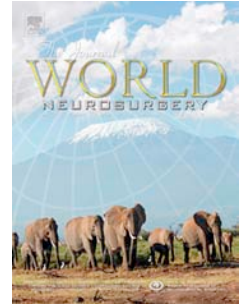


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**JAZZ, GUITAR AND NEUROSURGERY:
THE PAT MARTINO CASE REPORT**

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“I feel dropped cold, empty, neutral, cleansed... naked.”

“And slowly but surely, piece by piece, interrelationships began to revive themselves.”

P.M., 1944-

Abstract

We present the case of a professional jazz guitarist with temporal lobe epilepsy secondary to an arteriovenous cerebral malformation. He underwent a left temporal lobectomy in 1980. Following surgery, he presented with severe retrograde amnesia as well as complete loss of musical interest and capabilities. The patient's musical abilities recovered over time and he regained his previous virtuoso status. In 2007 his medical history, neuropsychological functions, and structural MRI were examined and revealed a remarkable degree of recovery of memory and musical abilities in the context of extensive temporal lobe resection. The neuropsychological findings and neuroanatomical features of the MRI were analyzed to try to understand the high degree of recovery of both long-term memory and musical processing abilities in this musician. This case also reveals the possibility of an unusual degree of cerebral plasticity and reorganization. Additionally, it emphasizes the question of musical virtuosism. This report shows that the musical capabilities of professional musicians, in specific cases, can completely recover even when much of the left temporal lobe has been removed.

Key words

Cerebral arteriovenous malformation, Music, Memory, Amnesia, temporal lobe, amygdala, hippocampus, Epilepsy, Neuropsychological Assessment, Brain Plasticity, Auditory-Motor Interrelations, Neuroscience, Brain, Neurological deficit

Introduction

Music is studied by a specific field of neurosciences, and musicians, traditionally, have been studied as an amalgamated group. Their musical activities were considered, overall, equal in terms of memory, but also, their perceptive, cognitive and motor functions. Also, there has been great interest in musicians' neurological disabilities acquired prior to the era of brain function imaging methods (10). Neuroscientists have suggested that musicians with enhanced motor skills possess greater capacity for plasticity because of enriched interhemispheric connections (13), and structural asymmetry of relevant brain areas (14).

P. A. (P. M. stage name) was born in Philadelphia in 1944 and was first exposed to jazz by his father, C. "Mickey" A., who sang and play guitar in local clubs. Having studied briefly with Eddie Lang, a famous jazz guitarist of the time, P. M., started playing guitar when he was twelve. He left school at that age to pursue a music career (1). Before his eighteenth birthday, he became an icon in the jazz scene, signed as a leader for Prestige Records at age 20. His key albums during this period include classics like "Strings!", "Desperado", "El Hombre" and "Baiyina", one of the first successful jazz adventure in psychedelic music.

This professional guitarist, had surgery to treat an intracerebral hemorrhage due to a cerebral arteriovenous malformation requiring a wide left temporal lobectomy. Before surgery, P.M. had a history of epilepsy associated with manic depression, but no

abnormalities in his musical capabilities. After surgery, he had an almost complete memory loss, showing the expected effect of an extensive injury to the left temporal lobe. He completely lost his musical capabilities including theory, technique and skills (1). In this report we bring into consideration the historical merits of this exceptional musician to the neurosurgical community. In addition, we present the neuropsychological tests and magnetic resonance imaging (MRI) findings of this professional musician who regained completely his previous virtuoso status.

Case Report

A 32 years-old, Italo-American professional guitarist, began in 1976 with holocranial headaches that gradually increased in frequency and intensity. This was associated with simple partial seizures evolving to a complex type. Partial seizures were characterized by autonomic manifestations: pallor, redness of the skin, tachycardia, epigastric discomfort feeling, and occasional vomiting. On the other side he had psychic crisis characterized as delusions and olfactory hallucinations, distortion of time, emotional expressions and behavioral disorders. These latter occurred often during 1977 (6). The psychic crisis increased in frequency and intensity, with behavioral changes, sometimes totally chaotic, with manic depressive crisis, and days of long bouts of absorbed state of complete disconnection with the environment. Complex partial seizures were happening occasionally followed by motor involvement and oroalimentary manifestations, lasting generally more than one minute. Usually the patient recovered with a confusional state, gradually returning to normal condition. During this period, he alternated his career travelling between the cities of New York and Philadelphia. By then, he had published 15 jazz music albums, the latter in 1977 called, oddly enough: "Exit". In addition, he presented with prolonged states of mania and depression, at least a

couple of suicide attempts, which led to frequent patient admission in psychiatric wards, drug prolonged treatment, and sporadic electroconvulsive therapy (1). In 1980, he travelled and settled in Los Angeles, where he suffered a generalized tonic clonic seizure proceeding to hospital admission. After a cerebral computed tomography, the first in his life, he was diagnosed with a complex arteriovenous malformation located in the medial and basal left temporal lobe with an associated hemorrhage. Doctors advise immediate surgery because of risk of life. Even so, the patient left the hospital and travelled to his hometown, Philadelphia, to undergo surgery. In the first surgery an intralesional hematoma was evacuated; while in the second surgery, performed after cerebral angiography, a left temporal arteriovenous malformation was completely resected by Dr. Simeone. The left temporal lobe resection comprised approximately 70%. After a postoperative period without incidents, the patient was discharged home. When discharged, he showed apparently no aphasia, but presented a profound retrograde amnesia, which included his own person, his environment and familiar people (6). Yet, he also had complete abolition of his musical capabilities. The rest of the physical and neurological examination was apparently normal.

Aided by his father, the patient was gradually introduced back into his past, with the help of photos, encounters with friends, including other musicians, and, mainly, by making him listening to his own records (2, 6). The patient, in turn credited to a computer the necessary help to revitalize his musical interest: a small Apple Macintosh with a tiny screen, and a 127K system with a music program. Although the patient had not studied music formally, the musical writing recovered with pencil and musical stanzas in song sheets, transcribing 516 scale studies of Japanese, Hungarian, Chinese, and some Byzantine scales. In this way, he was deeply involved with different musical cultures (12). He returned progressively, though slowly and with difficulty, to play the

guitar; this time as if it were a toy, "to escape the situation, and to please my father" (7). The process of memory retrieval took him about two years. Although he never lost the dexterity to do things with his hands, the necessary skill to play guitar again to his previous musical level, was brought back over years (6). In 1987 he returned to record a jazz album called, logically, "The Return". This settled a return to his professional life, which remains constant up to the present, except for an interruption of about two years for the death of his parents. At the moment, P.M. is a renowned jazz musician, working in continuous activity, with multiple awards, a tight professional schedule, and over 33 music albums recorded under his belt. He still resides in his native Philadelphia.

MRI findings

Measurements performed in five cerebral MRI of normal subjects were used as control. Damage to the left temporal lobe is extensive and it appears that the void has been filled with CSF. The lesion included the whole of the temporal pole area and extended underneath and lateral to the hippocampus and amygdala. The damage to inferior temporal cortex extends more posteriorly than does damage to the superior temporal cortex. In the inferior temporal lobe the very posterior portion of the temporal fusiform gyrus may be intact (*Fig 1*). Superior temporal cortex appears to exist from the position of the anterior end of the amygdala. Volume measures of the hippocampi indicate that the right hippocampus is relatively large and that the left hippocampus is somewhat smaller than this and below the range of the control subjects. However projection sites of the left hippocampus (left fornix, mammillary bodies and thalamus) appeared healthy and indicate that the left hippocampus may be well functioning. Left and right amygdalae were the same size and appeared normal (*Fig 2*). Volume measures indicate that they are rather small, however, and are outside the range of the control subjects

(Table 1). Volumetric measures indicated that the perirhinal cortex was normal on the right but abnormally small on the left (2 standard deviations below that of the controls and outside the control range). Entorhinal cortex was normal on the right but abnormally small on the left (2 standard deviations below that of the controls and outside the control range). Parahippocampal cortex was normal on the right but below the range of the controls on the left. Volume measures indicated a marked reduction in the volume of the left temporal lobe. The right temporal lobe was also small however (2 standard deviations below that of the controls and outside the control range).

Outside the left temporal lobe there was the possibility of increased atrophy to frontal and possibly parietal regions which may be greater than would be expected in someone of P.M.'s age.

Neuropsychology Report

The initial interview and some of the cognitive assessment were carried out during the first meeting in May 2007, at the MRI Unit, Hope Hospital, Salford, Manchester where P.M. also underwent conventional cerebral MRI. Further assessment was carried out in Philadelphia in August, 2007. The complete battery test performed is depicted in Table 2. There were two main findings from this cognitive assessment. The first includes confrontation naming and accessing the meaning of abstract and low-frequency words and, less frequently, in accessing accurate definitions of words in more common usage. For the Graded Naming Test, a test of confrontation naming that yields an IQ equivalent score, P.M.'s level of performance on this task was below what would have been expected given his intellectual functioning and impaired in comparison with the normative data from individuals of average intelligence. P.M. named 10 out of the 30 items which placed his score in the low average IQ range. As well as many later items,

earlier items were also failed (e.g. Scarecrow, corkscrew). On the majority of items P.M. could not name he retrieved some semantic information about the object. For example for “scarecrow” he said that it was “used to keep birds”. For “corkscrew” he said “it’s used to drill off....a wine bottle” For “retort” he said “something to do with chemistry”.

The second difficulty was with verbal recall. On tests of free recall (*Memory Doors and People*), P.M. performance was clearly impaired on the names test (verbal recall = 10th percentile) in comparison with the shapes test (visual recall= 75-90 percentile). In addition forgetting was clearly abnormal for verbal information (1st percentile) but not for visual information (75th percentile). The pattern of performance was not so clear cut on the recognition tests. Thus performance on the Names task (verbal recognition = 50 percentile) was better than performance on the Doors task (visual recognition = 10-25 percentile). In relation to scores on *set A* (easy) and *set B* (hard), P.M. obtained a score of 8 on each. This would indicate a normal performance on the hard items (50th percentile) but an impaired performance on the easy items (5th percentile). On the *California Verbal Learning Test II (CVLT II)*, P.M. showed a very steep learning curve over the five learning trials. On Trial 1 his score was 3 SDs below the normative data. On Trial 5 his score was 0.5 SDs above the normative data. Later questioning indicated that P.M. was using strategies to remember some of the words. His retention was good, dropping slightly at short delay recall but on short delay cued recall and long delay free and cued recall his score was 1 SD above the normative data. The cues presented at the short delay appeared to result in improved free recall at the long delay. P.M.’s recognition performance was good, 0.5 SDs above normative data. There was some repetition in P.M.’s recall but no increased rate of intrusion errors. For the complete scores see *Appendix 1*.

Discussion

The aim of the present report is to bring the historical merits of this exceptional jazz guitarist related to the neurosurgical community. In addition, we present his neuropsychological profile and imaging findings of this musician, after an extensive left temporal lobe lesion. To our knowledge, this case study represents the first clinical observation of a patient who exhibited complete recovery from a profound amnesia and regained his previous virtuoso status of jazz guitar player.

To summarize the main findings, the patient exhibited a specific but subtle impairment in certain aspects of language. This includes confrontation naming and accessing the meaning of abstract and low-frequency words; in addition, impairment in accessing precise definitions of more common usage words. Although the naming difficulty was marked, this was not apparent in the interview with the patient nor affected any conversation with him. The extent of the difficulty means that it might be expected to impact at least to some extent on his day to day functioning. The other difficulty is more subtle and might not be expected to impact on his daily life. The second impairment is related with verbal recall. This would be consistent with the results of the MRI indicating extensive left temporal lobe damage. Thus, although the left hippocampus is relatively intact, its inputs from the entorhinal, perirhinal and parahippocampal cortices would be disrupted. Interestingly although verbal recognition would also have been expected to be impaired this was not the case. In relation to scores on both sets, easy and hard, of the Doors and People Test, P.M. obtained a normal performance on the hard items but an impaired performance on the easy items. This would not be expected if there was a difficulty with visual memory. It is possible that the result is anomalous or that visual recognition on the easy items is normally mediated by verbal memory whereas this may be more difficulty on the hard items; though, P.M.'s normal verbal

recognition score would argue against this latter interpretation. Nonetheless, there is no doubt that P.M. has adjusted very well to his current situation, which includes his high level of up to date functioning. On the contrary, in comparison with the extensive nature of his left temporal lobe damage, his cognitive impairments seem mild.

In relation to the possibility that the arteriovenous malformation was present much earlier, some details from P.M.'s history appear consistent with evidence from people with damage to the temporal pole (9). There are reports that damage to this region can result in cycling changes in clinical levels of depression and this would be consistent with P.M.'s reports of a number of episodes of depression, up to three of these being treated with electroconvulsive therapy. While before surgery, P.M. had a history of complex partial epilepsy with manic depressive outbursts, he did not show any abnormality in his musical capabilities. The almost complete memory loss after resection of cerebral vascular malformation was the expected effect of the almost total absence of the left temporal lobe with underlying damage of the hippocampal region. His musical abilities including theory, technique and skills were completely lost. It is known that musicians use more the left hemisphere, it is also unquestionable the right hemisphere involvement (13, 14). Hence, this favors that the asymmetry of the left planum temporale is lower than in the general population. This "symmetry" of his hemispheres related to music exposure, possibly influenced the recovery and further development of musical abilities in P.M.

Even so, a number of other factors may be relevant to our case. First, we assume that the arteriovenous malformation had been present for the whole of P.M.'s life. We do not know the exact size of it, but generally arteriovenous malformations have a surround of non-functioning brain tissue that, ultimately, may increase in size and can interrupt blood supply to nearby regions (8, 15). Because of this, it is possible that some

developmental changes took place in P.M.'s brain and so function may not have lateralized as strongly as in most people, or may have had reorganized in other ways. Second, there is evidence that slow-growing lesions, such as arteriovenous malformations, and subsequent surgery allow extensive brain re-organization (3). Thus patients with slow growing lesions who have extensive resection in eloquent brain regions have been reported to return to normal functioning following surgery (4, 8). These studies have provided direct evidence for reorganization of function to brain regions adjacent to those that have been excised. A similar case is depicted in the report of Dufau et al. (5), exemplifying a complete left temporal lobe resection in a patient who returned to a normal socio-professional functioning. These findings could be relevant to our case. It is possible that the arteriovenous malformation grew in size, leaked blood which could have caused an enlarging malformation that finally produced the hemorrhage. Although the lesion was completely resected in two surgeries, it is unclear whether the surgeon resected the whole of the abnormal region visualized on current MRI or, most probably, this could have enlarged post surgery due to dying-back of non-connected neurons. Certainly, the main caveat of this report is that neuropsychological tests and MRI studies are very posterior to surgery, and, the lack of preoperative studies. It is said that he lost his memory completely but there is no objective data, only his testimony and from relatives; then you cannot directly compare or see the evolution, while only infer what happened. All that can be established objectively is the correlation between the current images and the neuropsychological tests.

Interesting in relation to P.M.'s musical career is evidence that the left temporal pole is responsive to complex auditory stimuli. Olson et al. (9) propose that its role is to link visceral emotional responses with representations of complex auditory stimuli. In

another case study Sellal et al. reported of a patient who exhibited dramatic changes in musical taste following left anterior temporal lobectomy (11). The direct relevance to our case is not clear, though, we know that P.M. stopped playing the guitar following surgery and this may have been related either to an emotional response or to his memory difficulty, or both.

P.M. acknowledged that his memory is at this time rather poor. Yet, it seems that this does not impact to any great extent on his daily life. He reported that he does not expend effort on trying to bring memories back even when they impinge on him but rather tries to push them away. In fact he views his situation as advantageous in that it allows him to live in the “here and now” without spending time thinking about the past. Probably, he views it as a positive thing that, ultimately, has enhanced his musical capabilities. It is also clear that P.M.’s emotional response to music changed after surgery, in that he plays music now because it is meaningful to him rather than because he wants to please other people or be competitive (1). (*Fig. 3*)

Finally, we hope that reporting this case may help to further understand the interrelationships of brain plasticity in terms of musical processing and memory. As seen in this case, we may infer that music capabilities can be fully reacquired even with almost complete absence of the left temporal lobe.

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Legends to Figures:

FIG. 1. Coronal T1-weighted MR images showing in the inferior temporal lobe the very posterior portion of the temporal fusiform gyrus may be intact (Fig 1). Superior temporal cortex appears to exist from the position of the anterior end of the amygdala. Left hippocampus appeared healthy and indicate may be well functioning.

FIG. 2. Axial T1-weighted MR images showing left and right amygdalae were the same size and appeared normal. Yet, volume measures indicate that they are quite small and are outside the range of the control subjects. Both entorhinal and parahippocampal cortex were normal on the right but abnormally small on the left.

FIG. 3. Mr. Pat Martino, circa 2007.

Appendix 1: complete scores of Mr. Pat Martino's neuropsychological profile.

Table 1: Comparison of medial temporal lobe structures in patient P.M. compared with mean volume estimates acquired from 5 healthy control subjects.

Structure	Patient PM		Mean control volume (n=5)			
	Right (cm ³)	Left (cm ³)	Right (cm ³)	Range (cm ³)	Left (cm ³)	Range (cm ³)
Hippocampus	3.29	2.01	2.91 (0.38)	2.34 – 3.40	2.85 (0.25)	2.51 – 3.11
Amygdala	1.21	1.21	1.74 (0.30)	1.41 – 2.10	1.68 (0.13)	1.52 – 1.85
Perirhinal	2.38	0.26	2.80 (0.73)	2.24 – 4.03	3.33 (0.83)	2.20 – 4.33
Entorhinal	1.03	0.73	1.04 (0.10)	0.91 – 1.16	1.13 (0.18)	0.92 – 1.36
Parahippocampal cortex	1.20	0.97	1.48 (0.36)	1.08 – 2.00	1.89 (0.58)	1.12 – 2.52
Temporal lobe	63.1	27.1	81.1 (4.91)	76.4 – 86.9	78.2 (4.27)	74.0 – 83.9

All volumes presented are in cm³, standard deviations are presented in parenthesis

Control age ranged between 43 – 62 years across the 5 subjects, mean age = 53.4years

Table 2: Neuropsychological battery test used in patient P.M. (see Appendix for detailed scores)

Cognitive Assessment Results

Intellectual Functioning

National Adult reading Test

Wechsler Abbreviated Scale of Intelligence

Attention/working memory

Digit Span

Language Functioning

Graded Naming Test

Pyramids & Palm Trees

Synonyms Task

Speed of Language Processing

Speed and capacity of Language Processing test (SCOLP)

Verbal Fluency

Memory

Doors & People

California Verbal Learning Test II (CVLT II)

AMIPB Figure Recall

Warrington Recognition Memory Test

Remote Memory

Memory for famous names and events

Autobiographical Memory

Venneri AMI

Facial Processing and expression recognition

Benton Facial Processing Test

Ekman-Friesen series

ACCEPTED MANUSCRIPT

Appendix 1**Intellectual Functioning***Pre-morbid IQ Estimate*

NART	P-FSIQ	P-VIQ	P-PIQ
Errors = 15	112	110	111

Current IQ Estimate

WASI	Raw Score	T-Score	Scaled Score	FSIQ
Vocabulary	58	51	10	110
Matrix Reasoning	26	61	13	(75%ile)

Attention/Working memory*Digit-Span*

Max Forward	Max Backward	Raw Score	Age scaled score
9	6	23	15

Language*Confrontation Naming*

Graded Naming Test	Raw Score	IQ Range
	10	Low Average

Language*SCOLP*

	Raw	Scaled	Percentile	Discrepancy
Spot the word	50	10	50	25
Speed of comprehension	44	8	25-50	

Verbal Fluency

	Raw	Age Scaled (from D=KEFS norms)
Letter (FAS)	43	11
Semantic (animals & boys names).	44	14
Switching (fruit/furniture)		
Total correct	15	13
Total switches	14	13
Semantic Clothing*	20	

*Included this as check for living/non-living discrepancy.

Design Fluency

	Raw	Age Scaled (from D=KEFS norms)
Filled dots	14	16

Memory

Doors & People

Test	Raw Score	Scaled Score	Percentile
People(verbal recall)	19	6	10
Names (verbal recog.)	17	10	50
Shapes (visual recall)	35	13	75-90
Doors (visual recog.)	16	8	10-25
Visual/verbal discrepancy			
Verbal Forgetting	-7	3	1
Visual Forgetting	0	11	75

CVLT II

	Raw Score	Standard/T score
Trial 1	2	-3
Trial 2	7	-0.5
Trial 3	9	0
Trial 4	11	0.1
Trial 5	12	0.5
Total	41	50 (T)
List B	4	-1
Short delay free recall	8	0
Short delay cued recall	12	1

Long delay free recall	12	1
Long delay cued recall	13	1
Total repetition errors	5	0.5
Total intrusion errors	0	-1
Serial order clustering (Bidirectional)	0.7	0
Semantic clustering	-0.2	-0.5
Recognition hits	14	0
Recognition false-alarms	2	-0.5
Recognition d'	2.7	0

Warrington

	Raw	Percentile	Discrepancy
Words	47	75-95	25 %ile
Faces	42	50	

AMIPB Figure

	Raw	Percentile
Copy %	100	90
Immediate %	86	75-90
Delay %	85	50-75
%retained	98	50-75

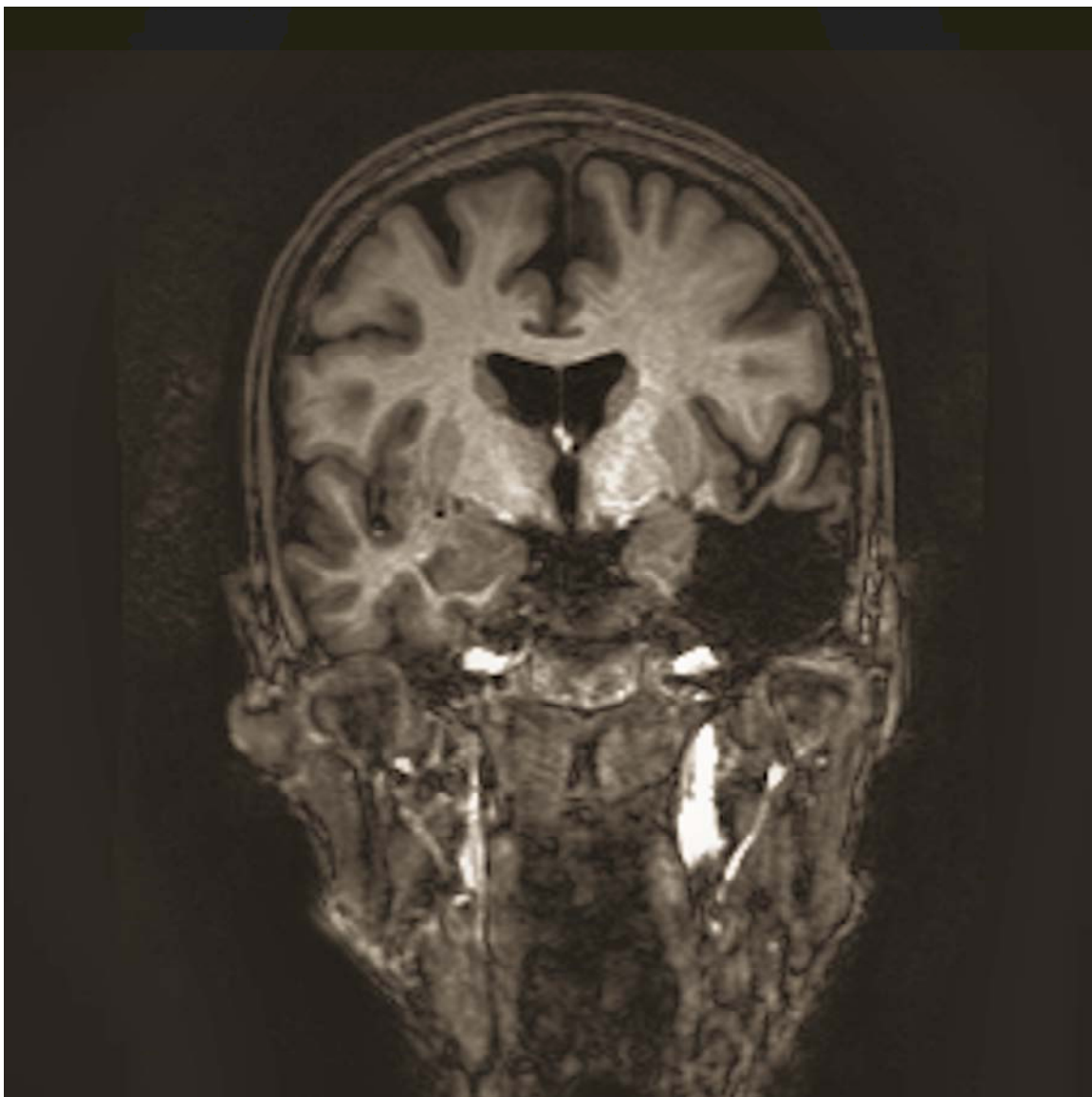
Face & expression recognition

Benton

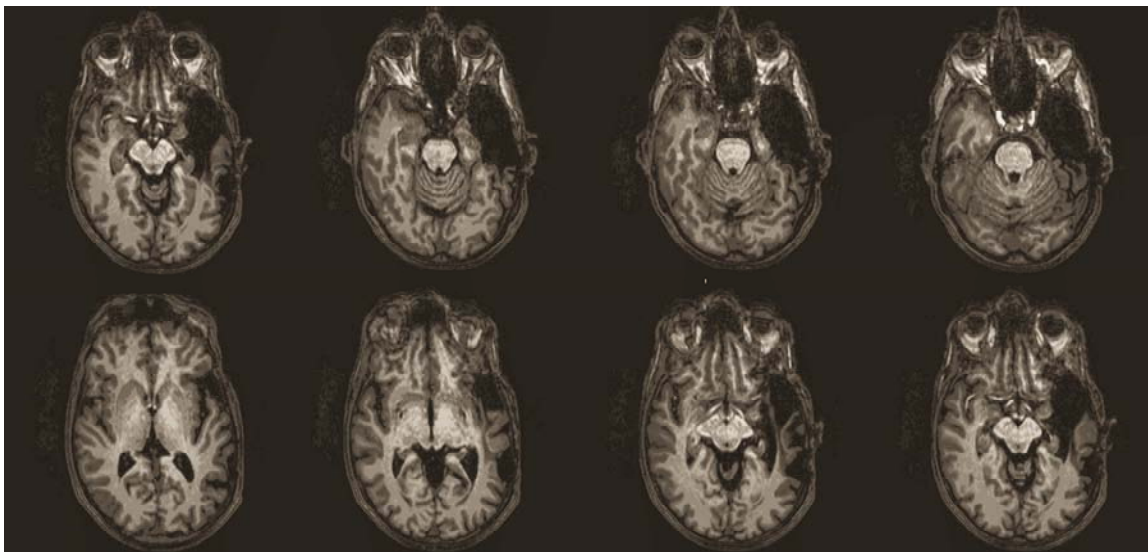
	Corrected Long Form	Category
	Score	
Short Form	53	Normal

Ekman Facial Expressions

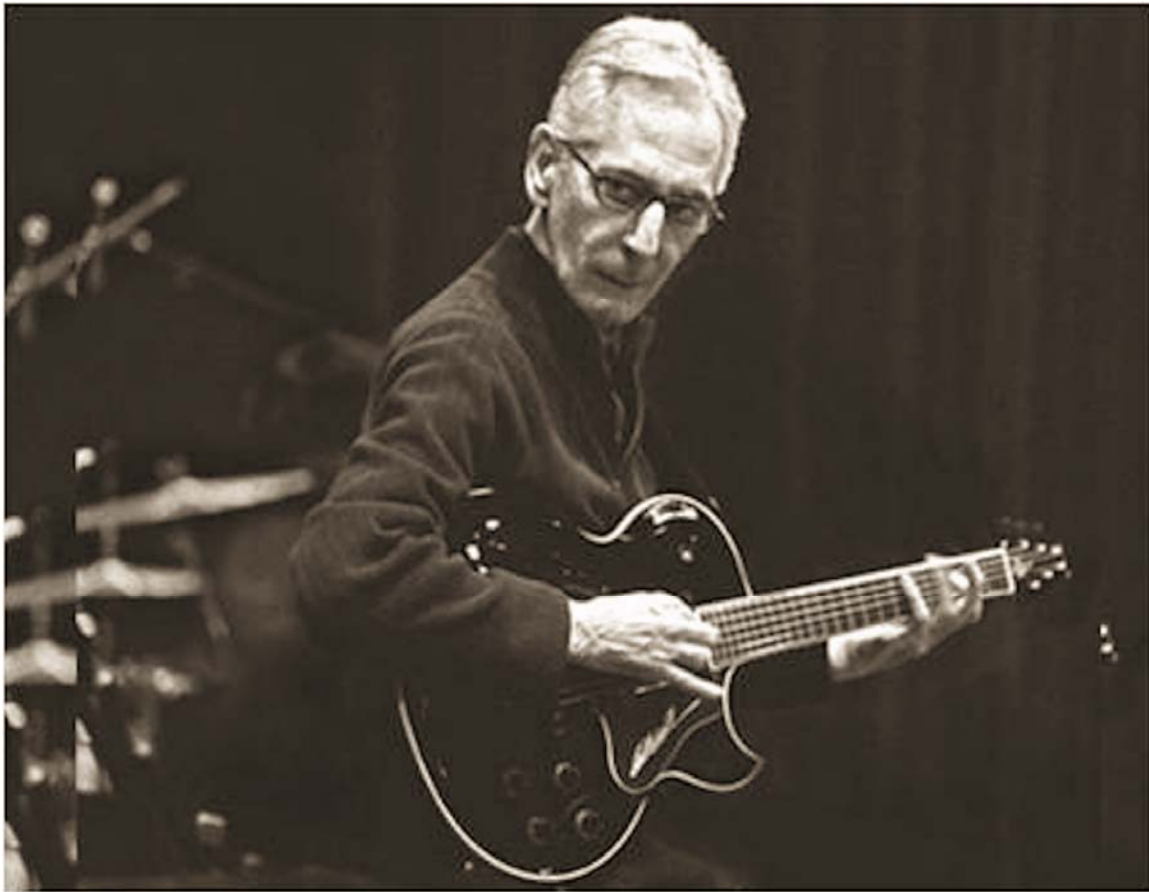
Expression	Score out of 10
Happiness	10
Sadness	9
Fear	4
Anger	9
Disgust	9
Surprise	10



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ACCEPTED MANUSCRIPT



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