

**SYMPTOMS AND PEDAGOGICAL APPROACHES TO
FOCAL EMBOUCHURE DYSTONIA IN THE TROMBONE AND TRUMPET**

DENTON THOMAS

**THE UNIVERSITY OF TEXAS AT AUSTIN
SCHOOL OF MUSIC**

17 FEBRUARY 2007

INTRODUCTION

This brief provides a concise summary of what embouchure dystonia is, how it affects brass players, and how scientific models of dystonia apply to pedagogical retraining. Musicians are at an understandable disadvantage when discussing dystonia and other medical conditions.¹ Over time, however, this lack of training has led to misunderstanding and confusion. Trombonist Don Kneeburg (Retired Professor of Trombone, University of Southern Florida; diagnosed with dystonia) has expressed concern that some musicians have become "afraid to know about [dystonia] because they're afraid they'll get it."² Discussion is provided to fill this gap between brass players and bonafide dystonia research.³

Interviews by the author and published literature suggest that musicians lack essential details of embouchure dystonia on three fronts. First, detailed individual experience stories are either rare or unavailable for review and discussion. Second, the average musician does not possess a rudimentary understanding of what medically constitutes an embouchure dystonia or how it impedes the music-making process. Finally, interdisciplinary discussions do not cover both current theoretical models and treatments, and how these two interact.

By providing information in these three areas (experiences, definition, and models affecting treatment), this document aims to provide a foundation for interdisciplinary specialists who encounter embouchure dystonia.

PERFORMER EXPERIENCE

There have been no generic descriptions of how dystonia affects musicians because each individual case is truly unique.⁴ A small number of publications include photographic or videographic aids which shed light on how the condition affects specific instrumentalists (*Illustration 2*). Limiting the field to embouchure dystonia also helps define specific details, but uncommon symptoms appear in most of the case studies from the last thirty years. Worst for musicians, these reports generally lack

1 Charles Thomas Turon, "Educational Prerequisites for Piano Teachers assisting in the Prevention, Detection, and Management of Performance-Related Health Disorders" (Ph. D. dissertation, University of Oklahoma, 2000).

2 K. Don Kneeburg, interview by author, 7 November 2007, telephone interview with electronic notes.

3 Robert Thayer Sataloff, Alice G. Brandfonbrener, and Richard J. Lederman, eds. *Textbook of Performing Arts Medicine* (New York: Raven Press, 1991), 201.

4 Sataloff et al., 1991: 194.

salient musical observations, details that can help the lay audience understand how a dystonia appears, develops, and affects musical technique. Applied music teachers and performers need this information in order to help understand and identify what is otherwise a painless neuromuscular disorder.^{5,6,7}

Two generalized experiences of embouchure dystonia follow below, each corresponding to interviews conducted by the author. These stories reflect the trends found in published works and avoid associating limiting dystonia to exact conditions. Instead, each concludes with a brief summary of the symptoms that have derailed the link between practice and musical development.

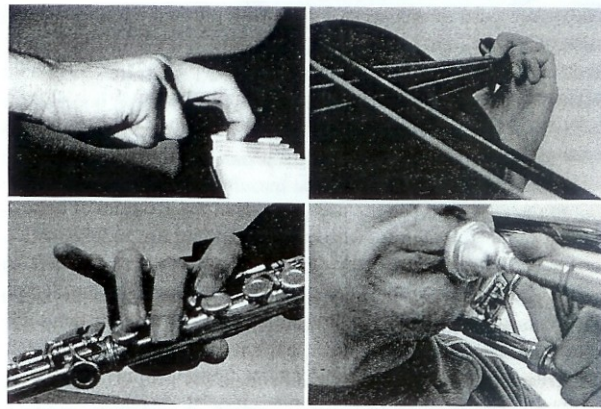


Illustration 1: Various musician's dystonias (Jabusch & Altenmüller, 2006: 267)

Experience 1: Unusual Embouchure Tremor and Fatigue

This is the ongoing experience of an early-40s professional trumpeter who has a career built on his flexibility in performing many styles and genres. His experience started with an unusual “quiver on a top space E” during a performance tour in the fall of 2004.⁸ At first he regarded this as nothing more than fatigue or due to an irregular touring and practice schedule. A dedicated return to structured practice, however, spread the symptom to a wider range, and increased the audibility of what is called a dystonic tremor.^{9,10} “By Christmas Day, I couldn’t even function. . . . It was a Christmas gig that I did, it

5 Hans-Christian Jabusch and Eckart Altenmüller, “Epidemiology, Phenomenology, and Therapy of Musician’s Cramp,” in *Music, Motor Control, and the Brain*, eds. Eckart Altenmüller, Jürg Kesselring, and Mario Wiesendanger (Oxford: Oxford University Press, 2006), 265.

6 Sataloff et al., 1991: 194.

7 Denton Thomas, “Embouchure Dystonia and the Overuse Syndrome: A Primer for Musicians,” *Maestro: ABODA National Newsletter* (February 2008) (in press).

8 Anonymous 1 (trumpet), interview by author, 8 November 2007, telephone interview with electronic notes.

9 Stanley Fahn, S. B. Bressman, and C. D. Marsden, “Classification of Dystonia,” *Advances in Neurology* 78 (1998).

10 Steven Frucht, Stanley Fahn, and Blair Ford, “Focal Task-Specific Dystonia Induced by Peripheral Trauma,” *Movement Disorders* 15, no. 2 (2000): 348.

was a very exposed quintet thing ... I wouldn't have called myself back after that one. Everyone I worked with was very supportive at the time."

A woodwind colleague introduced him to dystonia, describing it as a condition related to the overuse syndrome. Reading electronic information on embouchure dystonia startled the player:

I got online and I read this definition [of dystonia] and it scared the snot out of me. So I took 17 days off after that ... I took that whole week off between Christmas and New Year's ... I kept the New Year's gig because it was really lucrative. ... After that I took another week off, and I remembered going downstairs and opening up the case. Because if it was fatigue, after another week off [it would be alright] ... so I took the horn out of the case ... and darned me if it wasn't still there.

He "made [his] living playing trumpet" at the time, and still makes part of his living performing on trumpet despite continuing symptoms. He still feels competent to perform in "a commercial environment, and some jazz ... in an upper register – the compression is enough [to keep playing]." But he is not at all confident to "take any classical work, or any brass quintet work that's exposed."

The performer experiences severely reduced endurance, irregular fatigue and tremor. He makes unusual shifts to accommodate various ranges of the instrument:

I bite my tongue to hold my jaw steady in order to play a long tone for 6 counts...I know enough about the horn that every time my condition takes a new turn I find a way to compensate. ... I can get on a gig now, and my biggest challenges now are intonation. I'm hanging in there just to get the notes to happen. I manipulate so fiercely just to get the notes to happen [the upper and lower range embouchure positions are severely different]. A lot of the people I work with day to day are very understanding. ... I play as little as possible to just get by with what I know I need to do. There was a [time] that I would take 3 or 4 [gigs] in the day and I would be saying "just bring it on." Not anymore. At the end of a 4 hour gig I'll be playing on teeth.

For over a decade he had a consistent practice routine, a collection of exercises not substantially different from the routines used by professional trumpet players and university students. Daily exercises included long tones, lip slurs, articulation and accuracy exercises. In short, "the routine didn't have anything special. ... Most of it was based upon Jimmy Stamp", a trumpet pedagogue of the 20th

century (d. 1985). Ironically, Stamp had earned a reputation for solving embouchure ailments.¹¹

In hindsight, this particular trumpeter makes two observations regarding embouchure dystonia. First, he feels that a possible cause is “not resting enough, and not taking the break to recover from a physical activity ... If you find that a lot of the routines include a lack of rest, that’s probably something that you can put your finger on.” Second, he had kept up a reliable daily practice routine for 16 years, skipping a day for the first (memorable) time when a family member died. He felt that this “was probably a contributing factor” to the onset, although the calendar relationship for the two is indefinite.

Emotional trauma has been mentioned in published cases and other interviews, and emotional well-being is normally considered by pedagogues who work with injured musicians.^{12,13} Long-term affect of imbalanced rest during practice, however, has been largely neglected as a possible factor in published literature and interviews. Experimental research has shown that rest plays a significant role in the storage and consolidation of learned material, and that intermittent and varied practice show higher stability in the brain.^{14,15} These certainly affect the brain's response to practice activities, but an exact connection to dystonia has not been made.

This performer's experience shares the following characteristics with other cases:

- Audible changes to stability (tremor), endurance (fatigue), and range (preference for high range)
- Performance and experience history suggest practice routines were traditionally efficient and effective at a professional level, but practicing no longer leads to improvement
- onset at range breaks (*Illustration 1*)¹⁶
- Unusual emotional/psychological stress



Illustration 2: Bb trumpet range breaks described by Thompson in “The Buzzing Book”. Symptoms for trumpet players may begin at or near these breaks. (Thompson, 2001: 8)

11 “Stamp, James”; available from http://www.editions-bim.com/index.php?main_page=page&id=104&chapter=1; Internet, accessed 20 January 2008.

12 Jan Kagarice, interview by author, 1 June 2007, Las Vegas, Nevada, electronic notes.

13 Joaquin Fabra, “Embouchure Dystonia: Symptomatology”; available from <http://www.embouchuredystonia.com/>; Internet, accessed 1 February 2008.

14 Mayank R. Mehta, “Cortico-Hippocampal Interaction During Up-Down States and Memory Consolidation,” *Nature Neuroscience* 10, no. 1 (January 2007): 13.

15 Simon Overduin, Andrew Richardson, Courtney Lane, Emilio Bizzi, and Daniel Press, “Intermittent Practice Facilitates Stable Motor Memories,” *The Journal of Neuroscience* 26, no. 46 (15 November 2006): 11888.

16 James Thompson, *The Buzzing Book* (Vuamarens, Switzerland: Editions Bim, 2001): 8.

Experience 2: Severe Lock, Stutter, or Miscoordination

Amongst the author's interviews, four trombonists shared common dystonic symptoms.^{17,18,19,20} Three were symphonic performers professionally diagnosed with dystonia and have since retired to non-performance areas in music. The fourth, a university student, plays trombone as an avocation and has not been formally diagnosed.

Aside from this affliction, these four trombonists are unrelated and unknown to each other. They are significantly geographically divided, cover a wide age range (20-60), have dissimilar histories in instrumental study (conservatory, private school, public school), and performed on different instrumental makes. They did share a conscientious and dedicated approach to practice and performance, as evidenced by their high levels of professional achievement. The student also had high standards; auditions placed him in the top ten trombonists in his state during his eleventh and twelfth years of public school.

These four players shared a 'lock' or 'hesitation', an inability to smoothly and rhythmically begin a sound on the instrument. Also called an embouchure lock, a musical stutter, lip lock, or tongue lock, this has been reported as a feature of medically diagnosed embouchure dystonia.^{21,22,23} It includes unusual and involuntary tension and spasms that delay or prevent the production of sound on the instrument.

Two major types appear in the literature and interviews, though they have not been formally classified. Both occur at the moment between inhalation and exhalation. In one, a player experiences a tension which forces the tongue to stick to the the palette.^{24,25} The second is a spasm of the lips which either removes the seal between the mouthpiece and the embouchure, or tightly closes the aperture.²⁶ In both cases, the air flow is interrupted, timing, accuracy, and musicality suffer tremendously. Tone and stability of sound are compromised, tension builds, and kinesthesia (the body's sense of position) disintegrates. Severely afflicted players exert supreme physical and mental effort in order to produce

17 Newell Sheridan, interview by author, 17 January 2007, Austin, Texas, electronic recording.

18 Stefan Sanders, interview by author, 23 May 2007, Austin, Texas, electronic notes.

19 Ian Perry, interview by author, 12 January 2008, Melbourne, Australia, electronic recording.

20 Stephen Arthur, interview by author, 20 October 2007, Austin, Texas, electronic notes and video recording.

21 Steven Frucht, Stanley Fahn, and Blair Ford, "French Horn Embouchure Dystonia," *Movement Disorders* 14, no. 1 (1999): 172.

22 Martin Edmond Cochran, "A Comparison of the Behavior and Characteristics of Speech Stuttering with Musical Stuttering (i.e. Valsalva Maneuver) in Brass Playing," (D. M. A. diss., University of Alabama, 2004).

23 Alice G. Brandfonbrener, "Musicians with Focal Dystonia: A Report of 58 Cases Seen During a 10-year Period at a Performing Arts Medicine Clinic," *Medical Problems of Performing Artists* 10, no. 4 (December 1995): 122.

24 Interview with Stephen Arthur, 2007.

25 Interview with Newell Sheridan, 2007.

26 Interview with Ian Perry, 2008.

each note.

Musicians and speech therapists have studied this particular disorder more than principle medical teams. Per Alm's research on stuttering stated that “superfluous muscular activation accompanying stuttering may be a type of dystonia: involuntary contractions related to the basal ganglia disturbance.”²⁷ Martin Cochran's DMA dissertation decided otherwise for stuttering in musicians, however. He categorized musical stutters as a hyperactive valsalva reaction (involuntary blocking of the air passage due to emotional or physical stress), and provided studies and suggestions for how to prevent this reaction from becoming habitual.²⁸ Interviews and literature express a split between these two beliefs: medical dysfunction, or poor mechanics and lack of mental focus. It is likely that each apply and interact.

One of the symphonic performers interviewed reported a personal, emotional trauma near the time symptoms began. The other three did not note an acute emotional stressor, but the professional trombonists all expressed feelings of severe anxiety and stress because of the their occupation and community pressure. It is difficult to state whether the anxiety or dysfunction came first in each case, but emotional stress agrees with Cochran's study. The youngest interviewee recalled first experiencing articulation difficulties in the 8th grade (age 14), but had always felt that the condition was a manageable timing and coordination issue. He did not recall unusual psychological tension or stress during or preceding that time in his music study.

All of the performers felt that difficulty began and remained worst in the middle to low register of the instrument. On tenor trombone, symptoms began near C³ to Ab³, especially at soft dynamics or slow tempi. Bass trombonists were most distressed by brief, staccato pitches in the valve range (F³ to D³), “for instance, a short, staccato scale descending.” It is notable that, similar to the trumpet experience above, each of the performers expressed that high register playing (D⁴ and above) was either less affected or not affected. One post-professional bass trombonist stated that his difficulty led him to choose tenor works for performance because “well, high range is not a problem.”

Scales and patterns in the style of Kopprasch, Remington, etc. were tried by each but failed to produce lasting improvement. Weeks to months of practice spread symptoms in each player: difficulties affected a wider range of pitches, to a greater degree of tension, or with an increasing frequency. Each instrumentalist had compensated in a similar way, performing by utilizing air attacks, slurring into the offending range whenever possible, or deforming their embouchure and technique as

27 Per A. Alm, “On the Causal Mechanisms of Stuttering” (Ph. D. diss., Lunds Universitet, Sweden, 2005).

28 Cochran, 2004.

necessary in order to “make it happen.”

Although a stutter or lock was a primary feature for each performer, they also had other unusual difficulties. Two experienced tremor like the trumpet player above, especially in the low range. Two expressed a loss of a feeling of comfort with the mouthpiece, one described this as a loss of kinesthesia. All four suffered an accompanying physical constriction, loss of air flow, and tightening of the tone or loss of resonance.

These four performers share the following features with other cases:

- Severe decline in ability to articulate, coordinate, or focus at moment of articulation
- Symptoms resistant to traditional practice
- Onset at or near changes to instrumental tone (low harmonics, valve register)
- Emotional/psychological stress from condition is notable

SYNDROME

The two summaries above help to describe embouchure dystonia as a painless, involuntary muscular dysfunction with a characteristic onset. What follows are characteristics and timeline of embouchure dystonia as described by conversations with dystonic performers, interviews of teachers involved in retraining, and a review of published works.

Symptoms of Embouchure Dystonia

In November of 2007, Joaquín Fabra electronically published a list of symptoms associated with embouchure dystonia in Spain.²⁹ Fabra is geographically separated from dystonia research in the United States and the many published articles from the *Performing Arts Medicine Association* on embouchure dystonia and other dysfunctions (1986-present). Despite, his list reflects the physical and mental conditions discussed by dystonic performers and researchers in North America, Australia, Great Britain, Switzerland, Japan, and Italy.^{30,31} The following outline includes those symptoms of embouchure dystonia repeatedly found in interviews by the author, Fabra's list, and published works.

29 Fabra, 2007.

30 Interview with Ian Perry, 2008.

31 David Scragg, “Focal Dystonia: A discussion featuring Denis Wick, Bob Hughes, & Andy Berryman”; electronic recording available from <http://globalbones.net/schedule.php>; Internet, 9 December 2007.

Articulation Symptoms

- The tongue gets stuck to the palate, glottis impedes flow of air (sometimes called Valsalva maneuver, stutter, lock, hesitation, etc.)
- Tonguing becomes dull, heavy; may be uncontrollably slow or late

Embouchure Symptoms

- lips have no comfortable position on the mouthpiece; loss of kinesthesia
- lips hit the mouthpiece involuntarily, causing pain
- embouchure muscles function involuntarily, creating wry faces or consistent pitch errors
- tremor in embouchure and/or tone
- inability to center pitches (may begin at or around natural breaks, then spread)
- tension in face, mouth, throat, etc.

Respiratory Symptoms

- Difficulty in breathing or in sustaining
- Sensation of respiratory anguish and chest tightness

Other Symptoms

- physical and mental exhaustion shortly after starting playing
- loss or deterioration of mental clarity or ability to think in musical terms when playing
- psychological/emotional feelings of impotence, anguish, obsession, confusion, anxiety
- imbalanced or strong high register in contrast to middle or low register
- severe or uncontrollable miscoordination of tongue, air, and/or embouchure

Onset Details, Practice Resistance

For brass players, symptoms may begin with unusual inflexibility, difficulty centering the tone, or difficulty in articulation. “Unusual” means that these conditions show resistance to traditional practice over the span of weeks or months, and that technical or musical causes and cures cannot be found. The affected pitches vary at first, but may be inclined to lie on natural breaks between upper, middle, and lower ranges. The embouchure normally lacks resonance at range breaks, but balanced practice normally leads to ease in playing across them.^{32,33}

Trombonist and pedagogue Sam Burtis (freelance performer on multiple brass, New York, NY) has pointed out that some challenges can be caused by relatively simple technical deficiencies and therefore solved by traditional practice.³⁴ For these cases, Burtis emphasizes the importance of focusing on accurate time when practicing, as poor timing or coordination may generate all of the symptoms above. Poor time can be acquired by both performance environment and neglect, but the results are similar. Conveniently, Burtis's advice aligns with research models that describe how can rhythm help

32 Thompson, 2001: 8.

33 Sam Burtis, interview by the author, 7 January 2008, telephone interview and electronic recording.

34 Ibid.

optimize motor coordination in scenarios of neurological dysfunction or damage.³⁵

Brenda Smith and Robert Sataloff have emphasized the long-term risk created by poor breathing technique in vocal and wind musicians.³⁶ Damage can follow improper technique, so they encourage considering technical causes first for any performer dysfunction.

Unfortunately, embouchure dystonia is marked by poor practice results. Andy Berryman (solo trombone, Halle Symphony Orchestra; diagnosed and performs with dystonia) and Bob Hughes (London Symphony Orchestra, retired; diagnosed) both described how they developed symptoms which were resistant to practice.³⁷ Instead of being a means of improvement, effort caused the deterioration and spread of these imperfections to other ranges. Within months, this left Hughes with a musical range less than an octave.^{38,39} For a performer with a position with a major symphony orchestra, this is an uncommonly extreme change in ability. Each interview conducted by the author and most of those in the literature described similar progressions from limited difficulties to a severe disorder across many pitches, dynamics, and tempi.

Triggers, Predisposition

In 1991, Brandfonbrener stated that “We have seen a variety of abnormal patterns and involuntary movements and indeed have been more struck by the differences among various patients than by their similarities.”⁴⁰ Her description applies also to analyses of triggers and predisposing factors for embouchure dystonia, but the roles of injury and emotional or psychological trauma are often mentioned.

Two positions exist on the role of injury. Some specialists state that injury clearly causes some embouchure dystonias, especially dependent upon the location of trauma.^{41,42,43} Others take the opposite stance, arguing that injury does not precede enough cases for this to be a significant factor.⁴⁴ Jan

35 Michael Thaut, *Rhythm, Music, and the Brain: Scientific Foundations and Clinical Applications* (New York: Routledge, 2005): 92-93.

36 Brenda Smith and Robert Thayer Sataloff, *Choral Pedagogy* (San Diego, California: Singular Publishing Group, 2000): 64.

37 Scragg, 2007.

38 Ibid.

39 Interview with Jan Kagarice, 2007.

40 Sataloff et al., 1991: 194.

41 Vanessa K. Lim, Eckart Altenmüller, and John L. Bradshaw, “Focal Dystonia: Current Theories,” *Human Movement Science* 20, no. 6 (December 2001): 897.

42 C. Sankhla, E. C. Lai, and J. Jankovic, “Peripherally Induced Oromandibular Dystonia,” *Journal of Neurology Neurosurgery and Psychiatry* 65 (1998): 722.

43 Frucht et al., 2000: 348.

44 James Howard and Anthony Lovrovich, “Wind Instruments: Their Interplay with Orofacial Structures,” *Medical Problems of Performing Artists* 4, no. 2 (June 1989): 64.

Kagarice, a trombonist who has become well-known for assisting injured performers, believes that a trauma physically detached from the embouchure may still incite a dystonia.⁴⁵ She warns that mental distraction incites change, a view supported by research. Physical injuries are especially destructive to a musician's mental well-being compared to injuries and mental balance in the general population.⁴⁶

Kagarice, virtuoso performer David Vining, and others have also focused on emotional trauma as a primary factor inciting or aggravating embouchure dystonia.^{47,48,49,50} This is an important argument in support of the hypothesis of amateur trombonist and professional psychotherapist David Scragg.⁵¹ Scragg believes psychological factors are more significant than stated in the literature, and that hardiness, perfectionism, and learning experiences may all place significant stress on performers early in their lives. Hardiness in particular has been suggested to be higher in musicians than the general public, but this trait has not been analyzed in dystonic performers.⁵² To check his ideas, Scragg has plans for a long-term, international inquiry into the histories of a large population of performers with embouchure dystonia.

Other performance instructors show a stance similar to Scragg and Kagarice. Trombonist Philip Brink (University of Mahidol, Thailand) warned that over-emphasis of an otherwise simple challenge may incite an emotional response that prevents musical progress.⁵³ Joaquín Fabra, who has a similar role in Spain as Kagarice does in Texas, echoes Brink's admonition that playing all playing challenges should be taken as 'information for practice,' not medical warning signs.^{54,55}

Aside from injury and psychological stress, publications on embouchure dystonia have mentioned other possible risks. Brandfonbrener noted that a change in technique preceded onset of dystonia in enough of her patients to be noticeable (~14%).⁵⁶ On the opposite side, changes of

45 Interview with Jan Kagarice, 2007.

46 Camille Marguerite Sanders, "Understanding the Effects of Injury on a Musician's Identity and Self-Concept" (M. S. thesis, Rush University College of Nursing, 1998).

47 David Vining, interview by the author, 7 & 14 March 2007, telephone interview and electronic notes.

48 Interview with Jan Kagarice, 2007.

49 Hans-Christian Jabusch, Henning Vauth, and Eckart Altenmüller, "Anxiety as an Aggravating Factor during onset of Focal Dystonia in Musicians," *Medical Problem of Performing Artists* 19, no. 2 (June 2004): 75.

50 Barbara L. Sand, "Man for All Seasons," *Strad* 114, no. 1354 (February 2003): 132.

51 David Scragg, interview by author, 23 January 2008, telephone interview and electronic recording.

52 Kenneth G. Lombart, Gail Berenson, Paul Salmon, and Cheryl Powell Shook, "Performance Impairments, Injuries, and Stress Hardiness in a Sample of Keyboard and Other Instrumentalists," *Medical Problems of Performing Artists* 10, no. 4 (December 1995): 142.

53 Philip Brink, interview by author, 6 January 2008, telephone interview and electronic recording.

54 Ibid.

55 Fabra, 2007.

56 Brandfonbrener, 1995.

technique and equipment have been used as starting points for rehabilitation.⁵⁷ Repetitive stress and prolonged stereotypical movements have also been considered, but these are present in a much larger population of musicians than just those who develop dystonia.⁵⁸

Decline or Spontaneous Recovery

The negative affect of practice is a fairly universal experience in embouchure dystonia. Trombone pedagogue and retired British performer Denis Wick insisted that individuals who begin developing symptoms should immediately stop practicing rather than incite further damage.⁵⁹ Unfortunately, rest is not a solution in itself, and only seems to delay further decline.⁶⁰ In contrast, nineteenth-century doctors suggested catching writer's cramp early increased the chances of successful retraining.⁶¹ These two dystonias have dividing features, but it is hopeful to consider treatment following early diagnosis.⁶²

The majority of performer accounts describe how a player with a musical challenge proceeds at first as if difficulties arise from under-practice. This is an expected response; musical product is closely related to practice time.⁶³ Those that do consider overuse or other causes most often try rest and find it neutral or destructive.^{64,65,66} Practicing inevitably resumes and the situation declines.

Dystonic performers sometimes spend months or years practicing, researching, and learning more about their condition before discovering dystonia research. As one of the major European dystonia researchers, Eckart Altenmüller has examined individuals who had symptoms for between a month and 28 years.⁶⁷ Some performers are in a professional position where discussion is not supported

57 Frucht, 1999.

58 Raoul Tubiana, "Prolonged Neuromuscular Rehabilitation for Musician's Focal Dystonia," *Medical Problems of Performing Artists* 18, no. 4 (December 2003): 166.

59 Scragg, 2007.

60 Interview with Anonymous 1, 2007.

61 Sataloff et al., 1991: 197-198.

62 Karen Rosenkranz, Aaron Williamson, et al., "Pathophysiological difference between musician's dystonia and writer's cramp," *Brain* 128, no. 4 (2005): 928-929.

63 Lutz Jancke, "The motor representation in pianists and string players," in Eckart Altenmüller et al., eds. *Music, Motor Control, and the Brain*. (Oxford: Oxford University Press, 2006), 153.

64 Scragg, 2007.

65 Interview with Anonymous 1, 2007.

66 Anonymous 2 (violin), interview by author, 19 January 2008, Melbourne, Australia, electronic recording and video.

67 Hans-Christian Jabusch and Eckart Altenmüller, "Epidemiology, phenomenology, and therapy of musician's cramp," in Eckart Altenmüller, Jürg Kesselring, and Mario Wiesendanger, eds. *Music, Motor Control, and the Brain* (Oxford: Oxford University Press, 2006): 266.

by colleagues or the community, making individual research and investigation slow or impossible.^{68,69,70,71} Some report to uninformed specialists and receive mis-diagnosis as other disorders.⁷² The most fortunate few spend only weeks or months before finding a diagnosis of dystonia.^{73,74}

One interesting subset of embouchure dystonia is unmentioned in the medical literature. Bob Hughes mentioned that Altenmüller has observed 'spontaneous' recoveries of embouchure dystonia.⁷⁵ The author believes it is likely they include mild forms of 'lock' seen by brass teachers, some of which can resolve within as little as seven to fourteen days after onset.⁷⁶ The lack of professional documentation and details for spontaneous recoveries is not a sign that they do not occur, but rather that they may have been missed or dismissed as an unrelated phenomenon. These warrant focused discussion, as research may help decipher what behaviors or conditions make these spontaneous recovery possible.

DEFINING DYSTONIA

Despite twenty-five years of increasing attention and research, embouchure dystonia remains ambiguous to both musical and medical specialists. All involved suffer because the term 'dystonia' is ambiguous.⁷⁷ Dystonia “may imply three different meanings: (1) a physical sign; (2) a syndrome of sustained muscle contractions, causing twisting and repetitive movements and abnormal postures; [or] (3) the disease 'idiopathic (or primary) dystonia.’”⁷⁸ To further complicate matters, other names have been applied (often erroneously) to what is now called musician's dystonia: cramps, tics, palsies, stutter, and other labels according to geography, language, occupation, and otherwise random details.⁷⁹ The variety in terminology obstructs both the medical and musical communities.

To clarify, the embouchure dystonia which affects musicians is a condition defined by its

68 Scragg, 2007.

69 Interview with Ian Perry, 2008.

70 Interview with Newell Sheridan, 2007.

71 Interview with Anonymous 1, 2008.

72 Lisle Merriman, Jonathan Newmark, et al. “A Focal Movement Disorder of the Hand in Six Pianists.” *Medical Problems of Performing Artists* 1, no. 1 (March 1986): 18.

73 Ibid.

74 Jabusch and Altenmüller, 2006: 266.

75 Scragg, 2007.

76 Interview with Philip Brink, 2008.

77 C. Klein, “Movement Disorders: Classifications,” *Journal of Inherited Metabolic Disorders* 28 (2005): 426.

78 Ibid.

79 Thomas, 2008.

'physical signs', a normally painless muscular dysfunction grouped together with similar conditions.

Naming Conventions

The dysfunctions similar to embouchure dystonia are divided into some thirteen specific types according to their location, severity, and cause.⁸⁰ Focal dystonias, like embouchure dystonia, affect a limited area or location of the body and are identified with that body location (i.e. hand dystonia, embouchure dystonia, foot dystonia, etc.). Generalized dystonias occur over a large group of muscles or area of the body (lateral, cervical, etc.). A dystonia associated with a particular activity is labeled as "task specific" and then identified with that task: an individual with writer's cramp suffers when writing, golfer's yips affect the putting swing of a small number of athletes, and telegrapher's cramp affects the tapping hand.^{81,82} 'Musician's cramp' is one of these task-specific dystonias, and it strikes only when holding or playing an instrument.^{83,84} Age of onset allows categorization into early- and late-onset categories.⁸⁵

Dystonias can also be grossly categorized into two groups according to their root cause.⁸⁶ Primary (also called sporadic) dystonias are characteristic motor dysfunctions which arise without a clear cause. Occupational dystonias such as embouchure dystonia and writer's cramp fall into this category of 'primary dystonias.' In these cases, standard clinical tests including MRI, CAT scans, and other diagnostic tests usually show no remarkable results. Secondary dystonias arise due to another, root cause. Possible sources include traumatic brain injury (TBI), Parkinson's Disease (PD), inherited genetic mutations, and other diseases. Dystonias can also be a side effect of neuroleptics (antipsychotic drugs), hypoglycemia, and other causes.^{87,88} Individuals with a secondary dystonia are sometimes at risk from other conditions and clinical tests are encouraged.⁸⁹

80 "What is Dystonia?"; available from http://www.dystonia-foundation.org/pages/what_is_dystonia_/26.php; Internet, accessed 1 October 2006.

81 Frucht et al., 2000: 348.

82 Robert Bell, "Pick it up, it's Good: Utilizing Solution-Focused Guided Imagery with Golfers Experiencing the Yips." (Ph. D. dissertation, University of Tennessee-Knoxville, 2006).

83 Frucht et al., 2000: 248.

84 Lisle Merriman, Jonathan Newmark, et al., "A Focal Movement Disorder of the Hand in Six Pianists" *Medical Problems of Performing Artists* (March 1986): 18.

85 Vanessa Lim, Eckart Altenmüller, John Bradshaw, "Focal Dystonia: Current Theories," *Human Movement Science* no 20 (2001): 876.

86 John Brust, ed., "Dystonia" in *Neurology: Current Diagnosis & Treatment* (New York: Lange/McGraw Hill, 2007), 215.

87 N. C. K. Tan, A. K. Y. Tan, Y. Y. Sitoh, K. C. Loh, M. K. S. Leow, and H. T. L. Tjia, "Paroxysmal Exercise-Induced Dystonia Associated with Hypoglycaemia Induced by an Insulinoma," *Journal of Neurology* 249 (2002): 1615.

88 Eric Molho and Stewart Factor, "Possible Tardive Dystonia Resulting from Clozapine Therapy," *Movement Disorders* 14 no. 5 (1999): 873.

89 Brust, 2007: 215.

Brust described the main-stream approach, but it is important to know that these classifications are unfortunately in flux. For example, Malfait and Sanger recently published an investigation that classifies dystonias in a manner that directly disagrees with those above.⁹⁰

Occupational Dystonias

Embouchure dystonia was grouped with other 'occupational dystonias' in the 1980's.⁹¹ These have also been called occupational palsies, occupational cramps or just cramps, are by definition both focal and task specific, and are associated with stereotypical motor activities.^{92,93} Occupations requiring repetitive, precise motor control are at primary risk: writers, musicians, telegraphers, typists.

It is notable that the site of an occupational dystonia does not depend upon handedness or intrinsic characteristics of the patient.⁹⁴ Instead, the location of symptoms is solely dependent upon the task involved. Pianists are therefore most likely to develop symptoms in their highly active right hand, violinists in the left hand, brass players in the embouchure, writers in the writing hand, and so on.

Occupational cramps can spread to similar motor functions in some cases, but they are most often confined to the original task.^{95,96} Some musicians call this spread of symptoms a 'jump' or 'jumping'.^{97,98} Statistical reviews have linked age of onset to spread of symptoms.⁹⁹

Bias, Prevalence

Jabusch and Altenmüller summarized dystonia's bias in their 2006 summary of musician's cramp.¹⁰⁰ Symptoms begin at a variety of ages (~ 14 to 65), but most individuals present to doctors in their 30s or 40s. After adjusting for occupational gender bias, musician's dystonias definitely affect more men than women. That aside, women are still at risk.¹⁰¹

Focal dystonia affects a much higher fraction of musicians than dystonic syndromes affect the

90 N. Malfait and T. D. Sanger, "Does Dystonia Always Include Co-Contraction? A Study of Unconstrained Reaching in Children with Primary and Secondary Dystonia," *Experimental Brain Research* 176 (2007): 206.

91 Richard Lederman and Leonard Calabrese, "Overuse Syndromes in Instrumentalists," *Medical Problems of Performing Artists* 1, no. 1 (March 1986): 9.

92 Ibid.

93 Sataloff et al., 1991.

94 Lim et al., 2001: 879.

95 Frucht et al., 2000: 348.

96 Lederman and Calabrese, 1986: 9.

97 Interview with Don Kneeburg, 2007.

98 Interview with Anonymous 1, 2007.

99 Lim et al., 2001: 876.

100 Jabusch and Altenmüller, 2006: 265-268.

101 Kristen Waligora, interview by author, 5 January 2008, telephone interview and electronic recording.

general population: 1-2% musicians vs 0.1-0.15% in the general population (100 to 150 cases per million people).^{102,103} This unusually high prevalence has made musicians with dystonia important subjects for research.

All musicians with dystonia engage in repetitive and precise motions.¹⁰⁴ Focused practice may cause maladaptive changes that are explained by a neurological model of musician's dystonia.

Neuroplasticity as Risk

Neuroplasticity is the brain's ability to optimize itself by changing, reassigning, or creating new neuronal connections over a large-area.¹⁰⁵ This growth is guided largely by experience and how the brain perceives the usefulness of an activity. More than just simple learning, these alterations are significant and measurable physical changes. Lifelong musical practice increases cortical grey matter in specific areas, guiding structural changes that support perception, facilitate motor function, and help integrate multi-sensory input (visual, aural, and tactile).¹⁰⁶ Neuroplasticity allows the brain that plays music to be physically changed by it.^{107,108}

Brain malleability is particularly important to musician's dystonia theories because brain scans have connected unusual neuroplastic changes to musician's hand dystonia and writer's cramp (*Illustration 1*).^{109,110,111} This connection has influenced many areas of rehabilitation and training research. It also suggests that dystonic symptoms may be unlearned by the same behaviors with which they are created.¹¹²

Aside from explaining onset and possible rehabilitation, neuroplasticity helps explain the age

102 Jabusch and Altenmüller, 2006: 265.

103 T. T. Warner, "A Prevalence Study of Primary Dystonia in Eight European Countries," *Journal of Neurology* 247 (2000): 787.

104 Sataloff et al., 1991: 197.

105 O. A. Shavlovskaya, "Plasticity of Cortical Structures Under the Conditions of Neurological Deficit Accompanied by a Disorder of Hand Movement: Modern Approaches to Rehabilitation," *Human Physiology* 32, no. 6: 735.

106 Gottfried Schlaug, "Brain Structures of Musicians: Executive Functions and Morphological Implications," in Eckart Altenmüller, Jürg Kesselring, and Mario Wiesendanger, eds. *Music, Motor Control, and the Brain*. (Oxford: Oxford University Press, 2006): 142.

107 Alvaro Pascual-Leone, "The Brain that Plays Music and is Changed by It," *Annals of the New York Academy of Sciences* 930 (June 2001): 315.

108 Thomas F. Munte, Eckart Altenmüller, and Lutz Jancke, "The Musician's Brain as a Model of Neuroplasticity," *Neuroscience* 3 (June 2002): 474.

109 Munte, Altenmüller, and Jancke, 2002: 476.

110 Nancy N. Byl, S. Nagarajan, and A. L. McKenzie, "Effect of Sensorimotor Training on Structure and Function in Three Patients with Focal Hand Dystonia" *Society for Neuroscience Abstracts* (2000).

111 Karen Rosenkranz, Aaron Williamon, et al., "Pathophysiological Differences Between Musician's Dystonia and Writer's Cramp," *Brain* 128 (2005): 919.

112 Jabusch & Altenmüller, 2006: 280.

and occupation bias in dystonia populations. Musical brains become more plastic with age, letting them adapt quickly to new motor tasks.¹¹³ Completely unrelated, musicians spend long hours engaging in focused, rhythmic motor practices that catalyze neuroplastic changes.¹¹⁴ Over time, this combination of heightened response and continual, rhythmic input normally leads to musical proficiency. It also puts musicians at a higher risk of maladaptive changes that cause motor dysfunction.

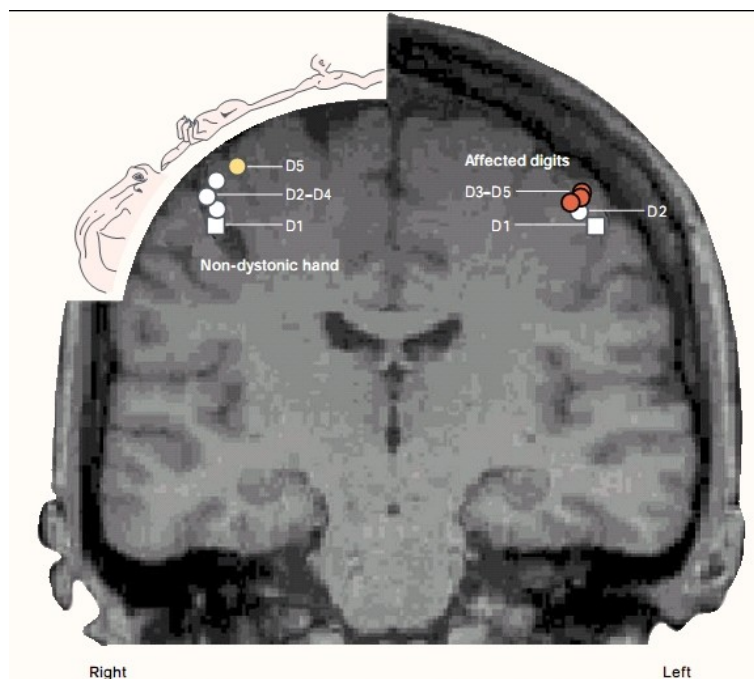


Figure 4 | Fusion of the somatosensory representation of single digits of the hand in a musician suffering from focal dystonia. The best-fitting dipoles to explain the evoked magnetic fields after sensory stimulation of single digits (D1–D5) are shown projected on the individual's magnetic resonance imaging scan. Whereas for the non-affected hand, the typical homuncular organization (inset) reveals a distance of ~2.5 cm between the sources for the thumb and the little finger (yellow circle and square on the right of the brain), the somatosensory representations of the fingers on the dystonic side are blurred, resulting from a fusion of the neural networks that process incoming sensory stimuli from different fingers (red circles). Modified, with permission, from REF. 13 © 1998 Lippincott, Williams and Wilkins.

Illustration 3: Neuroplastic response leads to irregular finger maps in a musician with hand dystonia

SIGNIFICANCE

In practical terms, the 1% prevalence of musician's dystonia equates to about one musician in each major symphony orchestra, or a handful of performers per four-year cycle at a large music institution. Conservative estimates suggest half of these will retire from performing.¹¹⁵ In reality, it is

113 Karen Rosenkranz, Aaron Williamson, and John Rothwell, "Motorcortical Excitability and Synaptic Plasticity is Enhanced in Professional Musicians," *The Journal of Neuroscience* 27, no 19 (9 May 2007): 5203.

114 Thaut, 2003: 79.

115 Stephan Schuele and Richard J. Lederman, "Focal Dystonia in Woodwind Instrumentalists: Long-term Outcome,"

difficult to determine exactly how many musicians are affected by or stop performing due to dystonia. Surveys of music professionals also have problems accounting for individuals who no longer perform because of a disability.¹¹⁶ Prevalence and statistical studies amongst clinical practitioners reflect those cases presenting to medical doctors, but not all cases seek help or become reported.¹¹⁷

The available case studies and experiments are largely dedicated to violinists, guitarists, and pianists with hand dysfunctions. Embouchure dystonias are next in prominence, while other musical dystonias receive negligible coverage (throat, voice, etc.). Statistically, hand dystonia does appear more than embouchure dystonia, but this may be due to the high population of professional string and piano instrumentalists.¹¹⁸ Hand dystonias are also attractive for practical reasons: hand symptoms occur in both musicians and non-musicians (allowing experimental controls), the hand has large physical sites for electronic and visual observation, and hand therapy already has a wide theoretical background.

PROFESSIONAL LIMITS

TREATMENT AND RETRAINING

Musicians are skilled movement specialists, both efficient and effective with their body use.¹¹⁹ Instrumentalists do learn as much as possible in order to understand and prevent personal injury, but they have limited ability to help themselves through a medical difficulty. Unfortunately, professional medical diagnosis and treatment of musician's dystonias did not significantly change during the twentieth century.¹²⁰ Lack of research and poor treatment efficacy justified the pragmatic approach taken by neurologists: performers with symptoms are currently encouraged to change occupations to a

Medical Problems of Performing Artists 18, no. 1 (March 2003): 15.

116 James Howard and Anthony Lovrovich, "Wind Instruments: Their Interplay with Orofacial Structures," *Medical Problems of Performing Artists* (June 1989): 70.

117 Lim et al., 2001: 877.

118 Jabusch and Altenmüller, 2006: 266.

119 Mary Spire, "The Feldenkrais Method: An Interview with Anat Baniel," *Medical Problems of Performing Artists* (December 1989): 160.

120 Sataloff et al., 1991: 197-198.

closely-related non-performance area, or to pursue alternative professional training.^{121,122,123,124}

Small-sample retraining trials have provided recoveries of hand dystonia and return to performance work.¹²⁵ However, musicians should be warned that a dystonia 'recovery' does not always mean a return to performance or the restoration of pre-affliction ability. The medical community has wide standards for the terms 'recovery' and 'successful.' A significant reduction in symptoms (frequency or amplitude) is medically successful, whether or not it may meet musical standards.¹²⁶ It should be understood that a medically acceptable improvement in symptoms is sometimes unacceptable for professional performance. Any musician returning to work in performance is certainly a success on both sides, but this seems especially uncommon in embouchure dystonia.^{127,128,129}

In 1991, The *Textbook of Performing Arts Medicine* described dystonia as the 'least understood and most difficult to treat' musician's disorder.¹³⁰ Almost two decades later, it is agreed to have many neurological, psychological, and behavioral components. The above discussion of focal dystonia as a maladaptive neuroplastic response is certainly relevant and expresses the clearest model of dystonia to date. It is also, however, simplistic. Embouchure and hand dystonias show unique neurological deficiencies in intracortical inhibition (ICI), sensory inhibition, motor timing, and a variety of other areas.¹³¹ Because the situation is complex, each concern is under exploration by specialized teams.

This complexity may be why Kagarice is concerned that little can be done by the musician's community to address this affliction.¹³² A complete retrainer would have qualifications in psychological, emotional, neurological, physical, and musical areas. Kagarice insists that, rather than mis-serving the afflicted, teachers and doctors must recognize their own limitations and pursue specialist attention wherever it is available. Not doing so overburdens those involved and reduces the likelihood of finding lasting solutions.

To further interdisciplinary discussion, Richard Lederman attempted to encourage behavioral research of musician's 'occupational cramp' two decades ago.¹³³ Not long after, he and his colleagues

121 Frucht et al., 2000: 350.

122 Interview with Ian Perry, 2008.

123 Interview with Newell Sheridan, 2007.

124 Jabusch and Altenmüller, 2006: 279.

125 Byl, Nagarajan, and McKenzie, 2000.

126 Sataloff et al., 1991: 198.

127 Scragg, 2007.

128 Interview with Stefan Sanders, 2007.

129 Jabusch and Altenmüller, 2006: 277.

130 Sataloff et al., 1991: 193.

131 Lim et al., 2001: 879-897.

132 Interview with Jan Kagarice, 2007.

133 Richard Lederman, "Occupational Cramp in Instrumental Musicians," *Medical Problems of Performing Artists* 3, no. 2

described how awareness and understanding between medical and musical professionals had increased between the late 1970's and 1991.¹³⁴ Despite this positive view, however, focal dystonia discussion is a rare topic for music publications. Jabusch and Altenmüller repeated Lederman's request for behavioral research in 2006, stating that "behavioral therapies and interdisciplinary strategies ... are promising, but the different approaches need to be evaluated ... "future research is required to identify 'beneficial behavior' on the instrument. This might, possibly, also be of help for finding strategies with the particular aim of prevention of musician's dystonia."¹³⁵

Four approaches to pedagogical or behavioral treatment follow, representing four views on the course of embouchure dystonia and retraining.

David Vining – Perfect Repetition

American virtuoso trombonist David Vining believes that his role in speaking about retraining is "to show people that there is hope."¹³⁶ Successful treatment efforts need attention. On the other hand, Vining warns that musicians must be careful "first and foremost, to do no harm." Practical and technical anecdotes must be carefully investigated. "Every [dystonic experience] is really singular," and to suppose otherwise is shortsighted. For a musician "to try and treat people or to offer advice ... is a bit ridiculous."

Vining experienced dystonia first hand starting in the summer of 2000. During a performance, he generated a lock or embouchure spasm that escalated into a loss of kinesthesia. Within three months, the condition had spread through a wide pitch range, making performance extremely demanding, uncomfortable, and distressing. Although he feels that "it never completely shut me down," he remembers he "had no control over [his] chops." Vining sought advice from peers and medical specialists for two years. He found Steven Frucht and then a diagnosis from Richard Lederman in May 2002.

Personal research and an article by Barbara Conable later led him to consider Body Mapping as a way to learn more about both his body use and how it may be used to better his existing abilities. By the time of interview (March 2007), Vining was symptom-free. He attributed some of his retraining success to the understanding and flexibility he gained through studying Body Mapping. He believes that studying movement therapy and understanding good body use also helped him solidify the

(June 1988): 50.

134 Sataloff et al., 1991: 201.

135 Jabusch and Altenmüller, 2006: 280.

136 Interview with David Vining, 2007.

invaluable treatment advice he received from Jan Kagarice.

In retrospect, Vining asserts the research models when he discusses the experience of embouchure dystonia: "We're dealing with neuroplasticity." In the face of involuntary motions or 'tongue lock,' Vining's practice required a supreme, dedicated effort: thousands of perfect repetitions over months of practice. For Vining, careful and patient practice returned his performance skills.

Brain scans have suggested that neuroplastic changes may begin in as little as 20 minutes of repetitive activity.¹³⁷ The short-onset view of neuroplastic responses lends support to the suggestion that disruptive symptoms may not appear immediately, and instead develop various degrees of severity over time.^{138,139} It also supports the idea that Vining's approach, over time, may gradually help restore specific types of motor function over time.

Jan Kagarice – Holistic Process

Kagarice feels that a thorough understanding of each performer's case history significantly helps her provide effective care. Since Kagarice is not a medical specialist, she begins with a thorough survey of musical and professional histories before moving on to emotional and physical considerations. Her thorough method sometimes uncovers details that have been dismissed.

Emotional and physical trauma are still significant factors in many cases. Traumas affecting performance ability can come from as early as birth, they may have been ignored as inconsequential, or they could be fully unconscious. A trigger also does not have to occur at the site of performance difficulty, as Kagarice believes that any change in mental focus can be detrimental. Over time, any condition which significantly distracts a performer is sufficient to change the effects of practice in the long-term.

The most difficult cases are those that require a review of the performer's medical history. In these situations, a root cause may be difficult or impossible to address by musical methods. Kagarice asserts that she and other musicians must be honest with their own limitations as performers, and she asserts that "we are not medical or psychological specialists." If there is a physical or mental imbalance, performers must be referred to a specialist. Kagarice has not become successful for addressing neurological dysfunctions per se, but rather her emphasis on ease and letting the body play the instrument as naturally as possible.

137 Heidi Haavik Taylor and B. A. Murphy, "Altered Cortical Integration of Dual Somatosensory Input Following the Cessation of a 20 min Period of Repetitive Muscle Activity," *Experimental Brain Research* 178, no. 4 (April 2007): 488.

138 Scragg, 2007.

139 Fabra, 2007.

Kevin Roberts is one performer who has visited Kagarice in Texas to seek her advice.¹⁴⁰ Roberts is a graduate of the Curtis Institute, a student of Norm Bolter and other established professional trombonists on the US east coast. By the age of 17, he was substituting for his teacher in the Boston Symphony. He won a Chilean orchestral position in 1992, and spent fifteen years in South America as a professional symphonic trombonist. He gradually developed an embouchure dystonia in the early years of 2000 and returned to the USA to seek assistance in 2007.

Roberts described some of his week-long study with Kagarice in a conversation with the author. First, he was especially adamant that he must not to allow himself to ingrain negative emotional responses during practice. Second, he asserted that performers must stay aware of both emotional and physical excess during practice. One could do "something that was slightly uncomfortable, working into a range that was uncomfortable. There's nothing comfortable about that." In short, discomfort is a warning sign that should not be ignored. Finally, Roberts had to gradually restore a belief that technique happens with little effort. With the instrument, "you have to let [the music happen]. It's not that you have to get out the way, you have to let it."

Roberts walked the author through three exercises that Kagarice provided to help his particular case. These exercises focused on blowing, ease, and focusing attention on sound product with little effort to control the embouchure. These concepts are not new, but they were presented in a verbal style that is difficult to capture on paper. It seems that Kagarice shares a quality attributed to pedagogue Carmine Caruso: "It was Carmine's approach that did the real work, and it can hardly be put into words, let alone written down."¹⁴¹ Kagarice's routines might be helpful on their own, but they require her delivery and understanding. She achieves results not through exercises but through her complete method: thorough investigation, consideration of many complications, the language and mode delivery, and a focus on discrete problems with achievable solutions.

Philip Brink, Troy Marsh – Unemotional Simplicity

Trombone Professors Philip Brink (University of Mahidol, Thailand) and Dr. Troy Marsh (University of Missouri-Columbia, ret.) had contrasting experiences with students who developed dystonia-like symptoms.^{142,143} Each professor has seen students experience a tongue lock or stutter with

140 Kevin Roberts, interview by author, 13 February 2007, Austin, Texas, electronic notes.

141 Sam Burtis, "Letters from New York: The Carmine Caruso Method"; available from <http://www.trombone.org/articles/library/letters-caruso.asp>; Internet, accessed 12 December 2007.

142 Troy Marsh, interview by author, 8 January 2008, telephone interview with electronic recording.

143 Interview with Philip Brink, 2008.

different degrees of long-term retraining success. Neither teacher could recall giving advice that was outside of the traditional brass player's repertoire. Each encouraged their students to reduce tension, restore ease to breathing and articulation, and take an unemotional approach to practice.

These professors both felt that mental or emotional reactions had a significant influence on whether or not long-term practice led to a decline in skills, observations in agreement with Vining, Fabra, and others. Kagarice's distraction theory certainly agrees. Research by Dolcos and McCarthy shows that emotional processing does interfere with cognitive functions, especially working memory.¹⁴⁴ Lim et al. traced a similar path for musician's dystonia, showing that emotional brain activity decreases neuroplastic response and increases resistance to chemical and behavioral treatments.¹⁴⁵

Byl et al., Candia et al., McKenzie – Medical approaches

Professional medical researchers have made significant gains in addressing musician's hand dystonias. This condition appears mostly in pianists, violinists, and guitarists, but many other instrumentalists are affected.

Previously, some cases have been aided by chemical and non-behavioral treatment attempts. Botulinum toxin (botox) injections provide relief for a small fraction of patients, but the side effects of this treatment makes it unsustainable for embouchure dystonia.^{146,147,148} Lim has noted that Arcatane is helpful in some dystonias, but this has proven ineffective for embouchure dystonia.^{149,150} Denis Wick expressed doubt that brain surgery treatments would be accessible in the foreseeable future.¹⁵¹ Curiously, invasive brain surgery and deep brain stimulation has helped restore some function in severe dystonias, but this is not a justifiable treatment for occupational dystonias.¹⁵²

Interdisciplinary treatments of hand dystonia have shown greater success than the more singular chemical approaches. One experiment restored 85-98% improvement on specific motor tasks, but only on a small group of three patients.¹⁵³ Another was effective enough that eleven of twelve hand dystonia

144 Florin Dolcos and Gregory McCarthy, "Brain Systems Mediating Cognitive Interference by Emotional Distraction," *The Journal of Neuroscience* 26, no. 7 (15 February 2006): 2072.

145 Lim et al., 2001: 902-903.

146 Ibid., 897-898.

147 Interview with Don Kneeburg, 2007.

148 Jabusch and Altenmüller, 2006: 275-276.

149 Lim et al., 2001: 897.

150 Jabusch and Altenmüller, 2006: 274.

151 Scragg, 2007.

152 Matthew Hebb, Paula Chiasson, Anthony Lang, Robert Brownstone, and Ivan Mendez, "Sustained Relief of Dystonia Following Cessation of Deep Brain Stimulation," *Movement Disorders* 22 no. 13 (2007): 1958.

153 Byl, Nagarajan, and McKenzie, 2000.

subjects returned to work (occupations not defined).¹⁵⁴ Rehabilitation for each trial consisted of "supervised therapy 1-2x/week, complemented with an intensive home program integrating sensorimotor activities with general fitness, stress free hand use, breathing, and posture exercises." The results from the first study in particular are hopeful because they let two musicians with dystonia return to performing. Reports on this and other successful medical trials have emphasized the significant cortical changes which occur as a result of rehabilitation.^{155,156}

Victor Candia has been able to rehabilitate some patients using novel motion constraints and exercises.^{157,158} Treatment focuses primarily on avoiding compensation and 'learned nonuse,' conditions which arise due to reassignment of tasks to non-dystonic muscles.¹⁵⁹ Scarlate and company repeated Candia's experiment with slight variations in 2001, achieving similar results.¹⁶⁰ These efforts show promise for dystonias that affect large muscles and limbs, but constraint-induced motion therapy in the hand does not have a parallel for the embouchure.

PEDAGOGY AND THE THERAPY MODEL

Vining asserts that "we're dealing with neuroplasticity," and Kagarice emphasizes the importance of attention.^{161,162} Rosenkranz's research suggests that practice increases the musician's malleability over time.¹⁶³ How these are all related, however, is not been well-defined. There has not been a published attempt to link pedagogical retraining techniques to the dystonia models of how dystonia develops.

Rhythm and attention are important concerns in the therapeutic application of music.¹⁶⁴

154 Nancy N Byl and A. McKenzie, "Treatment Effectiveness for Patients with a History of Repetitive Hand Use and a Focal Hand Dystonia," *Journal of Hand Therapy* 13, no. 4 (October 2000): 289.

155 Byl, Nagarajan, and McKenzie, 2000.

156 Victor Candia, Christian Wienbruch, Thomas Elbert, Brigitte Rockstroh, and William Ray, "Effective behavioral treatment of focal hand dystonia in musicians alters somatosensory cortical organization," *Proceedings of the National Academy of Sciences of the United States of America* 100, no. 13 (24 June 2003): 7942.

157 Ibid.

158 Victor Candia, Thomas Elbert, Eckart Altenmüller, et al. "Alteration of Digital Representations in Somatosensory Movement Therapy for Focal Hand Dystonia in Musicians," *Lancet* 353, issue 9146 (2 January 1999): 42.

159 Jeffrey Schwartz and Sharon Begley, *The Mind and the Brain: Neuroplasticity and the Power of Mental Force* (New York: Harper Perennial: 2002), 142.

160 G. Scarlate, S. Barbieri, A. Priori, A. Pesenti, and A. Cappellari, "Limb Immobilization for the Treatment of Focal Occupational Dystonia," *Neurology* 57, no 3 (14 August 2001): 405.

161 Interview with David Vining, 2007.

162 Interview with Jan Kagarice, 2007.

163 Rosenkranz et al., 2007.

164 Thaut, 2003: 79.

Rhythmic constraints affect how the body executes simple motor tasks and complex cyclic activities like walking. Aligning a motion to a periodic auditory cue (such as a metronome) encourages the body to optimize how it moves the body parts involved (hands, fingers, etc.). In the past 15 years of experiments with stroke and Parkinson's patients, rhythmic constraints have been used to improve motor activity in many ways: decreasing variability of motor paths and muscular excitation, increasing synchronization, refining final placement of hands and legs, and increasing muscular modulation (smooth contraction and motion).^{165,166} Interestingly, Kagarice, Vining, Burtis, and others all share an emphasis on the importance of returning focus to a clear musical concept – including strict adherence to rhythm and time.

Music theorist Justin London discusses how external, rhythmic stimuli direct focus of attention.¹⁶⁷ Musical time engages listeners and performers because it is a specific form of entrainment:

The guiding hypothesis of this book is that meter is a particular kind of a more general behavior. The same processes by which we attend to the ticking of a clock, the footfalls of a colleague passing in the hallway, the gallop of a horse, or the drip of a faucet also are used when we listen to a Bach adagio, tap our toes to a Mozart overture, or dance to Duke Ellington. As such, meter is not fundamentally musical in its origin. Rather, meter is a musically particular form of entrainment or attunement, a synchronization of some aspect of our biological activity with regularly recurring events in the environment. Meter is more, however, than just a bottom-up, stimulus driven form of attending. Metric behaviors are also learned - they are rehearsed and practiced. For musical rhythms are often stereotypical, stylistically regular, and hence familiar. So we fit, so to speak, patterns of events in the world to patterns of time we have in our minds (and, as we will see, our bodies).

London is certainly not the first to describe the aesthetic value of predictability and expectation, but it is relevant that he links temporal predictability to an increased 'attending to.' Increased attention is what Jeffrey Schwartz encourages in order to instigate neuroplastic changes, and what Hodzic suggests may affect what kind of changes occur.^{168,169}

If one accepts the maladaptive neuroplasticity model described above, focus of attention (FOA)

165 O. A. Shavlovskaya, "Plasticity of Cortical Structures Under the Conditions of Neurological Deficit Accompanied by a Disorder of Hand Movement: Modern Approaches to Rehabilitation," *Human Physiology* 32, no. 6 (December 2006): 737.

166 Thaut, 2003: 110-112.

167 Justin London, *Hearing in Time: Psychological Aspects of Musical Meter* (Oxford: Oxford University Press, 2004): 4.

168 Schwartz, 2003: 86.

169 Amra Hodzic, Ralf Veit, Ahmed A Karim, Michael Erb, and Ben Godde, "Improvement and Decline in Tactile Discrimination Behavior after Cortical Plasticity Induced by Passive Tactile Coactivation," *The Journal of Neuroscience* 24, no. 2 (14 January 2004): 446.

during practice cannot be neglected. Schwartz argues that FOA significantly influences the quality and efficiency of neuroplasticity.¹⁷⁰ He presents a thorough case, emphasizing that "attention must be paid" if activities are going to guide cortical organization. Neuroplastic changes do in fact occur when an individual is distracted, but this leads to complications.¹⁷¹ When distracted, experimental subjects who receive a high volume of repetitive sensory input experience coincidental adaptive and maladaptive neuroplastic changes. Hodzic theorizes that these maladaptive changes are always possible and expected in the brain (where neural real estate is at a premium).¹⁷² Like Schwartz, Hodzic also suggests that attention may be one factor affecting how the brain adapts to input.

CONCLUSIONS

Especially in the last ten years, significant gains have been made in understanding how musician's dystonia affects musicians and the brain. Unfortunately, the musical population has not been kept completely informed on this and other advances in research. As well, performer experiences remain largely unavailable for review, and retraining efforts are seldom discussed. Despite these shortcomings, it has been possible to describe embouchure dystonia as a motor disorder that arises from a maladaptive neuroplastic response. Performer experiences show musical-technical features that may be easily identified by even average musicians, but the only promising treatments require an interdisciplinary approach.

The following outline summarizes five main areas which may contribute to a case of embouchure dystonia: overuse, faulty technique, psychological imbalance, other biological factors, and neurological factors. This list aims to direct future pedagogical discussion and behavioral research toward the specific challenges affecting musicians with embouchure dystonia.

170 Schwartz, 2003: 86.

171 Hodzic et al., 2004: 444-445.

172 Hodzic et al., 2004: 445.

1. Address Overuse

- rest from practice^{173,174}
- consider other daily uses (other physical work or activities)¹⁷⁵
- assess the practice routine (integrate rest, variety)^{176,177}
- keep & review a practice journal, practice notes, etc.
- diet, water, general sleep & rest habits

2. Address Technique

- blowing/air technique (a la Kagarice)¹⁷⁸
- embouchure technique (esp. addressing range breaks)¹⁷⁹
- time concept (oscillating or discrete) and entrainment for coordination^{180,181}
- mental focus^{182,183}

3. Address Psychological and Emotional Stress

- acquire professional assessment^{184,185,186,187}
- integrate activities for focusing, general mental & physical health¹⁸⁸
- seek guidance from individuals who have experienced similar performance difficulties¹⁸⁹

4. Address Other Factors

- search for genealogical/familial trends (predisposition)¹⁹⁰
- review medical history - physical injuries, pharmaceutical or drug usage, etc.¹⁹¹
- consider dietary, mineral, glycemic risks^{192,193}

173 Richard Norris, *A Guide to Preventing and Treating Injuries in Instrumentalists* (San Antonio, TX: International Conference of Symphony and Opera Musicians, 1993), 8.

174 Howard and Lovrovich, 1989: 70.

175 Norris, 1993: 9.

176 Ibid., 103-108.

177 Simon Overduin, Andrew Richardson, Courtney Lane, Emilio Bizzi, and Daniel Press, "Intermittent practice facilitates stable motor memories," *The Journal of Neuroscience* 26 no. 46 (15 November 2006): 11890-11891.

178 Interview with Jan Kagarice, 2007.

179 Thompson, 2001: 8.

180 Interview with Sam Burtis, 2008.

181 London, 2004: 20-21.

182 Hodzic et al., 2004: 445-446.

183 Schwartz, 2003.

184 Interview with Anonymous 2, 2008.

185 Interview with Stefan Sanders, 2007.

186 Interview with David Scragg, 2008.

187 Lim et al., 2001: 902-903.

188 Interview with Stefan Sanders, 2007.

189 Interview with David Vining, 2007.

190 Jabusch and Altenmüller, 2006: 266.

191 Mohlo and Factor, 1999.

192 Tan et al., 2000: 1615.

193 Alm, 2005.

5. Address Possible Neurological Changes

- do not reiterate activities that cause offending symptoms (avoid reinforcing habits)^{194,195,196}
- address complications or alternative causes of symptoms
- avoid compensation (alternative fingerings, equipment, etc.) as a long-term solution¹⁹⁷
- explore medical treatments that reduce symptoms or enhance neuroplastic response
- acquire pedagogical/musical guidance for practice methods and scheduling^{198,199}
- design and implement exercises that transition between existing skills and desired skills²⁰⁰

194 Interview with David Vining, 2007.

195 Interview with Kevin Roberts, 2007.

196 Scragg, 2007.

197 Mark C. Davis, "Fearless: Badi Assad tackles exotic music and fights a debilitating disease," *Guitar Player* (1 March 2006): 58.

198 Interview with David Vining, 2007.

199 Interview with Jan Kagarice, 2007.

200 Interview with David Vining, 2007.

BIBLIOGRAPHY

ARTICLES

Altenmüller, Eckart. "Causes and Cures of Focal Limb Dystonia in Musicians" in *Health and the Musician: Proceedings of the 1997 York Conference (BAPA)*, Scott, R., and J. Black, eds. London: BAPA Publications, 1998.

_____. "Causes et Traitements de la Dystonie de Fonction chez les Musiciens: Une Etude sur 5 Ans (Causes and Treatments of Focal Limb Dystonia in Musicians: A 5-year Study)." *Medecine des Arts: Approche Medicale et Scientifique des Pratiques Artistiques* 36 (June 2001): 19, 22-27.

_____. "Focal Dystonia: Advances in Brain Imaging and Understanding of Fine Motor Control in Musicians." *Hand Clinics* 19, no. 3 (August 2003): 523-38.

_____, Vanessa K. Lim, et. al. "Aberrant Sensorimotor Integration in Musicians' Cramp Patients." *Journal of Psychophysiology* 17, no. 4 (September 2003): 195-202.

_____, Patrick Raget, Alexander Smidt, and Hubert R. Dinse. "Superior Tactile Performance and Learning in Professional Pianists: Evidence for Meta-Plasticity in Musicians." *European Journal of Neuroscience* 19, no. 2 (January 2004): 473-478.

_____, Yoshihiro Hirata, and Matthias Schulz. "Sensory Mapping of Lip Representation in Brass Musicians with Embouchure Dystonia." *Neuroreport: For Rapid Communication of Neuroscience Research* 15, no. 5 (April 2004): 815-18.

Brandfonbrener, Alice G. "Musicians with Focal Dystonia: A Report of 58 Cases Seen During a 10-year Period at a Performing Arts Medicine Clinic." *Medical Problems of Performing Artists* 10, no. 4 (December 1995): 121-127.

Byl, Nancy N., S. Nagarajan, and A. L. McKenzie. "Effect of Sensorimotor Training on Structure and Function in Three Patients with Focal Hand Dystonia." *Society for Neuroscience Abstracts* (2000).

_____, and A. McKenzie. "Treatment Effectiveness for Patients with a History of Repetitive Hand Use and a Focal Hand Dystonia." *Journal of Hand Therapy* 13, no. 4 (October 2000): 289-301.

Candia, Victor, T. Elbert, Eckart Altenmüller, et al. "Alteration of Digital Representations in Somatosensory Movement Therapy for Focal Hand Dystonia in Musicians." *Lancet* 353, issue 9146 (2 January 1999): 42.

_____, Christo Pantev, A. Engelien, and T. Elbert. "Representational Cortex in Musicians: Plastic Alterations in Response to Musical Practice." *Annals of the New York Academy of Sciences* 930 (June 2001): 300-314.

_____, Thomas Schafer, Brigitte Rockstroh, Thomas Elbert, Edward Taub, Harald Rau, and Eckart Altenmüller. "Sensory Motor Retuning: A Behavioral Treatment for Focal Hand Dystonia of Pianists and Guitarists." *Archives of Physical Medicine and Rehabilitation* 83, no. 10 (October 2002): 1342-1348.

_____, Christian Wienbruch, Elbert Thomas, Brigitte Rockstroh, and William Ray. "Effective Behavioral Treatment of Focal Hand Dystonia in Musicians Alters Somatosensory Cortical Organization." *Proceedings of the National Academy of Sciences of the U. S. A.* 100, no. 13 (24 June 2003): 7942-7947.

Dolcos, Florin, and Gregory McCarthy. "Brain Systems Mediating Cognitive Interference by Emotional Distraction." *The Journal of Neuroscience* 26, no. 7 (15 February 2006): 2072-2079.

- Fahn, Stanley, S. B. Bressman, and C. D. Marsden. "Classification of Dystonia." *Advances in Neurology* 78 (1998): 1-10.
- Frucht, Steven, Stanley Fahn, and Blair Ford. "French Horn Embouchure Dystonia." *Movement Disorders* 14, no. 1 (January 1999): 171-173.
- _____, B. Ford, and Stanley Fahn. "Focal Task-Specific Dystonia Induced by Peripheral Trauma." *Movement Disorders* 15, no. 2 (March 2000): 348-350.
- _____, S. Fahn, P. E. Greene et. al. "The Natural History of Embouchure Dystonia." *Movement Disorders* 16, no. 5 (September 2001): 899-906.
- Fry, Hunter J. H. "Treatment of Medical Problems of Performing Musicians: Overuse Syndrome." In *Applications of Music in Medicine*, ed. Maranto, Cheryl Dileo. Washington: NAMT Inc., 1991.
- Hallett, Mark. "Is Focal Dystonia a Central Nervous Problem?" *Medical Problems of Performing Artists* 14, no. 1 (March 1999): 4-7.
- Hebb, Matthew, Paula Chiasson, Anthony Lang, Robert Brownstone, and Ivan Mendez. "Sustained Relief of Dystonia Following Cessation of Deep Brain Stimulation." *Movement Disorders* 22, no. 13 (2007): 1958-1962.
- Hodzic, Amra, Ralf Veit, Ahmed A Karim, Michael Erb, and Ben Godde. "Improvement and Decline in Tactile Discrimination Behavior after Cortical Plasticity Induced by Passive Tactile Coactivation." *The Journal of Neuroscience* 24, no. 2 (14 January 2004): 442-446.
- Howard, James, and Anthony Lovrovich. "Wind Instruments: Their Interplay with Orofacial Structures." *Medical Problems of Performing Artists* 4, no. 2 (June 1989): 59-72.
- Iltis, P. W., and M. W. Givens. "EMG Characterization of Embouchure Muscle Activity: Reliability and Application to Embouchure Dystonia." *Medical Problems of Performing Artists* 20, no. 1 (March 2005): 25-34.
- Jabusch, Hans-Christian, Henning Vauth, and Eckart Altenmüller. "Anxiety as an Aggravating Factor during onset of Focal Dystonia in Musicians." *Medical Problem of Performing Artists* 19, no. 2 (June 2004): 75-81.
- _____, and Eckart Altenmüller. "Epidemiology, Phenomenology, and Therapy of Musician's Cramp." In *Music, Motor Control, and the Brain*, eds. Eckart Altenmüller, Jürg Kesselring, and Mario Wiesendanger, 265-282. Oxford: Oxford University Press, 2006.
- Jankovic Joseph, and H. Shale. "Dystonia in Musicians." *Seminars in Neurology* 9 (1989): 131-135.
- Klein, C. "Movement Disorders: Classifications." *Journal of Inherited Metabolic Disorders* 28 (2005): 425-439.
- Lederman, Richard J. "Occupational Cramp in Instrumental Musicians." *Medical Problems of Performing Artists* 3, no. 2 (June 1988): 45-51.
- _____. "Focal Dystonia in Instrumentalists: Clinical Features." *Medical Problems of Performing Artists* 6, no. 4 (December 1991): 132-136.
- _____, and Leonard Calabrese, "Overuse Syndromes in Instrumentalists," *Medical Problems of Performing Artists* 1, no. 1 (March 1986): 9.

- Leijnse, J. H. A. L. "Anatomical Factors Predisposing to Focal Dystonia in the Musician's Hand: Principles, Theoretical Examples, Clinical Significance." *Journal of Biomechanics* 30 (1997): 659-669.
- Lim, Vanessa K., and Eckart Altenmüller. "Musicians' Cramp: Instrumental and Gender Differences." *Medical Problems of Performing Artists* 18, no. 1 (March 2003): 21-26.
- _____, Eckart Altenmüller, and John L. Bradshaw. "Focal Dystonia: Current Theories." *Human Movement Science* 20, no. 6 (December 2001): 875-914.
- Lombart, Kenneth G., Gail Berenson, Paul Salmon, and Cheryl Powell Shook. "Performance Impairments, Injuries, and Stress Hardiness in a Sample of Keyboard and Other Instrumentalists." *Medical Problems of Performing Artists* 10, no. 4 (December 1995): 140-146.
- Lutz Jancke. "The motor representation in pianists and string players." In *Music, Motor Control, and the Brain*, Eckart Altenmüller, Jürg Kesselring, and Mario Wiesendanger, eds., 153-172. Oxford: Oxford University Press, 2006.
- Macauley, Beth L., and Karen D. Steckol. "Musical Stuttering: A True Scenario and a Genuine Phenomenon." *American Speech-Language-Hearing Association Leader* (5 October 2005): 8.
- Malfait, N., and T. D. Sanger. "Does Dystonia Always Include Co-Contraction? A Study of Unconstrained Reaching in Children with Primary and Secondary Dystonia." *Experimental Brain Research* 176 (2007): 206-216.
- Mehta, Mayank R. "Cortico-Hippocampal Interaction During Up-Down States and Memory Consolidation." *Nature Neuroscience* 10, no. 1 (January 2007): 13-15.
- Merriman, Lisle, Jonathan Newmark, et al., "A Focal Movement Disorder of the Hand in Six Pianists." *Medical Problems of Performing Artists* 1, no. 1 (March 1986): 17-19.
- Mohlo, Eric, and Stewart Factor. "Possible Tardive Dystonia Resulting from Clozapine Therapy." *Movement Disorders* 14, no. 5 (1999): 873-874.
- Munte, Thomas F., Eckart Altenmüller, and Lutz Jancke. "The musician's brain as a model of neuroplasticity." *Neuroscience* 3 (June 2002): 473-478.
- Overduin, Simon, Andrew Richardson, Courtney Lane, Emilio Bizzi, and Daniel Press. "Intermittent Practice Facilitates Stable Motor Memories." *The Journal of Neuroscience* 26, no. 46 (15 November 2006): 11888-11892.
- Pascual-Leone, Alvaro. "The Brain that Plays Music and is Changed by It." *Annals of the New York Academy of Sciences* 930 (June 2001): 315-329.
- Rosenkranz, Karen, Aaron Williamson, and John Rothwell. "Motorcortical Excitability and Synaptic Plasticity is Enhanced in Professional Musicians." *The Journal of Neuroscience* 27, no. 19 (9 May 2007): 5200-5206.
- _____, Aaron Williamson, et al., "Pathophysiological Differences Between Musician's Dystonia and Writer's Cramp." *Brain* 128, no. 4 (2005): 918-931.
- Sand, Barbara L. "Man for All Seasons." *Strad* 114, no. 1354 (February 2003): 132-36.
- Sankhla, Charulata, Eugene C. Lai, and Joseph Jankovic. "Peripherally Induced Oromandibular Dystonia." *Journal of Neurology Neurosurgery and Psychiatry* 65 (November 1998): 722-728.

- Scarlate, G., S. Barbieri, A. Priori, A. Pesenti, and A. Cappellari. "Limb Immobilization for the Treatment of Focal Occupational Dystonia." *Neurology* 57, no. 3 (14 August 2001): 405-409.
- Schlaug, Gottfried. "Brain Structures of Musicians: Executive Functions and Morphological Implications." In *Music, Motor Control, and the Brain*, Eckart Altenmüller, Jürg Kesselring, and Mario Wiesendanger, eds., 141-152. Oxford: Oxford University Press, 2006.
- Schuele, Stephan, and Richard J. Lederman. "Focal Dystonia in Woodwind Instrumentalists: Long-term Outcome." *Medical Problems of Performing Artists* 18, no. 1 (March 2003): 15-20.
- Schott, G. D. "The Relationship of Peripheral Trauma and Pain to Dystonia." *Journal of Neurology, Neurosurgery, and Psychiatry* 48, no. 7 (July 1985): 698-701.
- Shavlovskaya, O. A. "Plasticity of Cortical Structures Under the Conditions of Neurological Deficit Accompanied by a Disorder of Hand Movement: Modern Approaches to Rehabilitation." *Human Physiology* 32, no. 6 (December 2006): 735-741.
- Spire, Mary. "The Feldenkrais Method: An Interview with Anat Baniel." *Medical Problems of Performing Artists* (December 1989): 159-162.
- Tan, N. C. K., A. K. Y. Tan, Y. Y. Sitoh, K. C. Loh, M. K. S. Leow, and H. T. L. Tjia. "Paroxysmal Exercise-Induced Dystonia Associated with Hypoglycaemia Induced by an Insulinoma." *Journal of Neurology* 249 (2002): 1615-1616.
- Taylor, Heidi Haavik and B. A. Murphy. "Altered Cortical Integration of Dual Somatosensory Input Following the Cessation of a 20 min Period of Repetitive Muscle Activity." *Experimental Brain Research* 178, no. 4 (April 2007): 488-498.
- Thomas, Denton. "Embouchure Dystonia and the Overuse Syndrome: A Primer for Musicians." *Maestro: ABODA National Newsletter* (February 2008). [in press]
- Tubiana, Raoul. "Prolonged Neuromuscular Rehabilitation for Musician's Focal Dystonia." *Medical Problems of Performing Artists* 18, no. 4 (December 2003): 166-169.
- Warner, T. T. "A Prevalence Study of Primary Dystonia in Eight European Countries." *Journal of Neurology* 247 (2000): 787-792.

DISSERTATIONS

- Alm, Per A. "On the Causal Mechanisms of Stuttering." Ph. D. diss., Lunds Universitet, Sweden, 2005.
- Barrowcliffe, Kelly Dawn. "The Knowledge of Playing-Related Injuries Among University Music Teachers." M. Sc. diss., University of Western Ontario, Canada, 1999.
- Bell, Robert. "Pick it up, it's Good: Utilizing Solution-Focused Guided Imagery with Golfers Experiencing the Yips." Ph. D. diss., University of Tennessee-Knoxville, 2006.
- Cochran, Martin Edmond. "A Comparison of the Behavior and Characteristics of Speech Stuttering with Musical Stuttering (i.e. Valsalva Maneuver) in Brass Playing." D. M. A. diss., University of Alabama, 2004.
- LaBlance, Gary Robert. "Breathing Patterns of Individuals with Dystonia Musculorum Deformans." Ph. D. diss. (Speech Therapy), Northwestern University, 1984.

Sanders, Camille Marguerite. "Understanding the Effects of Injury on a Musician's Identity and Self-Concept." M. S. thesis, Rush University College of Nursing, 1998.

Turon, Charles Thomas. "Educational Prerequisites for Piano Teachers assisting in the Prevention, Detection, and Management of Performance-Related Health Disorders." Ph. D. diss., University of Oklahoma, 2000.

BOOKS

Altenmüller, Eckart, Jürg Kesselring, and Mario Wiesendanger, eds. *Music, Motor Control, and the Brain*. Oxford: Oxford University Press, 2006.

Brust, John C. M., ed. "Dystonia" in *Neurology: Current Diagnosis & Treatment*. New York: Lange/McGraw Hill, 2007.

Evans, James and Manfred Clynes, eds. *Rhythm in Psychological, Linguistic, and Musical Processes*. Springfield, IL: Charles C. Thomas, 1986.

Frucht, Steven J., and Stanley Fahn, eds. *Movement Disorder Emergencies*. Totowa, New Jersey: Humana Press, 2005.

Jankovic, Joseph, ed. *Dystonia*. New York: Demos Medical Publications, 2005.

London, Justin. *Hearing in Time: Psychological Aspects of Musical Meter*. Oxford: Oxford University Press, 2004.

Norris, Richard. *The Musician's Survival Manual: A Guide to Preventing and Treating Injuries in Instrumentalists*. San Antonio, Texas: International Conference of Symphony and Opera Musicians, 1993.

Parncutt, Richard and Gary E. McPherson, eds. *The Science & Psychology of Music Performance: Creative Strategies for Teaching and Learning*. New York: Oxford University Press, 2002.

Sataloff, Robert Thayer, Alice G. Brandfonbrener, and Richard J. Lederman, eds. *Textbook of Performing Arts Medicine*. New York: Raven Press, 1991.

Smith, Brenda, and Robert Thayer Sataloff. *Choral Pedagogy*. San Diego, California: Singular Publishing Group, 2000.

Thaut, Michael. *Rhythm, Music, and the Brain: Scientific Foundations and Clinical Applications*. New York: Routledge, 2005.

Thompson, James. *The Buzzing Book*. Vuamarens, Switzerland: Editions Bim, 2001.

Velotis, Calvin M. *Anxiety Disorder Research*. New York: Nova Science, 2005.

INTERVIEWS

Anonymous 1 (trumpet). Interview by author, 8 November 2007. Telephone interview and electronic notes.

Anonymous 2 (violin). Interview by author, 19 January 2008, Melbourne, Australia. Electronic recording and video.

Stephen Arthur. Interview by author, 20 October, 2007, Austin, Texas. Electronic notes and video recording.

Philip Brink. Interview by author, 6 January 2008. Telephone interview and electronic recording.

Sam Burtis. Interview by author, 7 January 2008. Telephone interview and electronic recording.

Jan Kagarice. Interview by author, 1 June 2007, Las Vegas, Nevada. Electronic notes.

K. Don Kneeburg. Interview by author, 7 November 2007. Telephone interview and electronic notes.

Ian Perry. Interview by author, 12 January 2008, Melbourne, Australia. Electronic recording.

Kevin Roberts. Interview by author, 13 February 2007, Austin, Texas. Electronic notes.

Stefan Sanders. Interview by author, 23 May 2007, Austin, Texas. Electronic notes.

David Scragg. Interview by author, 23 January 2008. Telephone interview and electronic recording.

Newell Sheridan. Interview by author, 17 January 2007, Austin, Texas. Minidisc recording and electronic notes.

Jeremy Stanek. Interview by author, 3 November 2007, Columbia, Missouri. Electronic recording and notes.

David Vining. Interview by author, 7 & 14 March 2007. Telephone interview and electronic notes.

Kristen Waligora. Interview by author, 5 January 2008. Telephone interview and electronic recording.

ELECTRONIC RESOURCES

William J. Mitchell, *City of Bits: Space, Place, and the Infobahn* [book on-line] (Cambridge, MA: MIT Press, 1995, accessed 29 September 1995); available from http://www-mitpress.mit.edu:80/City_of_Bits/Pulling_Glass/index.html; Internet.

Burtis, Sam "Letters from New York: The Carmine Caruso Method" [article on-line] (accessed 12 December 2007); available from <http://www.trombone.org/articles/library/letters-caruso.asp>; Internet.

Fabra, Joaquín, "Embouchure Dystonia: Symptomatology" [article on-line] (accessed 1 January 2008); available from <http://www.embouchuredystonia.com/>; Internet.

Scragg, David, "Focal Dystonia: A discussion featuring Denis Wick, Bob Hughes, & Andy Berryman" [audio recording on-line] (accessed 9 December 2007); available from <http://globalbones.net/schedule.php>; Internet.

"Stamp, James" [article on-line] (accessed 20 January 2008); available from http://www.editions-bim.com/index.php?main_page=page&id=104&chapter=1; Internet.

"What is Dystonia?" [article on-line] (accessed 1 October 2006); available from http://www.dystonia-foundation.org/pages/what_is_dystonia_/26.php; Internet.