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Bravo! Neurology at the Opera

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Abstract

Opera is a complex musical form that reflects the complexity of the human condition and the human brain. This article presents an introduction to the portrayal of medical professionals in opera, including one neurologist, as well as two characters in whom neurological disease contributes to the action of the musical drama. Consideration is also given to the neuroanatomy and neuropathology of opera singers with further speculation regarding the neural underpinnings of the passion of opera's audience.

The ability to create music is a universal human trait witnessed across societies throughout the ages. Song and dance continue to be pervasively used to tell stories of history and culture, to relax, and to simply entertain [Cross, 2003]. One such form of musical communication is opera, originating from the Latin for 'work' and sharing a root with the medical term 'operation' [http://www.merriam-webster.com/dictionary accessed Jan. 10, 2009]. Greenburg [1998] defines opera as 'a drama which combines soliloquy, dialogue, scenery, action, and continuous music with the whole to be greater than the parts'. With the advancement of neuroscience, it is increasingly more apparent that brain processes may actually contribute to this seemingly 'emergent property' of the opera experience.

The history of opera as a form of musical storytelling begins in the late Renaissance and early Baroque periods with composers such as Handel pursuing serious, often mythological, themes. As opera developed from the 18th through the 20th centuries, physicians and medical conditions began to be portrayed on the stage with variable prominence [Willich, 2006]. Herein brief consideration shall be given to the portrayal of physicians in opera, from *The Barber of Seville* to *Wozzeck*, culminating with an opera based on a neurolo-

gist's encounter with an interesting patient, *The Man Who Mistook His Wife for a Hat*. Additionally, two well-known operatic title characters suffering from presumed neurological disorders will be described, *Rigoletto* and Tom Rakewell of *The Rake's Progress*. In conclusion, a discussion of the neurology of vocal performance will be followed by what is currently known about the audience's oftentimes emotional response to operatic music.

Neurologists in Opera

In a systematic review of approximately 400 operas written in the 18th through 20th centuries, Willich [2006] identified 40 operas in which physicians appear on stage. The role of the physician in the action evolves in concordance with the social importance of physicians and the perception of medicine at the time the opera was conceived. Only one operatic character is clearly identified as a neurologist, but others provide context for the portrayal of both clinical and research medicine on stage. One of the early operatic physicians, Dr. Bartolo, a doctor in Gioacchino Rossini's *The Barber of Seville* [Rossini, 1816] provides a stark and unpleasant contrast to Figaro, a barber-surgeon, who offers the bulk of this opera's comedy and charm. Figaro, the jack-of-all-trades, assists in the deception of Dr. Bartolo, who is portrayed as arrogant and foolish as he plots to marry young Rosina for her inheritance. (It has been suggested in prior commentary on physicians in opera that Dr. Bartolo may not have been a medical doctor at all, but rather a doctor of law or some other area of study [Ober, 1976]; however, for purposes of this discussion we will assume that the composers and librettists were using the common connotation for the term.)

In Act I scene 1, Figaro celebrates his abilities by singing:

'Of a thousand professions, that of a barber is most noble…Razors, bibs, lancets and scissors, are always ready at my command…I am the city's factotum…Oh what a beautiful life! I tire little, and enjoy myself much…What a profession!' [Rossini, 1816, p 9].

On the contrary, in Act I scene 2, Dr. Bartolo is played a fool as he rests on his past accomplishments and perceived social role:

'To a doctor of my stature you dare offer such excuses…I advise you to use a better deception' [Rossini, 1816, p 35].

Although both characters portray a sense of inflated self-importance, the libretto and the score seem to support Figaro as the more likable character. With the evolution of medical practice, operas later in the 19th and 20th centuries tended to better acknowledge the role of a physician as a practitioner of medical science rather than simply a man with a title. However, even with its oversimplification of professional roles in medicine, this bel canto style comic

opera may well have captured in exaggerated form a dichotomy between the so-called 'medical' and 'surgical' personalities which continues to fascinate modern audiences (i.e. the highly rated American television serials *House* and *Gray's Anatomy*).

A century later, the evolving role of physician as research scientist results in the sinister doctor of Alban Berg's 1922 opera Wozzeck [Goldovsky,1986]. Not specifically identified as a neurologist, this physician sacrifices the well-being of his patient in order to further his own prestige, captured in musical form by the use of dimunition, a technique in which faster note values of the same theme are repeated by the orchestra to emphasize the vocal pitch set [Florin, 2005]. In the heartless words of the doctor '…O, my theory, my fame! I shall be immortal! Immortal! Immortal! …' as Wozzeck, a poor soldier is increasingly delirious and eventually psychotic as a result of the doctor's experimentation [Berg, 1955]. The altered mental status could be a representation of the central nervous system manifestations of nutritional deficiencies related to thiamine, niacin, or cyanocobalamin, but the specific condition is of little importance to the drama in comparison to the ethics, or lack thereof, of the physician as researcher.

More recently, favorably combining the contemplative traits of the medical personality and the role of the physician as research scientist, composer Michael Nyman and librettist Christopher Rawlence have adapted neurologist Oliver Sacks' clinical tale 'The Man Who Mistook His Wife for a Hat' into a contemporary chamber opera. At last a neurologist takes center stage with such lyrical lines as,

'Neurology's favorite term is deficit. For all of these… we have private words of every sort: aphonia, aphemia, aphasia, alexia, apraxia, agnosia, amnesia, ataxia…' [Nyman,1987, p 45].

The action of the opera surrounds an accomplished musician who presents with his wife to a neurology clinic where little is initially revealed beyond a few visuo-perceptual mistakes. The neurologist makes a house call and discovers that the patient suffers from visual agnosia. The doctor also discovers that the patient copes with his perceptual impairment by relying on routines coupled with familiar music. The neurologist sings:

'He still has a perfect ear! His memory's unimpaired, perfect tonal and rhythmic discrimination and expression – but what of the parietal regions, the fibres, nerves, neurons, the synapses of the occipital zones? What of the cytoarchitectonic, the structure of visual processing? How? What? Does he see?' [Nyman, 1987, pp 83–85].

Thus, 'The Man Who Mistook His Wife for a Hat' is truly a neurologist's opera as it combines the portrayal of a physician clearly identified as a neurologist and his quest for neuroanatomic localization with a patient suffering from a complex neurological disease. Their series of clinical encounters highlight the importance of celebrating a patient's humanity no matter how unique or intel-

Table 1. Possible neurological causes of kypho-scoliosis in the title character of *Rigoletto*

Cerebral palsy	Duchenne muscular dystrophy
Neurofibromatosis type I	Spinal muscular atrophy
Syringomyelia	Pott disease (tuberculosis)
Fredreich ataxia	Poliomyelitis
Charcot-Marie-Tooth neuropathy	Klippel-Feil anomaly (with cervical cord compromise)

lectually stimulating 'the case' may be [St Louis, 1992]. Moreover, this story remains especially timely as the patient on whom the title character was based most likely suffered from an atypical form of Alzheimer's disease [Sacks, 2007], one of the most prevalent neurological disorders in the world [Qiu et al, 2009].

Neurological Disease in Opera

Like the visual agnosia clearly identified and pivotal to the action of 'The Man Who Mistook His Wife for a Hat', the portrayal of an entirely different neuro-orthopedic condition [Fardon, 2002] plays a central role in the development of the action in Verdi's *Rigoletto* [1851]. The title character, a court jester, is portrayed as predominantly sympathetic, but inevitably cursed in the context of his physical deformity, a so-called 'hunchback', to which he solemnly refers:

'Oh rabbia! Esser difforme!' (Oh what a fate! To be deformed!) [Verdi, 1851, p 17].

His kypho-scoliosis may have resulted from any number of disorders, ranging from congenital anomalies to trauma, but according to a well-respected pediatric neurology textbook, 'The presence of scoliosis… in males of all ages should strongly suggest either a spinal cord disorder or a neuromuscular disease' [Fenichel, 1997]. Bearing this modern diagnostic pearl in mind, considerations in the differential diagnosis of Rigoletto include congenital and neurogenetic disorders as well as neuroinfectious etiologies (table 1).

While further diagnostic clues are seemingly absent from the libretto, it is clear that the courtiers are disgusted by Rigoletto's outward appearance when, after mistaking his daughter for his mistress, they comment with surprise,

'*Perduto ha la gobba? Non e piu difforme?*' (Has he lost his hunchback? He's no longer deformed?) [Verdi, 1851, p 7].

As is the case in all tragic operas, Rigoletto cannot escape his curse, and loses all that he loves in the end. This may reflect the pervasive attitude of the time toward patients struck with disfiguring conditions, a mixture of sympathy and an irrational fear of contagion and 'bad luck'.

In a less transparent example, *The Rake's Progress* most likely portrays dementia paralytica associated with neurosyphilis. Igor Stravinsky's only full-length opera paired with W.H. Auden and Chester Kallman's libretto is loosely based on the engravings of William Hogarth. The opera, originally produced in 1951, portrays the title character, Tom Rakewell, departing from his beloved and descending into a world of gambling, fornication, and risky investments, eventually losing his entire fortune in addition to his sanity. The power of Tom's love saves him from suicide, but he is cursed with 'madness' as a consequence of his reckless behavior. While there is no direct reference to venereal disease in the opera, musical reference to cause and effect as well as the historical context of the opera suggest that spirochete infection results in Rakewell's progressive and persistent dementia. Most notably, a similar chorus in the key of C appears only in the brothel and Bedlam scenes (fig. 1, 2), suggesting that the locations are one in the same, or one the result of the other [Hutcheon and Hutcheon, 1996]. Epidemiology provides an equally important clue to the neurological disease portrayed on stage, as the prevalence of syphilis at the time of the opera's debut was markedly higher at around 65 per 100,000 population in the 1940s compared to approximately 2.5 per 100,000 population in 2004 [Kent and Romanelli, 2008]. With the accessibility of screening tests of the serum and CSF, and intramuscular and intravenous antibiotics, the incidence of tertiary syphilis and its associated frontal and temporal lobe predominant dementia paralytica has plummeted. However, the themes of *The Rake's Progress* remain timely as other communicable diseases such as HIV have potentially delayed, yet equally devastating, neuropsychiatric consequences [Dubé et al., 2005].

Neurology of Vocal Performance

Vocal artistry most commonly predominated over orchestration and staging in opera performance of the 18th, 19th, and much of the 20th centuries. The neuroanatomy of singing is complex and involves all of the component parts of motor speech, including: respiration, phonation, resonation, and articulation. Respiration is supported by the diaphragm innervated by C3–5 nerve roots as well as the intercostal and abdominal musculature. Phonation and resonation involve the 9th and 10th cranial nerves, and articulation is reliant upon cranial nerves 7 and 12. The activity of the vocal folds is dependent on the function of the recurrent and superior laryngeal divisions of the vagus nerve. During

Fig. 1. The Rake's Progress Plate 3: Tavern Scene. Engraver: William Hogarth, in The Works of William Hogarth. In a series of engravings with descriptions, and a comment on their moral tendency by John Trusler (contributors John Hogarth and John Nichols). Original publication London, Jones, 1833. Current release date: Sept 4, 2007 [EBook No. 22500]. http://www.gutenberg.org/files/22500/22500-h/22500-h.htm. Accessed Oct 15, 2009.

phonation, the vocal folds are brought together near the center of the larynx by muscles attached to the arytenoids (fig. 3). As air is forced through the vocal folds, they vibrate and produce sound. By contracting or relaxing the muscles of the arytenoids, the qualities of this sound can be altered.

Additional neuroanatomic contributions to voice include circuits representing cortical motor control areas for the larynx and articulators as well as subcortical and cerebellar implicit motor memory areas. Vocal training increases activation on functional MRI scans in areas including the primary somatosensory cortex for vocalization, which demonstrates a greater activation in the right hemisphere in professional opera singers. Expert singers also

Fig. 2. The Rake's Progress Plate 8: Scene in Bedlam. Engraver: William Hogarth, in The Works of William Hogarth. In a series of engravings with descriptions, and a comment on their moral tendency by John Trusler (contributors John Hogarth and John Nichols). Original publication London, Jones, 1833. Current release date: Sept 4, 2007 [EBook No. 22500]. http://www.gutenberg.org/files/22500/22500-h/22500-h.htm. Accessed Oct 15, 2009.

demonstrate increased activation in the thalamus, basal ganglia, and cerebellum [Kleber et al., 2009]. Comparing professional vocalists with 'tone-deaf' singers suggests that a lack of connections between auditory and motor regions may result in poor vocal ability while the duration of vocal training for professional singers may correlate with both gray and white matter 'enhancements' [Schlaug, 2009].

Neurological disorders are not restricted to opera characters; the opera performers may also be afflicted with neurological disease from stage fright with dysautonomia to recurrent laryngeal nerve damage subsequent to chest surgery [Gould, 1986]. Also described is singer's dystonia which, like vocal dystonia that affects conversational speech, may have either an adductor or abductor

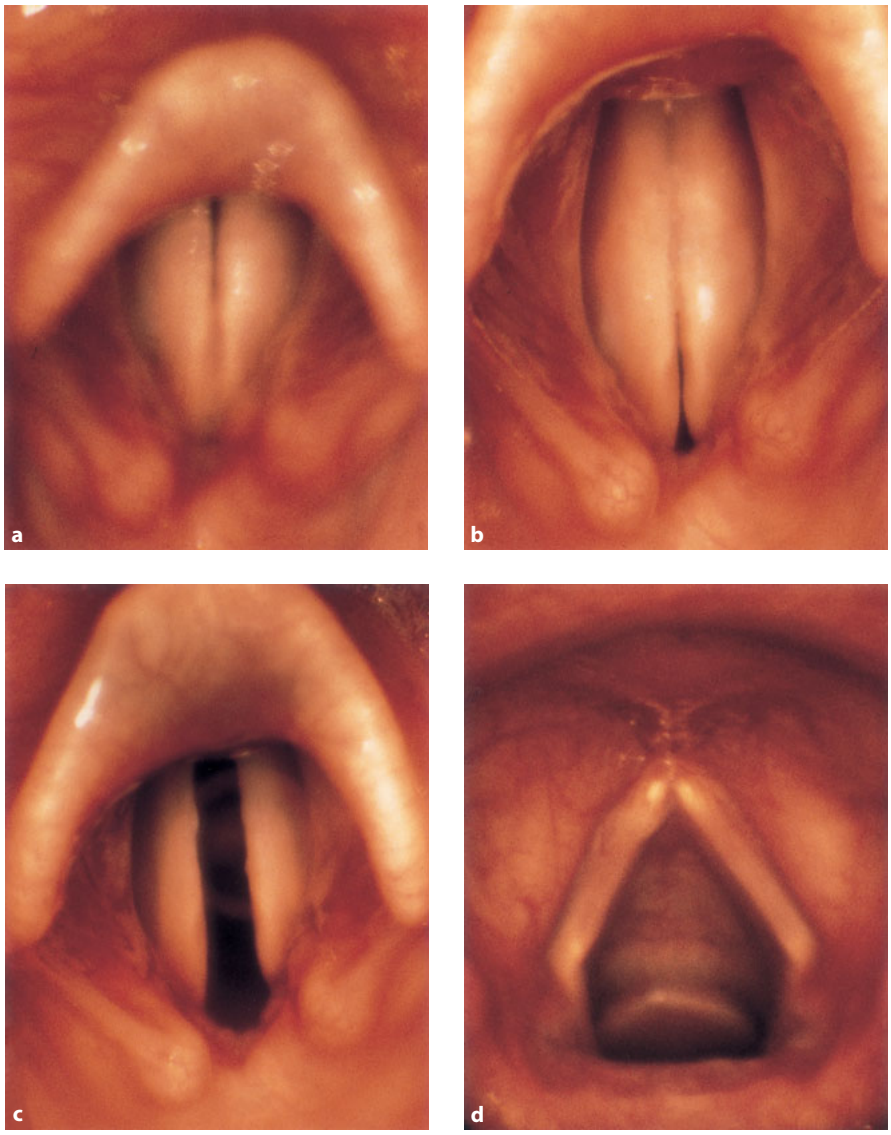

Fig. 3. Laryngoscopic view of the interior of the larynx in a living adult. ***a*** During loud phonation. ***b*** During whispering. ***c*** During quiet respiration. ***d*** During forced inspiration. From Köpf-Maier [2005].

character. Similar to other task-specific musicians' dystonias and overuse syndromes [Lockwood, 1989], singer's dystonia can be disabling from a vocational perspective given the associated loss of vibrato and truncated range observed in those afflicted [Chitkara et al., 2006].

Neurology of Opera's Audience

The portrayal of physicians (and a single neurologist) and neurological disease have obviously had a relatively minimal impact on the history of opera while the neuroanatomy of vocal performance has decidedly helped shaped the art form. Nevertheless, audience neurology, and the emotional response to opera in particular, may be the most important contributor to the perpetuation of opera performance, as the contemporary lack of widespread social and financial support for the art form cannot diminish the passion of opera fans [Stone, 2009]. While it is possible that opera fans are simply more passionate individuals, with some published evidence that opera fans are more likely than non-fans to accept suicide in the context of dishonor [Stack, 2002], it is equally tenable that it is primarily the emotional experience of perceiving live opera that compels a patron to return. The physicality of this experience from a fan perspective is well captured by Flaubert in *Madame Bovary* as Emma Bovary attends a performance of Donizetti's *Lucia di Lammermoor:*

> 'She yielded to the rippling of the melodies and she felt herself trembling all over, as though the bows of the violins were being drawn across her nerves.' [Flaubert, 1857, p 206].

Neuroscience has only recently begun to tackle the challenge of understanding such a profoundly emotional response to music. This response appears to vary according to musical training, be related to specific musical variables including tempo and mode, and may be mediated by subcortical dopaminergic pleasure circuits or even opioid receptors in the brainstem [Matthews, 2008]. It has even been hypothesized that the human mirror neuron system plays a role in the structural analysis of music, following auditory signal processing in the superior temporal gyrus and preceding emotional awareness and response processing in the anterior insula and limbic system [Molnar-Szakacs and Overy, 2006].

Opera extends beyond the labyrinthine human emotional response to music with the addition of language, an equally complicated stimulus. Functional MRI and electrophysiological data reveal an overlapping brain network of frontal and temporal regions responsible for the processing of songs with lyrics in which each dimension (language vs. music) is influenced by the processing of the other in an elaborate interaction [Schon et al., 2005]. Furthermore, as noted

by Hutcheon and Hutcheon [2000] in *Bodily Charm: Living Opera*, the emotional response to opera is not merely a response to music and language, but to the elements of comedy or drama with all of the other multi-modal sensory stimuli from elaborate sets to the responses of other audience members. Again, Flaubert captures the depth of this experience with Emma Bovary's trip to the opera:

> 'Two eyes were not enough to take in the costumes, the scenery, the characters…the velvet caps, the cloaks, the swords, that whole imaginary world pulsing to the music as though in the atmosphere of some other realm' [Flaubert, 1857, pp 206–207).

It seems as though the experience of opera may exceed the current framework of neuroscientific reductionism; thankfully this does not detract from the pleasure to be derived by those enchanted with both.

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