 years. It is simple and slow but I made numerous mistakes of notation. The succession of notes, even when correct as a result of having designated them by letters, made no musical sense: the emotional content the sequence of notes should convey, which determines phrasing and expression, was completely absent.

Attempts to play the left hand accompaniment to this melody revealed another defect. The accompaniment consists of a repeated pattern in which a pair of notes in the middle register is followed by two single notes in the bass, followed by three pairs of notes either ascending or descending back in the middle register again. The leap from the lower notes to the higher was often inaccurate by several whole tones, not just a semitone as in a fudged note or chord (Fig. 3A); the interval between the notes in the pair was correct but the pair was placed on the keyboard in a topographically incorrect position.

There were other similar errors. When there was a rising or falling succession of single notes, if the first was incorrect, the succeeding notes would follow in the correct sequence displaced by the amount the first note was in error but without the appropriate accidentals. These errors were thus of placement, the position on the keyboard being wrong, the 'contour' of the succession of notes being preserved but without what is known in musical terms as transposition (Fig. 3A and B).

Another common error also occurred when changes of register were needed. For example, if a descending succession of notes ended on C in the bass and the next note was C one octave higher, I might arrive two octaves higher (Fig. 3C). A related problem occurred when reading from one line to the next when I might play the correct notes, but an octave too high (if in the treble clef) or too low (if in the bass clef: Fig. 3D).

Other frequent errors included failing to remember accidentals for the full duration of a bar and reading a note as if it were in a different clef from that in which it was written. For example, I might read and play a note written in the bass clef as if it were in the treble (Fig. 3E). I had particular difficulty identifying and playing correctly notes written with several ledger lines above or below the stave. This is a common problem for amateurs, but I was now inaccurate playing notes with which I would have had little difficulty in the past. As to musical perception, I noticed on several occasions while listening to familiar music that for short periods (seconds) it sounded strange. On one occasion I was listening to Wagner's *Das Rheingold* on the radio and I

was forcibly struck by what seemed to be an unusual relative prominence of some of the inner parts of the musical texture. While this may have been due to an idiosyncrasy of interpretation by the conductor, I was struck at the time that there was something odd about what I was hearing, that it was not right. I had never before the stroke had such a sense of strangeness when hearing an unusual emphasis on inner parts in a particular performance.

Evolution of the musical deficit

From the beginning of January 2005 I established a daily routine on the recommendation of Professor Jurg Kesselring, a neurologist friend with whom I had often played chamber music in the past, and someone with a large experience of neurological deficits in musicians. A period of 15 min of technical exercises (scales, arpeggios, etc.) was followed by up to 1 h playing from sight, at first slowly. The Bach chorales remained very difficult for some weeks. In the first week I got out a volume of preludes and fugues by JCF Fischer that I had played on the clavichord in the 1960s, but not, so far as I can remember, since. To my surprise I found it easier to play this polyphonic music (in which several musical lines move independently) than the 'vertical' homophonic music of the chorales (in which the parts move in the same rhythmic pattern). There were still mistakes but, by the end of the first week, there seemed on some days to be fewer even in pieces I was playing for the first time for many years. But the music still did not make sense. The emotional content was absent.

Late in the second week, I started to play the Bach Goldberg variations that I know well from a two-piano version. One morning while playing a passage slowly, I suddenly found that a memory of it came back to me and the line made musical sense: I found that I was playing the notes with the proper phrasing and inflections of volume and conveying to myself their expressive content. Early in the third week, I tried the Italian Concerto again and found for the first time since the stroke that the treble melody of the slow movement now made expressive musical sense.

On January 22nd I played for the first time since mid-November with my piano duo partner (a retired paediatrician to whom I had explained my difficulties). We played slowly but he confirmed that at least some of the music was given its proper expression. I clearly had difficulty with the rhythm since I noted in my diary that in playing Stravinsky's very simple *Cinq Pièces Faciles*, my partner had had to count aloud for me. A few days later I attempted Bach chorales again and found that though I managed better than a month earlier, there were still numerous mistakes. A particularly surprising experience that day was my attempt at Debussy's prelude *La Cathédrale Engloutie*, which I have played for 50 years, at one time from memory though not for a decade or so. Though I played slowly, I managed it reasonably well. I was aware of a facilitatory interplay between actually reading the notes and my memory of them. I cannot comment

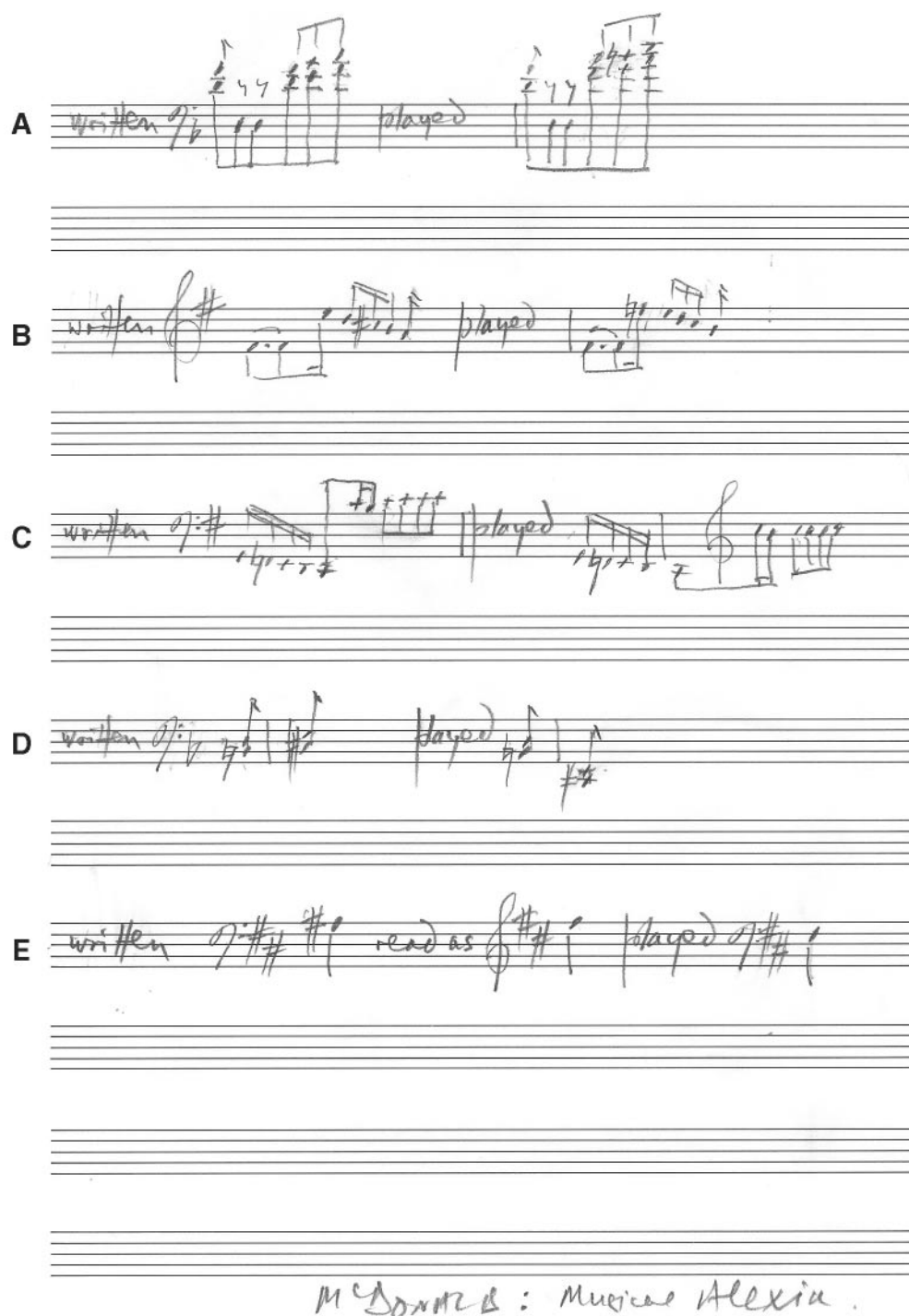


Fig. 3 (A–E) Examples of errors when playing the piano while sight-reading. See text for further explanations.

further on my ability to play from memory during this time, and whether it was more or less impaired than my ability to read, since I have seldom attempted to play from memory in the past 20 years.

Over the next month there was gradual improvement in my ability to read, especially polyphony, though all the defects persisted, the severity varying considerably from day to day.

At the end of February, Professor Kesselring visited. I had done some preparatory work over the previous couple of weeks on the Bach sonata for cello and keyboard BWV 1027. We were able to make a reasonable attempt at it. We played slowly but, he commented, musically, with appropriate expression and give-and-take between us. I was also able to read slowly through a Vivaldi cello sonata with him, achieving almost perfect accuracy and proper expression.

Clearly, I had improved considerably. By the beginning of March I had extended my reading to Scarlatti and Mozart (sonatas and concertos).

In mid-March, I went to France for a fortnight. There was a piano in the house and I continued my daily practising routine. There was variation from day to day but overall progress was encouraging. I read and played partitas and suites by Bach and the whole of the Art of Fugue (a work I know well in a two-piano version but had not previously played in its original form). I also made reasonable attempts at a number of Schumann pieces including the Kinderszenen, which I know well, though with the exception of one piece not from memory, and the Novelettes. During this time I noted that the emotional feeling appropriate to the music I was playing was often present, although there was marked variation from day to day.

In April, I began to work on the Bach Chromatic Fantasia and Fugue, which I had not previously studied. At first there were times when the fantasia did not make musical sense: there seemed just to be a succession of notes without musical relevance or emotional content. Within a few days this difficulty had largely resolved. I was agreeably surprised with the speed of progress I was making in reading the fugue, albeit slowly.

In the succeeding months the deficits became gradually less noticeable and I was able to return to playing two-piano music with increasing facility and could learn new pieces at approximately the same rate as before the stroke. Nevertheless, the difficulty in playing correctly notes that had several ledger lines above or below the stave remained an intermittent problem, as did the failure to sustain accidentals throughout a bar. Up to the time of writing (July 2006) I have remained more likely to make errors in timing and rhythm than in the past, although I must note that the latter has always been an area of difficulty, especially when the rhythm is complex. These difficulties are of course familiar to amateur players, but as a result of the stroke they were more marked than previously. All the deficits tended to vary in severity from day to day. Not until I came to write up my experience did I attempt to write musical notes. At first I thought there was no difficulty. But when I came to make a fair copy ~3 weeks later, I found that I had made errors of placement of the chords above the stave in Fig. 3C. In working out what they should be, I experienced the same sense of frustration as I had in 2005 with the dyscalculia and topographical disorientation. Figure 3C has been double checked and is now as I intend. I also found it more difficult than in the past to make the marks accurately and neatly on the page and I had some problems remembering to keep to the layout I had decided on.

In March/April 2006 I visited New Zealand again and for a period of 7 weeks scarcely touched the piano. When I returned to London, I found that the deficits that had been scarcely noticeable at the time I left were again marked. There had been considerable regression. However, once I resumed daily practice, which included technical exercises

and sight-reading, especially counterpoint (including Bach and Shostakovich preludes and fugues and partitas, sonatas and suites by Handel and other Baroque composers), as well as working systematically at unfamiliar duet and two-piano pieces by Beethoven and Debussy, the deficits diminished, so that within a month or so the level of competence I had in February 2006 was regained. The dependence on daily practice for maintaining one's skills is of course a commonplace. My former London teacher had been a piano student in Berlin in the 1920s and used to recount the saying current then that 'If you miss one day; you know. If you miss two days, your friends know. If you miss three, the whole world knows.' What is true for the professional wishing to maintain professional standards is, I found, equally true for the amateur afflicted by a stroke who wishes to retain regained skills.

During June 2006 I had an interesting illustration of the extent of recovery possible in some functions despite the persistence of deficits in others. We began work on the Beethoven Triple concerto. I was soon aware that there were numerous printer's errors in the piano score, which I recognized by the sound. While it was easy to guess from the context what the correct note might be, checking that it was so proved to be remarkably difficult. The process is a rather complicated visuospatial manoeuvre that involves identifying the note in question in an urtext score, which in the present case happened to be about half the size of the piano score. Worse, in the first movement for example, there were 16 lines and 4–10 bars per page in the former, but in the latter 10–14 lines and 6–28 bars on different pages. The two editions adopted different rehearsal mark conventions the placement of which did not correspond. The result was that what would ordinarily take me about a minute took five or more.

Recovery from other deficits

The difficulties encountered while walking in busy streets and most other manifestations of topographical disorientation had largely resolved by July 2006. On a visit to Venice in June, there was no difficulty in finding my way to a rare book shop in an unfamiliar area using a map, although on a trip to Oxford soon after I found on alighting from the bus in the High Street that I was unable at first to visualize the familiar route to Blackwell's Music Shop and the Ashmolean Museum. But I quickly recognized a lane and knew that by walking down it and turning left I would get to my first destination.

Some dyscalculia persisted until about this time, inconveniently manifested by my being unable to work out how much concentrated fertilizer I should add to a one and a half gallon watering-can when the instructions were given in scoops per litre.

Discussion

For the reasons I gave at the outset, it would not be appropriate for me to attempt an interpretation of the

significance of my observations for the general understanding of how the brain is involved in music. Nevertheless, I venture the opinion as a neurologist that many of the difficulties I had in reading music and playing it on the piano, and in writing it down, derived from a visuospatial deficit, other manifestations of which were also present and can be accounted for by the sole significant lesion detected by MRI, the infarct involving the right angular and supramarginal gyri. Explanations for the short-lived impairment of the ability to recognize instinctively the emotional content of a passage and conveying it in playing, and of the defect in rhythmic awareness are less clear.

Acknowledgements

I am grateful for the care of my colleagues and for much helpful discussion with them and others: Mr James Acheson, Professor Martin Brown, Professor Peter Goadsby, Dr Diana Holdwright, Professor Jurg Kesselring, Dr Nicholas Losseff, Dr Jason Warren, Professor Otto Wolff and Professor Tarek Yousry.

References

- Beverdort DQ, Heilman KM. Progressive ventral posterior cortical degeneration presenting as alexia for music and words. *Neurology* 1998; 50: 657–9.
- Brodal A. Self-observations and neuro-anatomical considerations after a stroke. *Brain* 1973; 96: 675–94.
- Brust JCM. Music and language. Musical alexia and agraphia. *Brain* 1980; 103: 367–92.
- Capelletti M, Waley-Cohen B, Butterworth B, Kopelman M. A selective loss of the ability to read and write music. *Neurocase* 2000; 6: 321–32.
- Chan D, Rossor MN. 'But who is that on the other side of you?' Extracampine hallucinations revisited. *Lancet* 2002; 360: 2064–6.
- Critchley M. Shipwreck survivors: a medical study. London: J and A Churchill; 1943.
- Critchley M. The parietal lobes. London: Arnold; 1953.
- Horikoshi T, Asari Y, Watanabe A, Nagaseki Y, Nukui H, Sasaki H, et al. Music alexia in a patient with mild pure alexia: disturbed visual perception of nonverbal meaningful figures. *Cortex* 1997; 33: 187–94.
- Judd T, Gardner H, Geschwind N. Alexia without agraphia in a composer. *Brain* 1983; 106: 435–57.
- Midorikawa A, Kawamura M, Kezuka M. Musical alexia for rhythm notation: a discrepancy between pitch and rhythm. *Neurocase* 2003; 9: 232–8.