# EPIDEMIOLOGIC SURVEY OF A UNIQUE TYPE OF TASK-SPECIFIC DYSTONIA IN BRASS MUSICIANS

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Brass musicians are known to experience a performance problem that is sometimes called *valsalva maneuver* or musical stuttering. This problem is known to cause difficulty starting a first note, tension in the throat, and tightness in the chest. Unfortunately, the research literature lacks sufficient details for evidence-based interventions. Therefore, the purpose of this study is to characterize and define this performance problem as experienced by brass musicians. An online epidemiologic survey was developed and deployed to collect data from brass musicians who have experienced this problem in their own playing. The survey was designed to acquire data in order to characterize and define the phenomenon through a biopsychosocial framework. The survey was also designed to assess whether this problem aligns with Altenmuller's heuristic model of motor control disruptions. A diverse group of brass musicians ($n$ = 252) participated and offered relevant details for characterizing and defining this problem. Analysis of characteristic data suggests this problem is not a form of musical stuttering. Considering these data through Altenmuller's model suggests that this problem is experienced as a spectrum of motor disruptions that can develop into a unique type of musician's dystonia. While additional research is warranted, the results of this study are applicable to brass musicians, brass pedagogues, music educators, and performing arts health clinicians.

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## ACRONYMS AND TERMINOLOGY

IOP = Intraocular pressure

THS = Trombone Health Survey

*Valsalva maneuver* = When this phrase appears in italics, it refers to the performance problem, distinct from the normal human function Valsalva maneuver (first word always capitalized, no italics).

VAS = Visual analog scale

# PREFACE

I developed the disorder discussed in this study after transferring to California State University Northridge as an undergrad in trombone performance. I had a 3-day hospital stay in my first semester, which forced me to take 2 weeks off the horn to let my body recover. My professors advised me to spend my first day back on the horn only playing long-tones for about an hour which, being a good student, I did. Everything was fine until I got to Eb below the staff where, as I went to blow air into the horn, my body suddenly froze. I distinctly remember it: My chest tightened, throat tensed up, and I simply couldn't get the air to move. It felt like I was choking. It only lasted a second or two before my air exploded out in a burst. I assumed it was just a random thing that wasn't worth worrying about, but all my low Ebs that day had a little hitch.

Over the next couple weeks, that hitch spread to my entire range on the horn, until eventually it happened every time I tried to start a note. It would get worse or better in certain situations, but it was always there to some degree. I was barely able to get through my jury piece that first semester.

This marked a 4 ½ year struggle for me. Some days I could forget about it, some days I could barely play. Some days I would break down in the practice room. I took lessons with every trombone player in LA who would take my money, most of them big names. They gave me tips and tricks, and some of them would work for a short bit— none more than a week or so. The problem always came back, eventually. Thinking my problem was bad technique, or not working hard enough, I would practice more and more, harder and harder. Which, of course, just made it worse. My peers thought I was dedicated, but really, I was struggling just to keep it together.

One day, while reading through Doug Yeo's website, I found a description of my problem. I was stunned! I had never heard anyone mention it, let alone write an article on it. It was an excerpt from Brad Howland's "Breathing and the Valsalva Maneuver" article. Obviously, the article didn't help long term. It was mostly the same kinds of tricks I had heard from teachers for years, but it was incredible to hear that I wasn't alone. This knowledge gave me enough courage to actually tell someone about my problem, for which I was rewarded by having a professional orchestral trombone player telling me it's a common problem; which lead to him listing famous trombone players he personally knows who also have it. It was incredibly liberating for me, and made my entire life a little brighter.

Reading Brad's article brought me to Arnold Jacobs, and Arnold Jacobs brought me to Jan Kagarice at UNT. Within 1 semester with her, my symptoms were severely reduced, and within 16 months they were gone. By the time I graduated with my master's degree I was completely cured. However, looking back at my experience would always make me angry. This thing almost broke me, almost got me to quit, and nobody knew anything about it. By that time, I knew this problem was actually pretty common amongst brass players, but there was (and still remains) so little (helpful) information on it. Why are there no real studies about this? Why is there essentially one article on it written by a brass musician? Plus, why was Jan's method so effective, when 4+ years and at least a dozen teachers couldn't make a dent?

These questions got me into the field of performing arts health at UNT. My studies there helped me grow academically, I published an article on musculoskeletal pain in trombonists in

MPPA, and eventually I came full circle to dedicating myself to researching this problem. This document marks the first steps towards understanding, treating, and preventing this performance disorder in brass musicians. I hope it can help someone.

# CHAPTER 1

# INTRODUCTION

Brass musicians are known to experience a performance problem that affects their ability to start a first note on their instrument. One name for this problem is *valsalva maneuver*, a term that is often attributed to Arnold Jacobs. Alternatively, some authors have called this problem “musical stuttering” due to similarities to speech stuttering; however, there is not enough information to know if this classification is accurate. Eckart Altenmuller uses the term “tongue stopper” to represent this problem, and describes it as being experienced along a spectrum of severity.[1] This spectrum is Altenmuller’s theoretical model, which describes a progressive worsening of motor disturbances from less severe motor problems, such as motor fatigue, overuse pain, and choking under pressure, to more severe movement disorders that have become part of the procedural memory, such as musician’s dystonia. Together, while these contributions provide some insight into the characteristics and classification of this phenomenon, additional research is warranted.

In his online article *Breathing and the Valsalva Maneuver*, principal trombonist for the Victoria Symphony Orchestra Brad Howland wrote about a performance problem he calls *valsalva maneuver*, stating “I used to think that it bothered five to ten percent of brass players, but now that I understand it better and have fixed it for myself, I know that it affects all brass players!”[2] The problem he wrote about does not have a formalized name or classification, but is sometimes called *valsalva maneuver*; which is also the name of a normal function of human

[1] Altenmuller et al., 2014.

[2] Howland, n.d.

anatomy.[3] This problem has been the subject of online forums and articles,[4,5] and discussed by Arnold Jacobs[6] and other notable pedagogues in interviews.[7] Jacobs also described brass musicians experiencing antagonistic muscle contractions related to respiration, which he believed was caused by harmful levels of tension when playing their instrument.[8] Those who experience this problem describe a difficulty starting a first note and holding air back after inhalation. This increases pressure in the chest and throat. Despite various references over several decades, there is no known academic literature about a performance problem by this name.

The absence of known academic sources is the most notable problem with the literature related to *valsalva maneuver*. Lacking scientific documentation calls into question whether the problem truly exists, and how commonly it is experienced by musicians. Attempting to establish its existence therefore requires tracing various forms of anecdotal evidence, despite their limited value.

The earliest reported mention of a performance problem by the name *valsalva maneuver* is attributed to Arnold Jacobs during a lesson with Richard Erb,[9] a bass trombonist from New Orleans. In a 1966 lesson with Jacobs, Erb sought help for a problem that Jacobs

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[3] For the sake of clear distinctions, *valsalva maneuver* (in italics) is used when discussing the performance problem and Valsalva maneuver (no italics) remains the label for the human function.

[4] Everett, 3 Mar 2015.

[5] Garcia, 1994.

[6] Frederikson, 1996.

[7] Heath, 2016; Grose, n.d.; McIlwain, 2010.

[8] Live interview with Arnold Jacobs.

[9] Frederikson, 1996.

called similar to the Valsalva maneuver. Other interviews concerning lessons between Jacobs and a student with this problem can be found, as well as transcripts of masterclasses in which Jacobs discusses the problem.[10]

This collection of interviews and transcripts makes it clear that Arnold Jacobs knew of this problem as early as 1966, and that it had been a known issue to the musical community. Jacobs himself said in a masterclass that he has seen "players galore" with this problem.[11] Despite these records, the performance problem *valsalva maneuver* remains largely unstudied. Brad Howland's article[12] is commonly cited by musicians, and remains perhaps the only substantial source of information. The available information is not sufficient to help music pedagogues to identify this issue. Also, considering the similarities between this problem and common technical faults (holding tension in the throat, late attacks, etc.), it is not clear when common playing difficulties can be considered to have worsened into a more serious problem.

A further problem with the literature of the performance problem *valsalva maneuver* is the name. Based on the available information, it appears that Arnold Jacobs never called this problem *valsalva maneuver* himself. The interviews and transcripts suggest that he simply described this problem as being similar to the phenomenon Valsalva maneuver. While it is difficult to say with any certainty, as Jacobs did not actually write anything himself, this suggests that musicians over time heard this reference and began using the term as a label. However, this name comes with several distinct problems.

[10] Frederikson, 1996.

[11] Frederikson, 1996.

[12] Howland, n.d.

The phenomenon Valsalva maneuver is a physiological function of the human body. It consists of closing off the nose and glottis, pressing the diaphragm down against the abdomen, and increasing intrathoracic pressure. It is commonly triggered while performing tasks such as defecating, childbirth, lifting heavy objects, and sneezing. The term Valsalva maneuver is from Antonio Valsalva's 1704 treatise,[13] and is a standard item in the medical lexicon. While this phenomenon may be outwardly similar to the performance problem of this study, in that both problems create tension in the chest, it is both confusing and incorrect for two separate and unrelated problems to share a single name.

Valsalva-like symptoms when playing brass instruments were also attributed to a "hesitation problem." A 2016 dissertation from Texas, which contains an epidemiologic survey of French horn players, found that 38.1% ($n$ = 24) of his survey's subjects reporting first-hand experience of this problem.[14] Based on the description provided by this dissertation, it is likely that it is the same issue as the performance problem *valsalva maneuver*. However, Akers did not provide the description of the "hesitation problem" that was presented to the subjects. Without knowing precisely what the subjects were responding to, or if they all believed they were responding to the same problem, the validity of the entire study's findings are called into question.

A similar problem is described in the literature for "musical stuttering." The term musical stuttering stems from a 1952 case study that reports the experience of a person whose

[13] Yale, 2005.

[14] Akers, 2016.

trumpet playing temporarily mirrored their speech stuttering.[15] The stutterer described this problem as causing difficulty striking a first note, and throat grunts following attacks of notes. Three other single-subject case studies followed,[16] all of which described this problem as musical stuttering and made comparisons to speech stuttering literature. These three studies described each individual's problem as facial muscle "freezing," body stiffening, closure and tightening of the throat, tightness in the chest, and a general difficulty starting a first note. It was mostly described as affecting the initiation of first notes.

A 2004 epidemiologic study provided the only known epidemiologic data about musical stuttering.[17] This study consisted of a survey of 225 musicians, including 69 musicians who reportedly experienced musical stuttering. However, this study mostly reported only qualitative data. The author seemed to base conclusions and comparisons off a few, or sometimes an unspecified, number of subjects. While this study adds value as a reference, and for comparisons to demographic data, the lack of systematic and quantitative methods limit the generalizability of the information provided from this study.

In total, these five studies on musical stuttering are insufficient for comparing and/or labeling this problem as a form of speech stuttering. For example, while the symptoms sound like stuttering, differences with the age of onset, years before recovery, recovery rates, and presence of physiological symptoms call this label into question. One author has even called the comparisons "speculative and circumstantial."[18]

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[15] Van Riper, 1952.

[16] Silverman & Bohlman, 1988; Meltzer, 1992; Packman & Onslow, 1999.

[17] Cochran, 2004.

[18] Packman & Onslow, 1999, p. 297.

Eckart Altenmuller, who is a prolific researcher of musician's dystonia, used the name "tongue stopper" to describe this problem.[19] Altenmuller describes this as a manifestation of choking under pressure in brass musicians. However, while this term describes one aspect of this problem, it also suggests it specifically targets the tongue. Descriptions from both musical stuttering and *valsalva maneuver* describe a problem that impacts the tongue as well as the chest, throat, abdomen, and in some cases the entire body.[20]

In general, the application of the varied terms used for this problem has created a lack of connectivity between studies. Sources are spread out over several disciplines, creating a body of literature that is inconsistent and hard to find. Studies often lacked references to previous efforts, and therefore limited continuity and progression. A quote by a 2013 committee charged with defining musculoskeletal disorders states that "accurate terminology is essential for unambiguous communication and sharing of knowledge."[21] This quote summarizes many of the difficulties with researching what is commonly called *valsalva maneuver* or musical stuttering. Studying this problem forces researchers to search by random key words in a hunt for related information. If the terms musical stuttering and *valsalva maneuver* are not accurate, continuing to label this problem as such will continue to separate future studies.

Besides the studies related to this problem being few and difficult to find, the methodologies used for investigating this problem may be insufficient for detailed characterization and classification. The bulk of the available literature about either *valsalva*

[19] Altenmuller et al., 2014.

[20] Silverman & Bohlman, 1988.

[21] Albanese et al., 2013, p. 866.

*maneuver* or musical stuttering are case studies, anecdotal evidence, and expert opinion. These types of studies are among the lowest forms of evidence[22] due to their susceptibility to bias and lack of robust methodology. Together, the current body of literature offers limited scientific value.

Creating an accurate definition would likely solve many of the problems described above. As stated, the studies on musical stuttering simply describe the experience of individual musicians, and do not attempt to create a unified understanding of this problem. The lack of a clear and accurate definition makes it difficult, if not impossible, to identify this problem in musicians. Furthermore, without a clear description of this problem's characteristics and a formal definition, the quality of research is not only hindered, but the investigation of interventions and preventative measures is slowed down. Finally, since there are no clear descriptions or definitions of this problem, this problem is virtually unknown to the field of medicine, creating a large inability for performing arts health practitioners to identify this problem in musicians.

Much of Altenmuller's recent research has been directed on developing a flow-chart[23] and a spectrum-like heuristic model,[24] both of which describe the progressive worsening that occurs in motor control problems. Altenmuller's model describes how less-severe types of motor disturbances such as motor fatigue, choking under pressure, or the so-called "tongue stopper" can develop into a serious motor control disorder like musician's focal dystonia. Figure

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[22] Burns et al., 2011.

[23] Altenmuller et al., 2014, p. 170.

[24] Altenmuller et al., 2014, p. 170.

1 visualizes this progression through the progressive subtypes of his model. The subtypes of problems on the left side of the spectrum, which might normally occur during specific aspects of music making, can start to become habitualized and manifest more frequently. When this occurs, the problems typically also gain in severity and become less treatable by interventions. If not successfully treated, motor control problems can progressively worsen, moving to subtypes further along the spectrum, and eventually become disorders such as musician's dystonia. Altenmuller's spectrum-like model captures the order of severity of motor control disorders.[25]

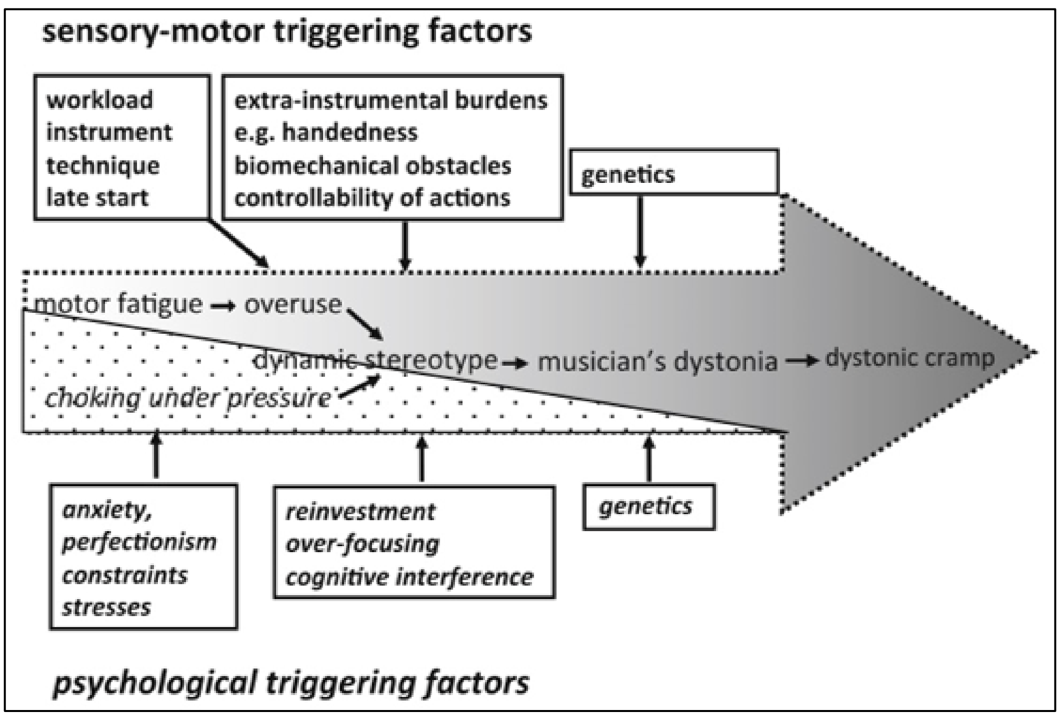


**Figure 1: Altenmuller's heuristic spectrum model.**

Furthermore, a recent study applied Altenmuller's model to better understand the *yips*, a form of task-specific dystonia that impacts golfers.[26] Similar to musician's dystonia, the yips is

[25] Altenmüller et al., 2015.

[26] Ioannou et al., 2018.

a form of task-specific dystonia that affects golfers by creating jerks and tremors caused by increased muscle tension during putting. Recently, researchers out of Germany investigated the similarities between the yips and musician's dystonia by comparing the results of 4 psychometric tests.[27] The authors of that study used the results of those tests to compare the yips to the musician's dystonia literature. Their hypothesis was that the yips-affected golfers would have similar test results as musicians with musician's dystonia, suggesting both disorders are related, and that studies of musician's dystonia are applicable to the yips. Finding a strong relationship would speed up research of the yips and the proposal of interventions, since musician's dystonia has been researched to a much greater extent.[28] These results were further compared to Altenmuller's model, and found that the yips is experienced along the same spectrum of progressive worsening as musician's dystonia, further supporting their shared etiologies.

## Rationale

By utilizing a strategy similar to Ioannou's study, the current study proposes to use Altenmuller's model as the basis for studying what's previously been described as *valsalva maneuver*, tongue stopper, or musical stuttering. If the results demonstrate that this problem follows the same path of progressive worsening along the frequency, intensity, timing, and effectiveness of interventions, the results would suggest that both problems share etiologies. Considering known evidence, it is likely true that this problem can develop into a unique form

[27] Ioannou et al., 2018.

[28] Ioannou et al., 2018.

of musician's dystonia. Understanding how to classify musicians who report experiencing these challenges would provide focus for researchers and accelerate the creation of effective intervention and preventative measures.

Due to the apparent similarities between this problem and the yips, one strategy for investigating this problem would be to partially replicate McDaniel's 1989 survey of the yips in golfers.[29] While there are limitations to how well a survey can characterize a complex motor control problem, they are acceptable for taking, as McDaniel puts it, a "first step" towards an epidemiological understanding of a problem.[30]

The purpose of epidemiologic studies are to understand a problem enough to explain its etiology, predict its distribution, and eventually develop empirically derived interventions.[31] While case studies are valuable for discovery and creating hypotheses,[32] they are not as valuable in justifying conclusions due to their increased susceptibility to bias. Non-empirical research has been found to be the least reliable when proposing interventions.[33] Burns ranks observational studies, such as Cochran's epidemiologic survey, as lower in value than controlled trial studies, but still higher than case studies in the validity of the information they provide. They are also better for rare or less known problems.[34]

However, several methodological challenges arise when considering how to obtain valid

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[29] McDaniel et al., 1989.

[30] McDaniel et al., 1989.

[31] Kleinbaum et al., 1982.

[32] Vandenbroucke, 2001.

[33] Burns et al., 2011.

[34] Burns et al., 2011, p. 4.

and reliable data from brass musicians who have experienced this problem. On one hand, Altenmuller noted in a personal correspondence that "from the 6,500 patients I have seen maybe 10 suffered from [this problem]" whereas the principal trombonist of the Victoria Symphony Orchestra estimated that 5-10%[35] of all brass musicians are affected by this problem at some level.[36] These disparities may reflect the lack of health seeking behavior among those with this problem. Regardless, the existing data is insufficient to effectively determine subject sample characteristics such as size. Therefore, initial investigations should attempt to recruit a large and diverse population who indicate that they have some levels of experience with this problem.

Another methodological challenge is the potential lack of awareness among musicians. While anecdotal evidence suggests this problem is common among brass musicians, there are no known studies that describe levels of awareness among musicians. Furthermore, some may simply consider this problem as the manifestation of poor practice habits or technique. For this reason, the recruiting strategy must clarify inclusion criteria in simple and straight forward terms in order to create interest and willingness to participate.

To address these challenges, an online epidemiologic survey with a broad recruiting strategy might be the best method for involving a sufficient number of musicians who have experienced this problem in their own playing. This approach was implemented and successful in a recent study of occupational health problems of trombone players.[37] Applying similar

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[35] He also claims that he now believes all brass musicians to suffer from this problem to some degree, but it is not known if he is being hyperbolic.

[36] Howland, n.d.

[37] Wallace et al., 2016.

epidemiologic survey techniques to the current study might result in a robust sample of brass musicians with this problem.

Another challenge is related to recruiting brass musicians who have experienced this problem in their own playing. One approach is to first create an operational description based on the best information available. Approaching this challenge further highlights the weaknesses of the previous literature. The four case studies reporting on musical stuttering provide descriptions of the experience from each patient and fail to present a clear and unified description of this problem. The epidemiologic study by Akers provided quantitative data, but the wording of his questions were often unclear as to what is being assessed and how. Cochran based conclusions on small or unspecified population sizes. Together, these sources are insufficient to allow the creation of a single, clear, thorough, and reliable description of this problem.

Developing an operational description for recruitment would have to encompass the known information about the problem while allowing for the inclusion of likely factors that are not recognized in previous studies. If successful, the data could then be used to create a more thorough and accurate definition. This strategy is similar to Zaza's 1997 study, where survey responses were used over the course of the collection process to shape their definition of playing-related musculoskeletal disorders (PRMDs).[38] While this strategy would not allow estimates of prevalence, data from participating musicians would allow for characterizing the problem along the full spectrum according to Altenmuller's model.

[38] Zaza & Farewell, 1997.

Once an operational description is developed, determining the best way to construct a survey tool for such a complex problem creates further challenges. Because of the scarcity of reliable and meaningful academic articles, anecdotal sources may provide preliminary insights into how to investigate this problem. For example, one musician reported being constantly affected by this problem since the 80s, whereas another musician reported random experiences every few months for several weeks at a time.[39] The seemingly random nature of this problem gives limited value to traditional survey measurement scales—i.e. "How frequently have you experienced this problem?" For this reason, new ways of investigating timing, frequency, and intensity must be created.

Investigating characteristics of motor control phenomena present unique challenges. One strategy for understanding this problem involves a model that includes biological, psychological, and social factors that impact a person's overall health.[40] This biopsychosocial framework recognizes that a person's health is the result of inter-related factors and allows for a more holistic understanding. Applying this model to an investigation of this phenomenon would allow a more balanced and complete view of how this problem is experienced. For example, contextualizing this problem requires assessments of changes in practice habits prior to developing this problem in order to better understand what changes precipitate it. This information could provide the basis for developing and testing preventative measures.

Finally, by applying Altenmuller's model and its subtypes as criteria, survey items could be designed to assess and potentially validate developmental and temporal pathways

[39] Obtained in personal interviews while creating the survey for this study.

[40] Borrell-Carrió et al., 2004.

associated with developing severe forms or manifestations of this problem. Previous reports do suggest that this problem follows the progressive worsening described by Altenmuller and is experienced along a spectrum of severity. Creating survey items capable of supporting this perspective, particularly if the data suggests the potential for developing a unique type of focal dystonia, would help performing arts medicine professionals understand how these disorders develop in patient populations. Similarly, findings could help musicians and music pedagogues recognize concerns early, and determine when a problem related to technique has progressed into a more severe dysfunction.

## Purpose

The available information suggests that some brass musicians experience abnormal problems starting a note that can severely impact their ability to perform. However, research data is needed to characterize and define this problem in a way that helps musicians, pedagogues, and health care providers understand if and when this problem has progressed beyond addressing with normal practice techniques. One method for meeting this need is to collect information from musicians who have personally experienced this problem in their own playing using online epidemiologic survey techniques. Once obtained, data can be examined through Altenmuller's spectrum-like model of motor control disorders.

Therefore, the purpose of this study is to characterize and define an understudied performance problem experienced by musicians who play brass instruments. The specific aims of this study are to:

1. Create an operational description of this problem in order to recruit musicians who have experienced this problem in their own playing.

2. Create an online epidemiologic survey capable of characterizing this problem in brass musicians.

3. Recruit musicians and collect data using the constructed online epidemiologic survey.

4. Analyze the data in order to characterize the experience.

5. Assess data through Altenmuller’s model of motor control disorders.

6. Create a data-driven definition of this problem.

The available evidence suggests that this problem will align with Altenmuller’s model of progressive worsening of motor control disorders. It is predicted that there will be a pattern of increasing severity in the frequency, intensity, fluctuation, negative impact on the musician’s ability to play, positive impact of interventions, and the manifestations of the “primary symptoms.” If found to be true, these results will suggest that the complex set of motor disruptions that make up this phenomenon is capable of progressively worsening into a unique type of musician’s dystonia.

CHAPTER 2

# STATE OF THE LITERATURE

## *Valsalva Maneuver*

The most notable characteristic of the literature related to *valsalva maneuver* is the absence of known academic sources. Lacking scientific documentation calls into question whether the problem truly exists, or how commonly it is experienced in musicians. Attempting to establish its existence therefore requires tracing various forms of anecdotal evidence, despite their limited reliability.

The earliest reported mention of a performance problem by the name *valsalva maneuver* is attributed to Arnold Jacobs. In *Arnold Jacobs: Legacy of a Master*, Richard Erb recounts his 1966 lessons with Arnold Jacobs:

> I had three one-hour sessions over a period of two weeks. After observing my playing, he gave me a general but concise overview of the anatomy of the thorax and abdomen, referring to the large charts and models in his studio. Armed with this information (almost all of it new to me) he explained in detail the physiological phenomenon known as the Valsalva Maneuver. The vast amount of new material in that first half of the first session was not presented in any simplified or watered-down version.[41]

While this is the earliest known mention of a problem labelled as *valsalva maneuver*, it is not known when Jacobs first became aware of this problem, or when he began working on retraining musicians. From the quickness of his success with retraining Mr. Erb, it can be extrapolated that Jacobs had some previous experience working with students who had this problem. A similar mention of Jacobs' work with this problem comes from a 2014 interview of Daniel Perantoni:

[41] Stewart, 1987, p. 19.

> I remember Mr. Jacobs working on that with some players—I don't want to mention any names—major players who were having some severe problems, and [they] didn't know what the heck it [was]. You just [kept] going [to] see what [you could] do.[42]

This quote states that Jacobs had, at least once, worked with several musicians at the same time who had this problem, suggesting that musicians seeking help for this problem was not uncommon. The frequency of his work with this problem is supported by a transcription of a 1995 masterclass at the International Brassfest in Bloomington, Indiana from the book *Song and Wind* by Brian Frederikson:

> You should feel pressure in the neck. When that happens there are changes not just in the neck, but there are changes throughout the entire respiratory system. This is used in nature as part of the Valsalva Maneuver to increase the pelvic pressures. Those women who have had babies had to bear down [he makes a pushing sound] in order to get the infant out.
>
> I've had players galore that use a form of this while they are playing the instrument. They can get the air out under high pressure, but they cannot use very much air. There is not much room for the reduction phenomenon that takes place with emptying or taking the air out of the lungs.[43]

While "players galore" is not a precise description, Jacobs at least admits to students regularly seeing him for this problem. Further support for the commonality of this problem as called *valsalva maneuver* comes from Brad Howland's online article *Breath and the Valsalva Maneuver*:

> I know all about the Valsalva Maneuver (VSM), because I suffered from it for many years. I used to think that it only bothered five to ten percent of brass players, but now that I understand it better and have fixed it for myself, I know that it affects all brass players![44]

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[42] Heath, 2016, p. 39.

[43] Frederikson, 1996, p. 103.

[44] Howland, n.d., para. 7.

And from another Richard Erb quote:

> I think it is worth sharing a bit of the technical aspect of this for several reasons. First, no one else had even the vaguest notion what to do about it. Curiously, I have had some discussions with other students of Mr. Jacobs' and none relates a similar problem or any awareness of such a problem. This is surprising because I have observed this phenomenon in the general population of brass players with considerable frequency.[45]

It is also worth noting that, while these sources refer to this problem as *valsalva maneuver*, there is no record of Jacobs himself using that name for this problem. However, since Jacobs never wrote anything himself, it appears this name became common parlance among musicians due to Jacobs' references to the Valsalva maneuver and their similarity in physiological functions. Richard Erb summarizes these similarities:

> The cause of the difficulty is simply the presence of static air, held under pressure in the lungs by the closing off by tongue, lips or glottis. When the lungs are full, the diaphragm is, of course, in its downward contracted position. When the top of the system is closed, great pressure in the lungs may be generated by the opposing (to the diaphragm) musculature of the abdominal wall. This also results in greatly increased pressure on the contents of the abdominal cavity. When this pressure is sensed and processed in the brain, the autonomic nervous system reacts in a typical pattern of behavior known to physiologists as the Valsalva Maneuver. (Valsalva (1666-1723) was an Italian anatomist and physiologist who first described this phenomenon.) Simply put, the response has this effect: the diaphragm maintains or increases the downward pressure or contraction. The tongue maintains a simultaneous effort to block the airway, thus maintaining internal pressure. Now while the diaphragm's primary function is one of inhalation, this secondary or supportive use of it is essential to the body in several functions such as emptying the bowel or bladder or in childbirth. The crucial point to understand is that this pattern of responses is triggered through the autonomic nervous system and therefore totally beyond one's conscious control. The tongue at that moment of high internal pressure will not respond to a conscious command to begin a note.[46]

This quote touches on a concern with the name *valsalva maneuver* for this performance

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[45] Stewart, 1987, p. 17.

[46] Stewart, 1987, p. 18.

problem. The term Valsalva maneuver has been a part of the medical lexicon since the 1704 treatise *De Aure Humana Tractatus* by Italian surgeon and physician Antonio Maria Valsalva.[47] The maneuver is triggered by closing the airway at the mouth, nose, or glottis and attempting to forcibly release air.[48] This creates an increase in intrathoracic pressure, and changes to heart rate and blood pressure. It is a normal physiological function that humans perform when sneezing, lifting weights, defecating, giving birth, etc.

Considering the Valsalva maneuver's history and clinical functions, there are several reasons why it is inappropriate for this performance problem to be called *valsalva maneuver*. Primarily, the Valsalva maneuver is essential for clinical assessment of autonomic function, and a valuable test for heart failure.[49] Having a significant use in clinical autonomic system assessment, it is easy to imagine problems arising should a musician seeking professional help for this performance problem tell a medical doctor they are having problems with "the Valsalva maneuver." Furthermore, while both the Valsalva maneuver and the performance problem *valsalva maneuver* seem to create intrathoracic pressure through the attempted forced expiration of air through the air passage, descriptions from available sources describe fundamental differences in the triggering mechanisms for the two phenomena. The Valsalva maneuver is an unconscious physiological function that can be consciously triggered, whereas the performance problem *valsalva maneuver* appears to be a unique motor control problem. Finally, and perhaps most importantly, there is simply not enough information about the

[47]Yale, 2005.

[48] Pstras et al., 2016.

[49] Yale, 2005, p. 36.

performance problem to make a comparison between the two phenomena anything more than superficial.

## Musical Stuttering

The earliest known reference to the term "musical stuttering" is from the *Journal of Speech and Hearing Disorders* in 1952.[50] A letter-to-the-editor bears the first-hand account of a speech stutterer who, while studying trumpet in college, had briefly experienced a stutter-like problem while playing his instrument. The story describes a semester where self-diagnosed anxiety, brought on by a harsh and highly critical teacher, caused this student's speech stuttering to bleed over into trumpet playing. The subject reported "difficulty striking the first note," that they couldn't make an attack after bringing the horn up, and that attacks were followed by "throat grunts." These symptoms were reportedly similar to how this individual's speech stuttering manifested.[51]

The next journal article on musical stuttering is from a 1988 case report of another speech stutterer who also experienced stutter-like irregularities while playing the flute.[52] In a letter to the author, she describes a four or five-month period where she would experience throat tension, facial muscle "freezing," and stiffening of the body muscles. This problem would only happen before the first note of a piece, and would sometimes last 15-30 seconds. Differently from Van Riper's 1952 letter, this person's musical stuttering was not similar to their speech stuttering. Her speech stuttering manifested as part-word or whole-word repetitions

[50] Van Riper,1952, p. 433.

[51] Van Riper,1952, p. 434.

[52] Silverman & Bohlman, 1988, p. 427.

randomly throughout speech, and not freezing on the first word. She stopped experiencing her problem at the end of a four or five-month period of heavy competition, which is similar in duration to Van Riper's patient.

A third case-study from 1992 describes the experiences of a horn player who experienced both speech and musical stuttering.[53] The subject describes his musical stuttering as a blocking of the flow of sound, closure and tightening of the throat, and a breakdown in coordinated tongue movement. The subject claims this fluency problem has been part of his French horn playing throughout his musical career. Unlike the previous two studies, this musician's experience did not completely stop by the time of the article's publication. The author of the article assumes the problem stems from trait anxiety due to high levels of perfectionism in music as well as normal speech communication, and a perceived exaggeration of any flaws in either. It's important to note that, unlike the previous articles, this is an abridged report of the French horn player's case history written by the musician's speech therapist.

The fourth and final known journal article on musical stuttering is a 1999 case study about a speech stutterer who played the trombone.[54] The subject, called M, reported "hesitant stumbling attacks" and "false starts," tightness in the chest and respiratory muscles, and a sense of locking up at the start of musical phrases.[55] M likened the experience to his speech stuttering in feel, and noted that the syllables "ta" and "da" which are used in brass playing for articulating notes, are also syllables he is most likely to stutter on. He believed the use of the

[53] Meltzer, 1992.

[54] Packman & Onslow, 1999.

[55] Packman & Onslow, 1999, p. 296.

tongue in starting tone production caused both his speech and musical stuttering.

There are notable differences between these four reports. All four articles describe the problem as only occurring prior to the onset of the first note. However, the report by Van Riper did not report any strictly-physical symptoms,[56] whereas Studies 2-4 all reported a version of muscle tension, or "locking up," before playing. Van Riper and Silverman's subjects both recovered after a period of months, while Meltzer's and Packman's patients never stopped experiencing this problem. All differences in experience are possibly due to the inconsistencies in reporting. Two of the articles contain unabridged stories, one summarizes their experience in a single sentence, and the final provides a detailed question and answer section. Furthermore, the total subject population of four musicians, all of whom play different wind instruments, were reporting on experiences spaced decades apart. These inconsistencies demonstrate a necessity for a more scientifically valid form of investigation.

The only known epidemiologic information of this problem comes from a 2004 survey out of the University of Alabama.[57] This study found that 69 out of 225 mixed brass musicians (30.7%) had experienced this problem. There are notable similarities between the results of this survey and the four case-studies previously described. Subjects for Cochran's survey reported experiencing "locking up," tightness in the chest and/or throat, hesitation, and difficulty starting the first note – all symptoms of this problem that were also reported by the case-studies above. Manifestations of this problem were primarily experienced just prior to playing the first note.

[56] Van Riper(1952) reports difficulty striking the notes, grunts in the throat, and profuse sweating.

[57] Cochran, 2004.

While Cochran's study provides the most robust description of the problem previously available, it makes enough errors to call its validity into question. One of the primary hypotheses of the study was to investigate the link between musical stuttering and speech stuttering— a link that Cochran believes is "clearly reinforced."[58] However, many of the relationships used to formulate these links are based on a small or unreported number of responses. For example, Cochran seems to suggest that musical stuttering has a neurological link to speech stuttering based on two responses.[59] The role of Perfectionism on the experience of musical stuttering is supported by a single written response.[60] Hypotheses made through individual datum are less externally valid to a target population[61] and lack scientific value.[62] Furthermore, Cochran states a prevalence of 17.7%,[63] despite stating that 69 subjects validly reported experiencing musical stuttering, with no discussion of how this figure is obtained.[64] Finally, Cochran states an "incidence" of 30%, even though it is not possible to measure incidence in a single epidemiological survey.

These five articles represent the known academic sources about musical stuttering. However, the evidence provided by them is insufficient to support the conclusion that this performance problem is a form of speech stuttering. Cochran claims that their key

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[58] Cochran, 2004, p. 30.

[59] Cochran, 2004, p. 34.

[60] Cochran, 2004, p. 33.

[61] Kleinbaum et al., 1982.

[62] Mathews, 1977.

[63] Cochran, 2004, p. 36.

[64] The total survey population is 225. If prevalence is based on lifetime prevalence (and there are is no indication it is otherwise) the prevalence should be 30.7%.

characteristics are identical,[65] in direct contrast to Packman's statement that the link to musical stuttering is speculative and circumstantial.[66] While basic descriptions of the two problem's symptoms have similarities, the assumption they are therefore the same classification of disorder necessitates ignoring several important distinctions. The symptom of this problem that effect the physiology, described by Cochran as an involvement of the Valsalva mechanism (throat constriction, upper body/abdomen tightening), are not found in any known forms of speech stuttering.

Development and recovery periods are also greatly different. Speech stuttering typically occurs in the early stages of speech development,[67] with 95% of stuttering onset occurring within the first 48 months of age,[68] whereas Cochran found musical stuttering typically was developed after high school, averaging 17 years into their musical training. Only one of the subjects of the four musical stuttering case studies experienced their problem in the early stages of their musical development,[69] with the other three subjects developing theirs after six years of musical training[70] or during college.[71] Recovery rates for speech stuttering have been reported at 71.4% within two years[72] and 74% within four years[73]; whereas Cochran reported a life-time recovery rate of 42%. Although reported speech stuttering recovery rates vary

[65] Cochran, 2004, p. 44.

[66] Packman & Onslow, 1999, p. 297.

[67] Yairi & Ambrose, 1999.

[68] Yairi & Ambrose, 2013.

[69] Meltzer, 1992, p. 260.

[70] Silverman & Bohlman, 1988, p. 427.

[71] Packman & Onslow, 1999, p. 294; Van Riper, 1952, p. 433.

[72] Månsson, 2000.

[73] Yairi & Ambrose, 1999, p. 20.

greatly,[74] the recovery rate reported by Cochran is still much lower than the average speech stuttering recovery rates.

While quantitative comparisons expose dissimilarities between musical stuttering and speech stuttering, substantial similarities exist between musical stuttering and the performance problem "valsalva maneuver." Both occur almost exclusively prior to initiation of a first note, both cause repeated first notes, and both include similar physiological reactions (constriction of the throat, tightness in the chest and respiratory muscles). Based on these similarities, it is likely that both musical stuttering and the performance problem *valsalva maneuver* are different names for the same performance problem.

However, there is no evidence to support this hypothesis beyond shallow comparisons of anecdotal evidence. In regard to musical stuttering classified as a form of speech stuttering, Packman notes in his article "any functional relationship between the two must be regarded as speculative,"[75] which is similarly true for the relationship between the performance problem *valsalva maneuver* and musical stuttering. A more rigorously employed epidemiological survey of this problem in brass players would allow the proposal of a more valid and reliable classification for musical stuttering and the performance problem *valsalva maneuver*.

## Other Literature

A 2016 dissertation by Derek Wayne Akers studied a "hesitation problem" in French horn players[76]. Akers describes this problem as:

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[74] ASHA, n.d.

[75] Packman & Onslow, 1999, p. 297.

[76] Akers, 2016.

> The brass player takes a breath and as he or she begins the process of exhaling, the player is interrupted with an unwanted break of the process. Instead of articulating in time, when the instrumentalist wants to execute the attack, he or she hesitates creating a delayed response or even a complete lock up for a few seconds. Sometimes in extreme cases, the player cannot execute a note at all.[77]

Akers sent an online survey to 75 horn professors, private horn teachers, and professional horn players. He found that 88% (*n* = 66) of subjects had heard of this problem, 84% (*n* = 53) had taught at least one student who experienced this, and 38.1% (*n* = 24) had experienced it firsthand. Of those who reported firsthand experience, 54% (*n* = 13) had it for less than one year, and 16% (*n* = 4) had it for more than five years. However, there is no explanation for how he described the problem to subjects taking the survey, which makes it difficult to determine the veracity of this data.[78] It is unknown if the subjects were given any explanation about what was being investigated beyond the description "hesitation problem." It should also be noted that Akers' dissertation did not include any references to any of the musical stuttering literature, or clearly state if his "hesitation problem" is the same as the performance problem of this study, or *valsalva maneuver*.

A study of "tuba" [79] players measured the cardiovascular changes in musicians while they played low, middle, and high Bbs, and also had them reproduce true Valsalva maneuvers at three levels (10mmHg, 40mmHg, 60mmHg).[80] The study found that "tuba" players experienced cardiovascular changes similar to the Valsalva maneuver while playing high notes.

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[77] Akers, 2016, p. 6.

[78] While Akers' dissertation is almost certainly describing the same disorder as *valsvala maneuver* and musical stuttering, I discuss this paper here because there are no other studies using the term "hesitation problem."

[79] While "tuba" is used in the title, the methods section describes them as playing euphonium or saxhorn.

[80] Elghozi et al., 2008.

It is worth noting that the greatest changes in pressure occurred in the early stages of expiration. However, Elghozi only included healthy players, and was not investigating problems or any other performance abnormalities. While it reported the players experienced an increase in thoracic pressure similar to Valsalva maneuver, this appears to be a normal function of playing their instrument.

A pilot study by Dr. Peter Iltis took real-time MRI videos of French horn players while playing a modified horn made of graduated-diameter plastic tubing attached to a non-ferromagnetic bell. The video showed that players made adjustments to the size of their glottis fissure while playing the horn.[81] It is not known if these adjustments were made consciously or unconsciously. A similar study by Dr. Iltis found that horn players manipulated the movements of their tongue and jaw during lip trills.[82] While the level of expertise differed between Dr. Iltis' two studies, both included musicians without known performance problems. These studies are mostly intended to inform pedagogy, and not necessarily investigations of any performance problem.

Both dissertations by Cochran's and Akers's describe an increase of pressure inside the mouth and throat during an experience of "locking up." Cochran describes it as:

> Inhalation is normal, but instead of easing the air fluently, the tongue locks into place. Air pressure is built up in the mouth and lungs, causing tension in the abdomen, chest, throat, and mouth.[83]

Akers describes "locking up" as being caused by one of two actions:

[81] Iltis et al., 2017.

[82] Iltis et al., 2017.

[83] Cochran, 2004, pp. 2-3.

> Building pressure behind the tongue when trying to articulate and closing the glottis which does not allow the breath to move forward into the mouth cavity.[84]

It is important to note that neither of these dissertations are citing academic sources of information for these descriptions. Cochran's description is based on an unknown source, likely attributed to personal experience. Akers' description comes from unknown literature. Akers also cites qualitative responses to his survey. However, he does not provide information on the number of responses this description is based on, any variation in the responses, if there were any further descriptions not included, or any other related information. While there is limited reliability in using these two sources as evidence for an increase in intraocular pressure during a "lock up," increases of intraocular pressure in the mouth and throat during wind instrument playing has been described by other studies.[85]

Schmidtmann measured an increase in intraocular pressure (IOP) in 37 brass musicians.[86] This study measured the differences in intraocular pressure when playing low, medium, and high frequency pitches. It also measured the increases in intraocular pressure during "everyday playing conditions," which consisted of 10 minutes of instrument-specific warmups and repertoire compiled by experienced, professional musicians. This study found that playing a sustained tone on a brass instrument increases IOP, with higher frequency pitches creating higher IOP. Playing a well-known piece of repertoire for 10 minutes saw an increase in IOP over the first two minutes, followed by a gradual decrease in IOP over the remaining eight minutes. However, this study did not provide instrument specific data, which

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[84] Akers, 2016, p. 6.

[85] Schmidtmann et al., 2011.

[86] Banzhoff et al., 2017.

does not allow for determining the measurements of trombones separate from other brass instruments. It also does not indicate if any of the 37 professional musicians recruited for the study experienced any performance issues.

Pressure levels inside the larynx were measured in tuba, trumpet, French horn, and trombone.[87] Using a pressure transducer in the mouthpiece and a hypopharyngeal probe inserted through the nose, Stasney was able to measure how much pressure in cmH2O was experienced by four musicians playing four identical pitch frequencies. These pressures were found to differ greatly, with the trombone player experiencing 0-6 cmH2O in the mouthpiece, and 10-70cmH2O in the larynx. The French horn had the highest hypopharyngeal pressure levels, with 0-20cmH2O in the mouthpiece, and 35-150+ cmH2O in the larynx.

This study suffered from a small population of only four musicians in total, with one musician for each instrument. Compounding the study's problems of personnel, 3 of the subjects were professional musicians in the Houston Symphony, while one was a graduate student at Rice University. This study also included a secondary test to measure the difference in pressure levels when the musicians were purposefully instructed to play with "bad technique."[88] By purposefully playing with "bad technique," the hypopharyngeal probe measured increased pressure levels in the larynx. It could then be assumed that how the instrument is played is a determinant for pressure levels in the mouth and throat, and that high levels of mouth and throat pressure are not necessarily inherent to brass instrument. It could also be reasonably assumed that at least some high-pressure levels found in this study were

[87] Stasney et al., 2003.

[88] Stasney et al., 2003, pp. 154-155.

due to individual playing deficiencies. What is therefore not known is whether musicians reporting higher IOP levels during “locking up” is due to “bad technique,” the effects of the performance problem, or is typical for playing a brass instrument. Furthermore, how much of experiencing “locking up” in the first place is an effect of playing with “bad technique”?

Descriptions of *valsalva maneuver*/musical stuttering and its effect on the glottis during performance resembles spasmodic dysphonia, a form of task specific focal dystonia that impacts the larynx. Spasmodic dysphonia is a speech and voice disorder that causes vocal tremor, voice breaks, restricted pitch and loudness ranges, hoarseness, and requires effortful phonation.[89] Similar to other forms of focal dystonia, spasmodic dysphonia develops mid-life, and typically progresses gradually during the first year. Diagnosing spasmodic dysphonia is difficult due to a lack of objective diagnostic measurements. Spasmodic dysphonia can therefore only be diagnosed via clinical observation, and can take 3.95 years for a conclusive diagnosis to be given.

There are some similarities between spasmodic dysphonia and the performance problem *valsalva maneuver*. Both problem cause interruptions to sound production, and both cause excessive tension in the glottis.[90] However, current literature suggests there is great variability to when interruptions occur relative to vocal onset in spasmodic dysphonia patients.[91] Spasmodic dysphonia has been found to occur, with variability, both pre- and during-phonation.[92] In contrast, both Erb and Arnold Jacobs noted that the “locking”

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[89] Ludlow et al., 2008; Sapienza et al., 2000; Chen et al., 2018.

[90] Stewart, 1987, p. 17.

[91] Sapienza et al., 2000, p. 509.

[92] Chen et al., 2018.

experienced by *valsalva maneuver* primarily occurs before tone production. Cochran reported that musical stuttering mostly occurred before the first note of a piece in the subjects of his survey. These suggest a different pattern of onset between spasmodic dysphonia and reports for both *valsalva maneuver* and musical stuttering. It appears that spasmodic dysphonia occurs more consistently across all aspects of speech, whereas *valsalva maneuver* and musician's dystonia only occur before the initiating tone.

Differences also include the impact of environmental factors. Subjects of Cochran's study of musical stuttering found that moments of high stress increased the likelihood of experiencing a "lock-up." Cannito found that those with spasmodic dysphonia experienced greater trait anxiety and depression, but no significant increase caused by state anxiety.[93] While the affective causes of spasmodic dysphonia are not well known, other forms of musician's focal dystonia have also been shown to not be significantly impacted by situational stress levels.[94]

## Dystonia

A recent committee of international experts defined dystonia as:

> a movement disorder characterized by sustained or intermittent muscle contractions causing abnormal, often repetitive, movements, postures, or both. Dystonic movements are typically patterned, twisting, and may be tremulous. Dystonia is often initiated or worsened by voluntary action and associated with overflow muscle activation.[95]

Dystonia can affect a single part of the body, or the entire body. Focal dystonia is a form of

[93] Cannito, 1991.

[94] Altenmuller et al., 2015, p. 96.

[95] Albanese et al., 2013.

dystonia that affects one body region, such as the hand. Examples of focal dystonia are writer's cramp and the yips. These are also examples of task-specific dystonia, which are forms of dystonia that are triggered by a specific repeated action. Task-specific dystonia differ from paroxysmal dystonia in that the muscle contractions cease after the action is stopped. The two common forms of musician's dystonia are embouchure dystonia and focal hand dystonia.

Based on the available description, the problem known as *valsalva maneuver* and musical stuttering meets the consensus definition of dystonia as quoted above. Cochran's study describes overflow muscle activation in the form of tightness in the chest[96] and constriction of the larynx,[97] lasting sometimes for several seconds.[98] Several of the case studies on musical stuttering noted that the "locking up" happens primarily when voluntarily attempting to play a first note. These descriptions combine to characterize the movement problem as sustained muscle contractions, initiated by the voluntary action of starting a first note on a wind instrument, associated with overflow muscle activation and abnormal movements. Based on these descriptions, this problem meets the definition of dystonia. Since this problem has been described to only occur during wind instrument playing, it is likely a form of task-specific dystonia. It is not yet known if this problem only impacts one body site or several, so it could be either focal, multi-focal, or segmental dystonia.

## Altenmuller's Spectrum Model

Eckart Altenmuller created a spectrum-like heuristic model to aid in clinical dystonia

[96] Cochran, 2004, p. 24.

[97] Cochran, 2004, p. 20.

[98] Cochran, 2004, p. 20.

diagnosis. This model, a continuation of Smith's (2003) spectrum-like continuum of the yips, demonstrates the way in which motor disturbances and motor control problems can gradually worsen into motor control disorders such as focal dystonia (Figure 2).[99] Initial motor disturbances, such as motor fatigue or overuse pain, might cause a musician to alter their movement patterns, increase the number of muscles recruited for the task, or increase the force exerted by the muscles. Over time, this alteration of the muscle pattern can lead to adaptations in the central nervous system. The more frequently this maladaptation is performed, and the longer the period it is employed, the more engrained and dysfunctional this movement becomes. If not successfully treated, this deterioration of the task execution can develop into task-specific focal dystonia.[100]

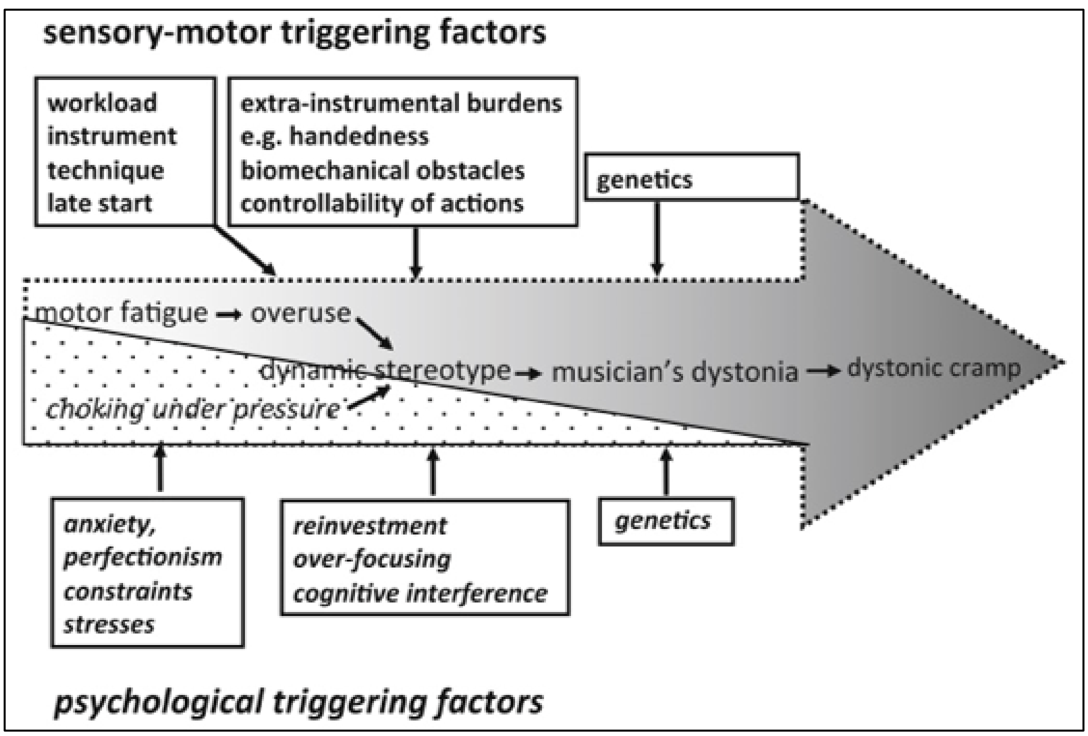


**Figure 2: Altenmuller's heuristic spectrum model.**

[99] Altenmuller et al., 2014.

[100] Altenmuller et al., 2015.

Altemuller's "heuristic" model involves six subtypes of motor problems. The first and earliest developed subtype is motor fatigue. This problem typically occurs after long periods of use, or after long periods of disuse when the muscles have lost their strength and endurance. This is the most commonly experienced of the motor control problems. Motor fatigue can progress to an overuse injury if sustained too often or over too long a period.[101]

Choking under pressure (CuP) is a cognitive-based motor control problem often found in musicians. Choking under pressure is when a highly skilled individual gives a substandard performance during a high-stress situation.[102] Hill et al. define it as any significant decrease in performance under a pressurized condition.[103] It is only considered CuP when preparation and intent match the capabilities of the performer. Altenmuller proposes that CuP is linked to self-focus during skill execution, which can create an anticipation of an error in musicians.[104] The anticipation of a mistake, or pre-error, can happen 50ms before the actual mistake.[105] Regular occurrence of this rapid disturbance to skill execution could lead to an alteration to the central nervous system's motor control.[106]

If motor control problems, like the ones described above are allowed to continue in a musician's playing, they can form permanent or semi-permanent changes to the sensorimotor network. Altenmuller has described this phase of the progression of motor control disorders as

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[101] Quarrier, 1993.

[102] Gropel & Mesagno, 2019.

[103] Hill & Shaw, 2011.

[104] Altenmüller et al., 2015.

[105] Ruiz et al., 2009.

[106] Altenmuller et al., 2015, p. 93.

“dynamic stereotype.”[107] Altenmuller’s definition of a dynamic stereotype is:

> When motor incoordination and lack of motor control persist for more than 4 weeks, even though rest has been observed and careful rehabilitation under the guidance of a therapist or teacher has been attempted, one can assume that a more grave alteration of sensorimotor networks leading to a deterioration of motor programs in the CNS.[108]

The term dynamic stereotype is a reference to Ivan Pavlov’s work on conditioned response, in which he describes the cerebral cortex’s ability to create a fixed response based on external stimuli[109]; dynamic stereotype is the point where a behavior becomes learned. In context of choking under pressure, a dynamic stereotype has been created when the dysfunctional playing that occurred during high-stress performance becomes habitualized outside of a high-stress performance setting.

Dynamic stereotypes are similar to focal dystonia, except they create a less extreme response. Dynamic stereotypes are more modifiable, more fluctuating, and are more capable of being temporarily improved. There is a rare likelihood that a dynamic stereotype can respond to trick changes in tactile feel, whereas focal dystonia does not. Focal dystonia also creates a more distinct reaction than dynamic stereotype, and is experienced more severely. In general, dynamic stereotype can be understood to be the earliest stages of a motor control problem developing into a disorder that can eventually progress into focal dystonia.[110]

The final developmental stage and most severe motor control disorder in Altenmuller’s model is focal dystonia. Although uncommon in musicians, musician’s dystonia has been known

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[107] Altenmuller et al., 2015, p. 93.

[108] Altenmuller et al., 2014, p. 166.

[109] Windholz, 1996.

[110] Altenmuller et al., 2015, p. 96.

to end even the most prominent and skilled musician's career. The initial stages of development are marked by relatively subtle changes in muscle control, which can often take the form of antagonistic muscle contractions. Focal dystonia in musicians has been known to develop into generalized dystonia, which effects non-musical tasks. In very rare cases, it has been known to segment into different body parts.[111]

Most of these six motor control problems include unique aspects that make them distinct from their counterparts. The shape and coloring of the heuristic model (Figure 1) as it shifts from left to right demonstrate a progressive increase in frequency and intensity of how often a musician experiences it, and a decrease in fluctuation of *how* it is experienced. Problems in the less-severe portion of the model are also more effected by treatment methods, including rest and professional healthcare intervention. Whereas more severe disorders like dynamic stereotypes and musician's dystonia that have developed into dysfunctional motor programs are considered untreatable, or unlikely to be treated. This spectrum-like heuristic model was designed to utilize the distinguishing characteristics of each problem that clinicians use for identifying motor control problems in musicians. The intent of the model was to provide a tool for clinicians to reference when deciding on interventions.

While information on the performance problem *valsalva maneuver* or musical stuttering is scarce, the descriptions that exist meet the criteria for a form of focal dystonia. Indeed, the description is nearly identical to the yips, a known form of focal dystonia that effects golfers. The similarities with these two problems likely stem from the similarities between golf and

[111] Altenmuller et al., 2015, p. 96.

making music. Golf and music are both performance-based activities that require years of intensive practice, precision, and control of fine muscle control.

## The Yips

The yips is a performance disorder in golfers that has been described as jerks, tremors, or freezing that specifically interrupt a golf putting stroke.[112] It has been found to worsen as golfers approach the hole, where the smoothness of the putting action becomes more crucially important.[113] McDaniel was the first to study the golf performance disorder the yips.[114] His study consisted of an epidemiological survey of the yips and sought to investigate the characteristics and severity of a disorder already known to golfers. McDaniel's 69-item survey provided sufficient data to allow him to propose classifying the yips as a form of focal dystonia. Smith believed the disorder could be classified along a spectrum between choking and a form of focal dystonia.[115]

The yips shares several similarities to the performance problem *valsalva maneuver*. Both the yips and *valsalva maneuver* have been described as a "freezing"[116] of motion during skill execution. The yips were reported as especially common during the forward swing of the club. This description matches Cochran's finding that musical stuttering typically only occurred before the first note.[117] The subjects of McDaniel's survey reported experiencing the yips after

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[112] Smith et al., 2003; Sachdev, 1992.

[113] Smith et al., 2003.

[114] McDaniel et al., 1989.

[115] Smith et al., 2003, p. 26.

[116] McDaniel et al., 1989, p. 193.

[117] Cochran, 2004, p. 42.

20.9 years of golfing experience, similar to subjects of Cochran's 2002 survey reported first experiencing musical stuttering at an "advanced level" of musical performance, having either earned at least one music degree or having playing for an average of 17 years. Akers' survey also found that 50% ($n$ = 11) of subjects who experienced "hesitation" developed the problem as a graduate student/professional. No consistent strategies for intervention have been proposed for any studies.

The similarities between the yips and *valsalva maneuver*/musical stuttering (i.e.: affected part of movement, involuntary muscle contractions, years of experience at onset, ineffectiveness of treatment) suggest that both problems share similar etiologies. Smith suggested that the yips might exist on a continuum between choking and focal dystonia, with the exact classification being dependent on each individual golfer's experience.[118] Considering the similarities between these two performance problems, it is possible that *valsalva maneuver*/musical stuttering is also experienced along a continuum, as proposed by Smith (2003). It is therefore possible that, with an accurate continuum model as a basis for comparison, *valsalva maneuver*/musical stuttering could also be classified as a spectrum of disruptions capable of worsening into a unique type of task-specific dystonia.

## Epidemiologic Study of Health in Trombonists

The application of scientific principles should be applied to the study of the health of trombone players and the health risks associated with playing the trombone. However, there is a relative lack of scientific literature on the health of trombone players. Few studies include

[118] Smith et al., 2003, p. 26.

trombone-specific data, instead lumping all brass instruments into a generic "brass" category,[119] resulting in a lack of health knowledge that is specific to trombone players. It has been theorized that instrumentalists experience pain based on the unique biomechanical demands of the instrument.[120] Without instrument-specific data on the health of trombone players, there is insufficient information to accurately understand the health risks involved with trombone playing.

In response to the lack of empirical trombone health data, the UNT Trombone Health Survey (UNT-THS) was created to be the world's first epidemiologic study of the health problems experienced by trombone players.[121] This survey investigated the pain experienced by 316 trombone players in 46 body-sites over the past year (Figure 3), and reported quantitative data on the 15 most prevalent sites (Figure 4).

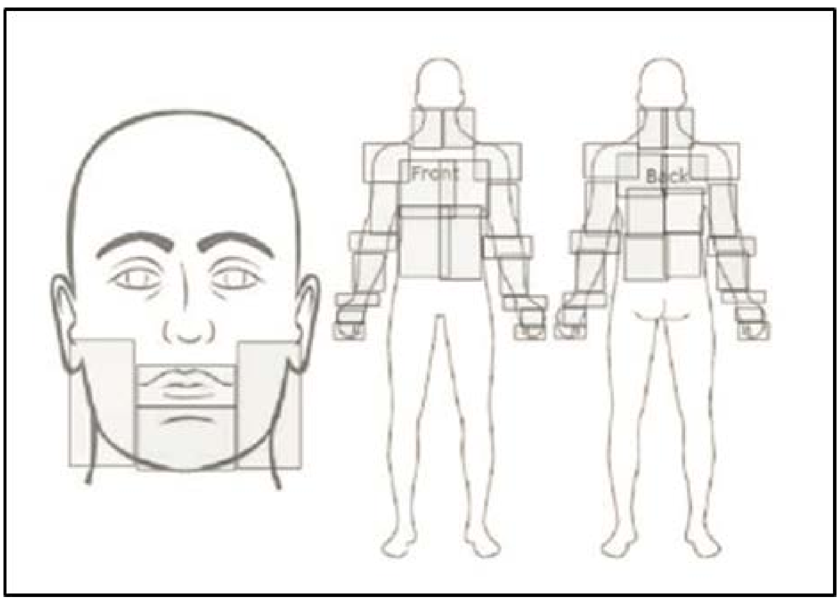


**Figure 3: Body map used in the Trombone Health Survey.**

[119] Fishbein et al., 1988; Fry, 1986; Morse et al., 2000; Knapik et al., 2007; Nemoto & Arino, 2007; Manchester, 1988; Shoup, 1995; Ackermann et al., 2012.

[120] Chesky et al., 2002.

[121] Wallace et al., 2016.

| Musculoskeletal Site | Total | Male | Female |
|---|---|---|---|
| Lips | 74 (23.4) | 57 (21.1) | 17 (40.5) |
| Left shoulder front | 55 (17.4) | 50 (18.5) | 4 (9.5) |
| Jaw | 54 (17.1) | 43 (15.9) | 11 (26.2) |
| Left lower back | 48 (15.2) | 35 (13.0) | 12 (28.6) |
| Left neck back | 46 (14.6) | 38 (14.1) | 8 (19.0) |
| Right lower back | 42 (13.3) | 31 (11.5) | 10 (23.8) |
| Left hand front | 35 (11.1) | 31 (11.5) | 4 (9.5) |
| Left shoulder back | 35 (11.1) | 28 (10.4) | 7 (16.7) |
| Right neck back | 33 (10.4) | 28 (10.4) | 5 (18.5) |
| Right upper back | 33 (10.4) | 17 (6.3) | 16 (38.1) |
| Left upper back | 33 (10.4) | 22 (8.1) | 11 (26.2) |
| Left wrist front | 32 (10.1) | 24 (8.9) | 8 (19.0) |
| Left elbow front | 29 (9.2) | 26 (9.6) | 3 (7.1) |
| Left upper arm front | 28 (8.9) | 25 (9.3) | 3 (7.1) |
| Left forearm front | 26 (8.2) | 20 (7.4) | 6 (14.3) |

**Figure 4: Prevalence rates for the 15 most-selected pain sites in the Trombone Health Survey.**

The study provided descriptive data about how trombonists experience pain related to trombone playing. It found that pain-sites generally clustered around three musculoskeletal regions: the embouchure region, the upper-left extremity, and the back region (Figure 5).

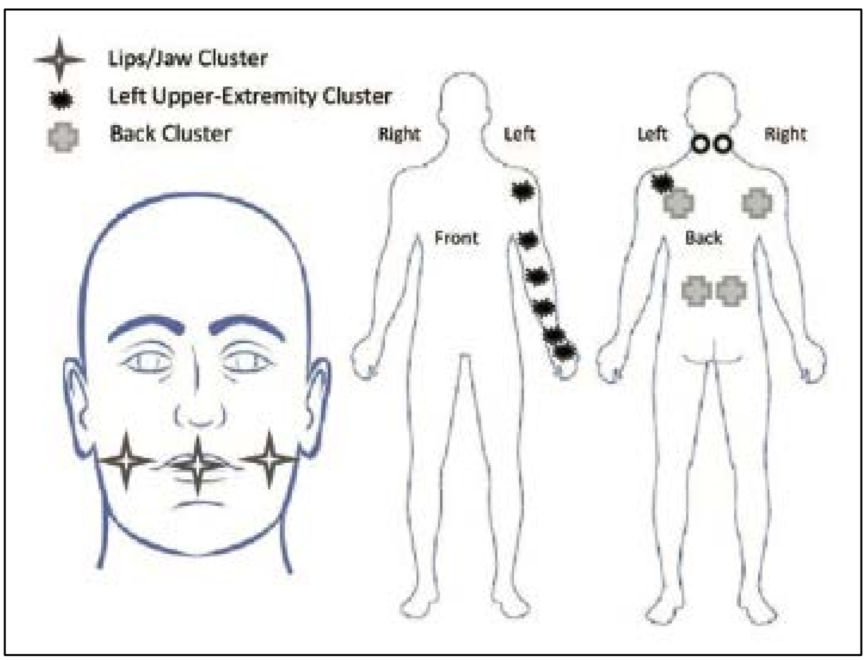


**Figure 5: The 3 pain-site clusters identified in the Trombone Health Survey.**

The first pain-site cluster consisted of the *lips* and *jaw*, which were the first and third most commonly selected pain-sites. Comparing the lip and jaw pain data to other studies is difficult, as few studies have included the lip and jaw pain experienced by trombone players. Of the studies that investigated lips or jaw in trombonists, one included a small sample size[122] (*n* = 16), one used the vague term "loss of lip" in reporting lip issues,[123] and one was a summary of visits to a musician's health clinic and not a sample of the general musical population.[124] The THS found that 23% of trombonists reported lip pain in the past year, compared with other studies' reports of 30% embouchure fatigue[125] and 42% lifetime prevalence.[126] A possible explanation for the high rates of pain in these sites is trombonists applying too much mouthpiece force against their lips, which has been measured to reach 10,500 newtons in trombone players.[127]

The second pain-site cluster reported was the left-upper extremity, consisting of seven sites from the left hand to the left posterior deltoid. The *left shoulder front* (left anterior deltoid) was selected with the second highest overall prevalence (17.4%), while the other six sites along the extremity were selected by between 8% and 11% of the population (Figure 3). This contrast suggests a difference in biomechanical function between the anterior deltoid and the other sites along the extremity when playing the trombone. It is theorized that the anterior

[122] Ackerman et al., 2012.

[123] Chesky et al., 2002.

[124] Lederman, 2001.

[125] Steinmetz et al., 2014.

[126] Storms et al., 2016.

[127] Froelich, 1987.

deltoid is responsible for sustaining mouthpiece force against the lips, while the rest of the left upper-extremity supports the weight of the instrument against gravity, which would account for the difference in pain experienced along these sites.

The third pain-site cluster found in the study was in the upper and lower back. Lower back pain (LBP) is one of the most common causes of pain in the world, with one literature review finding 38% of the general population reporting having experienced LBP within the past year.[128] In our study, back pain was reported differently in both the left and right sides of the upper back compared to the left and right sides of the lower back. This is a departure from previous literature on brass musicians, which found that back pain was experienced laterally depending on where the instrument's weight was held.[129] It is theorized that this is due to the different functions of the upper versus lower back: e.g. the upper back muscles support holding the arms and the trombone in front of the body, while the lower back muscles support the musician's trunk stability while sitting upright in a chair. Since the abdominal and extensor muscles that normally help support the lumbar region in this position must be left free to move during tone production, the lower back muscles are particularly taxed, likely contributing to LBP.

The results from this study allowed for several proposed interventions. First, pain was most commonly reported in the lips, jaw, and anterior deltoid – three sites that are impacted by the amount of mouthpiece force applied. It is possible to utilize mouthpiece force sensors to measure relationships between mouthpiece force and experiences of pain in these sites. If a

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128 Hoy et al., 2012.

129 Chesky et al., 2002.

relationship is found, steps could be taken to lessen the force used while playing the trombone. Second, the pain along the left-upper extremity is possibly due to supporting the weight of the instrument, and could be alleviated by research into the effectiveness of ergonomic support devices. It might also be possible for support devices to alleviate pain in the upper back by altering how the instrument's weight is held. Finally, research into chair design, back supports, and posture recommendations could all lead to control of LBP related to trombone playing.

The value of the interventions proposed by the THS study come from having a large population of trombone players complete the survey. Having the largest known population of trombonists respond increases the value and validity of the information reported. The data obtained in this study allows for understanding and predicting the pain sites of trombone players, which in turn allows for the proposal of accurate interventions, all of which meet Kleinbaum's definition of epidemiology.[130] The strength of the UNT-THS showcases the benefits of using an online survey for an epidemiologic study. It is likely that these benefits will also apply to the investigation of motor control problem such as the performance problem *valsalva maneuver* and/or musical stuttering.

[130] Kleinbaum & Kupper, 1982.

# CHAPTER 3

# METHODS

## Procedures

Respondents to the survey were first required to agree to an institutional review board (IRB) approved consent form. They were then presented with the same description of the problem provided in the announcement, and given a yes/no question asking "Have you ever experienced this problem in your own playing?" Those who clicked "Yes" were continued onto the rest of the survey, and their responses were possibly included in the data analysis. Those who clicked "No" were thanked for their time, and the survey was terminated. Subjects were not allowed multiple attempts.

Recruitment was primarily accomplished through an IRB approved survey announcement (Appendix A). The announcement contained a short biography of the author, a description of the problem being investigated, an outline of what subjects should expect from the survey, a sharable link to the survey, and contact information for the author (Appendix B). The announcement was sent to a database of 6,400 college-level brass instrument professor's email addresses collected from individual accredited institution websites found through the National Association of Schools of Music's website. This database was manually obtained by the author. The announcement was also posted on appropriate Facebook pages dedicated to brass instruments. The moderators for these groups were contacted for permission before the announcement was posted. Lastly, the announcement was posted on several brass instrument organization websites. The announcement encouraged further distribution to anyone who would be interested in taking or distributing the survey. The intention was to receive the largest number of responses possible through a snowball distribution strategy.[131]

A second round of distribution began three weeks after the initial set of emails. Responses were collected for approximately four weeks before data collection began. This procedure obtained IRB approval. Responses were saved on the author's UNT Qualtrics account. Data was analyzed using SPSS version 25. This procedure received IRB approval.

## Participants

The target population for the study was brass instrument musicians who have experienced this problem in their own playing. The survey population only included musicians who responded "yes" to having experienced this problem in their own playing, based on the definition described below. Musicians who selected "no" to experiencing this problem in their own playing were excluded from the survey population. Of the musicians who reported experiencing this problem in their own playing, subjects were included if they were 18 years old or older and completed the entire survey. Detailed case selection criteria can be seen in Appendix C. Following the case selection process, 252 subjects were included in data analysis.

## Creating the Operational Description

Two primary sources were used in creating the description of this problem: the four single-subject case studies on musical stuttering published in SLP journals, and transcriptions of Arnold Jacobs'[132] descriptions of this problem in the book *Song and Wind*.[133] The description

[131] Atkinson & Flint, 2001.

[132] Jacobs is often discussed by experts when writing about this problem. For this reason, it felt prudent to go straight to the source.

[133] Frederikson, 1996.

was then sent to professional brass musicians and pedagogues who expressed interest in helping with the study. After several rounds of back-and-forth edits between the professional musicians, the following definition for this problem was developed:

> Several influential brass instrument teachers have noted working with students who experience a freezing sensation when starting a note on a wind instrument. Arnold Jacobs used the term "Valsalva maneuver" when discussing this problem, saying it was not uncommon among his students. Jacobs described this problem as an increase in internal air pressure, closure in the throat, and a choking sensation. Other academic articles reported wind players who experienced "musical stuttering," which they described as a perceived tightening of the chest and throat muscles, a sense of "locking up," and subsequent delayed, explosive, or rapidly repeated first note. However, little is actually known about this problem, how it is experienced by brass musicians, or if there are other ways in which this problem manifests.

## Survey Tool Overview

The survey was developed using Qualtrics survey software.[134] Survey items included multiple-choice questions, 100-point visual analog scale (VAS) sliders, and text entry boxes. Skip-logic and display-logic were included for survey navigation.

The survey was broken into 10 blocks of questions. Each block related to a different aspect of inquiry related to this problem or information about the respondent. On the respondent's end, each block represented one page of questions. The blocks for the survey were:

1. IRB approved consent form
2. Demographics
3. Primary experience questions
4. Physical effects questions

[134] Version 2018-2019, Qualtrics, Provo, UT

5. Playing impact questions
6. First experience questions
7. Misc
8. Attitudes
9. Musical demographics
10. Movement-Specific Reinvestment Scale
11. Performance anxiety

Blocks 7, 8, 10, and 11 are intended for future studies, and are not included in the current study. The survey was created using Qualtrics v. 2018-19 online survey creation program.[135] A PDF version of the entire survey can be found in the supplemental file, Appendix D.

## First Experiences Section

The question "Rate how your practice habits changed prior to first experiencing this problem" was created in order to determine the role of changes to practice habits on the onset of this problem. Two separate 100-point VAS sliders were used to investigate the frequency and intensity of how the respondent's practice habits changed. Similar to Figure 8, these sliders were positioned in the middle at 0 and could be moved to indicate either a negative change (-50) or positive change (50). The negative side of the slider was labeled "significantly decreased" and the positive side was labeled "significantly increased." The musician's age when this problem was first experienced was measured using a text entry box.

[135] Qualtrics Survey Software, 2017. Qualtrics, Provo, UT, USA

Characterization

The strategy used to investigate the characteristics of this problem was borrowed from the Borrell-Carrió et al. psychosocial model of health.[136] Borrell-Carrió et al. recognized that "health" involves a complex interplay of many factors, and separated the biological, psychological, and social factors to obtain a holistic view of each patient's unique experience. Each individual factor could then be investigated and treated, turning complex diseases into manageable pieces. The biopsychosocial model was adapted to investigate the characteristics of this problem by separating it into eight factors that represent different aspects of motor control problems (Figure 6). Each factor could then be measured, compared, and discussed, resulting in a holistic view of this complex problem.

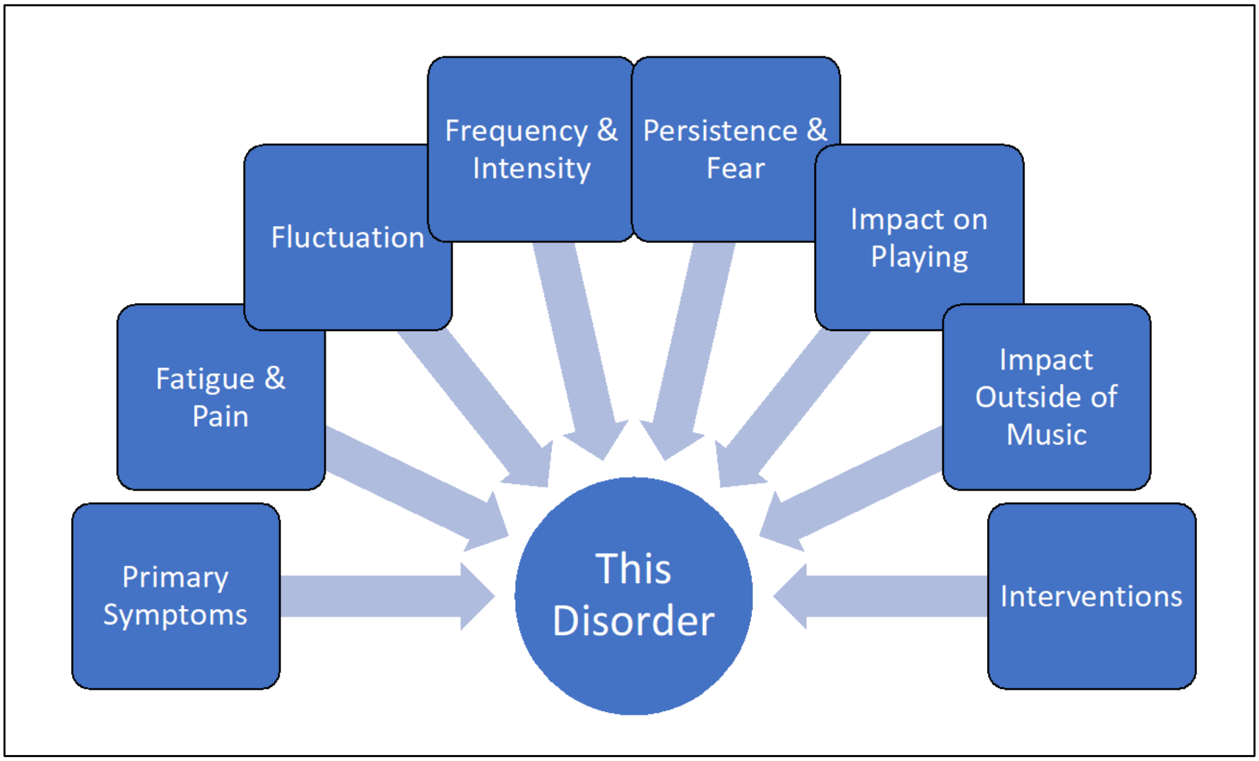



**Figure 6: Visualization of the 8 factors that make up the characterization of this problem.**

[136] Borrell-Carrió et al., 2004.

The first factor for characterizing this problem is primary symptoms (Figure 7). This component consists of three 100-point VAS sliders to measure the most common symptoms, as described in the case studies discussed above, including one "other" measure (which was followed by a text entry box for clarification). The three symptoms were devised by taking the descriptions of this problem from the four case studies and organizing them by similarities. These symptoms are: (1) difficulty starting a first note, (2) tension in the throat, (3) tightness in the chest and upper body, and (4) other.

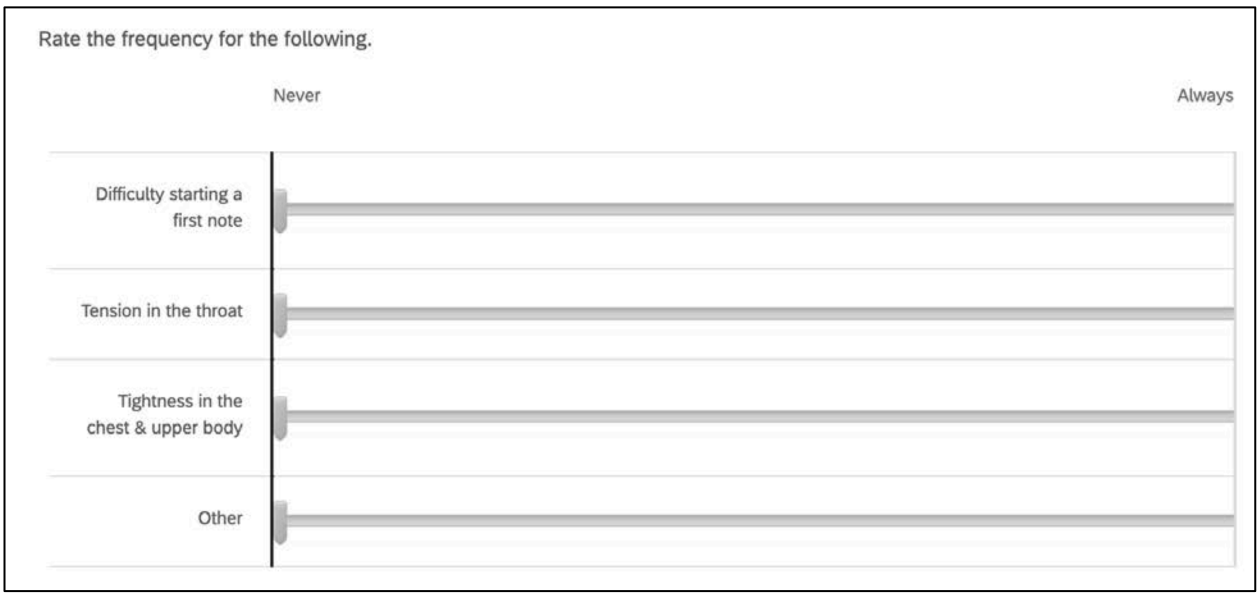
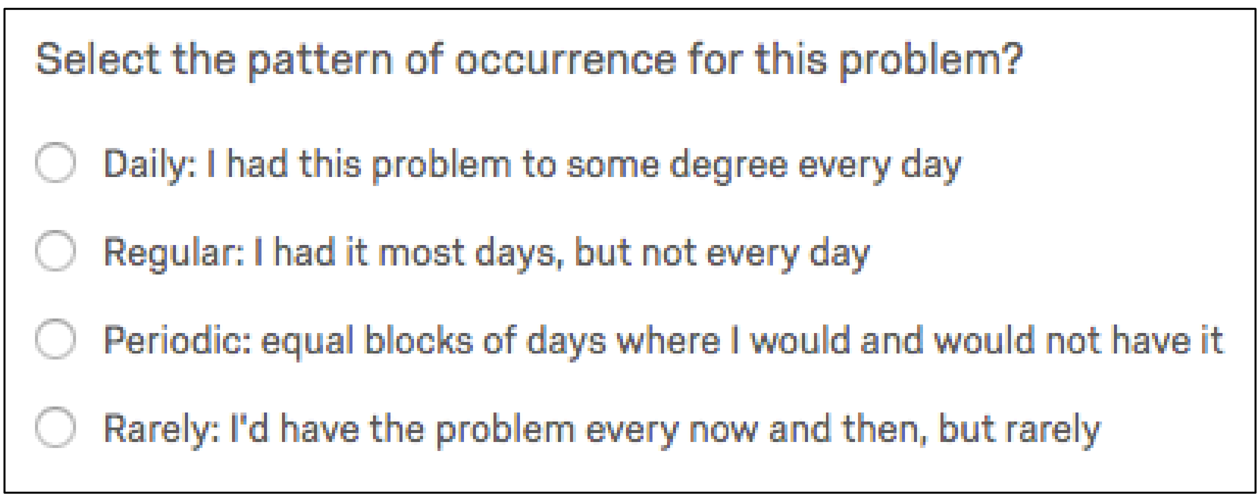



**Figure 7: Screenshot of the Patterns of Occurrence: Frequency question from the survey.**

The second factor for characterizing this problem is fatigue and pain. This consists of four 100-point VAS sliders that measure the frequency of fatigue for the following: (1) tongue, (2) throat, (3) respiratory system, and (4) mental. Following this are three VAS sliders measuring the frequency of pain in the tongue, throat, and respiratory system. If the slider is moved for any of these variables, a follow-up set of sliders appears with *intensity* of pain at the same sites. Frequency and intensity of mental pain were not measured, since it was assumed the concept of "mental pain" might lead to confusion.

The third factor for characterizing this problem is fluctuation, measured with three questions. The first question asked "Select the pattern of occurrence for this problem," and showed four ordinal response options (Figure 8).[137] If a respondent selected "daily" or "regularly," display-logic showed a 100-point VAS slider asking "Rate the level this problem fluctuated *from day to day*." The third question of this factor asked "Rate the level of fluctuation *within a single day*," also measured with a 100-point VAS slider. These three questions provide information on fluctuation ranging from the broadest to narrowest perspective.


Select the pattern of occurrence for this problem?

- Daily: I had this problem to some degree every day
- Regular: I had it most days, but not every day
- Periodic: equal blocks of days where I would and would not have it
- Rarely: I'd have the problem every now and then, but rarely

**Figure 8: Screenshot of the Patterns of Occurrence: Fluctuation question from the survey.**

The fourth factor for characterizing this problem separately measured the frequency and intensity of their experience. Each question was separated into three measurements of timing: (1) before the first note *of a piece*, (2) before the first note *after a rest*, and (3) *while* playing. The timing options were derived from the four case studies above. This factor

[137] These four options essentially created a 4-point Likert scale.

represents the frequency, intensity, and relative timing of the problem's symptoms into a single set of variables.

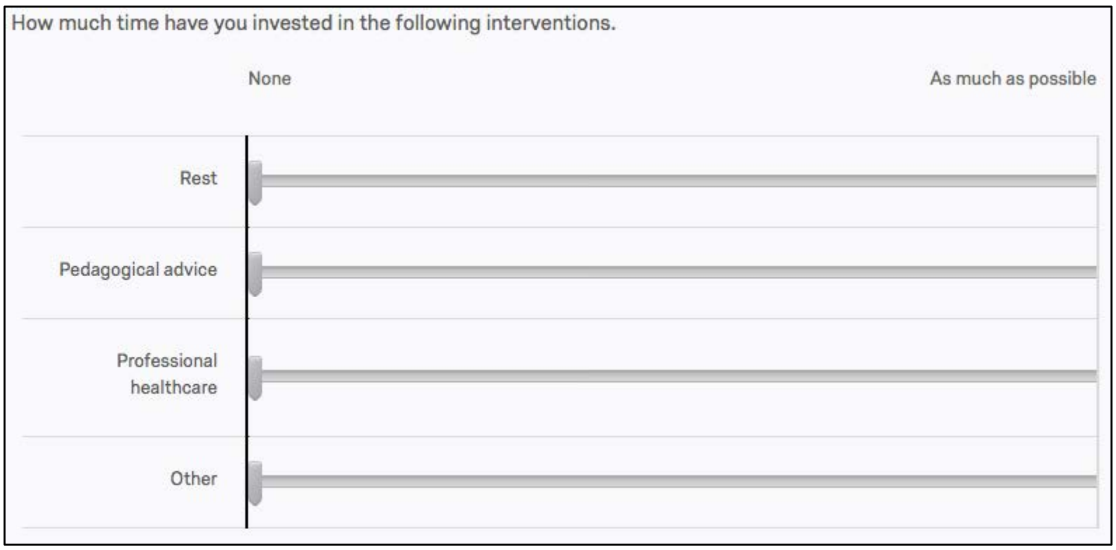
The fifth factor for characterizing this problem is persistence and fear, consisting of two questions. The first question asked "Did this problem persist for more than 4+ weeks despite pedagogical advice and/or professional healthcare?" with multiple choice answers yes/no/unsure. The second question of this component asked "Rate the frequency this problem was accompanied by fear of failure and/or increased anxiety," measured with a 100-point VAS slider. The two ends of the slider were labeled *never* to *always*. The text for both of these questions was derived from Altenmuller's description of a dynamic stereotype and choking under pressure respectively (see below).

The sixth factor for characterizing this problem measured the impact on playing, and asks "Rate the level of impact this problem has on your ability to play your instrument." It was measured using a 100-point VAS slider labeled *none* to *severely debilitating*.

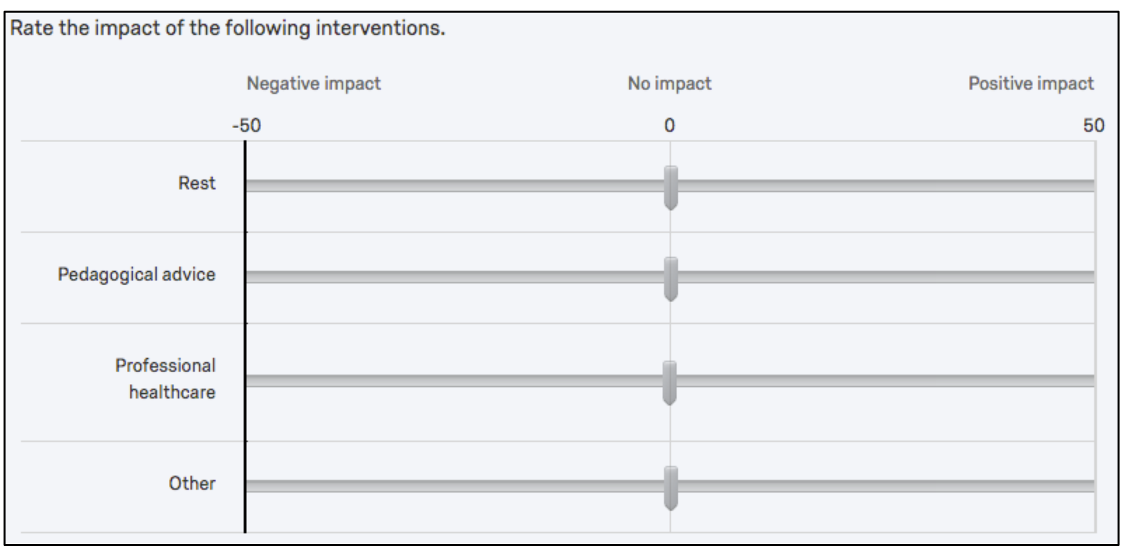
The seventh factor for characterizing this problem measured the impact *outside* of playing. This question asked "*Outside of music*, how has this problem negatively impacted you in the following ways?" and consisted of four 100-point sliders labeled: (1) psychologically, (2) professionally, (3) personally/socially, and (4) breathing/speaking. The ends of the sliders were labeled *not at all* to *severely debilitating*.

The eighth and final factor for characterizing this problem is interventions. It consists of two questions containing four VAS sliders, each labelled: (1) rest, (2) pedagogical advice, (3) professional healthcare, and (4) other. The first set of variables was measured using a 100-point VAS slider asking "How much time have you invested in the following interventions?" (Figure

9a). Using display-logic, moving a slider past 0 displayed the second question, “Rate the impact of the following interventions” with the same four variables as above. However, the ends of this VAS slider ranged from -50 to +50, with the slider positioned in the middle at 0. The -50 side was also labeled “negative impact,” and the positive end was labeled “positive impact” (Figure 9b). Since it is possible for an intervention to do harm, this slider allowed subjects to report each intervention as having a positive *or* negative impact on their problem.




**(a) Time invested**




**(b) Impact**

**Figure 9: Screenshot of question used to measure the impact of interventions.**

## Assessment of the Classification Model

This study designed three assessments to determine whether this problem follows the same patterns of progressive worsening outlined in Altenmuller's spectrum-like model. A consistent pattern of worsening for all three assessments will provide evidence that this problem is experienced as a spectrum of increasingly severe motor disruptions.

The first model assessment was designed to align with dynamic stereotypes, a subtype of musician's dystonia. This subtype is a "soft sign," describing the early stages of musician's dystonia.[138] Altenmuller describes this subtype as:

> When motor incoordination and lack of motor control persist for more than 4 weeks, even though rest has been observed and careful rehabilitation under the guidance of a therapist or teacher has been attempted, one can assume a more grave alteration of sensorimotor networks leading to a deterioration of motor programs in the CNS. We have called this condition "dynamic stereotype (DS)".[139]

To align with this subtype, the first assessment asked subjects "Did this problem persist for more than 4 weeks, despite pedagogical advice and/or professional healthcare?" Based on Altenmuller's description of this subtype, subjects who respond "yes" are considered the high-severity group, and subjects who answer "no" are considered the low-severity group.

The second model assessment was designed to align with the level of fluctuation. A distinct characteristic of musician's dystonia is that it fluctuates very little compared to less severe subtypes, whereas the least severe subtypes on the spectrum are experienced with the greatest amount of fluctuation. Therefore, subjects who reported experiencing this problem daily are considered the high-severity group, and subjects who reported experiencing this

[138] Altenmuller et al., 2014, p. 166.

[139] Altenmuller et al., 2014, p. 166.

problem non-daily are considered the low-severity group. This assessment does not directly align with a specific subtype.

The third model assessment was designed to align with choking under pressure, which is a less-severe subtype on Altenmuller's spectrum. This question asked subjects "Rate the frequency this problem was accompanied by fear of failure and/or increased anxiety." Rather than comparing groups, this question gathered interval data that was used for investigating relationships.

In order for these assessments to be reliable, it is important that the same set of variables are used for each. This reduces the variability between the three tests. The model assessment variable set consists of distinct factors related to the severity of a motor control problem. This set of questions contains variables from six of the factors for characterizing this problem. They are: (1) primary symptoms; (2) frequency and intensity; (3) fluctuation; (4) impact of interventions; (5) impact on playing; and (6) frequency of fear and anxiety. These six variables are the yard-stick against which the three assessments were conducted.

This strategy allowed for assessing this phenomenon's classification using Altenmuller's model of progressive worsening. The first two model assessments provided transparent categorization of the subjects into high-severity and low-severity groups. Worsening for these assessments was determined if the high-severity group reported more frequency, more intensity, less fluctuation, less of a positive impact from interventions, more fear & anxiety, and a greater impact on performance. The third assessment investigated the relationship between higher levels of fear and anxiety and the overall severity of this problem. Worsening for this assessment was determined if correlations are found between fear and anxiety and the different factors in the model assessment variable set. A consistent pattern of worsening for all three assessment provides strong evidence that this problem is experienced as a spectrum of increasingly severe motor disruptions. This pattern therefore suggests that this phenomenon is a spectrum of progressively worsening motor disruptions, similar to known types of musician's dystonia.

## Evidence-Based Definition

The strategy used to investigate the characteristics of this problem incorporated a biopsychosocial model of health.[140] Survey items regarding biological, psychological, and social factors were intended to obtain a holistic perspective. Using this concept, the disorder was divided into 8 separate factors representing different aspects of its characterization. The data for these factors, provided by survey responses, were subjectively analyzed and included in the definition based on their significance in understanding how this disorder is experienced.

Inclusion was determined if a large percent of the population responded to a survey item, or if it was reported at a remarkably high mean. Factors related to physiological manifestations (throat and chest, and upper respiratory system), fatigue, and pain were included for their importance in identifying symptoms. Factors related to the social factors, mental health, and impact on playing were included. Finally, outcomes from the classification model assessment were included to further aid in early identification of this problem, as well as recommendations for interventions and future research.

[140] Borrell-Carrió et al., 2004.

## Data Analysis

The demographics section was analyzed using descriptive statistics, since it did not include investigations of relationships or comparisons. These analyses included prevalence, count with percentage of the population, and means with standard deviations. The questions from Table 2 were answered using text entry boxes, but no responses required alteration.

The first experiences section was analyzed using descriptive statistics, since it did not include investigations of relationships or comparisons. “Age when first experienced” was answered using text entry boxes, but no responses required alteration. Means with standard deviations for the positive habit changes were computed using *only* the data from subjects who reported a positive change; the same was found for negative habit changes. “Total population” was calculated from all responses for the entire population.

The first and second factors for characterizing this problem (primary symptoms) were designed to analyze prevalence and means with standard deviation for the entire survey’s population. Data from these questions were analyzed using descriptive statistics, since it did not include investigations of relationships or comparisons.

The second factor for characterizing this problem (fatigue and pain) was designed to analyze prevalence and means with standard deviation, for the entire survey’s population. Data from these questions were analyzed using descriptive statistics, since it did not include investigations of relationships or comparisons. Correlations between site-specific frequency of fatigue, frequency of pain, and intensity of pain were calculated using Pearson’s correlation coefficients in order to understand the relationship between fatigue and the frequency/intensity of pain, and the relationship between frequency and intensity of pain.

The third, fourth, fifth, and seventh factors for characterizing this problem were designed to analyze prevalence, and means with standard deviation, for the entire survey's population. The sixth and eighth factors for characterizing this problem were designed to analyze count with percent of the survey's population, and means with standard deviation for the entire survey's population. Data from these questions were analyzed using descriptive statistics, since it did not include investigations of relationships or comparisons.

Since analysis of the first two model assessments consisted of nominal data being compared against interval data, these two questions were analyzed using 2-tailed independent sample *t*-tests for significance. Analysis for the third model assessment contained entirely interval data, and so was analyzed using Pearson's correlation coefficients with SPSS's bivariate correlation function. Statistical significance was measured at a 95% confidence interval.

Creating the high-severity and low-severity groups was accomplished by computing a new variable from the "patterns of occurrence" question. All statistical analysis was performed using SPSS ver. 25.[141]

[141] IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.

# CHAPTER 4

# RESULTS

## Demographics and Musical Background

Subjects were mostly male (82.5%) with a mean age 39.2 years old. Tenor trombone was the most represented instrument (*n* = 70, 27.8%), followed by trumpet (*n* = 54, 21.4%) and French horn (*n* = 48, 19.0%). Most subjects considered themselves classical musicians (*n* = 198, 78.6%).

**Table 1: Demographics**

| | | n (%) | Mean ± SD |
|---|---|---|---|
| Age | | 252 | 39.2 ± 15.3 |
| Gender | Male | 208 (82.5) | |
| | Female | 43 (17.1) | |
| Primary Instrument | Trumpet | 54 (21.4) | |
| | French Horn | 48 (19.0) | |
| | Tenor Trombone | 70 (27.8) | |
| | Euphonium/Baritone | 21 (8.3) | |
| | Bass Trombone | 35 (13.9) | |
| | Tuba | 24 (9.5) | |
| Musician Identity | Classical musician | 198 (78.6) | |
| | Jazz musician | 21 (8.3) | |
| | Commercial/Pop musician | 9 (3.6) | |
| | Other | 22 (8.7) | |

On average, subjects started their primary instrument at 11 years old and received private lessons at 13. Subjects studied with a mean of nine private lesson instructors, and received 12 years of formal instruction on their primary instrument.

**Table 2: Musical Demographics**

| | Mean ± SD |
|---|---|
| Age Started Primary Instrument | 11.5 ± 3.4 |
| Age Started Receiving Private Lessons | 13.6 ± 3.9 |
| Years of Formal Training | 12.5 ± 7.7 |
| Number of Private Lesson Instructors | 9.6 ± 63.4 |

Over 80% of subjects for this study reported holding a performance degree. One-fifth of the subjects reported holding a doctoral degree (*n* = 53, 21.0%), with perhaps an overlapping number holding a bachelor's degree (*n* = 155, 61.5%) and master's degree (*n* = 129, 51.2%). Approximately 20% of the survey population reported no college level performance degrees (*n* = 49, 19.4%).

**Table 3: Music Performance Degrees**

| | n (%) |
|---|---|
| Bachelor's | 155 (61.5%) |
| Master's | 129 (51.2%) |
| Doctorate | 53 (21.0%) |
| Artists Diploma | 15 (6.0%) |
| None | 49 (19.4%) |

## Current Experience

Half of the subject population reported *currently* experiencing this problem in their own playing (*n* = 127, 50.4%) as no longer experience it in their own playing (*n* = 125, 49.6%). The percentage of males currently experiencing this problem (*n* = 109, 52.4%) was higher than the percentage of females (*n* = 17, 39.5%). Currently experiencing this problem was more common among tenor trombone players (*n* = 42, 60.0%) and baritone/euphonium players (*n* = 13, 61.9%) compared to other brass groups.

**Table 4: Currently Experiencing the Problem**

| | | Yes n (%) | No n (%) |
|---|---|---|---|
| Total Population | | 127 (50.4) | 125 (49.6) |
| Primary Instrument | Trumpet | 24 (44.4) | 30 (55.5%) |
| | French Horn | 20 (41.7) | 28 (58.3%) |
| | Tenor Trombone | 42 (60.0) | 28 (40.0%) |
| | Euphonium/Baritone | 13 (61.9) | 8 (38.1%) |
| | Bass Trombone | 17 (48.6) | 18 (51.4%) |
| | Tuba | 11 (45.8) | 13 (54.2%) |
| Gender | Male | 109 (52.4) | 99 (47.6%) |
| | Female | 17 (39.5) | 26 (60.5%) |

First Experiences

The mean age when subjects reported experiencing this problem was just under 21 years of age (20.8). Prior to first experiencing this problem, the total population reported a slight mean increase in their practice frequency (7.6 $\pm$ 20.6) and intensity (8.5 $\pm$ 20.0). Subjects who reported a negative change to practice habits reported similar levels for both frequency (-21.8 $\pm$ 13.1) and intensity (-21.8 $\pm$ 11.0). The same was true for subjects who reported a positive change to frequency (26.8 $\pm$ 15.1) and intensity (26.3 $\pm$ 15.1). Approximately half of the subjects (*n* = 140, 55.6%) reported no change to practice habits prior to experiencing this problem.

**Table 5: Change in Practice Habits Prior to First Experience**

| | Frequency | | Intensity | |
|---|---|---|---|---|
| | n (Prevalence %) | Mean ± SD | n (Prevalence %) | Mean ± SD |
| Total population | 252 (100%) | 7.6 ± 20.6 | 252 (100%) | 8.5 ± 20.0 |
| Negative Change | 38 (15.1) | -21.8 ± 13.1 | 32 (12.7) | -21.8 ± 11.0 |
| Positive Change | 102 (40.5) | 26.8 ± 15.1 | 108 (42.9) | 26.3 ± 15.1 |

## Characterization

As discussed in the Methods section, the biopsychosocial model was adapted to investigate the characteristics of this problem by separating it into eight factors that represent different aspects of motor control problems (Figure 6). These eight factors are: (1) primary symptoms; (2) fatigue and pain; (3) fluctuation; (4) frequency and intensity; (5) persistence and fear; (6) impact of playing; (7) impact outside of music; and (8) interventions.

### Factor 1: Primary Symptoms

The most prevalent primary symptoms were difficulty starting a first note (92.1%), tension in the throat (78.6%), and tightness in the chest & upper body (69.4%). "Other" was the least prevalent primary symptom (24.6%), but was reported at the highest mean frequency (56.4 ± 27.5). The second most frequent primary symptom was difficulty starting a first note (50.1 ± 28.0).

**Table 6: Primary Symptoms**

| | Prevalence (%) | Frequency Mean ± SD |
|---|---|---|
| Difficulty starting a first note | 92.1 | 50.1 ± 28.0 |
| Tension in the throat | 78.6 | 45.1 ± 28.6 |
| Tightness in the chest & upper body | 69.4 | 42.3 ± 28.2 |
| Other | 24.6 | 56.4 ± 27.5 |

Factor 2: Fatigue and Pain

Mental fatigue was the most prevalent (69.8%) and frequent (52.0 ± 27.9) type of fatigue. While tongue pain was reported with the highest prevalence (19.0%), throat pain was reported with both the highest frequency (28.0 ± 27.2) and intensity (25.9 ± 28.2) of pain. Fatigue was more prevalent than pain at all sites. The reported range for all variables in this category were 0-100, with the exceptions of respiratory system pain frequency (0-73), respiratory pain intensity (0-75), and throat pain intensity (0-91).

Table 8 includes a bivariate correlation matrix between the frequency of fatigue, the frequency of pain, and the intensity of pain for the tongue, respiratory system, and throat. Out of 45 different correlative analyses, 24 (53%) were found to be statistically significant. All measurements of fatigue were significantly related ($p$ < .001). Expectedly, the frequency of pain was significantly correlated with the intensity of pain for the same body-site.

**Table 7: Fatigue and Pain**

| Site | Fatigue | | Pain | | |
|---|---|---|---|---|---|
| | | Frequency | | Frequency | Intensity |
| | Prev. (%) | Mean ± SD | Prev. (%) | Mean ± SD | Mean ± SD |
| Tongue | 42.5 | 32.7 ± 21.4 | 19.0 | 26.7 ± 22.4 | 22.8 ± 20.5 |
| Respiratory System | 37.7 | 35.7 ± 25.2 | 16.3 | 27.5 ± 21.0 | 21.5 ± 18.4 |
| Throat | 42.1 | 32.3 ± 23.7 | 10.3 | 28.0 ± 27.2 | 25.9 ± 28.2 |
| Mental* | 69.8 | 52.0 ± 27.9 | | | |

* Mental pain was not measured in the survey, as it was thought to be a confusing concept for subjects.

**Table 8: Correlations between Frequency and Intensity**

| | | Fatigue | | | | Pain Frequency | | | Pain Intensity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Tongue | Throat | Resp Sys | Mental | Tongue | Throat | Resp Sys | Tongue | Throat | Resp Sys |
| Tongue Fatigue | Pearson Corr. | 1 | .268** | .278** | .314** | .375** | .115 | .085 | .482** | -.021 | -.139 |
| | Sig. (2-tailed) | | .000 | .000 | .000 | .000 | .069 | .176 | .000 | .860 | .243 |
| Throat Fatigue | Pearson Corr. | .268** | 1 | .396** | .287** | .185** | .524** | .170** | .117 | .525** | -.080 |
| | Sig. (2-tailed) | .000 | | .000 | .000 | .003 | .000 | .007 | .329 | .000 | .504 |
| Resp Sys Fatigue | Pearson Corr. | .278** | .396** | 1 | .290** | .199** | .156* | .467** | -.015 | -.135 | .471** |
| | Sig. (2-tailed) | .000 | .000 | | .000 | .002 | .013 | .000 | .899 | .257 | .000 |
| Mental Fatigue | Pearson Corr. | .314** | .287** | .290** | 1 | .154* | .193** | .201** | .105 | .061 | .111 |
| | Sig. (2-tailed) | .000 | .000 | .000 | | .014 | .002 | .001 | .379 | .612 | .355 |
| Tongue Pain Freq | Pearson Corr. | .375** | .185** | .199** | .154* | 1 | .096 | .192** | .939** | -.078 | -.010 |
| | Sig. (2-tailed) | .000 | .003 | .002 | .014 | | .127 | .002 | .000 | .513 | .935 |
| Throat Pain Freq | Pearson Corr. | .115 | .524** | .156* | .193** | .096 | 1 | .265** | -.079 | .617** | -.079 |
| | Sig. (2-tailed) | .069 | .000 | .013 | .002 | .127 | | .000 | .509 | .000 | .509 |
| Resp Sys Pain Freq | Pearson Corr. | .085 | .170** | .467** | .201** | .192** | .265** | 1 | -.073 | -.038 | .812** |
| | Sig. (2-tailed) | .176 | .007 | .000 | .001 | .002 | .000 | | .540 | .752 | .000 |
| Tongue Pain Intsy | Pearson Corr. | .482** | .117 | -.015 | .105 | .939** | -.079 | -.073 | 1 | .006 | -.059 |
| | Sig. (2-tailed) | .000 | .329 | .899 | .379 | .000 | .509 | .540 | | .962 | .624 |
| Throat Pain Intsy | Pearson Corr. | -.021 | .525** | -.135 | .061 | -.078 | .617** | -.038 | .006 | 1 | -.005 |
| | Sig. (2-tailed) | .860 | .000 | .257 | .612 | .513 | .000 | .752 | .962 | | .968 |
| Resp Sys Pain Intsy | Pearson Corr. | -.139 | -.080 | .471** | .111 | -.010 | -.079 | .812** | -.059 | -.005 | 1 |
| | Sig. (2-tailed) | .243 | .504 | .000 | .355 | .935 | .509 | .000 | .624 | .968 | |

Resp Sys = respiratory system; Freq = frequency; Intsy = intensity; Pearson Corr = Pearson's correlation. ** correlation significant at the 0.01 level (2-tailed); * correlation significant at the 0.05 level (2-tailed).

Factor 3: Fluctuation

A large percentage of subjects reported experienced this problem on a daily basis (45.2%). The mean fluctuation from day to day was reported as slightly higher (38.2 $\pm$ 29.2) than fluctuation within a day (32.2 $\pm$ 29.6).

**Table 9: Levels of Occurrence and Fluctuation**

| | | n (%) | Mean $\pm$ SD |
|---|---|---|---|
| "Did you experience this problem …" | *Daily | 114 (45.2) | |
| | *Regularly | 57 (22.6) | |
| | Periodically | 37 (14.7) | |
| | Rarely | 42 (16.7) | |
| Level of Fluctuation… | *Day to Day | | 38.2 $\pm$ 29.2 |
| | Within a Single Day | | 32.2 $\pm$ 29.6 |

*Using skip-logic, only subjects who chose the responses "daily" or "regular" were shown the question "rate the level this problem fluctuated from day to day."

Factor 4: Frequency and Intensity

Nearly all subjects reported experiencing this problem before the first note *of a piece* (90.1%), and with a high mean frequency (62.1 $\pm$ 27.4). Experiencing this problem before the first note *after a rest* was also very prevalent (81.0%) and frequent (48.4 $\pm$ 27.0). This problem was most intensely experienced before the first note *of a piece* (67.0 $\pm$ 28.2) and before the first note *after a rest* (48.5 $\pm$ 26.5).

**Table 10: Frequency and Intensity ("How did this problem occur?")**

| Variables | n (%) | Frequency Mean $\pm$ SD | Intensity Mean $\pm$ SD |
|---|---|---|---|
| Before first note *of a Piece*? | 227 (90.1) | 62.1 $\pm$ 27.4 | 67.0 $\pm$ 28.2 |
| Before first note *after a Rest* | 204 (81.0) | 48.4 $\pm$ 27.0 | 48.5 $\pm$ 26.5 |
| *While* playing | 120 (47.6) | 39.5 $\pm$ 30.3 | 41.4 $\pm$ 29.9 |

Factor 5: Persistence and Fear

Most subjects reported that this problem persisted more than 4 weeks despite pedagogical advice and/or professional healthcare (*n* = 150, 59.5%). Nearly all subjects reported some frequency of increased fear & anxiety accompanying this disorder (92.9%), which was reported as the second highest mean of the entire survey (65.6 $\pm$ 29.9).

**Table 11: Persistence (More than 4 Weeks)**

| Yes<br>n (%) | No<br>n (%) | Unsure<br>n (%) |
|---|---|---|
| 150 (59.5) | 30 (11.9) | 21 (8.3) |

Factor 6: Impact on Playing

Nearly all subjects reported this problem as having some level of impact on their playing (*n* = 233, 92.5%). The mean level of debilitating impact 51.5 $\pm$ 29.1.

Factor 7: Impact Outside of Music

This problem most commonly impacted the subjects psychologically (34.5%). Outside of music, this problem had the greatest impact on the subjects' professional lives (44.4 $\pm$ 28.3), which was also the second-most prevalent impact outside of music (30.2%). All types of impact were reported with a range of 0-100, except for breathing/speaking, which had a range of 0-72.

**Table 12: Negative Impact Outside of Music**

| | n (%) | Mean $\pm$ SD |
|---|---|---|
| Psychologically | 87 (34.5) | 40.6 $\pm$ 28.6 |
| Professionally | 76 (30.2) | 44.4 $\pm$ 28.3 |
| Personally/Socially | 51 (20.2) | 33.4 $\pm$ 22.9 |
| Breathing/Speaking | 41 (16.3) | 26.3 $\pm$ 17.3 |

Factor 8: Interventions

Pedagogical advice was the most common intervention used by the subject population (77.4%). The intervention with the highest mean positive impact was "Other" (35.2 ± 17.5), followed by pedagogical advice (28.6 ± 15.1). Pedagogical advice was also reported as having the greatest *negative* impact (-17.5), and overall the most positively impactful (22.5 ± 18.6). Rest was reported as the second least *negatively* impactful (19.1 ± 18.3), and overall the second most positively impactful (9.2 ± 16.6). Professional healthcare was the least frequent intervention (19.0%) and had the smallest positive impact (20.4 ± 15.8), the greatest *negative* impact (-23.9 ± 21.2), and the lowest overall impact (2.4 ± 11.34).

**Table 13: Time Invested and Impact of Interventions**

| Type | Time Invested | | Positive | | Negative | | Total Population | |
|---|---|---|---|---|---|---|---|---|
| | n (%) | Mean ± SD | n (%) | Mean ± SD | n (%) | Mean ± SD | n (%) | Mean ± SD |
| Rest | 146 (57.9) | 52.4 ± 29.5 | 91 (36.1) | 24.6 ± 14.7 | 9 (3.6) | -19.1 ± 18.3 | 100 (39.7) | 9.2 ± 16.6 |
| Pedagogical Advice | 195 (77.4) | 66.4 ± 29.9 | 181 (71.8) | 28.6 ± 15.1 | 6 (2.4) | -17.5 ±13.0 | 187 (74.2) | 22.5 ± 18.6 |
| Professional Healthcare | 48 (19.0) | 40.0 ± 28.8 | 35 (13.9) | 20.4 ± 15.8 | 7 (2.8) | -23.9 ± 21.2 | 42 (16.7) | 2.4 ± 11.3 |
| Other | 35 (13.9) | 77.8 ± 26.0 | 47 (18.7) | 35.2 ± 17.5 | 6 (2.4) | -20.5 ± 23.2 | 53 (21.0) | 6.8 ± 17.3 |

Overall impact was calculated by averaging scores across the total population for each intervention.

## Assessment of the Classification Model

This study designed three assessments to determine whether this problem follows the same patterns of progressive worsening outlined in Altenmuller's heuristic model. A consistent pattern of worsening for all three assessments will provide evidence that this problem is experienced as a spectrum of increasingly severe motor disruptions.

The first assessment asked subjects "Did this problem persist for more than 4 weeks, despite pedagogical advice and/or professional healthcare?" and placed subjects wo answered "yes" into the high-severity group, and subjects who answered "no" into the low-severity group. The second assessment placed subjects who experienced this problem daily into the high-severity group, and subjects who experienced it non-daily into the low-severity group. The third assessment analyzed the levels of association of the question "Rate the frequency this problem was accompanied by fear of failure and/or increased anxiety" and the assessment variable set.

Model Assessment 1

The high-severity group for the first model assessment was larger ($n$ = 150, 59.5%) than the group who answered no ($n$ = 30, 11.9%).

The high severity group reported significantly higher frequencies for the primary symptom difficulty starting a first note ($50.9 \pm 30.6$) than the low-severity group ($29.2 \pm 20.4$, $p < .001$). The high-severity group also reported significantly more frequency for "Other" ($17.1 \pm 30.0$) than the low-severity group ($2.2 \pm 7.7$, $p = .008$).

The high-severity group reported experiencing this problem significantly more frequently before the first note *of a piece* ($63.4 \pm 29.1$) compared to the low-severity group ($40.1 \pm 30.9$, $p < .001$). Frequency before the first note *after a rest* was also significantly higher for the high-severity group ($45.4 \pm 30.3$) than the low-severity group ($27.6 \pm 27.1$, $p = .003$). The high-severity group also reported experiencing this problem more intensely before the first note *of a piece* ($66.6 \pm 31.5$) than the low-severity group ($42.7 \pm 34.9$, $p < .001$), and before the first note *after a rest* (43.9 ± 30.6) compared to the low-severity group (27.6 ± 26.8, $p$ = .007).

Fluctuation within a single day was not significantly higher for the high-severity group (37.1 ± 29.6) than the low-severity group (26.6 ± 25.2, $p$ = .071). The fluctuation from day to day was slightly higher for the high-severity group (39.3 ± 29.1) than the low-severity group (38.2 ± 31.2).

Rest was a significantly more impactful intervention for the low-severity group (16.7 ± 19.2) than the high-severity group (7.0 ± 15.8, $p$ = .003). Pedagogical advice was also found to have a significantly greater impact for the low-severity group (34.6 ± 16.1) than the high-severity group (22.9 ± 18.2, $p$ = .001).

The impact of this problem on playing was higher for the high-severity group (56.7 ± 28.8) than for the low-severity group (34.5 ± 29.4, $p$ < .001). Similarly, the frequency that this problem was accompanied by increased fear and/or anxiety was significantly higher for the high-severity group (68.6 ± 28.3) than for the low-severity group (39.2 ± 34.2, $p$ < .001).

**Table 14: Model Assessment 1**

| Variable | | No<br>Mean ± SD | Yes<br>Mean ± SD | Sig.<br>(2-tailed) |
|---|---|---|---|---|
| Primary Symptoms | Difficulty starting a first note | 29.2 ± 20.4 | 50.9 ± 30.6 | <.001 |
| | Tension in the throat | 31.7 ± 28.3 | 38.1 ± 31.0 | .296 |
| | Tightness in the chest & upper body | 28.4 ± 31.2 | 29.8 ± 29.5 | .809 |
| | Other | 2.2 ± 7.7 | 17.1 ± 30.0 | .008 |
| Timing *Frequency* | Before the first note *of a piece* | 40.1 ± 30.9 | 63.4 ± 29.1 | <.001 |
| | Before the first note *after a rest* | 27.6 ± 27.1 | 45.4 ± 30.3 | .003 |
| | *While* Playing | 20.2 ± 31.2 | 21.6 ± 31.2 | .823 |

| Variable | | No<br>Mean ± SD | Yes<br>Mean ± SD | Sig.<br>(2-tailed) |
|---|---|---|---|---|
| Timing *Intensity* | Before the first note *of a piece* | 42.7 ± 34.9 | 66.6 ± 31.5 | <.001 |
| | Before the first note *after a rest* | 27.6 ± 26.8 | 43.9 ± 30.6 | .007 |
| | *While* Playing | 18.9 ± 32.1 | 17.8 ± 28.6 | .843 |
| Fluctuation | Within a single day | 26.6 ± 25.2 | 37.1 ± 29.6 | .071 |
| | Day to day | 38.2 ± 31.2 | 39.3 ± 29.1 | .901 |
| Impact of Interventions | Rest | 16.7 ± 19.2 | 7.0 ± 15.8 | .003 |
| | Pedagogical Advice | 34.6 ± 16.1 | 22.9 ± 18.2 | .001 |
| | Professional Healthcare | 0.6 ± 2.3 | 2.8 ± 12.5 | .341 |
| | Other | 4.1 ± 12.5 | 6.1 ± 17.0 | .549 |
| Impact on Playing | | 34.5 ± 29.4 | 56.7 ± 28.8 | <.001 |
| Fear & Anxiety | | 39.2 ± 34.2 | 68.6 ± 28.3 | <.001 |

Analysis is based on the question “Did this problem persist for more than 4 weeks, despite pedagogical advice and/or professional healthcare?” For assessment purposes, subjects who responded “yes” are the high-severity group, and subjects who responded “no” are the low-severity group.

Model Assessment 2

The high-severity group for the second model assessment was smaller (*n* = 114, 45.2%) than the low-severity group (*n* = 136, 54%).The high-severity group reported significantly higher means for all four primary symptoms when compared to the low-severity group. Similarly, the high-severity group reported significantly higher mean frequency and intensity before the first note *of a piece*, before the first note *after a rest*, and *while* playing when compared to the low-severity group. The mean intensity before the first note *of a piece* for the high-severity group was the highest mean score reported for the second assessment (73.8), and the second highest mean score was frequency before the first note *of a piece* for the high-severity group (71.2).

The level of fluctuation from day to day was reportedly higher for the low-severity group

(42.1 ± 23.3) compared to the high-severity group (36.2 ± 31.6, *p* = .214) However, the high-severity group reported greater fluctuation within a single day (34.2 ± 32.1) compared to the low-severity group (30.2 ± 27.0, *p* = . 280).

The impact of rest for the low-severity group was significantly higher (12.3 ± 17.4) compared to the high-severity group (5.6 ± 14.9, *p* = .002). The levels of impact for the other interventions were not significantly different across groups. Pedagogical advice had a very slightly higher mean for the low-severity group (22.6 ± 18.5) than the high-severity group (22.4 ± 18.9, *p* = .909).

The high-severity group reported this problem as having a significantly greater impact on playing (63.4 ± 29.4) than the low-severity group (34.1 ± 25.7, <.001). Finally, the frequency that this problem was accompanied by fear of failure and/or increased anxiety was significantly higher for the high-severity group (71.6 ± 28.1) compared to the low-severity group (51.8 ± 34.9, *p* < .001).

**Table 15: Model Assessment 2**

| Variable | | Non-Daily Mean ± SD | Daily Mean ± SD | Sig. (2-tailed) |
|---|---|---|---|---|
| Primary Symptoms | Difficulty starting a first note | 35.4 ± 26.0 | 58.9 ± 29.6 | <.001 |
| | Tension in the throat | 28.6 ± 25.1 | 44.3 ± 35.7 | <.001 |
| | Tightness in the chest & upper body | 25.5 ± 27.9 | 33.4 ± 32.6 | .039 |
| | Other | 8.8 ± 21.4 | 20.2 ± 33.2 | .001 |
| Timing *Frequency* | Before the first note *of a piece* | 43.5 ± 28.8 | 71.2 ± 28.8 | <.001 |
| | Before the first note *after a rest* | 28.4 ± 26.1 | 51.8 ± 31.1 | <.001 |
| | *While* Playing | 14.6 ± 22.5 | 24.0 ± 34.3 | .010 |

| Variable | | Non-Daily Mean ± SD | Daily Mean ± SD | Sig. (2-tailed) |
|---|---|---|---|---|
| Timing *Intensity* | Before the first note *of a piece* | 44.5 ± 32.8 | 73.8 ± 30.5 | <.001 |
| | Before the first note *after a rest* | 26.5 ± 25.7 | 49.3 ± 32.2 | <.001 |
| | *While* Playing | 11.7 ± 21.3 | 21.3 ± 32.8 | .006 |
| Fluctuation | Within a single day | 30.2 ± 27.0 | 34.2 ± 32.1 | .280 |
| | Day to day | 42.1 ± 23.3 | 36.2 ± 31.6 | .214 |
| Impact of Interventions | Rest | 12.3 ± 17.4 | 5.6 ± 14.9 | .002 |
| | Pedagogical Advice | 22.6 ± 18.5 | 22.4 ± 18.9 | .909 |
| | Professional Healthcare | 3.0 ± 12.5 | 1.8 ± 9.9 | .413 |
| | Other | 5.1 ± 15.5 | 8.7 ± 19.1 | .118 |
| Impact on Playing | | 34.1 ± 25.7 | 63.4 ± 29.4 | <.001 |
| Fear & Anxiety | | 51.8 ± 34.9 | 71.6 ± 28.1 | <.001 |

For assessment purposes, subjects who experienced this problem daily are the high-severity group, and subjects who experienced it non-daily are the low-severity group.

Model Assessment 3

The third model assessment analyzed the relationship between the frequency of increased fear & anxiety and the model assessment variable set.

Statistically significant correlations were reported for the primary symptoms difficulty starting a first note ($p < .001$), tension in the throat ($p < .001$), tightness in the chest & upper respiratory system ($p < .001$), and "other" ($p = .007$). Difficulty starting a first note was reported with the strongest correlation ($r = .324$), and "other" was reported with the weakest correlation ($r = .170$).

Significant levels of association were reported for the frequency before the first note *of a piece* ($r = .385$, $p < .001$), before the first note *after a rest* ($r = .365$, $p < .001$), and *while* playing (*r* = .132, *p* = .036). Similar relationships were reported for the intensity of this problem before the first note *of a piece* (*r* = .442, *p* < .001), before the first note *after a rest* (*r* = .357, *p* < .001), and *while* playing (*r* = .143, *p* = .023). The intensity of this problem before the first note *of a piece* had the strongest correlation of this set (*r* = .442), but the frequency before the first note *of a piece* was the second strongest (*r* = .385).

Neither of the measurements of fluctuation were found to have statistically significant relationships. Fluctuation from day to day was reported to have one of the few negative correlations (*r* = -.015) for the third model assessment, although it was very weak.

The only interventions that had statistical significance were rest (*r* = -.161, *p* = .015) and “other” (*r* = .479, *p* < .001). Professional healthcare had the weakest relationship of the third assessment (*r* = .032). Finally, there was a significant relationship between the impact of this problem on playing (*r* = .479, *p* < .001). This relationship was the strongest correlation in the third model assessment.

**Table 16: Model Assessment 3**

| Variable | | Fear and Anxiety | |
|---|---|---|---|
| | | Pearson Corr. | Sig. (2-tailed) |
| Primary Symptoms *Frequency* | Difficulty starting a first note | .324 | <.001 |
| | Tension in the throat | .279 | <.001 |
| | Tightness in the chest & upper body | .249 | <.001 |
| | Other | .170 | .007 |
| Timing *Frequency* | Before the first note *of a piece* | .385 | <.001 |
| | Before the first note *after a rest* | .365 | <.001 |
| | *While* Playing | .132 | .036 |
| Timing *Intensity* | Before the first note *of a piece* | .442 | <.001 |
| | Before the first note *after a rest* | .357 | <.001 |
| | *While* Playing | .143 | .023 |

| Variable | | Fear and Anxiety | |
|---|---|---|---|
| | | Pearson Corr. | Sig. (2-tailed) |
| Fluctuation | Within a single day | .107 | .090 |
| | Day to day | -.015 | .841 |
| Impact of Interventions | Rest | -.161 | .015 |
| | Pedagogical Advice | -.109 | .103 |
| | Professional Healthcare | .032 | .638 |
| | Other | .243 | <.001 |
| Impact on Playing | | .479 | <.001 |

Levels of association between the model assessment variable set and the question "Rate the frequency this problem was accompanied by fear of failure and/or increased anxiety" were analyzed using Pearson's correlation coefficients.

CHAPTER 5

# DISCUSSION

## Demographics, Musical Background, and First Experiences

Subjects were mostly males with an average age of 39 years. The largest brass instrument group represented were tenor trombone players, followed by trumpet and French horn. Almost 80% identified themselves as classical musicians. The average age they started learning their instrument was between 11-12 years old or middle school in the American school system. On average, subjects started private lessons around 8$^{th}$ grade and reported having over 9 private lesson instructors. Finally, over 1/3 reported holding a Bachelor's degree while another 1/3 reported a Master's degree in music. Only 20% reported holding no degrees in music performance. This study population represents a heterogeneous sample of educated musicians who play brass instruments. Age and experience levels are broad and similar to demographics reported in previous epidemiologic studies of brass musicians,[142] including gender distributions.[143] All brass instrument groups are represented and reflect a more diverse population than what was reported in previous studies of this problem by Cochran[144] or Aker.[145]

The age range (6-68) reported for first experiencing this problem was slightly wider than that of musician's dystonia (18-60).[146] The average age to first experience this problem was

[142] Wallace et al., 2016.

[143] Wallace et al., 2016; Chesky et al., 2002.

[144] Cochran, 2004.

[145] Akers, 2016.

[146] Altenmuller & Jabusch, 2010.

about 10 years younger compared to studies of musician's dystonia.[147] Approximately 35% reported first experiencing this problem before they were 18 years old, reinforcing the idea that this problem is experienced along a spectrum of severity that begins with a less-severe experiences of this problem.

Due to the ages involved and engagement in college-level training, the data suggests that many started experiencing this problem as collegiate students pursuing a degree in music performance. In addition to being away from home for the first time and perhaps struggling for approval from peers and teachers, this context is known to be highly stressful for some individuals and may be an important factor in the development of this problem. Altenmuller and others recognize that choking under pressure, typically related to debilitative anxiety, can function as a precursor to developing habitual motor disturbance[148] and impairment[149]. Plus, the data about the time of first experiencing this problem clearly coincides with likely increases in practice time and intensity required by music majors.

## Characterization

The strategy used to investigate the characteristics of this problem incorporated a biopsychosocial model of health.[150] Survey items regarding biological, psychological, and social factors were intended to obtain a holistic perspective. As organized and discussed below, this study assessed 8 factors designed to reflect this model. Additional items were also included in

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[147] Altenmuller & Jabusch, 2010, p. 4.

[148] Altenmuller et al., 2014, p. 172.

[149] Altenmuller et al., 2014, p. 172.

[150] Borrell-Carrió et al., 2004.

order to align data with Altenmuller's heuristic model of progressive worsening of musician's dystonia.[151]

Factor 1: Primary Symptoms

Factor 1 assessed the prevalence and frequency of the primary symptoms. Subjects were presented 3 specific primary symptoms and the option to select "other." Instructions also guided subjects to report the frequency of occurrence for each category. Data revealed that over 90% (92.1%) of subjects reported difficulty starting a first note as the primary symptom and that they experienced this symptom 50% of the time. This finding suggests an underlying motor control problem that has the potential for acute psychosocial ramifications due to the inability to initiate voluntary exhalation for tone production at the desired time and quality. Obviously, the consequences of this problem could be direct and severe to any musician either studying or involved as a professional.

Over 75% reported tension in the throat suggesting a physiological dysfunction that potentially inhibits voluntary exhalatory air flow. Nearly 70% reported tightness in the chest and upper respiratory system suggesting involvement of the neuromuscular system responsible for controlling voluntary exhalation. Perhaps tension in the throat reflects a sensation of stopped air as indicated by the tongue-stopper term used by Altenmuller to describe this problem.[152] Similarly, the sensation of pushing air against a closed system mimics what is experienced when executing the Valsalva maneuver, thus explaining the use and application of

[151] Altenmuller et al., 2014.

[152] Altenmuller et al., 2014, p. 172.

this term by Jacobs.[153]

Factor 2: Fatigue and Pain

Factor 2 assessed levels of mental and physical fatigue related to this problem. Nearly 70% reported mental fatigue associated with this problem, and that subjects experienced mental fatigue 50% of the time. Fewer subjects reported experiencing tongue (42.5%), throat (42.1%), and respiratory fatigue (37.7%). Fewer than 20% reported problems with physical pain at these sites.

The loss of control and the accompanying stress and anxiety associated with the physiological manifestations of this problem may be reciprocal. While reported experiences of pain were less prevalent and severe than measurements of fatigue, and physiological fatigue was less prevalent and severe than mental fatigue, there is a known relationship between stress levels and musculoskeletal problems.[154] A 2002 study found that psychosocial stressors such as time pressure and emotional threat are risk-factors for upper-extremity musculoskeletal disorders.[155] In this study, stress-based musculoskeletal problems manifested as inefficient movements caused by antagonistic co-contractions. Van Galen developed a model suggesting that state and trait anxiety levels increase antagonistic muscle contractions during task execution that can lead to slower response times, muscle stiffness, and eventually muscle strain.[156]

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[153] Frederikson, 1996.

[154] Kenny & Bronwen, 2013.

[155] Van Galen et al., 2002.

[156] Van Galen et al., 2002, p. 408.

Furthermore, the significant associations of these data suggest interactions between fatigue and frequency of pain in the tongue, throat, and respiratory system (Table 8). This finding suggests the problem manifests across of cluster of inter-related body sites. A 2016 study of trombonists found that pain was experienced in three clusters[157] and that each pain cluster underscored various biomechanical demands that impact a physiologic system. For example, trombonists reported physical pain along the entire left upper-extremity that is likely due the biomechanical loading associated with holding, stabilizing, and controlling the instrument over the left shoulder. Similarly, the data from the current study suggests interactions between the tongue, throat, and chest. Perhaps involuntary closure of the glottis or placement of the tongue at the moment of voluntary exhalation creates sustained and uncomfortable tension in the chest similar to Valsalva maneuver described above. Additional research is needed to investigate the basis for these possible interactions.

These data also suggest a temporal interaction between these various factors that worsens over time. Altenmuller describes mental fatigue as a cause of temporary deterioration of motor control.[158] Furthermore, self-focus theory finds that poor execution creates an increased attention on conscious skill control.[159] These concepts suggest that, as mental fatigue sets in and control deteriorates, those experiencing this problem begin to direct more attention to motor control and thereby further increasing mental strain and fatigue. This cycle of increasing mental stress and deteriorating motor control might help explain how motor fatigue

[157] Wallace et al., 2016.

[158] Altenmuller et al., 2014, p. 164.

[159] Bawden & Maynard, 2001.

can progress into dynamic stereotypes and eventually lead to musician's dystonia,[160] particularly in musicians who are predisposed.[161] The significant correlations between mental fatigue, site-specific fatigue, and frequency of pain found in this study (Table 8) support the concept of a temporal cycle of factors that lead to decreased control of forced expiration.

Factor 3: Fluctuation

Factor 3 assessed the degree of fluctuation that subjects experienced this problem. Response options included 4 categories. The levels of fluctuation within a single day and day-to-day were measured on a 100-point VAS slider. Results showed that over two-thirds (67.8%) reported experiencing this problem daily or most days, and suggests an underlying neurologic component specific to the task of playing an instrument. The data suggests that this dysfunctional neurologic response to playing an instrument can become a perpetual obstacle during music making. Furthermore, the levels of fluctuation within a single day indicate that most subjects experience this problem is more or less the same every time they play their instrument. The impact on the mental health of musicians with this problem could be severe. Similar loss of functionality is a known cause of depression in athletes with high athletic-identity.[162] Studies of the Athletic Identity Measurement Scale have found that the loss of ability to perform can create a subsequent loss of self-esteem and personal identity.[163] Considering the similarities between athletes and musicians, the impact of constant disruptions

[160] Altenmuller et al., 2014, p. 166.

[161] Altenmüller & Furuya, 2017.

[162] Doherty et al., 2016, p. 1069.

[163] Green, 2001.

to performance are likely contributing factors for severe psychological problems.

Factor 4: Frequency and Intensity by Musical Context

Factor 4 assessed how this problem occurs in different musical contexts. Three 100-point VAS sliders measured the prevalence, frequency, and intensity of this problem (1) before tone initiation and (2) during continuous tone production. A majority of subjects (90.1%) reported this problem occurring before the first note *of a piece*. Subjects also reported experiencing this problem 62% of the time at a severity level of $67.0 \pm 28.2$. Fewer subjects (80%) reported this problem occurring before the first note *after a rest*. About 50% reported experiencing this problem *while* playing.

A 2004 study found that musicians experience the highest levels of performance anxiety when performing as a soloist.[164] Since training as a musical soloist is an essential aspect of music performance education, the social pressure of walking on stage and starting a piece of music creates an unavoidable psychological weight on students. Van Galen's model of high anxiety causing muscle stiffness and slower response time assumes a greater decrease in performance as situational anxiety peaks.[165] The increased psychological burden of this specific musical context likely creates greater state-anxiety, and would account for why the first note *of a piece* is more severe than the first note *after a rest*.

The distinct difference in how this problem was reported *while* playing also supports the task-specific nature of this problem. The greater prevalence, frequency, and intensity reported

[164] Miller & Chesky, 2004.

[165] Van Galen et al., 2002.

before the first note *of a piece* and *after a rest* indicate there is more anticipatory stress tied into starting a note from silence. Dysfunctional movements caused by choking under pressure can develop into conditioned reactions that continue to trigger when not in a high-stress situation, which are the developmental steps for motor disorders like musician's dystonia.[166] Based on the data from this study, along with anecdotal sources,[167] longer rests may create more severe experiences of this problem. Personal interviews have discussed a sense of motion from starting a note which diminishes over time after playing has stopped. However, increased anxiety associated with starting performance still causes greater disruptions before the first note *of a piece*.

Factor 5: Persistence and Fear

Factor 5 assessed (1) whether this problem persisted despite pedagogical advice and/or professional healthcare and (2) the extent that this problem was accompanied by fear and anxiety.

Over half the subjects (59.5%) continued experiencing this problem for more than four weeks despite seeking professional help. The length of time this problem persisted indicates it was more severe than musculoskeletal problems such as motor fatigue and overuse pain. Motor disturbances that persist for this long are a "soft sign," indicating the problem has advanced into a more severe alteration to task-specific motor function.[168]

Nearly every subject (92.9%) reported this problem was accompanied by fear and

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[166] Altenmuller et al., 2014, p. 166.

[167] Gathered from personal interviews conducted while creating the survey for this study.

[168] Altenmuller et al., 2014, p. 166.

anxiety in two out of every three attempts to play their instrument. Fear created by the anticipation of errors can lead to attempts to correct the mistake before it occurs through conscious controlling of the movements called “reinvestment.”[169] However, these attempts at control can create cognitive interference and dysfunctional movements.[170] Considering the high frequency this problem is accompanied by fear and anxiety, it is likely that “pre-error” disruptions are a regular occurrence for many subjects, increasing the likelihood for habitualized motor dysfunctions leading to motor control disorders.

Factor 6: Impact on Playing

Factor 6 assessed the impact of this problem on the ability to play. Nearly every subject (92.5%) reported an impact on their ability to play their instrument. Subjects reported that this problem reduced their musical performance abilities by 50 percent.

By the time a musician graduates from college with a performance degree, they have likely practiced for approximately 10 years. According to Ericsson’s theory on the acquisition of expert practice, this is the length of time needed to obtain an expert level of skill on a task.[171] The amount of time and dedication required to gain musical proficiency and earn a college degree is enormous; the impact on a musician’s psyche and feelings of self-worth when these abilities start to deteriorate are likely equally large. Furthermore, modern musicians are expected to interact musically online via YouTube video posts and social media presence.[172] On

[169] Altenmuller et al., 2014, p. 172.

[170] Altenmuller et al., 2014, p. 172.

[171] Ericsson, 2008, p. 990.

[172] Altenmuller et al., 2014, p. 163.

top of the loss of musical abilities and personal identity is the absence from their musical community.

### Factor 7: Impact Outside of Music

Factor 7 assessed the impact outside of music. Subjects responded to four VAS sliders measuring the frequency this problem impacted different biopsychosocial factors. About one-third of subjects were impacted psychologically (34.5%) and professionally (30.2%) outside of music. As previously discussed, major psychological burdens can lead to the development of habitualized motor disturbances.[173] A psychological and/or professional burden that continues to impact a musician outside of a musical context can be assumed to create greater stress once the musical context has been resumed. Increased stress can then lead to worsened motor disturbances, further perpetuating the reciprocal nature of performance disruptions.

More than 80% reported that this problem does *not* impact general breathing or speaking. This suggests motor disturbances related to this problem that prevent the exhalation of air are not a general dysfunction of the respiratory system, but rather a task specific motor control problem that disrupts voluntary exhalation only.

### Factor 8: Interventions

Factor 8 assessed time invested in three specific interventions and the impact of those interventions. Over three-quarters reported investing time in pedagogical advice and 71% reported that pedagogical advice had a *positive* impact. Only 48 subjects (19%) invested any amount of time seeking professional healthcare interventions. Professional healthcare was

[173] Altenmuller et al., 2014, p. 172.

reported with the smallest *positive* impact and the largest *negative* impact. The collection of both positive *and* negative impacts for each intervention is a testament to the quality of the survey constructed for this study.

These data indicate subjects believed this problem to be performance-based and considered pedagogical expertise sufficient for intervening. However, the results suggest this is primarily a neurological and psychological phenomenon. As previously discussed, high levels of fear, anxiety, and stress reciprocate and progressively worsen motor disruptions. Once the disruptions become habitualized into the procedural memory, it can be assumed that standard pedagogical methodologies are no longer affective.[174] Altenmuller recommends that specialized retraining of dysfunctional reinvestment could reduce symptoms.[175] While similar retraining methods have been shown to be effective performance tools in a small population of wind musicians,[176] no known pedagogical methodologies have shown repeated success in retraining.

It is more likely that high *positive* impact reported by subjects represent “islands of well-being,” which are temporary reductions in motor disturbances caused by advice or sensory tricks.[177] A raising of cultural awareness about the long-term ineffectiveness of pedagogical intervention methodologies could shift musicians away from pedagogical advice, and towards more clinical measures. Including information about neurologic movement disturbances into NASM accreditation standards would be large cultural shift in the attention placed on these problems.

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[174] Stahl & Frucht, 2017.

[175] Altenmuller et al., 2014, p. 174.

[176] Mornell & Wulf, 2018.

[177] Altenmuller et al., 2014, p. 166.

## 8-Factor Characteristics Analysis: Summary

Altenmuller's heuristic model describes task-specific motor control problems as sets of related disruptions.[178] These disruptions make up distinct subtypes that are subclassified along a spectrum of progressive worsening.[179] However, analysis of the eight-factor characteristics data identified closer interaction between individual factors. These factors reciprocate worsening and feed each other's severity until the musician's motor disruptions become dystonic; i.e., fear of anticipated error can cause increased muscle stiffness, which in turn creates greater fear of anticipated error, etc.

The close interaction of separate factors highlights the importance of early identification and intervention. Identifying a characteristic disruption early could halt the reciprocating worsening before it can progress. Furthermore, if the problem becomes habitualized it will be more resistant to interventions, furthering the need for early identification.

A crucial first step is awareness of this problem, its characteristics, and how they can cycle and progress into a performance disorder. The characteristic data described above allows a few provisional questions to aid in identifying this problem: (1) is this problem caused by an uncontrolled delay to voluntary exhalation; (2) is the problem limited to specific musical contexts; (3) is the musician too self-focused when the problem occurs; (4) does he/she experience this problem daily or near-daily; (5) is the problem accompanied by increased far and/or anxiety; (6) how long has the problem persisted; and (7) is the problem impacted by rest and professional help?

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[178] Altenmuller et al., 2014.

[179] Ioannou et al., 2018.

## Assessment of the Classification Model

Altenmuller's model describes a pattern of progressive worsening of motor disruptions, leading to the development of musician's dystonia. Three questions for investigating the characteristics were also designed to assess whether the problem of this study follows a similar pattern of progressive worsening. A similar pattern will be determined if (1) the results for the first two model assessments demonstrate a more severe experience for the high-severity groups when compared to the low-severity groups, and (2) the results for the third model assessment demonstrate a more severe experience when this problem is more frequently accompanied by fear and anxiety. If a pattern of worsening is demonstrated in all three assessments, it can be assumed that this problem is experienced as a spectrum of motor disruptions that can begin as a temporary and infrequent problem and worsen into a unique type of musician's dystonia.

### Model Assessment 1

The first model assessment was designed to align with "dynamic stereotypes," an early stage of the development of musician's dystonia. Subjects responded to the question "Did this problem persist for more than 4 weeks, despite pedagogical advice and/or professional healthcare?" with either yes, no, or unsure. Subjects who answered yes were considered the high-severity group, and musicians who answered no were considered the low-severity group. Subjects who responded "unsure" were not included in this analysis.

Out of 18 comparisons used for the first assessment, 13 aligned with Altenmuller's model. Of these 13 comparisons, 10 were found to be statistically different as shown in figure 9. The variables that did *not* align with Altenmuller's model were: (1) intensity *while* playing, (2) fluctuation within a single day, (3) fluctuation from day to day, (4) impact of professional healthcare, and (5) impact of “other” intervention.

These results show that subjects whose problem persisted for more than four weeks despite professional help also experienced greater frequency of primary symptoms. The frequency and intensity of their experience was greater in all musical contexts measured, except for the intensity *while* playing. This problem fluctuated more frequently for the high-severity group. The high-severity group was also more impacted by professional healthcare as an intervention. However, the high-severity group was less impacted by rest and professional healthcare as interventions for this problem. Finally, the high-severity group experienced significantly more frequent fear and anxiety, and their playing was significantly more impacted.

For the data regarding interventions to align with Altenmuller’s model, the high-severity group needed to report *less* impact of interventions. In the case of rest and pedagogical advice, the lower averages reported by the high-severity group support alignment with Altenmuller’s model. While impact of professional healthcare as an intervention did not align with the model, fewer subjects reported time invested in this type of intervention compared to rest and pedagogical advice.

Comparisons between levels of fluctuation across the two groups did not match Altenmuller’s model of progressive worsening. Altenmuller’s model describes motor disorders to be *less* fluctuating and more consistent than problems positioned on the left side of his spectrum. It was assumed that the high-severity group would report lower average frequencies of fluctuation. Why the high-severity group reported increased levels of fluctuation requires further study.

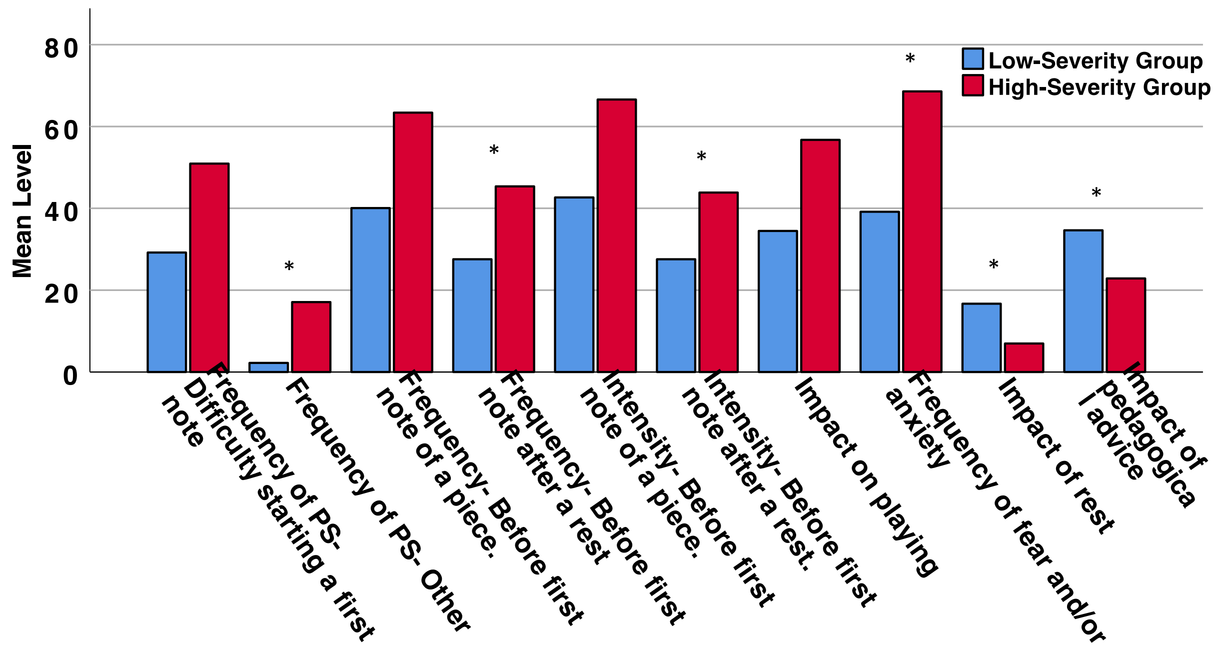


**Figure 10: Comparisons between high-severity and low-severity groups for the first assessment. Red bars represent the group of subjects whose problem persisted more than four weeks.**

Model Assessment 2

The second model assessment compared subjects who experienced this problem daily (the high-severity group) from musicians who experienced this problem non-daily (the low-severity group). Subjects responded to the "patterns of occurrence" question on a 4-point ordinal Likert scale.

Out of 18 comparisons used for the first assessment, 16 aligned with Altenmuller's model. Of these 16 comparisons, 13 were found to be statistically different. The variables that did *not* align with Altenmuller's model were: (1) fluctuation within a single day, and (3) impact of "other" intervention. Figure 11 shows select comparisons reported with a significant difference between the high-severity and low-severity groups.

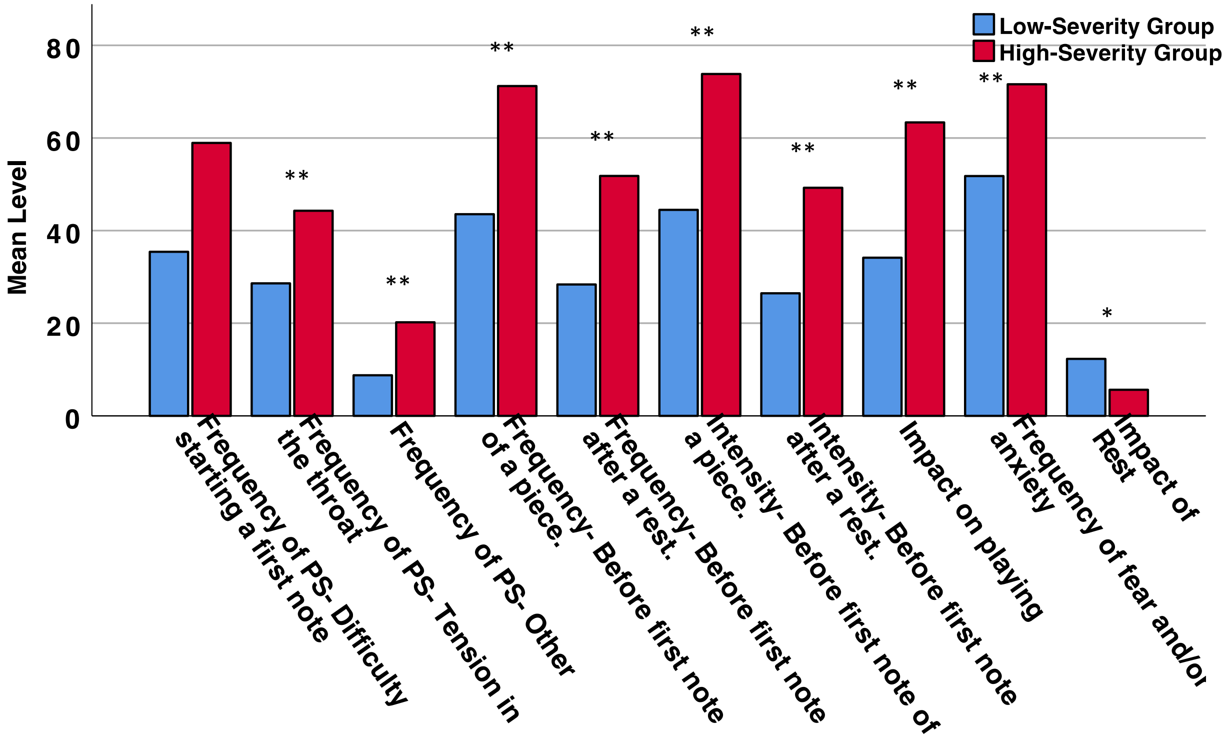


**Figure 11: Comparisons between high-severity and low-severity groups for the second assessment. Red bars represent the group of subjects who experienced this problem daily.**

The low-severity group reported a greater average impact from all three specified interventions. Similar to fluctuation, this indicates an alignment with Altenmuller's model. However, the difference in impact of pedagogical advice was essentially identical between the high-severity group (22.4) compared to the low-severity group (22.6).

Aligning with Altenmuller's model for the second model assessment required the high-severity group to have less fluctuation. While the fluctuation from day to day *did* align with this model, the high-severity group reported greater fluctuation within a single day. Further investigation is required to understand why fluctuation within a single day did not align with Altenmuller's model.

Model Assessment 3

The third assessment model was designed to align with choking under pressure, a subtype associated with performance anxiety. Subjects responded to the question “Rate the frequency this problem was accompanied by fear of failure and/or increased anxiety” along a VAS slider. Alignment with Altenmuller’s model was determined if a positive correlation was found for all variables except those of fluctuation and interventions, which required a negative correlation for alignment.

Out of 17 comparisons used for the first assessment, 14 aligned with Altenmuller’s model. Of these 14 comparisons, 12 were found to be statistically different. The variables that did *not* align with Altenmuller’s model were: (1) fluctuation within a single day. (2) impact of professional healthcare, and (3) impact of “other” intervention.

The interventions rest and pedagogical advice were reported with negative correlations, with rest being significant ($p$ = .015). Since Altenmuller’s model describes disturbances on the more severe end of the spectrum as being less impacted by interventions, these results support the third assessment’s alignment with Altenmuller’s model.

The two variables that did *not* align with Altenmuller’s model were pedagogical advice and fluctuation within a single day. As discussed above, the low response rate for pedagogical advice could have impacted the analysis. However, further investigation is required to understand why fluctuation within a single day did not align with Altenmuller’s model.

## Factors Outcomes from Model Assessments

Out of 53 individual analyses across all assessments, 43 (81%) matched Altenmuller’s model of worsening. Of these 43 analyses, 35 (81%; 66% of all analyses) were significantly different or correlated. Two variables did not align with Altenmuller's model in any of the assessments: (1) fluctuation within a single day and (2) the impact of "other" intervention. Professional healthcare did not align with Altenmuller's model in two of the three assessments.

Primary Symptoms

The frequency of all primary symptoms were greater for the high-severity groups in the first and second assessments. The third assessment found significant positive correlations for all four primary symptoms. Overall analyses of the primary symptoms aligned with Altenmuller's model.

Out of the three specified primary symptoms, "difficulty starting a first note" demonstrated the strongest and most consistent relationships for all classification questions. Since the physiological aspects of this disorder (throat and chest & upper respiratory system) did not have the same strength of relationships, it can be assumed they are not susceptible to worsening behavior to the same degree. Combined with characteristic data reported above (Table 6), the evidence suggests that difficulty starting a first note is the most fundamental primary symptom. It appears that this disorder *can* manifest bodily tension, and it is likely to do so, but bodily tension is not an essential aspect of the disorder.

Tension in the throat was reported with the second highest prevalence rate and frequency. Tightness in the chest and upper respiratory system was less prevalent and reported with less frequency, and was the weakest association of the primary symptoms in the model assessments. This suggests there is an order to the manifestations of this problem. Similar to

Wallace's 2016 study of pain in trombonists[180] and Zuhdi's study of guitarists,[181] it is likely that there is a clustering effect between these two sites. Furthermore, the consistent differences reported throughout the data suggest that tightness in the chest is less characteristic of this problem, and might even be a reaction to throat tightness; i.e., caused by the throat closing and causing a "backup" of pressure in the lungs.

While the results suggest an order to throat and chest tension, it could also be a difference in how temporal-spatial impairments manifest. Studies have found that the topographical location of multiple sensory inputs overlap in the somatosensory cortex[182] of musicians with dystonia. The location of overlaps was dependent on the musician's workload; e.g., overlap existed in the left hand of string players.[183] It is possible that the different physiological manifestations of this problem represent differences in how it is developed. For example, musicians who are prone to playing with increased pressure in the chest manifest "tightness in the chest" as a primary symptom, due to the brain's neuroplasticity conflating the two signals.

Only the first assessment did not find a significant relationship between the two groups for throat tension and chest tightness. The second and third assessments were directly related to motor disruption severity, i.e. the frequency of fear and anxiety, and the pattern of occurrence. However, the first assessment was a measurement of duration and impact of interventions. This suggests that the physiological manifestations of this problem might not be

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[180] Wallace et al., 2016.

[181] Zuhdi et al., 2020.

[182] Altenmuller & Jabusch, 2010, p. 5; Desrochers et al., 2019, p. 79.

[183] Altenmuller & Jabusch, 2010, p. 4.

tied to the overall severity. This is consistent with other known forms of musician's dystonia, which are not associated with physical pain.[184]

Frequency and Intensity by Musical Context

Analysis of all three model assessments found significant relationships between the frequency and intensity of motor disruptions in 16 out of 18 analyses. Frequency and intensity before the first note *of a piece,* and before the first note *after a rest*, were greater for the high-severity groups in the first and second assessments. Only the frequency and intensity *while* playing for the first assessment did not match this pattern. The second assessment found significant positive correlations between all analyses. All three assessments aligned with Altenmuller's model.

This data reinforces the task-specific nature of this problem, as well as suggesting that it is partly dependent on specific musical contexts. While before the first note *after a rest* was also associated with worsened experience, this study provides evidence that the strongest social pressures are linked to starting a piece of music.

The assumption that there is more psychological burden associated with starting a note is supported by the data for "*while* playing." While all three assessments reported more frequency and intensity as worsening progresses, the data for "*while* playing" was inconsistent with the other two musical contexts. This suggests there is more fear and anxiety associated with starting notes from silence than other musical contexts.

[184] Altenmuller et al., 2014, p. 166; Altenmuller & Jabusch, 2010, p. 3.

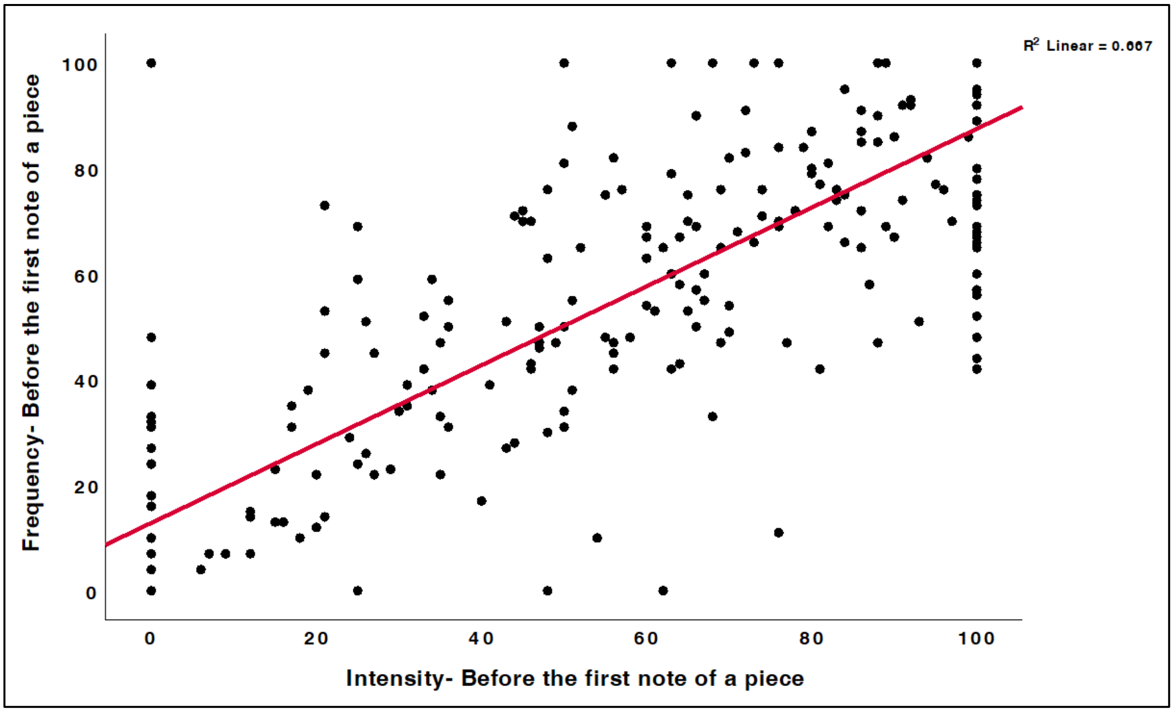


**Figure 12**: **The frequency of this disorder before the first note of a piece, analyzed against the intensity before the first note of a piece.**

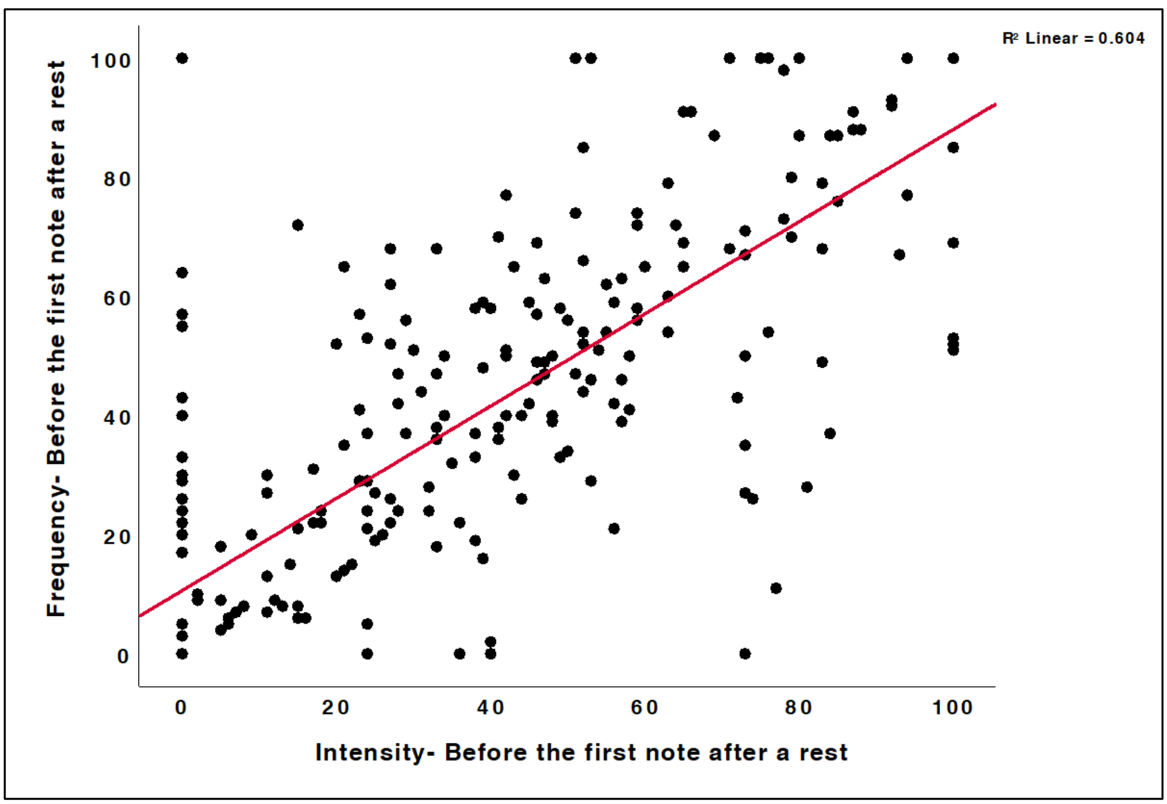


**Figure 13: The frequency of this disorder before the first note after a rest, analyzed against the intensity before the first note after a rest.**

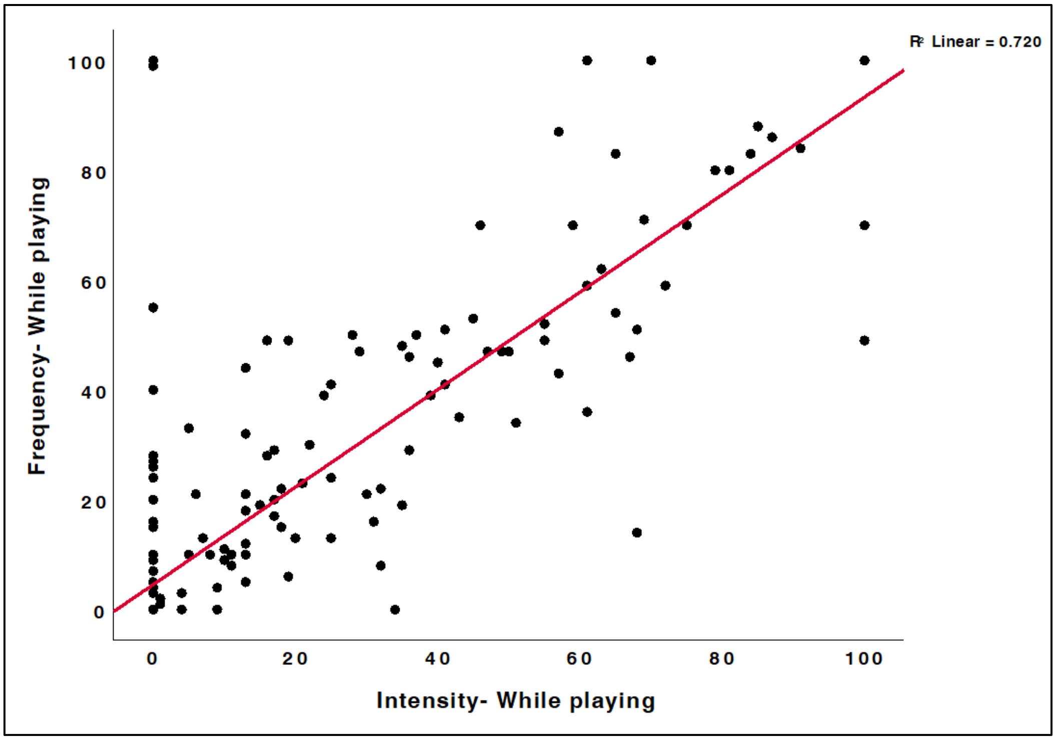


**Figure 14: The frequency of this disorder while playing, analyzed against the intensity while playing.**

Finally, as shown in Figures 12-14, significant correlations were found between the frequency and intensity of motor disruptions before the first note *of a piece*, before the first note *after a rest*, and *while* playing. The strength of these relationships suggests that frequency of occurrence impacts the intensity of the experience. Altenmuller's model describes the worsening subtypes as gaining in frequency and severity[185]. This data provides further evidence for this phenomenon's alignment with Altenmuller's model.

Fluctuation

For fluctuation to align with Altenmuller's model, the level of fluctuation needed to be *less* for high-severity groups in Assessments 1 and 2, and a negative correlation for the third

[185] Altenmuller et al., 2014, p. 170.

assessment (six total analyses). However, only two of the six analyses matched this model. The fluctuation questions were the least consistent variables in all three assessments.

One characteristic of musician's dystonia is that it becomes more consistent as it becomes habitualized. Since the results of this study suggest this problem develops along a similar pattern of progressive worsening, it would be assumed that the fluctuation levels reported would be *smaller* for the disorder measurements. However, the variable "within a single day" did not align with this model in any of the assessments, and fluctuation from day to day was reported at a slightly higher level for the first assessment.

This data suggests a difference in *how* this disorder fluctuates. While Altenmuller describes musician's dystonia to be less fluctuating,[186] the data from this study suggests the level of fluctuation is dependent on the period of time measured. A musician whose problem is classified on the more-severe end of the spectrum is likely to experience a wider variety of motor disruptions within a single day. However, the aggregate experience over multiple days is likely to be *less* fluctuating— which was consistent with this data.

### Impact of Interventions

For the impact of interventions to align with Altenmuller's model, the high-severity groups for the first two assessments needed to report lower averages, and the third assessment needed to report negative correlations. The impact of rest and pedagogical aligned with the model for all three assessments.

The lower mean impact of rest and pedagogical advice reported by subjects in the high-

[186] Altenmuller et al., 2014, p. 166.

severity group category suggest that their impact on this motor problem is dependent on its severity. A primary characteristic of musician's dystonia is that interventions have minimal long-term impact.[187] While less-severe subtypes such as dynamic stereotypes can be responsive to different pedagogical and psychological techniques, treatment protocols for musician's dystonia typically focus on individual symptoms.[188] While some research into effective pedagogical methodologies have been studied, none are known to have predictable long-term effects.[189]

Less than 20% of the total subject population sought professional healthcare for their problem. Those that sought professional healthcare reported almost no positive impact from the intervention. Even musicians whose experience had severely impacted their playing did not seek professional healthcare, treatment, or advice. Further research is needed to understand this health-seeking behavior that may be due to lack of awareness, knowledge, or beliefs about the origins of this problem. Regardless, performing arts health professionals should encourage a more proactive response to early symptoms and manifestations of this problem.

### Impact on Playing

All three assessments of the impact on playing aligned with Altenmuller's model. This relationship was statistically significant in all three assessments.

Music performance requires extensive training and repetition in order to develop the resources needed to play music at a high level. Disruptions in the ability to control or

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[187] Jabusch & Altenmuller, 2006.

[188] Altenmuller et al., 2014, p. 174.

[189] Altenmuller & Jabusch, 2010, p. 8.

coordinate these resources will impact the learning process while increasing self-doubt, worry, and fear. While the impact of this problem on learning was not measured in the current study, it is assumed that musicians on the more severe end of the spectrum experience greater difficulty improving.

Fear and Anxiety

The frequency of fear and anxiety was significantly greater for the high-severity groups in model assessments one and two, and therefore aligned with Altenmuller's model.

Increased levels of fear, anxiety, and the perceived inability to handle performance demands can create maladaptive movements and increased muscle stiffness.[190] This situation is called "choking under pressure" and is reportedly common among performing artists and students.[191] Regular increases in muscle tension while playing, and the accompanying maladaptive movements, can become habitualized into the beginnings of musician's dystonia.[192] It is likely that habitualization of a fear-based loss of control is a contributor to the worsening of this problem.

For example, an early manifestation of this problem might be an unexpected delay in tone production. Fear of a second experience might create a greater hesitation, which then creates a greater sense of fear and a worsened delay, reciprocating until the player is unable to start a note at the desired time and quality. This would account for the increased levels of fear & anxiety reported in the more severe experiences of this problem. The reciprocation of

[190] Altenmuller et al., 2014, p. 165.

[191] Altenmuller et al., 2014, p. 165.

[192] Altenmuller et al., 2014, pp. 170-171.

increasing fear and subsequent delay of tone can continue until the problem develops into musician's dystonia.

## Assessment of the Classification Model: Summary

The results from all three analyses of the classification model provide substantial evidence that this problem aligns with Altenmuller's model of progressive worsening in motor control disorders (Table 17).

**Table 17: Comparisons of All Model Assessments**

| Variable | | Assessment 1: Did it Persist? (Sig.) | Assessment 2: Daily vs Non-Daily (Sig.) | Assessment 3: Associations with Fear & Anxiety (Sig.) |
|---|---|---|---|---|
| Primary Symptoms | Difficulty starting a first note | <.001 | <.001 | <.001 |
| | Tension in the throat | .296 | <.001 | <.001 |
| | Tightness in the chest & upper body | .809 | <.001 | .039 |
| | Other | .008 | .007 | .001 |
| Timing *Frequency* | Before the first note *of a piece* | <.001 | <.001 | <.001 |
| | Before the first note *after a rest* | .003 | <.001 | <.001 |
| | *While* Playing | .823 | .036 | .010 |
| Timing *Intensity* | Before the first note *of a piece* | <.001 | <.001 | <.001 |
| | Before the first note *after a rest* | .007 | <.001 | <.001 |
| | *While* Playing | .843 | .023 | .006 |
| Fluctuation | Within a single day | .071 | .090 | .280 |
| | Day to day | .901 | .841 | .214 |
| Impact of Interventions | Rest | .003 | .015 | .002 |
| | Pedagogical Advice | .001 | .103 | .909 |
| | Professional Healthcare | .341 | .638 | .413 |

| Variable | | Assessment 1: Did it Persist? (Sig.) | Assessment 2: Daily vs Non-Daily (Sig.) | Assessment 3: Associations with Fear & Anxiety (Sig.) |
|---|---|---|---|---|
| | Other | .549 | <.001 | .118 |
| Impact on Playing | | <.001 | <.001 | <.001 |
| Fear & Anxiety | | <.001 | | <.001 |

Analysis for the first assessment used independent samples t-tests to compare groups of musicians whose problem did and did not persist 4+ weeks despite professional health. Analysis for the second assessment used independent samples *t*-tests to compare musicians who experienced this problem daily to those who did not. Analysis for the third assessment measured levels of association between the frequency of fear & anxiety and the model assessment variable set.

All three assessments represent different ways of judging the severity of this problem, and in all three cases the more severe aspect showed a subsequent worsening in the overall experience of this problem. These results suggest this problem is a spectrum of motor control disruptions that is capable of worsening into a unique type of musician's dystonia.

## Evidence-Based Definition

This problem is an involuntary task-specific impediment to the timing and quality of tone initiation. Associated with heightened psychological and social pressures, the problem is often first experienced during college-level music performance education. Psychological stressors can reciprocate physiological disruptions, leading to habitualized patterns that can progressively worsen into task-specific musician's dystonia.

Associated symptoms include tension and fatigue in the tongue, throat, and chest. Symptoms rarely include pain and are strongly associated with mental fatigue. Impact on non-music activities, including breathing or speaking, are uncommon. However, the inability to start a first note can result in severe negative psychological and/or professional outcomes.

## Other Comparisons

The research for this problem has been hindered by its misclassification. Mislabeling this problem has created a body of literature that is scattered and unprogressive. Making comparisons to other motor phenomena will focus and direct future literature by eliminating erroneous classifications. A large and robust data set will allow for the most accurate comparisons with motor problems that have been, or might potentially be, used to classify the problem of this study.

The subject population of this study is larger than that of either previous epidemiological studies of this problem,[193] and was the only study to be entirely populated by musicians with personal experience. Cochran's survey of musical stuttering received responses from only 69 affected musicians. Akers' dissertation of a "hesitation problem" received responses from only 24 musicians with that problem. The number of subjects who met the inclusion criteria for this study was nearly three times more than both of those survey populations combined. The size and quality of the subject population and data from this study allow for more thorough and accurate comparisons than those of previous studies.

## The Yips

Comparisons of the yips and the problem of this study show similarities between the task impaired and the function of that impairment. In both cases, high-anxiety situations, such as a live performance or golf competition, create small motor disturbances during a particularly worrying task. In yips-affected golfers, this disturbance can manifest as jerks or tremors during

[193] Since his writing is not clear, it still cannot be reliably known if the problem from Akers' study is the same problem as this study.

putting.[194] In musicians with this problem, a similar disturbance can manifest as a delayed or explosive first note. Both of these manifestations share a similar halting motion before the initiation of a task, and both are more commonly triggered when performance anxiety is present. Both problems are also found in occupations that require intense practice to earn proficiency. Finally, both impact a part of the task that is considered to need the most precision: starting a first note, and putting.

A prevalent model of the yips suggests that it manifests in two types, dependent on the etiology of each golfer's specific issue.[195] Type I is when a golfer's problem manifests as physical, dystonic movements, such as spasms, tremors, and contortions. Type II is when a golfer's problem is more psychosocial, similar to choking under pressure. Ioannou expanded on this concept in yips by splitting the yips into 2 broad types with 5 subtypes (Figure 15).[196]

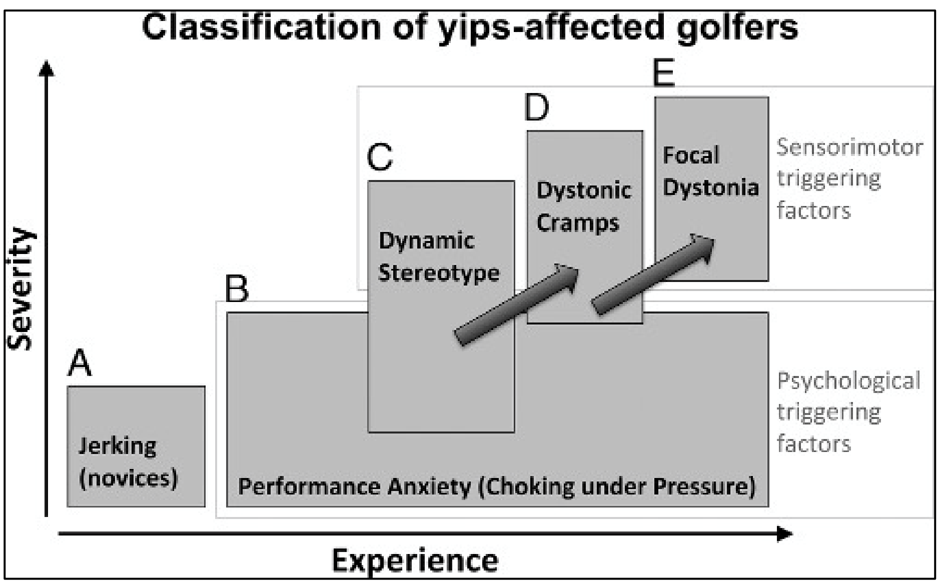


**Figure 15**: **Flowchart of the progressive worsening of the yips in golfers.[197]**

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[194] McDaniel et al., 1989.

[195] Smith et al., 2003.

[196] Ioannou et al., 2018.

[197] Ioannou et al., 2018.

Ioannou's spectrum is also split into physical and psychosocial symptoms, but with additional sub-categories representing the slow degradation of physical movements as the golfer loses further motor control. Ioannou is co-author on Altenmuller's model of musician's dystonia, referenced in this study. Based on the similar structures of the two models, the results of the current study suggest this problem follows the same spectrum-like degradation of control as the yips. While the current study did not include psychometric tests, the results from the third assessment suggest this problem is also impacted by increased state anxiety.

The yips and the problem of the current study also appear to have similar prevalence rates, both of which are significantly greater than any known forms of dystonia. The relative commonality of performance anxiety-induced motor disturbances (subtype B[198]/Type II[199]) is a reasonable explanation for why the yips, as well as the problem of this study, are so prevalent. McDaniel's study reported a prevalence of 28% in his epidemiological survey.[200] Cochran's study found a prevalence of 30%. While the current study excluded some musicians from the analysis, approximately half of all the musicians who opened this study's survey have experienced this problem. While this does not represent an accurate measurement of prevalence, it still suggests a larger population than would likely have been found if this problem had the same prevalence as musician's dystonia (~1%).[201]

The results of this study present similarities between this problem and the yips. Ioannou noted a similar relationship between the yips and musician's dystonia. In his study, he states

198 Smith et al., 2003.

199 Ioannou et al., 2018.

200 McDaniel et al., 1989, p. 193.

201 Altenmuller & Jabusch, 2010, p. 3.

about the subtypes of the yips and musician's dystonia:

> A parallel can be drawn between findings indicating performance deterioration in musicians who suffer from performance anxiety with studies revealing yips-symptoms exacerbated under stressful situations.[202]

What remains to be seen in future studies is exactly how much the yips and the current problem parallel each other. The results of the current study suggest commonalities will be found between triggering factors, psychological profiles, and levels of expertise common to each subtype. Investigating the role of increased stress as a triggering factor would also help with identifying subtypes similar to the yips. Applying similar psychometric tests as those used in Ioannou's study would strengthen the association between these two problems.

Finally, it is expected that the current study will improve the amount and quality of future research. Ioannou states that the yips is an under-investigated problem compared to musician's dystonia.[203] However, the first known study of the yips was almost 30 years earlier.[204] The musical community deserves to not wait 30 years for an improved understanding of this problem. The similarities found between this problem and the yips will hopefully aid in the classification, and accelerate the research towards developing interventions.

## Musical Stuttering

Van Riper's 1952 study was the first to apply the classify of musical stuttering.[205] On the surface, speech stuttering and the problem of the current study are similar. They both involve a

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[202] Altenmuller & Jabusch, 2010, p. 3.

[203] Ioannou et al., 2018, p. 2218.

[204] McDaniels et al., 1989.

[205] Van Riper, 1952.

loss of fluidity creating repetitive, delayed, or explosive articulations of sounds. Both can primarily impact the onset of tone production. What's more, the subjects in all four musical stuttering case studies described their problem as speech stuttering on their instruments. Packman notes that there are similarities in the motor functions of both speech and playing a wind instrument.[206] However, in that same study Packman wrote that "any functional relationship between the two must be regarded as speculative."[207] The data from the current study show that many of the similarities between stuttering and this problem are superficial, and over-balanced by dissimilarities.

The musical stuttering literature commonly discusses fear of failure as being an underlying cause of both speech and musical stuttering. Silverman hypothesizes that the fear of failure from his subject's first "block" caused the subsequent "blocks."[208] Meltzer claims that music and speech share exaggerations of perceived flaws, leading to hypersensitivity and expectations of failure.[209] Anticipating failure is theorized to be one cause of speech stuttering, leading the authors of the four case studies to hypothesize that similar fears lead to similar mechanical issues with sound production. However, fear and anticipation of failure is also a noted characteristic of choking under pressure,[210] which is a primary cause for developing the yips. Ioannou 2018 shows that choking under pressure is the largest subtype of the yips in golfer's and musician's dystonia (Figure 15). Furthermore, dynamic stereotypes is described as

[206] Packman & Onslow, 1999, p. 297.

[207] Packman & Onslow, 1999, p. 297.

[208] Silverman & Bohlman, 1988, p. 428.

[209] Meltzer, 1992, p. 262.

[210] Altenmuller et al., 2014, p. 165.

what happens when long-term choking under pressure becomes habitualized responses.[211] This suggests that the presence of anticipatory fear of failure is a common performance problem.

The difference in age of onset between this problem and speech stuttering suggests different etiologies. Although Cochran did not provide an average age of onset for musicians who experienced musical stuttering, around 65% of his study reported playing at an advanced level at onset.[212] The current study found an average of 9.3 years of experience prior to first experiencing this problem. Over 86% of Akers' study reported developing the "hesitation problem" during undergraduate or college/professional life.[213] This evidence reflects the age of onset found in the current study (20.8) more than that of speech stuttering (average between 2-5 yr).[214]

Cochran hypothesizes that the later age of onset for musical stuttering is due to musical proficiency taking far longer to learn compared to speech. He claims that the fluency of an 11-year-old speaker would be comparable to a professional musician,[215] justifying a later age of onset when comparing communication proficiency level. However, this figure is based on the highest *range* for years of experience, not the *average*. The average age, between 2-5 years old, would be a much lower level of proficiency in speaking than that of an 11-year-old; arguably much lower than that of a 30-year-old music college graduate. Furthermore, the ages of onset for both this study and Cochran's study of musical stuttering align with the age of onset for

[211] Altenmuller et al., 2014.

[212] Cochran, 2002, p. 30.

[213] Akers, 2016, p. 31

[214] It's important to remember that this study measured the *first* experience of this problem, and not when it reached dystonic levels. This likely led to a much smaller average years of experience than other studies.

[215] Cochran. 5.

musician's dystonia (30s).[216] Finally, the average range of onset for musician's dystonia (18 to 60)[217] more closely resembles the range reported for this problem (6 to 68) than it does speech stuttering (18 months to 12 years).

The reporting of pain and fatigue related to this problem further separates it from stuttering. Approximately 40% of the subject population reported experiencing fatigue in the throat, tongue, and respiratory system related experiencing this problem. Nearly 20% reported experiencing tongue pain related to this problem. Physical pain or fatigue are not known to be associated with speech stuttering, a point that is accentuated by Cochran's study not measuring pain or fatigue. While pain is not closely associated with focal dystonia in musicians, prolonged experiences of pain when playing can lead to the development of focal dystonia.[218,219] Furthermore, available literature for this problem characterize it with tension in the throat, tightness in the chest and respiratory system, and/or a general "locking up" of the physical body.

Finally, the average length of time between onset and recovery for this problem is much different than that of speech stuttering. As stated earlier, recovery rates for speech stuttering have been reported at 71.4% within two years[220] and 74% within four years,[221] whereas Cochran reported a life-time recovery rate of 42% for respondents of his survey. While not

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[216] Altenmuller & Jabusch, 2010, p. 4.

[217] Altenmuller & Jabusch, 2010, p. 4.

[218] Altenmuller et al., 2014, p. 166.

[219] Altenmuller & Jabusch, 2010, p. 3.

[220] Månsson, 2000.

[221] Yairi & Ambrose, 2013, p. 20.

necessarily accurate recovery rates, nearly half of the subject population of this study (49.6%) reported no longer experiencing this problem in their own playing. Furthermore, those who reported no longer experiencing it reportedly recovered an average of 10 years after first experiencing it, with a range of 0 years to 52 years between first experiencing and no longer experiencing. The reported life-time recovery rates and time before recovery for this problem are vastly different from what's been reported for speech stuttering.

In summation, compared to known types of speech stuttering, the problem of the current study is reported to have a later age of onset, greater average years of experience at onset, a longer average period before recovery, a much lower recovery rate, is accompanied by pain and fatigue, and primarily affects a more limited aspect of phonation. Perhaps most importantly, although the four case-studies argue that the speech stutterers are experiencing a musical version of their stuttering, very few subjects from Cochran's study experienced speech stuttering,[222] suggesting the connection found in the case studies are outliers. All of these results suggest this problem is not a musical form of stuttering.

## Spasmodic Dysphonia

In the process of creating this study, and presenting lectures at professional conferences, several performing arts health professionals pointed out the similarities to spasmodic dysphonia. As with musical stuttering, spasmodic dysphonia shares immediate similarities with the problem of this study. Comparing characteristic data from this study to spasmodic dysphonia will hopefully guide direct future studies. As with musical stuttering, while

[222] The exact number is unknown, but Cochran only mentions 2 musicians experiencing speech stuttering.

some of the characteristics of this problem resemble spasmodic dysphonia, the results of this study suggest they are not related phenomenon.

The age of onset for spasmodic dysphonia is mid-life, with an average age of 46 $\pm$ 15 years. This is approximately 20 years later older than the average age found in this study.

Spasmodic dysphonia is not strongly associated with manifestations of pain.[223] Contrarily, 42% of subjects reported experiencing tongue and/or throat fatigue, and upwards of 20% experienced tongue or throat pain to some degree.[224] The differences in pain and fatigue between the two phenomena suggest different etiologies. Furthermore, spasmodic dysphonia effects the larynx by creating involuntary voice breaks, tremors, and/or a strained and choking sound. However, it is a focal type of dystonia isolated to the larynx and vocal folds.[225] The problem of the current study reportedly effects the throat (non-specific to the larynx), tongue, and chest/upper respiratory system— all sites unaffected by spasmodic dysphonia.

Spasmodic dysphonia is not a task-specific form of focal dystonia that is not relegated to the onset of phonation.[226] A positive diagnosis of spasmodic dysphonia requires a clinical speech assessment to find at least one or more voice breaks per three sentences, and minimum rating for the amount of choking sound that occurs while sustaining a vowel for five seconds.[227] Contrarily, subjects of the current study reported experiencing this problem before starting a note. While they both disrupt tone production, it seems that spasmodic dysphonia is not as

[223] Ludlow et al., 2008.

[224] Cochran's study did not include any measurements of pain.

[225] Ludlow et al., 2008, p. 2.

[226] Ludlow et al., 2008.

[227] Ludlow et al., 2008, p. 3.

limited to specific times when compared to the problem of the current study.

In summation, when compared to the problem of the current study, spasmodic dysphonia's age of onset is later in life, it has more limited physiological manifestations, is less associated with pain or fatigue, and is not limited to specific parts of speech. While there are many questions remaining about the problem of this study, the dissimilarities between known characteristics suggest they are unrelated phenomena.

Other Comparisons: Summary

Comparisons using this study's characteristics data strongly suggest that the problem of this study is not a form of musical stuttering. While the effect of this problem on wind instrument playing sounds similar to some types of speech stuttering, differences in the onset and various characteristic information suggest they are separate issues. Similarly, while both effect the larynx, differences in known characteristics suggest this problem is not a form of spasmodic dysphonia. It is hoped that, by making these comparisons, the results of this study will aid future research, as well as help performing arts health professional with intervention recommendations.

# CHAPTER 6

# CONCLUSIONS

This study was created in response to deficits in the literature regarding this problem. While brass pedagogues have discussed this problem in interviews, academic studies did not provide enough information to investigate interventions or preventative measures. In response, this study sought to create an online epidemiological survey of this problem in brass musicians. Characteristic information from this survey was used to create a formalized definition. Characteristic data was also compared to Altenmuller's model of progressive worsening to assess whether this problem is experienced along a spectrum of disruptions. These results suggest this problem is a spectrum of motor disturbances capable of progressing into a unique form of task-specific musician's dystonia.

The results from this study represent the most comprehensive body of knowledge of this problem. Subject responses provided detailed characteristic information about the symptoms and associated physiological manifestations experienced by musicians. Interactions between psychological and physiological factors were identified and found to influence each other in a reciprocating pattern of worsening. This problem was found to impact the lives of musicians outside of music, suggesting psychological and social burdens continue to weigh on musicians when not playing their instrument. Finally, it was found that musicians do not commonly seek professional healthcare for their experience of this problem.

It was predicted that this problem would align with Altenmuller's model was supported by the results of this study. The results from this study indicate this problem follows the same pattern of progressive worsening as musician's dystonia, suggesting it is experienced along a spectrum of progressively increasing severity. This problem is characterized by a set of motor disruptions that can start as mild interference and worsen into a unique form of musician's dystonia. It also shares similarities in prevalence, level of expertise at onset, and subtypes of experience with the yips— further suggesting the parallels between this problem and known types of task-specific dystonia. Whether dystonic movements primarily affect the throat, tongue, respiratory system, a combination of different sites (suggesting it is not a focal dystonia, but either segmental or multi-focal), or another unknown site requires further investigation.

While this problem shares some similarities to musical stuttering, differences in onset, etiology, physiological effects, and the timing at which it is experienced all suggest they are unrelated. Furthermore, the term *valsalva maneuver* is misleading and inaccurate, and should not be used in reference to this phenomenon.

Finally, spreading awareness of this problem is a crucial task moving forward. It is important for the musical community's health that musicians, particularly those involved in music pedagogy and education, understand that development and progressive nature of motor control problems. Efforts to disseminate academic understanding of neurologic factors related to performance problems is vital for collaboration between musicians and medical practitioners and researchers.

# CHAPTER 7

# LIMITATIONS

It is unclear if the demographics from this study are indicative of the brass musician population as a whole, the population of the musicians who received this survey, or musicians who have experienced this problem in their own playing. One possibility is the greater likelihood for classical musicians to seek treatment for musician's dystonia,[228] possibly signifying a link between the types of training involved for this profession.[229] However, considering the size of the NASM brass faculty email database compiled for this survey, it is likely that most responses originated from a college or university brass faculty member. This origin could be a large contributor to these demographic figures.

Furthermore, while collecting the institutional email addresses for the database, it was noted that the two most common instruments taught at colleges were trumpet and trombone. This is likely due to them being the primary brass instruments in jazz and commercial music. Having instructors of these instruments teach jazz as well as classical would make a college more marketable, as well as help smaller colleges save money on faculty by *only* hiring these instruments for their brass studios (many smaller colleges will hire one trumpet teacher for all high brass, and one trombone teacher for all low brass, and both will teach jazz). It is possible that, in order to save money on employment, colleges music programs have inadvertently skewed the brass teacher population towards these two instrument groups— thus affecting the

[228] Altenmuller, 2003, p. 532.

[229] Prevalence figures such as the one referenced here must be taken in context. This study reported the demographics of the population of musician's who visited a musician's dystonia clinic between 1994-1999, which consisted of 89% classical musicians. This is *not* a true sampling of the musical population.

population of this study.

Since one goal of this study was to construct an accurate definition of this problem, it was decided that any definition provided to subjects in the survey itself could not validly be used to identify affected musicians. For that reason, it is unknown what exact percentage of subjects actually experienced this problem in their own playing. It is possible that some portion believed this survey was about a different problem. While the strategy used in the current study was the most practical based on contemporary information, future studies will benefit from this survey's groundwork.

One side effect of not having a solid foundation of research when designing this survey was the extra amount of time and text needed for simple statements. A prime example is the need to provide subjects with an extensive operational definition due to the lack of a formalized name. This was further complicated by having to refer to the phenomenon as "this problem" in the survey; both of which added of extra text (the yips had the benefit of being known amongst golfers by the time of McDaniel's survey[230]). While the current survey was ambitious in its length, it needed to exclude important scales such as the Frost Perfectionism Scale or State-Trait Anxiety Index. Both of these have been shown to impact the development of musician's dystonia,[231] and would have been helpful additions to this study. However, for the sake of survey brevity, and the occasional need to guess about what would be important, those psychometric scales were excluded.

This survey excluded "tongue" as one of the primary symptom sites. While this problem

[230] McDaniel et al., 1989, p. 192.

[231] Altenmuller & Jabusch, 2010, p. 6.

has been called “tongue stopper” by Altenmuller, it was assumed that the tongue’s involvement in disruptions was a reaction to other physiological symptoms. For this reason, tongue was considered a secondary issue not directly responsible, and was not included in the primary symptoms list. While this decision perhaps reduced the completeness of the data from this survey, it is unlikely that the tongue’s inclusion in the primary symptoms factor would have altered the definition or classification conclusions. However, future studies into physiological symptoms should certainly include it as an important physiological site to investigate.

There are possible methodological issues with the term “while playing” used in factor four of the characterization sections. This term was used in response to the need for brevity, and was intended to indicate any moment of time after tone has been initiated. The variable was meant to differentiate from tone *initiation*. However, it is possible that misunderstandings of this intention lead to inaccurate responses.

Finally, there are no known studies that allow for direct quantitative comparisons with the outcomes described in this study. Since no characteristic data to the extent of this study exist, it is not possible to compare these results to another set of characteristics. This study’s strategy for proposing a classification was weaker than if there was a more direct point of comparison.

# CHAPTER 8

# RECOMMENDATIONS

## Research

This study recommends that future research focus on two lines of inquiry. First, investigations into early identification would help develop preventative measures. The current study found that body-sites likely interact as clusters, with tension in one site creating or exacerbating tension in another. Targeted studies into what sites are involved, orders of involvement, and possible hierarchies of tension would clarify how these disruptions are first developed. More information on the reciprocation of psychological stressors on physiological tension would further help identify musicians in the early stages, as well as guide music educators in avoiding risk-factors. Further investigations into psychological stressors would also help with understanding the neurological factors associated with this phenomenon.

The second research recommendation is pedagogical methods that are harmful and/or helpful. Self-focus has been identified as a causal factor for motor disruptions related to the yips.[232] Similarly, reinvestment and focus of attention theories have been found to create discoordination that can lead to habitualized disruptions.[233] Focus of attention investigations such as the work of Gabriele Wulf[234] and more recently by Mornell[235] would help identify teaching methods to avoid and encourage. This would be of particular importance to the National Association of Schools of Music, which does not require incorporating this type of

[232] Bawden & Maynard, 2001.

[233] Altenmuller et al., 2014; Bawden & Maynard, 2001, p. 938.

[234] Wulf, 2013.

[235] Mornell & Wulf, 2018.

research into education curriculum.

While efforts were made to create a name for this problem, it was ultimately determined that there is not yet sufficient information for doing so. It is likely that any name based on the current information might be inaccurate and require replacing. Since one basis for this study was that the phenomenon had too many inaccurate names, it seemed hypocritical to possibly add to the issue. Future research should make efforts to target investigations into accurate naming.

## Pedagogy

Reinvestment, a theory that consciously controlling processes that are normally controlled unconsciously, has been suggested to have a role in the development of the yips.[236] Gabriele Wulf has documented the effect of a similar concept, what she calls focus of attention, on various simple tasks.[237] Recently, focus of attention has been tested on a small population of wind musicians.[238] Contrarily, many pedagogical methodologies are based on conscious control of the body during instrumental performance. For instance, Donald Reinhardt's pivot system,[239] the Breathing Gym,[240] and various concepts of embouchure manipulation such as those of Philip Farkas,[241] all guide students and musicians towards conscious manipulation of the body. Anecdotal sources suggest these types of methodological approaches can be helpful and

[236] Masters & Maxwell, 2008; Bawden & Maynard, 2001.

[237] Wulf, 2013.

[238] Mornell & Wulf, 2018.

[239] Wilken, n.d.

[240] Pilafian & Sheridan, 2002.

[241] Farkas, 1962.

successful tools. However, there are complex genetic and psychological factors that cause a small percentage of people to be predisposed to developing dystonic movements.[242]

Academic studies on motor learning and the development of motor control dysfunctions suggest that pedagogical methodologies like those mentioned above could be contributing to the development of motor control disorders. Therefore, it is recommended that pedagogical methods avoid directing students towards the conscious manipulation of their body. Instead, educators should find ways of achieving the same results by directing attention away from the physical body. The author of the current study intends to conduct research on these topics after the publication of the series of articles stemming from the current survey are concluded.

Finally, the data of this study suggests that special attention must be paid to the health and well-being of students when increasing practice and rehearsal efforts. The Yerkes-Dodson law states that performance decreases after an arousal peak has been surpassed.[243] Similarly, arousal beyond a certain point has been found to become debilitating[244]— an outcome supported by the results of the current study. Therefore, sudden increases in practice habits should be closely monitored for unhealthy changes that might lead to worsening performance issues. Similarly, increased mental arousal inherent to solo performance should be considered a risk-factor for performance problems,[245] particularly with inexperienced students. Healthcare professionals should be notified if worsening continues without improvement.

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[242] Altenmüller & Furuya, 2017; Altenmuller & Jabusch, 2010, p. 5.

[243] Yerkes & Dodson, 1908.

[244] O'Brien et al., 2005.

[245] Miller & Chesky, 2004.

APPENDIX A

IRB APPROVAL LETTER

**[EXT] IRB-19-190 - Initial: Exempt Approval for Online Study**

UNT_IRB@cayuse.com <UNT_IRB@cayuse.com>
Tue 4/30/2019 3:43 PM

**To:** Chesky, Kris <Kris.Chesky@unt.edu>
**Cc:** Wallace, Eric <EricWallace@my.unt.edu>

UNT
EST. 1890

THE OFFICE OF RESEARCH AND INNOVATION
Research and Economic Development

April 30, 2019

PI: Kris Chesky
Study Title: Epidemiological Study of a Performance Problem in Brass Musicians

RE: Human Subjects Application # IRB-19-190

Dear Dr. Kris Chesky:

In accordance with 45 CFR Part 46 Section 46.104, your study titled "Epidemiological Study of a Performance Problem in Brass Musicians" has been determined to qualify for an exemption from further review by the UNT Institutional Review Board (IRB).

Attached to your IRB application in the Study Detail section under the Attachments tab are the consent documents with IRB approval. Since you are conducting an online study, **please copy the approved language and paste onto the first page of your online survey. You may also use the enclosed stamped document as the first page of your online survey.**

No changes may be made to your study's procedures or forms without prior written approval from the UNT IRB. Please contact The Office of Research Integrity and Compliance at 940-565-4643 if you wish to make any such changes. Any changes to your procedures or forms after 3 years will require completion of a new IRB application.

We wish you success with your study.

Sincerely,

Shelley Riggs, Ph.D.
Professor
Chair, Institutional Review Board

SR:jm

# APPENDIX B

# SURVEY ANNOUNCEMENT USED FOR RECRUITMENT

**Survey Announcement for Brass Musicians:**
I am a doctoral student at the University of North Texas, and a researcher with the Texas Center for Performing Arts Health. As part of my dissertation, I'm conducting a survey to investigate a performance problem that is experienced by some brass instrumentalists. You can find more information about me, and my previous research on this and other topics, at the Texas Center for Performing Arts Health.

Several influential brass instrument teachers have noted working with students who experience a freezing sensation when starting a note on a wind instrument. Arnold Jacobs used the term "Valsalva maneuver" when discussing this problem, saying it is not uncommon among his students. Jacobs described this problem as an increase in internal air pressure, closure in the throat, and a choking sensation. Other academic articles reported wind players who experienced "musical stuttering", which they described as a perceived tightening of the chest and throat muscles, a sense of "locking up", and subsequent delayed, explosive, or rapidly repeated first note. However, little is actually known about this problem, how it is experienced by brass musicians, or if there are other ways in which this problem manifests.

The survey can be taken and/or distributed with the following link:
https://unt.az1.qualtrics.com/jfe/form/SV_0uosvEnaSTpDpuB

The purpose of this survey is to define and characterize this problem in brass players. If you know any brass instrumental musicians, teachers, or students over 18yo who have experienced this problem, please send them this link and announcement. I would also appreciate sending this information to anyone who could help this survey reach as many impacted musicians as possible.

This survey will ask questions about your musical background, musical habits, musical experiences, and health history. *No personal data will be collected by this survey. Please allow approximately 20 minutes for completion.* Feel free to contact me at the email address below with any questions at any time.

Eric Wallace, MM
ericwallace@my.unt.edu

# APPENDIX C

# CASE SELECTION CRITERIA

| |
|---|
| Removed subjects who did not respond to Q7 (*n* = 74) |
| Remaining populatio*n* = 707 |
| Removed subjects who did not select "Yes" on Q7 (*n* = 278) |
| Remaining populatio*n* = 429 |
| Removed subjects who dropped out after Q8 (*n* = 81) |
| Remaining populatio*n* = 348 |
| Removed subjects who reported ages <18yo (*n* = 2) |
| Remaining populatio*n* =346 |
| Removed subjects who dropped out after Q23 (*n* = 51) |
| Remaining populatio*n* = 295 |
| Removed subjects who dropped out after Q34 (*n* = 26) |
| Remaining populatio*n* = 269 |
| Removed subjects who dropped out after Q42 (*n* = 4) |
| Remaining populatio*n* = 265 |
| Removed subjects who dropped out after Q48 (*n* = 6) |
| Remaining populatio*n* = 259 |
| Removed subjects who dropped out after Q60 (*n* = 5) |
| Remaining populatio*n* = 254 |
| Removed subjects who dropped out after Q71 (*n* = 2) |
| Remaining subject populatio*n* = 252 |

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