An exploration of trumpet valve rotation: Its mechanics, sound, and notation

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An Exploration of Trumpet Valve Rotation: its mechanics, sound, and notation.

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Abstract

Many contemporary performers and composers seek new sounds through extension of traditional instrument techniques. For the trumpet one such extended technique is valve rotation, the rotation of a trumpet piston valve within its casing to effect the timbral complexity of airstream effects. Intrigued by the possibilities, I have embarked on an exploration of trumpet valve rotation, a path which has become significant to my creative practice. When searching for resources to inform my exploration it was evident that there is limited: documentation referring to trumpet valve rotation; investigation into the application of trumpet valve rotation in improvisation and composition; and methods for the effective communication (both aural and written) of the technique. Through the creation of two original works for solo trumpet and the development of both a static and animated notation this practice-based research aims to address these gaps in the academic literature. In addition detailed description of the physical parameters, sonic characteristics and best practice when using trumpet valve rotation are included. The included creative works are: iMprov #13 (2017) — solo trumpet improvisation, and Minutiae (2017) — for solo piston valve trumpet.
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Chapter 1: Introduction

...experimental music is primarily an exploratory activity undertaken to test the validity and explore the parameters of (musical or non-musical) processes, situations and/or ideas which, in themselves, pose questions about established and accepted musical contexts from a position outside of these contexts. (Fox 2002 p. 19)

There has always been a push by experimental musicians and composers to search out new processes and techniques in order to create their music and sound art. This tradition of experimentation and extension of sound and instrument boundaries can take on many forms or trajectories. In my own practice I currently find myself drawn to the airstream effects produced by the trumpet and the physicality of rotating the trumpet valves. The vast contrast of airstream timbres available to the player through this technique has opened up a sound world within my creative practice that I find completely intriguing and requiring significant investigation.

The valve rotation technique employs the rotation of the valves within the valve casings, directing the air that is moving through the trumpet in unconventional ways. Its most effective use, as I perceive it, is to change the timbre and complexity of airstream effects. However, valve rotation is yet to be fully investigated in the academic sense. Extended techniques such as flutter tonguing, growling, half-valving and lip bends (Cherry 2009), to name a few, all have a place within mainstream genres. It is perhaps valve rotation’s origins in non-idiomatic and free improvisation contexts, as well as its low volume when performed, that have hindered its inclusion in compendia of extended techniques to this point in time. These purely improvised genres remain under-researched compared to composition and performance in the Western Classical tradition.

The historical origins of valve rotation are not clear and warrant further research, however these origins are not crucial to this dissertation. From a personal perspective the technique was first brought to my attention by Craig Pedersen in August 2015 during a workshop at the Western Australian Academy of Performing Arts (WAAPA). A search of available performances and recordings that incorporate valve rotation is challenging given the improvised nature of much of the material. In this dissertation I discuss audio and video examples from Axel Dörner (Sossi, 2017),

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1 Airstream effects — blowing air through the instrument without producing a note.
2 Craig Pedersen — ‘trumpet player, composer and educator based out of Montréal. An active freelance musician specializing in jazz and free music’ [https://www.craigpedersen.com](https://www.craigpedersen.com)
3 Axel Dörner — Key figure in [http://www.efi.group.shef.ac.uk/musician/mdorner.html](http://www.efi.group.shef.ac.uk/musician/mdorner.html)
Craig Pedersen (Pedersen, 2015), and Nate Wooley⁴ (Reilly, 2016) as a sample of what I assume is a much larger pool of recorded material involving valve rotation. A search for compositions involving valve rotation has uncovered a fully notated work, *speckle* (Gottfried 2016), for amplified trumpet, trombone, violin and percussion. Rama Gottfried’s composition uses the rotation of the third trumpet valve with a graphic notation choreographing its rotation.

To this point in time valve rotation seems a difficult technique for performers and composers to utilise due to limited: documentation referring to trumpet valve rotation; investigation into the application of trumpet valve rotation in improvisation and composition; and methods for the effective communication (both aural and written) of the technique. These gaps have been addressed by the set of research outputs described in this dissertation.

I have used a practice-based research approach to investigate and document the parameters and sonic characteristics of trumpet valve rotation. During this period of exploration I devised a graphic notation for trumpet valve rotation. I tested and refined the documentation and notation by composing and improvising two new works. Lastly, I developed resources for performers and composers — a software application, including utilisation notes.

The knowledge gained through my exploration of and creation with valve rotation is presented in the dissertation, accompanied by an analysis of the two creative works I have improvised, composed and performed for solo trumpet.

The process of creation and research were concurrent and intertwined throughout this practice-based research. However in presenting the findings I have chosen to lead the reader from technique exploration to creative output. Thus, this document presents an interrogation of the relevant literature and recorded material (Chapter 2), describes the physical and acoustic characteristics of valve rotation (Chapter 3), outlines considerations for composers and performer when implementing valve rotation (Chapter 4), presents a static and animated graphic notation for the technique (Chapter 5 and 6), and reveals the creative process and reflectively analyses two original works for solo trumpet that utilise valve rotation; *Minutiae* (O’Connor, 2017b) (Chapter 7, audio in Appendix 1A) and *iMprov #13* (O’Connor, 2017a) (Chapter 8, audio in Appendix 2A).

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⁴ Nate Wooley - ‘Wooley is considered one of the leading lights of the American movement to redefine the physical boundaries of the horn [trumpet]’ [http://natewoorley.com/about.html](http://natewoorley.com/about.html)
Chapter 2: Literature review

Creative practice, exegesis and research

In undertaking research directly related to my own creative practice I first sought to
understand the relationship between arts practice and academic research. Scholarly discussion
about the relationship between arts practice and academic research is ongoing, and the
classification and definition of key activities are yet to be agreed upon (Candy 2006). The point of
differentiation between everyday arts practice (‘pure practice’, ‘arts practitioner practice’) and
academic arts research (‘practice-based research’, ‘practice-led research’) is the production of
original knowledge (Candy, 2006). The main focus of academic arts research should be ‘to add
knowledge where it did not exist before.’ (Candy 2011 p.1)

Three kinds of Academic arts research have been proposed — ‘research into art’, ‘research
through art’ and ‘research for art’ (Frayling 1993 p.5). These categories are differentiated in relation
to artefact creation and whether the artefact can sufficiently communicate knowledge. The
‘research for art’ (Frayling 1993 p.5) category requires knowledge to be ‘embodied in the
artefact’ (Frayling 1993 p.5), which may be problematic in an academic context because it negates
the need for traditional text or verbal communication of knowledge. Scrivener (2002) asserts that
an artefact alone cannot convey knowledge, in the academic research sense of the word, although
the production of the artwork can lead to knowledge.

Research gains knowledge and although images and artefacts are acceptable
outcomes it would appear that they are only relevant to research if their
production leads to knowledge. (Scrivener 2002 p.2)

Similarly, Candy (2011) identifies two kinds of academic arts research, differentiated primarily
by whether an artefact is created.

If the research process is primarily based around making an artefact, the
research could be said to be practice-based. If the research leads primarily to
new understandings about practice, it is practice-led. (Candy 2011 p.35)

How then is new knowledge to be created and communicate in ‘research through
art’ (Frayling 1993) and ‘practice-based research’ (Candy 2011)? The former sets out that the
creative artefact must be accompanied by significant documentation to ‘communicate the
results’ (Frayling 1993) of the research. More recently practice-based research has been
defined as an investigation that ‘positions creative works and exegetical texts together as an integrated whole’ (Harrison cited in Draper and Hitchcock, 2013). Therefore the knowledge embodied in creative work is communicated by the accompanying exegetical text.

In the case of a creative thesis, the outcome of the independent research is a body of creative work. The role of the exegesis is to present the research framework: the key questions, the theories, the disciplinary and wider contexts, of the project. (Fletcher and Mann, 2004, p.1)

The creation of two new works for solo trumpet (i.e. the artefacts) in the course of my research places my project in the domain of practice-based research. The two new works are accompanied by this dissertation (i.e. the exegesis) that extensively documents and critically evaluates the knowledge created during my research. The artefacts plus the exegesis comprise the contribution of my work to the field of extended trumpet techniques, composition and improvisation.

**Extended trumpet techniques**

There is a rich history in music and art of extending beyond the conceived limitations of any given instrument. (Pedersen and Dörig, 2014, p.1)

In my reading so far I have been unable to find research that directly references the trumpet valve rotation technique. The technique is commonly found in the free improvised or non-idiomatic improvised genres, where academic research into instrument technique seems to be lacking at this point in time; this may account for the limited discussion of valve rotation.

There are however documents relating to extended trumpet techniques with a focus on composed music in the Western Classical tradition and Jazz music. Doctoral theses by Amy K. Cherry (2009), Cameron L. Ghahremani (2016) and Attilio N. Tribuzi (1992) are often cited for their descriptions and categorisations of extended trumpet techniques. They each offer their definition of extended technique — ‘ways of playing a traditional instrument that produce new and often unexpected sounds’ (Cherry, 2009, p16), ‘outside of the technical demands found in the common practice of trumpet performance’ (Tribuzi, 1992, p.3), and ‘creates a new sound and is produced by means beyond a traditional trumpet technique, it should be labeled as extended’ (Ghahremani, 2016, p.2).
These definitions are sufficient within the genres investigated, though in the experimental and improvised music genres the terms ‘new’ and ‘common practice’ become problematic. Some non-idiomatic improvisers have built their performance vocabulary entirely on what some would call extended techniques. The commonality of these extended technique for these performers re-contextualises the extended techniques as standard techniques for those performers. Ghahremani (2016) and Wilmoth (2006) acknowledged that the definition of extended technique is largely based on context, ‘what actually constitutes an extended technique is dependent upon the conventions of the time in which it was made’ (Wilmoth, 2006).

In situating the research within academia it is advantageous to label valve rotation as an extended trumpet technique, allowing for ease of understanding by readers. Tribuzi (1992) defines two categories of extended trumpet technique, ‘lip-produced sounds’ and ‘non lip-produced sounds’, and outlines further subcategories within these. When considering trumpet valve rotation within Tribuzi’s (1992) categorisation I find it doesn’t fit effortlessly into any category or subcategory, but spans many.

Valve rotation is a ‘non-lip produced’, ‘airstream effect’ but I would also consider it a ‘non-standard valve technique’, it may well be considered as ‘timbre modification’ also. Tribuzi (1992) does leave room for the combination of techniques in ‘extensions of traditional effects’, for techniques that are the result of combining other standard techniques. Perhaps valve rotation technique is an extension of extended techniques, in that it is the combination of non-standard valve technique and airstream effect.

Pedersen and Dörig (2014) discuss ‘removing valves’ (p.15) from the trumpet and express a notation for the technique. The un-pitched result of blowing air through the trumpet with the valves removed is described. I would consider this a closely related technique to valve rotation as it involves the non-standard manipulation of the valves within the valve casing. However the specifics of rotation are not discussed. Pedersen and Dörig (2014) also mention ‘wind sounds’ (p. 1), providing a detailed description and syntax for their notation, in effect a common practice notation.

**Notation**

When dealing with extended techniques and composition, it’s important to note that there are no fully codified systems of extended technique notation. (Pedersen and Dörig, 2014, p.vii)
All examples of notating extended techniques discussed by Pedersen and Dörg (2014), Tribuzi (1992), Cherry (2009), and Ghahremani (2016) are based on the augmentation of traditional western notation, often using differing note heads and/or text instructions to direct performers. Vickery, Devenish, Hope and James (2017) highlight the expansion of the timbral palette in the post-common practice period and the resulting alternative notation adapted in contemporary percussion composition. Increasingly detailed sonic exploration has lead to a new standard of practice in which ‘the development of notation uniquely suited to the technical, physical and musical demands of any given new work’ (Vickery, et al., 2017) is a priority for the composer. Similarities can be drawn between this discussion of expanded percussion notation and the notation of trumpet valve rotation.

In light of the challenges presented by the valve rotation technique I have chosen to develop a graphic notation. In consideration of Pedersen and Dörg (2014) and Vickery, et al. (2017) I find that the new notation developed in this research is not a fully codified system and doesn’t attempt to create a standard for the notation of valve rotation. However it does facilitate composition within my own practice, incorporating valve rotation, and may be adopted by others.

When considering a graphical notation it is essential to further specify detail within this broad area of scoring techniques. Kojs (2011) proposes the term ‘action-based notation’ which ‘illustrates what to perform and how to perform it’ (p.65) as opposed to using notation that dictates the desired result.

Luigi Russolo, John Cage, Mauricio Kagel, Fluxus musicians, and Scratch Orchestra associates were among the first to develop graphical and verbal instructional choreographies which suggest musical actions. (Kojs, 2009, p.286)

Valve rotation notation is therefore a graphical instructional choreography, an action-based notation for valve rotation. The writing of Moody (2009) considers the physics of notation in relation to visual notation in software engineering. Although Moody (2009) is not talking directly about music the discussion around visual language is informative. ‘Only by understanding how and why visual notations communicate can we improve their ability to communicate: description provides the foundation for prescription’ (Moody, 2009, p.760).

Moody (2009) goes on to reference Shannon and Weaver’s (1998) theory of communication and the two fundamental processes of encoding and decoding. Though I am aware of some of the underlying theories of visual language and notation I did not consciously consider these theories during development of the notation. The conception and development of the notation came from an
experiential place, through improvisation, composition, and performance. I foresee Moody (2009), Shannon and Weaver (1998), and texts like Bertin’s *Semiology of Graphics* (1983) will be invaluable in future research and refinement of the valve rotation notation.

Notation is undeniably important in music, defining the syntax with which musicians interpret formalised thoughts or, in other words, the composer’s ideas. Its advent was significant in broadening the scope of musical education and in the emergence of written legacies, but also in introducing constraints in music composition. (Lopes, 2014, p.1)

**Relevant performers, composers and repertoire**

As mentioned in the Introduction, a search of available performances and recordings involving valve rotation is challenging given the improvised nature of potential resources, though I have found improvised examples from Axel Dörner (Sossi, 2017), Craig Pedersen (Pedersen, 2015), and Nate Wooley (Reilly, 2016), as well as a composition by Rama Gottfried (Gottfried, 2016).

*speckle* (Gottfried, 2016) for amplified trumpet, trombone, violin and percussion uses the rotation of the third trumpet valve with graphic notation choreographing its rotation. Gottfried (2016) notes the inspiration of Axel Dörner and Robin Hayward, two revolutionary brass musicians who employ valve rotation techniques.

In concert footage involving Axel Dörner he can be seen rotating trumpet valves, changing the timbre of air sounds. In a brief observational analysis of events in his duo performance with Kevin Drumm (Sossi, 2017) I found that Dörner favours the third valve for rotation and the first and second valve for more conventional use. Most interesting is Dörner’s persistence with the sustained, gritty, whistle-like squeals that arise when the third valve is in certain positions.

Craig Pedersen’s *wind noise with spaces like eight* (2015) contains sounds that I would describe as ‘air glissandi’ (00:17, 01:13, frequently between 01:47 and 02:25). Though I have no visual confirmation to confirm the use of valve rotation in this recording, I have heard and seen Pedersen produce similar textures at other times and conclude that valve rotation is likely used at these points in this recording.

Nate Wooley, in duo with Charmaine Lee (Reilly, 2016), unscrews the first valve top cap at 06:20 in the performance and then rotates the valve such that greater back pressure is built up in the instrument, creating a constricted, gurgling sound. Wooley then releases this pressure at

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5 Refer to Figure 1, page 10 for detail on the physical structure of a standard piston valve trumpet.
varying intervals by depressing the first valve or opening the water key on the tuning slide. As the improvisation continues the first valve is rotated rapidly in conjunction with being raised in and out of the valve casing, finally being removed completely from the instrument.

If we widen our field of view slightly to encompass compositions involving extended trumpet techniques, we find works for solo trumpet by Stockhausen (1983), Gruber (2000), Turnage (2004) and many more which use airstream effects, multi-phonics and slide removal from among the array of extended techniques. Efficient use of expanded common practice notation is often the means of scoring these compositions.

What then renders these forces visible is a strange smile (or, First Study for Figures at the Base of a Crucifixion) (Cassidy, 2008) employs a hyper-specific notation of individual valve, slide and embouchure movements through a combination of graphic notation and rhythmic and dynamic elements from common practice notation. Cassidy (2008) uses small squares to depict valves, filling them in to varying amounts to notate the degree to which they are depressed. Though Cassidy (2008) does not utilise valve rotation the example of a system for choreographing specific gestures on the trumpet is relevant.

Cat Hope’s Black Tide (Hope, 2017a, 2017b) for double bell trumpet and sub woofer utilises the Decibel ScorePlayer⁶ to present a graphic scrolling score. The use of the extended trumpet techniques, sub tone and airstream effects, described as ‘breath only’ (Hope, 2017b) in the work, and their graphical representation is pertinent to my work. Works by Ryan Ross Smith, foremost Study No. 8 (Smith, 2012), employ rotating elements as does the valve rotation animated notation presented in this thesis. There are also cues to be taken from Smith's (2012) presentation of these scores via the digital video medium. ‘Study No. 8 illustrate[s] the creative potential that real-time screen scores can lend to composers’ (Lopes, 2014, p.229).

The works cited above were discovered in a targeted search devised using prior knowledge of the field. There remains a need for a more detailed and exhaustive search for extended trumpet techniques in contemporary composition and improvisation and their practical notation. Furthermore a focus on valve rotation within these works may uncover more examples. This would be within the scope of a doctoral research project.

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⁶ Decibel ScorePlayer — ‘an iPad application that enables network-synchronised scrolling of proportional colour music scores on multiple tablet computers’ (Decibel New Music Ensemble, 2017)
Chapter 3: Valve rotation

The physics

The piston valve trumpet (Figure 1) is a partly cylindrical, partly conical tube with three piston valves part way along the tube (Berkopec, 2013). With valves in their resting state the air passes through the valves without entering the valve slides and the instrument is at its shortest length in this configuration. When any valve is depressed the air is then able to pass through the corresponding valve slide, thus adding to the overall length of the tube (Figure 2). When all three valves are depressed simultaneously the trumpet is in its longest tube-length configuration. If the valve cap is loosened and the valve lifted out of its guide it can be rotated. This creates the misalignment of valve pathway and instrument tube resulting in the opening through which air can travel being smaller than the bore of the instrument.

Figure 1. Labeled line drawing of the trumpet.

Figure 2. Piston valve, airflow when neutral and depressed.
Misalignment creates two physical characteristics that influence the air sound — the change in bore or aperture (shown in red in Figure 3) and the change in length of the pathway. Air will speed up through these smaller apertures and become more turbulent due to the inconsistency of the bore. Figure 3 also shows that two pathways within the instrument have been opened up, allowing air to travel along two lengths of tube simultaneously. I hypothesise that this accounts for the occasionally polyphonic textures to the airstream effect, as two lengths of tube, possessing different fundamental frequency responses, colour the air sound — all three valves have the capacity to rotate.

![Figure 3. Misaligned valve due to 90 degree clockwise rotation.](image)

**Slide removal**

A common technique used by experimental trumpet players is the removal of valve slides. The removal of a valve slide creates an opening for the projection of sound, additional to the sound being projected from the trumpet bell (Figure 4). This can effect timbre, pitch and spatialisation of the sound. Due to the relatively small distance between sound projection points, the spatial effect is perhaps most apparent to the performer and may not be as evident to the listener. I refer to this as micro-spatialisation in my own work, because of the very subtle variation it introduces⁷.

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⁷ Trumpet player and composer Callum G’Froerer accentuated this spatialisation by close miking these open slides and bell, distributing sound through a 4-channel surround speaker array during a performance of *Charcoal 6* at Perth Town Hall, 2017.
Slide removal achieves an added complexity of timbre with air stream effects. The polyphonic nature of the air textures is pronounced when there are two points from which the sound can project. For example, air emanating from the open third valve slide has a slightly different timbre to that emanating from the bell. As these emanations are occurring simultaneously the perceived result is a single air texture with increased complexity. With the use of valve rotation the air flow to these projection points can be varied fluidly.

**Moisture interaction**

When any trumpet player plays the instrument there a build-up of moisture within the trumpet. In common playing circumstances this moisture is emptied via one or more ‘water keys’ on the instrument. Due to the small apertures created within the instrument when valves are rotated, there is frequently interaction of moisture and airstream, causing the moisture to vibrate in these apertures. This vibration often produces small sound artefacts nestled in the overarching airstream sound. I have referred to these as ‘moisture tones’ as I perceive them to have a greater degree of discernible pitch than the overarching air stream sound.
The sound

Through qualitative observation and the creation and analysis of audio spectrograms\(^8\) I have attempted to understand the nuances within the sound produced when using the valve rotation technique. Appendix 3A show the spectrographic output from the rotation of each single valve through 360° over approximately 10 second (corresponding audio samples at Appendix 3B, 3C and 3D). All experiments were done using an Adams A9\(^9\) Bb trumpet and every effort was made to keep air flow and rotation speed uniform across all tests. The resultant phenomena are described below.

*No flow zones*

![Spectrogram showing no flow zones for each valve](image)

**Figure 5.** 2nd valve 'no flow zone' shown on spectrogram (Appendix 3A)

**Figure 6.** Collated no flow zones for each valve.

This experiment has revealed degrees of rotation on each valve where air does not flow through the trumpet. Knowledge of these areas means that composers and player can use them to stop air (and therefore sound) when necessary or avoid these areas when constant sound is required. The no flow zone of the second valve occurs between rotational positions \(g\) and \(h\).\(^{10}\)

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\(^8\) Spectrogram displays ‘the energy of each frequency band over time, is perhaps the most accurate method for the precise visual representation of sound’ (Vickery, et al., 2017).

\(^9\) Adams A9 — Bb trumpet made by the Adams Custom Brass in the Netherlands, modelled on the legendary Martin Committee trumpet.

\(^{10}\) Rotational positions have been given letter names for easy reference.
(Figure 5). There is one no flow zone for each valve but there seems to be no consistency between valves. Figure 6 collates the no flow zones of each valve into an easy to reference image, the grey areas being that of no air flow.

**Moisture tones**

I have found that many of the interesting moisture tones happen on the bounds of these no flow zones, where the aperture for air to move through is very small. A small, squeaky upward glissando is heard as the first valve passes the flow/no-flow boundary (Figure 7). The most interesting feature of the moisture tone is its manifestation as an additive layer of sound. Performance analysis presented in Chapter 7 and 8 find this layering phenomena musically effective.

![Figure 7. Spectrogram of 1st valve moisture tone.](image)

**Air sound variations**

The rotation of the valves changes the timbre and pitch of the air noise. Fellhauer (2013) describes the ‘spectral filter’ effect of slow depression of trumpet valves and a similar effect is created by valve rotation. Figure 8 shows a section of the third valve rotation that could be broadly describe as air noise. After moving clockwise past point c the timbre of that air changes, sounding lower, and there is a sense of pitch to the sound, though difficult to describe. This is displayed in the spectrogram (Figure 11) where clear harmonic lines are visible and noise energy moves lower
on the frequency scale. A band of noise between 2000Hz and 12000Hz becomes a harmonic upper sound from 4500hz to 12000Hz and the white noise remains below 4500Hz.

A significant proportion of the variations in air timbre is due to changes in sound energy above approximately 2500Hz, and thus quite subtle in an aural sense. The moisture tones seem to have fundamental frequencies under 1000Hz, explaining their higher audibility and more easily discerned pitch.
Air glissandi occur in a few rotational positions, the most complex of which is from the second valve between rotations $b$ and $c$. Figure 9 focusses on a point where glissandi move upward and downward, simultaneously. Approaching the $c$ rotation position (Figure 9) glissandi make their way to 4800Hz, 6375Hz and 8000Hz whilst a glissando descends to 11000Hz.
Chapter 4: Rotation in composition, practice and performance

This chapter distills knowledge I have gained during practice-based explorations of trumpet valve rotation, into a resource for performers and composers. The material is structured in a style inspired by Pedersen and Dörig’s (2014) publication *Trumpet Sound Effects*. Topics include posture and technique, instrument modification and preparation, and limitations of the valve rotation technique. Under each heading the performer and composer considerations are presented together, as I find their concerns to be largely similar in relation to valve rotation.

**Hand positioning for rotation**

The trumpet is most commonly held with the left hand around the valve block and the right hand poised above the valves. To some degree this works when rotating trumpet valves, but small changes to hand position are needed. I have found that a minimum of the thumb and one other finger are required to grasp and rotate a single valve (Figure 10).

![Figure 10. Holding trumpet, thumb and finger grip valve button.](image)

In music requiring simultaneous rotation of two valves I have found it effective to hold the trumpet between the palms (Figure 11). This allows the thumbs and fingers freedom to grasp the valve buttons. In situations requiring simultaneous rotation of all three valves it is possible to use an index finger, contacting all three valve buttons (Figure 12). This is very difficult to control and thus three-valve simultaneous rotation is only practical where an indeterminate result is acceptable.
A trumpet valve could continue to rotate in a single direction continuously. However at some point in each 360° rotation the trumpet player will have to release the valve button and grasp it again for further rotation. Hence the consistency of consecutive full rotations is not absolute. Further complications with full rotations are discussed in the *Guide and notches* (p. 21) section of this chapter.
The majority of my practice and performance with valve rotation has been without the mouthpiece. The lips are placed around the leadpipe to create a seal (Figure 13), resulting in increased consistency of air flow and greater endurance of the embouchure muscles.

There are a few considerations when playing sans mouthpiece, the first being the change in air resistance of the instrument. The bore (inner diameter) of the leadpipe is approximately twice that of a mouthpiece, hence air flow encounters less resistance. The performer must practice to achieve the optimal air velocity for their performance. In practice I have been caught out, thinking that a given breath would last the required duration, but was unable to complete the phrase.

In rudimentary experiments I have sought the air flow duration of a single exhalation through the trumpet and find:

- with mouthpiece, forming embouchure as if to play a note. Air flow duration: 19 seconds
- with mouthpiece, lips around mouthpiece forming a seal. Air flow duration: 6 seconds
- sans mouthpiece, lips sealed around lead pipe. Air flow duration: 4 seconds
- sans mouthpiece, lips around leadpipe, valves rotated. Air flow duration: 45+ seconds.

The final of these tests was constrained by my need to breathe in, as opposed to lack of air to expel. Which brings me to circular breathing, I have found that the added resistance due to rotated valves, using the sans mouthpiece technique, creates ease of circular breathing such that a
sound can be produced for many minutes (as can be heard in the iMprov #13 (O'Connor, 2017a) recording, Appendix 2A).

Both performer and composer will need to decide how best to approach music that has conventional pitched notes as well as airstream valve rotation techniques. Performers might play entirely (i.e. including during valve rotations) with a mouthpiece, or could have two instruments available, one of which is without a mouthpiece. Composers should be aware that any removal or addition of mouthpiece will require a few seconds and may need to be accommodated in the score.

Valve components

Buttons

The valve rotation technique takes minimal instrument modification to facilitate performance, though further preparations are required, and discussed below. The difference between modification and preparation being the permanency of the former and ease of reversal of the latter. As discussed earlier there is no part of a trumpet valve that reveals its rotation to the performer, thus a mark must be placed on the valve button to communicate its rotational position.

I have found the quickest and most readily available solution is the use of fine tip permanent marker — experiments with adhesive dots and stickers proved tedious. Figure 14 shows the application of a rotation mark on the first valve button of the trumpet using a permanent marker pen\textsuperscript{11}. With this method of modification I have found no adverse effects to the instrument and the marks are easily removed with a cleaning solvent when required — some would perhaps call this an instrument preparation due to its ease of reversibility.

\textsuperscript{11} Artline 250 Permanent Marker 0.4

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure14}
\caption{Marking the valve buttons.}
\end{figure}
Before applying the valve marks it is very important to check that your valves are oriented and tightly secure in the standard position, hence making the marks an accurate representation of valve rotation. Over time I have noticed that the marks fade and a reapplication of permanent marker is necessary. I think it would be feasible to engrave these marks in the valve buttons permanently.

**Top caps**

To allow the valves to be lifted out of their valve guide notches the valve top caps must be loosened. It is most effective to unscrew these the minimum amount that will facilitate rotation, thus reducing excessive clicking noises that results from loose valve top caps.

**Guides and notch**

The valve guide’s (Figure 15) function is to sit in the valve notch to prevent the valve from rotating so that in standard playing situations the instrument functions normally. For valve rotation this creates a significant obstacle when initially rotating from the standard position, or when moving past the standard position. In practice I have adopted approaches in order to minimise the intrusion of the valve guides.

![Figure 15. Valve guide](image-url)
Prior to the start of performance I rest each valve as close to neutral position as possible taking into account the first rotation each valve will perform in the piece. For example, if the first rotation of the first valve is from neutral to 45° clockwise I will sit the valve slightly to the left of neutral, out of the locked position. This has an imperceptible effect aurally and allows the first movement to be unencumbered by the valve guide.

When moving through the neutral position, as would happen if you were performing a rotation greater than 360° for example, the valve will lock or catch preventing smooth rotation. To overcome this I have found larger degrees of rotation (>180°) should be carried out with a light upward, pulling force on the valve button, allowing the guide to jump the valve notch. This has implications with regard to hand placement and valve button hold as discussed earlier.

Modification of the valve guide system is an area I intend to research further in the future. A stepped system within the valve casing, where rounded valve guides slide in and out of notches may allow smoother 360°+ rotation and show the potential for greater accuracy of final valve position.

**Slides**

Removal of valve slides, as mentioned in *The physics* (see Chapter 3), is effective for projecting air from other points in the trumpet. The real problem here is the instability of the instrument as you remove a slide. Proper maintenance of the valve slides with the application of slide grease will be helpful, but even still I have found removal to be cumbersome.

My preference is to have a set procedure for removing the slides so as to not get caught out mid-performance. My lefthand is charged with removing the third slide due to its hold position being directly in contact with that slide. The right-hand, which is not relied upon for take the weight of the instrument, can remove the first or second slides as needed.

Composer and performer need both be aware that slide removal while blowing through the trumpet can create fluctuations in air sound which may be undesirable. It is far cleaner in my opinion to give slide removal gestures space within the composition and/or performance.

**Quick reference for the composer**

- Rotation of two valves simultaneously is possible, but more practical if the speed of rotation of the two valves is the same.
• Rotation of three valves simultaneously is impractical. If accuracy of final position is not a concern it can be used.

• Slide removal is best undertaken on its own, with no other gesture accompanying.

• Performance without a mouthpiece is recommended, though this does decrease duration of sustained air due to decreased resistance.

**Future modifications**

I have mentioned engraving the valve button marks and developing a stepped notch system for the valve guides. Perhaps the inclusion of a tactile marker, in the form of a raised dot or line on the valve button could negate the need to look at the valves, thus freeing the performers eyes for looking at the score.

I feel that the valve rotation technique could be used in more complex simultaneous gestures if the player didn't have to hold the instrument themselves. Thus, a structure or stand that held the trumpet, allowing access to leadpipe, valve buttons, and valve slides is something I will be working on in the future. Furthermore, in conjunction with the Valverotator animated notation app (Chapter 6) it may be possible to develop mechanically actuated mechanisms that would rotate each valve based on the composition that has been programmed.
Chapter 5: A notation for valve rotation

Due to the difficulty of describing the nuances of sound made with the valve rotation technique I started notating the actions required to generate the sound. Results vary slightly from performance to performance, but my hope is that the relationship between sounds within a performance is maintained in subsequent performances. As discussed in the literature review this approach fits into the action-based model of notation discussed by Kojs (2011).

In developing this action-based notation the intuitive nature of the symbols was of utmost importance. Vickery, et al., (2017) note the importance of ‘semantic soundness—the degree to which the graphical representation makes intuitive sense to the reader—rather than necessitating learning and memorisation of new symbols’. This chapter outlines my development of the graphic notation which occurred concurrently with improvised experiments using valve rotation and development of an animated score composer/player using Max 6\(^{12}\) (discussed in Chapter 6). Experiments and sketches are titled in italics below, as per my practice notes.

Evolving through practice

My first attempt at notating valve rotation occurred after consecutive practice sessions improvising with the technique. Wishing to gain control of the sounds produced and recreate the more interesting of possibilities it seemed obvious that I needed a way to notate my experiments. The modification of the valve buttons to include marks as a visual representation of the rotation degree seemed natural, thus I marked the valves with a permanent marker pen and continued to improvise with the technique. When I found an interesting texture I transcribed the direction of these marks, labelling the sketch *Set and Forget* (Figure 16). Intended as a starting point from which to improvise *Set and Forget* presents a concept that developed into *Minutiae* (O’Connor, 2017b) (discussed in Chapter 7).

After working from *Set and Forget* and similar sketches it became apparent that the orientation of the symbols was not particularly intuitive. The horizontal placement of the valve graphics incorrectly orients the valves when compared to the trumpet player’s perspective (Figure 17). From the trumpet player’s perspective the first valve is at the bottom of the frame and the third at the top. Due to the angle from which the valve buttons are viewed, it’s also easier to read the

\(^{12}\) Max 6 — version: 6.1.10, Copyright 2012 Cycling '74
valve marks when they’re directed back towards the player, which led me to select this direction as the neutral, unrotated position.

The notation in *Progression Sketch #1* (Appendix 4A, excerpt Figure 18) takes the perspective of the trumpet player into account, orienting the valve symbols vertically and the rotation marks toward the player when unrotated. The ‘ticks and crosses’ in *Set and Forget* (Figure 16) that dictated the removal of valve slides have become squares — slide in place (filled), and slide removed (unfilled). The ticks and crosses possess established meanings that were unhelpful, or even confusing when used in this way.
Progression Sketch #1 (Appendix 4A) is my first attempt at choreographing valve rotation and air velocity, with the aim of creating a piece solely involving valve rotation. In Progression Sketch #1 the dotted lines mean air is to be blown through the instrument, and the height of the valve cluster graphic on the page is the velocity of that airstream. The sketch is played left to right and the duration is proportional to the spacing of the valve clusters graphics. Progression Sketches #2 and #3 (Appendix 4B and 4C) were unusable as notation experiments, however they did help to identify the more difficult parameters represent in notation — duration of events, direction of rotation, and velocity of air.

![Progression Sketch #1](image)

**Figure 19.** Excerpt from Valverotator Test Score 2 score.

Valverotator Test Score 2\(^{13}\) (Appendix 5B) was designed in Adobe Illustrator\(^{14}\) and presents solutions for the rotation and air velocity parameters (Figure 19). In Figure 19 we can see a red block of colour, the depth of this block dictates air stream velocity. When the air velocity block encompasses the whole valve cluster graphic the air velocity is at its maximum, if it’s a very thin red line it is very slow air, and if no red block is present then the performer does not blow through the instrument.

Valverotator Test Score 2 (Appendix 5B) can now imply direction of rotation. A line with an upward arch, attached to the top of a valve diagram, describes clockwise rotation, whilst a downward arch attached to the bottom means an anticlockwise rotation. Above the valve cluster

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\(^{13}\) Valverotator Test Scor 2 is named thus because of its involvement in the development of the Valverotator app (see Chapter 6).

\(^{14}\) Adobe Illustrator CC 2015 — 19.2.1, Copyright 1987-2015 Adobe Systems Inc. All rights reserved.
graphics are the durational indicators, both geometrically proportional and with a duration in seconds inscribed above.

In order to choreograph the movement of slides the small black squares symbolising the slides are detached from their corresponding valve. The valve slide choreography is via a dotted line pre-empting the slide removal (Figure 20), telling the trumpet player that by the next frame the slide should be removed. In Figure 20 the third slide graphic appears detached in the second frame, instructing the performer to remove the third slide from the instrument. Slide removal can be slightly clumsy whilst moving air through the instrument (as mentioned in Chapter 4). In Valverotator Test Score 2 all the slide movements are undertaken without the flow of air through the instrument. A document describing all symbols and their meaning within Valverotator Test Score 2 is at Appendix 5C.

![Figure 20. Excerpt from Valverotator Test Score 2 score.](image)

**Static score**

Having developed a set of symbols that allows for the transcription of valve rotational position, therefore facilitate composition with the valve rotation, the question then arises; how does one create and present a composition? I have worked with two methods, the static score and the animated score.

In the history of notated music the creation of a static score, often on paper, is the predominant form of presenting a composition; ‘The paper-based technology of CPN [common practice notation] has remained almost unchanged for 400 years’ (Vickery, et al., 2017). Due to my exposure to paper-based presentation I first engaged with this medium. The advantages of the static score are: accessibility due to the lack of technical equipment required to perform the work;
the aesthetic nature of symbols arranged on a page, which some find pleasing; and the ease of
discussion and education, everything is visible at all times and thus can be referred to efficiently.

*Valverotator Test Score 2* (Appendix 5B) is an example of a static score for valve rotation. In my practice I found these scores playable and aesthetically pleasing. Scope for future work may include directions for tongue position, posture and valve depression.

There are some deficiencies in the static score, the most pertinent is the lack of efficiency when composing the work. There are also issues of ensemble synchronisation that many composers have chosen to solve via animated scores. In order to find a more efficient means of composition for valve rotation, and wishing to utilise new technologies, Dr. Lindsay Vickery and I developed a software application (app)\(^{15}\) for composition and performance of valve rotation scores (discussed in the following chapter).

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\(^{15}\) *app* — shorthand for a software application running on an Apple Mac operating system.
Chapter 6: Valverotator: Animated notation app

Comparatively rapid technological advances, perhaps chief among them colour printing and multimedia-based screen presentation have provided an opportunity for the expansion of the possibilities of the musical score through more comprehensive and integrated data representation. (Vickery, et al., 2017)

Key to the West Australian and Australian new music community is the Decibel New Music Ensemble featuring leading composers and performers in the genre. Decibel's focus on ‘interpretation of graphic notations and pioneering digital score formats for composition and performance’ (Decibel New Music Ensemble, 2017) have inspired my development of an animated graphic notation for trumpet valve rotation. In collaboration with my supervisor Dr. Lindsay Vickery (Decibel member) we have created a score composition and performance software app. The animated music notation presents solutions to the challenges of duration of gestures, the communication of non-standard instrument techniques, and also provides efficiencies in the scoring process as a vector graphics program is no longer required.

The animated score went through a number of versions. Full revision notes are in Appendix 6A, with accompanying video content at Appendix 6B, 6C, and 6D. This chapter summarises the development of the Valverotator app (Appendix 6F) and provides an explanation of the functionality of the current version of the app with reference to existing research in dynamic scoring techniques.

Development

When first considering an animated notation for trumpet valve rotation Vickery first brought to my attention Study No. 8 (Smith, 2012). The use of rotating dial-like objects as the basis for the score were undoubtably similar to the graphic representation of the trumpet valves I had devised for static scoring (Figure 21). From here the selection of the appropriate platform for the software development was the first consideration. Decibel ScorePlayer was first considered due to the recent development of ‘Canvas’ mode (James et al, 2017). It was thought that the rotation of valve graphics could be presented in the Decibel ScorePlayer. Unfortunately the ability to rotate score segments was not yet achievable in Canvas mode and at that point the ScorePlayer was discarded as a viable platform. The recent score Southern Currents (Travers, 2017) by Meg Travers does employ a rotating playhead in the ScorePlayer environment and this will be a starting point for further consideration of the ScorePlayer. The next platform evaluated was Max 6.

16 Decibel New Music Ensemble http://www.decibelnewmusic.com/who-we-are.html
The standard Dial in Max 6 bears a striking resemblance to the valve graphic representation I developed for static scoring and quickly became the platform for the development of the animated notation for valve rotation (Figure 22).

The initial versions of Valverotator employed Max 6 function objects that the composer could manipulate to input the degree of rotation at the desired point in the composition. When pressing play this information would then be fed into the dial objects, rotating them accordingly. Each Dial had a corresponding function object and the velocity of air was directed by a fourth function object that affected the opacity of the background colour of the Dials.

The immediacy of rotational movement was noted as problematic in that there existed no forewarning to an imminent rotational gesture (Appendix 6A). In discussing ‘contact’ in animated music notation Smith (2015) notes the ‘setup’ before a point of contact and the ability of the setup to convey performance instructions. To build on Smith’s (2015) example, the conductors baton
falls, stopping at an invisible boundary to denote the instant of the downbeat. If the falling of the baton did not precede contact with the invisible boundary the performer would not have the necessary information to decipher this as the instant of the downbeat. To translate this to the dynamic valve rotation notation, there is required a setup before the motion of a valve in order to convey performance instructions to the performer, giving them forewarning of the rotational gesture. The concept of the setup is perhaps even more pertinent to the exhalation of air through the instrument, which of course requires a preparatory inhalation.

This has been solved by numerous composers by way of the scrolling screen score. In the case of the Cat Hope’s *liminum* (Hope, 2012) symbols move towards and past a playhead. At the point of contact with the playhead the instructed gesture is to be actualised. It is the influence of this scrolling score, playhead relationship that manifested the animation of the function objects within the Valverotator app. These function objects contain ‘x, y’ data points connected by a line, and from version three onwards of Valverotator they scroll from right to left into a playhead. Due to the close proximity of the valve and slide compound primitive\(^{17}\) to the left side of the playhead I’ve chosen to terminate the scrolling objects at the playhead, so as to avoid cluttering of the other information presented.

The scrolling function objects bundle three pieces of information for the performer:

- Direction of rotation via the direction of slope of the line.
- Relative speed of rotation via the gradient of the line.
- Instant of the actualisation via the contact point of function line and playhead.

On paper this seems to be all the information the performer would need to execute the gesture, however the scrolling function objects lack ‘semantic soundness’ in this scenario, decoding of rotational information from scrolling line graphs being unintuitive. Valverotator combines a playhead, valve symbol, and scrolling function object for each valve, a more intuitive and fully descriptive structure\(^{18}\) (Figure 23). In rehearsal ‘I found keeping my focus on the valve diagrams and the scrolling information in [my] periphery was most effective’ (Appendix 6A).

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\(^{17}\) Compound primitive — ‘Two or more primitives can be seamlessly combined in such a way that a secondary primitive enhances or embellishes the primary, creating a compound primitive’ (Smith, 2015).

\(^{18}\) Structure — ‘A structure refers to two or more primitives in some interrelated relationship’ (Smith, 2015)
In relation to the opacity change of the Dial backgrounds which was used to communicate air velocity change ‘I found that when my focus shifted from the changing colour, and then I returned, I had lost the direction of the change. Was it still becoming more opaque or more solid?’ (Appendix 6A). Valverotator 3 employs a Max 6 multislider bar oriented vertically to communicate air velocity (Figure 24). In practice this is more intuitive because the minimum and maximum air velocities are clear at all times, a full multislider bar and empty multislider bar respectively.

Smith’s (2015) term ‘intersection’ lends itself to discussion of the animated notation of the trumpet valve slide. Figure 25 show the valve slide geometric primitive\(^\text{19}\) [primitive], simply a

\(^{19}\) Primitive — ‘A primitive is an irreducible static or dynamic symbol.’ (Smith, 2015)
square. It is not the slide primitive's shape that is important in transferring performative instruction but its intersection with the valve button primitive. As the scrolling slide function object contacts the playhead the slide primitive detaches from the valve primitive (Figure 25). It is this state of attachment or detachment that is intuitively decoded by the performer.

![Figure 25. Slide primitive in attached and detached positions.](image)

The final version of Valverotator uses colour to visually separate aggregates. Each aggregate is formed from identical primitives to control the same parameters for each valve and air velocity, thus the use of colour differentiates the streams of information, preventing ambiguity in the decoding process. The specific colours were intuitively selected to contrast with one another and the white background. The valve slide compound primitive is subtly different in opacity to its relative valve rotation compound primitive (Figure 25).
Composing with Valverotator

Figure 26 shows the screen when the Valverotator app first opens. The composer must first input a total duration for the piece. Later changes to the total duration of the piece affect the duration of individual events, a future revision will address this issue. Next the composer simply draws onto the function objects, via a sequence of x, y coordinates, a line representing temporal changes in each parameter under the trumpet players control — valve rotation, slide position and air velocity. Figure 27 (p. 34) displays a complete score. The piece can then be played by pressing ‘space bar’, paused by pressing ‘enter’ and reset to the start by pressing ‘esc’.

Figure 26. Valverotator app opening screen, before composition.

As mentioned earlier the Valverotator app bypasses the use of image creation software to notate composition and facilitates fast turnaround from idea to score. Furthermore the ability to make small adjustments or additions with minimal disruption to the entirety of the score is an advantage. Over the course of this research I have created three scores for with Valverotator app, two being translation of static scores (Appendix 6B and 6C) and the third composed entirely within the Valverotator app (Appendix 6D). It was obvious to me when creating this final composition that ‘The magic of Valverotator is the immediacy with which one can compose’ (Appendix 6A).
Distribution and performance

Valverotator, the composition tool, is a Max patch (Appendix 6E) that can be distributed to be run within Max 6 installed on any computer. We have also built a standalone OS X\textsuperscript{20} app, using Max 6, that requires no additional software to run (Appendix 6F). It has been successfully tested in OS X El Capitan 10.11.6.

When considering the completion, distribution and performance of score the robust and universal nature of the delivery format is incredibly important. Thus, in the course of this research I have been using the Quicktime ‘screen record’ function to capture as a video the animated score for distribution and performance of Valverotator scores. The plethora of devices available to performers at this time mean that the playback of video is easily within the grasp of most. Furthermore, the ease of format conversion (eg. from .mov to .mp4) is also prevalent negating problems when confronted with differing operating systems and device architecture.

Future research

At present the program works effectively as a fast and efficient way to craft a score. The final version of the Valverotator app present in this dissertation is by no means a perfect solution to the animation of trumpet valve rotation. Continued development and refinement are necessary.

\textsuperscript{20} OS X — Apple Mac operating system.
Contained within the *Progress Notes* (Appendix 6A) the following seem like the next problems to tackle:

- Addition of numerical readout in degrees of rotation when placing a point anywhere on the function object in order to increase accuracy when composing.
- The ability for the function objects to dimensionally scale dependant on the duration of the composition, avoiding cramped unreadable valve changes.
- Relocation of the air velocity multislider such that is more at the centre of the performers focus.
- Additional parameters in the codification of the slide compound primitive. Can amounts of slide extension be notated? Rather than the binary, attached or detached, movement currently codified.

The two new works I created — *Minutiae* (O’Connor, 2017b) and *iMprov #13* (O’Connor, 2017a) — are more complex than Valverotator can manage at this point, e.g. it would require a means to specify valve depressions, differing tongue and articulation techniques, and different postures. These additional techniques make valve rotation a rich and interesting manipulation of the trumpet and contribute to a balanced and complete artistic statement.

It was beyond the scope of the current project to extend Valverotator to incorporate these techniques, and it became apparent that including parameters for these other techniques may be difficult to program in Max 6. To develop the Valverotator app further the transition or incorporation of the Decibel ScorePlayer system may be necessary. I can envisage a Cat Hope, Lindsay Vickery style scrolling score, possessing far more detail than the Max 6 function objects, along side the rotating valve and slide animations, a best of both worlds scenario.

Another avenue for future development is the extension of the valve rotation technique to ensembles with brass instruments capable of valve rotation. Currently the performance of multiple scores in video format could be synchronised using software such as Multivid. The Decibel ScorePlayer also has networking capability for performance in this way. I can envisage brass quintets or larger ensembles performing pieces scored with Valverotator or a future relation of Valverotator.

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Chapter 7: *Minutiae* (2017)— for solo trumpet

*Minutiae* (O’Connor, 2017b) (2017) is my first completed composition involving valve rotation, an extrusion of my experimental trumpet practice focusing on improvisation with this technique. The creative process began with a single rotation configuration that I wrote down during a practice session, naming the sketch *Set and Forget* (Figure 16, p. 24). The original concept was a series of compositions where you ‘set’ the rotational state and then ‘forget’ about it, improvising within that configuration. After a process of rehearsal and refinement I performed *Minutiae* (O’Connor, 2017b) for solo trumpet at *Shock of the New 2017.2*, 6th October 2017.

Creative process

Improvisation

A large proportion of my daily trumpet practice involves freely improvising, exploring alterations in technique or sound production and employing these sound discoveries in my music. In the middle part of 2017 these improvisations gradually became more focused on the results of rotating valves when producing airstream sounds. I was often surprised and intrigued by the sounds that were emanating from the trumpet, the layering of textures, the range of timbre available, the strange sonic artefacts settled within white noise, as have all been discussed above. However, I found it difficult to construct musical structures due to my nascent control and ability to predict what sound was about to be produced. There is of course something purely improvisatory and exciting about creating in that space where you are genuinely unsure what will happen if you do ‘x’ or ‘y’, but after a period of time I wanted to control the sounds, find more complex timbre, and construct more coherent performances utilising valve rotation.

That is not to say that I wished to discontinue improvising with these sounds, but move towards an ‘intellectually supported improvisational practice’ (Constanza, 2015) with regard to my implementation of valve rotation. To subsume the technique into my broader, constantly developing improvisational language. At that time I marked the valve caps with a permanent marker in order to see, when playing my trumpet, the degree of rotation of any valve at the point at which I played an intriguing sound. Now the corresponding rotation states could be easily recorded in my practice.

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*Shock of the New 2017.2* — WAAPA’s staff and post graduate performance evening.
diary, and in that way the sketch for *Set and Forget* was made. Equally important, I arrived at the concept of writing down rotational configurations as starting points for improvisation.

**Composition**

Having found this initial concept, ‘rotational states as starting points for improvisation’ I began a compositional process using the working title *States*, and later *States for Improvisation*. *States (5/8/17)* (excerpt in Figure 28) is a sketch of the six selected states of rotation with an earlier form of the notation, though further developed than that shown in *Set and Forget*. *States (5/8/17)* (Appendix 1B) also provides text instructions for the performer, the general thrust of which is to say the rotational position and are prescribed and everything else is at the discretion of the performer. The instructions close with the remark ‘This is a piece about investigation and discovery, truly jump into something where you’re not sure what will sound, or not’ (Appendix 1B).

![Figure 28. Excerpt from State (5/8/17) score.](image)

**Rehearsal and refinement**

After a short period of rehearsing *States (5/8/17)* I had the feeling there needed to be more inspiration and/or direction for the performer and the idea of using a spectrographic image from a previous improvisation was applied. *States (31/8/17)* (Appendix 1C) incorporates an artists impression of a spectrogram after each rotation state (excerpt in Figure 29). This visual information is intended to be indeterminate and thus the performer is to interpret as they see fit. For example, the performer may choose to take this literally and play from left to right, or look at it as a whole image and decipher its complexity, using that in their performance.
Satisfied with the concept and presentation of the piece I sought to find optimal rotational positions that gave the greatest degree of timbral contrast. Through improvising exclusively with valve rotation and airstream effects I collated six ‘states of rotation’ that I found sonically interesting and contrasting from one another, to replace those present in States (31/8/17). The six states were photographed during this improvisational process (Figure 30), at this point the work was retitled State for Improvisation (10/9/17) (Appendix 1D, excerpt in Figure 31).

Figure 29. Excerpt from States (31/8/17) score.

Figure 30. Valve positions for States for Improvisation (10/9/17).
The final development that occurred before the premiere performance was the breaking of the left to right method of reading the score. I like the idea that every performance of the piece can follow a path chosen by the performer, thus the images had to be arranged such that the morphology of the score did not define discrete starting and finishing points. Appendix 1E is the final version of the score including the final title, *Minutiae* (O’Connor, 2017b) (excerpt at Figure 32). The valve rotation diagrams now occupy the centre of the indeterminate spectrographic information and these images are evenly, but in no particular order, placed around the page.

**Figure 31.** Excerpt from *States for Improvisation (10/9/17)* score.

**Figure 32.** Excerpt from *Minutiae (2017)* score.
Performance

*Minutiae* (O’Connor, 2017b) (Appendix 1A) was premiered at *Shock of The New 2017.2* (6th October 2017). I performed the work myself, acoustically in the Spectrum Project Space and it was recorded by Stuart James and Lindsay Vickery. In order to examine this performance I have generated an audio spectrogram (Appendix 1F) and focused on areas of interesting sonic material. Appendix 1F also lays out elements of the score onto this spectrogram of the performance for a clear visual representation of my navigation through the scored material. Discussion using excerpts of this spectrogram and qualitative observation are presented below.

Analysis

The analysis of past performance is an extremely important process within my creative practice. A brief analysis with the use of the audio spectrogram has the potential to refine and direct future creation. This information is presented in a short list of observations with supporting spectrographic images. Timings are given in minutes and seconds MM:SS.

At 00:14 into the performance, *a.1* (Figure 33) the density of noise energy moves up from approximately 6000Hz to 6800Hz whilst the upper harmonics remain stable. In listening to this section one perceives two sounds occurring at once.

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23 Spectrum Project Space — a white wall gallery at ECU, Mt Lawley Campus.
Throughout the section from 1:46 to 2:16 in the performance (Figure 34) I had formed a conventional embouchure and was trying to produce a trumpet tone through the very restrictive valve rotation configuration. At 834Hz (b.1) the ‘almost speaking pitch’ is audibly existing in a background layer to the rapid valve manipulations that produce punctuated, detached bursts of air (b.2).

Between 03:47 and 04:08 (Figure 35) a rising and falling siren-like pitch (c.1) is present amongst airstream noise (c.3). Interjected silences were made by abruptly halting the air flow (c.2). The consistency of undulation in the siren-like pitch gives the impression that it is happening even in the silent interjections.
Vertical bands (Figure 36) are apparent at each single rapid valve depression or release (d.2). Each intervening texture is a complex, multi-layered airstream sound (d.1). The repeatability of the manipulation, either a simple valve depression or release, allows for repetition of these complex airstream textures.

Moisture interaction (Figure 37) creates a kind of chirping sound (e.1) that bounces above a stable air tone (e.2), with harmonics at approximately 410Hz and 600Hz.
The presence of very actively shifting squeaking tones (f.1, Figure 38) arising from moisture interaction in the trumpet can be heard. They continue amongst rapid valve manipulation (f.2) until settling as a multi-phonic with fundamental frequencies at 2508Hz and 2637Hz (f.3). Two distinct pitches are audibly, dancing around these frequencies.

**Evaluation**

As also described in the following chapter, the *iMprov #13* (O’Connor, 2017a) improvisation, the strength of the valve rotation technique, revealed in the development of *Minutiae* (O’Connor, 2017b) is the ability to create multi-layered sounds, simultaneously producing smaller audible artefacts within walls of airstream texture, and creating varied and complex timbres of airstream noise. I will continue to perform *Minutiae* (O’Connor, 2017b), exploring the possibilities of these six rotation configurations.
Chapter 8: *iMprov #13 (2017) — solo trumpet improvisation*

This chapter details my solo improvised performance at *iMprov #13* 24 (Appendix 2A), a concert series convened by TURA New Music, 9th October 2017. Key to the research is the analysis of rotation techniques manifested in this work. I hope that in singling out effective uses for these techniques I can continue to develop an improvisational language based on valve rotation.

Continual experimentation with valve rotation during the research period led to the technique forming an increasing portion of my improvisational vocabulary. Thus the subset of my improvisational vocabulary utilised in this solo performance is all sound produced with valve rotation techniques. The set is an exploration in and of its own, as well as a first in my practice in the sense of constraining myself to a pre-selected sonic palette with which to improvise. There could be larger questions to ask here about the nature of composition and improvisation and whether setting out, as I did, with this clearly premeditated concept is strictly improvisation. For the purpose of this research I will proceed referring to the performance as an improvisation, in the knowledge of this premeditation.

**Influences**

My solo performance works are greatly influenced by the music I’ve consumed and the people who have created it. Many threads can be traced from this improvisation back to the artists that have preceded me, to whom I owe very much. A large amount of the recorded music I listen to is solely by trumpet players or featuring them heavily. Rather than list all, who undoubtably have contributed here, it is pertinent to mention the solo trumpet performers that have inspired my performance. Nate Wooley is the first to come to mind, mentioned earlier as a user of the valve rotation technique. I admire and try to incorporate into my performance Wooley’s embrace of the development of language and vocabulary, and a method of performance which is very much ‘stand and deliver’, an intense and serious experience.

Axel Dörner’s commitment to airstream effects as the basis for his improvised music and his use of static block textures inspires my work. The feeling of letting the sounds be themselves and hearing through them, into all the nuance of an airstream texture, is a result I aim to project in my performance. I also draw from performers such as Joe McPhee25 where the spirit of exploration and connectedness to a rich tradition are palpable.

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Practice plan and outcomes

My participation in *iMprov #13* began with being booked for the show, a little over two months prior. Recollecting the thoughts and processes in the lead up to this performance, my initial practice plan was to work up to the performance by improvising a little longer each day until I got to the desired time frame, approximately 20 minutes. A daily practice focused not on sound, but endurance, with two goals in mind — gaining a connection to time, and developing ideas in the moment.

Concurrently I was working with the valve rotation technique, deepening my knowledge through experimentation. In the preceding week, by my estimate, the ratio of ‘valve rotation airstream effects’ to ‘trumpet notes’ I achieved in practice was about 20:1. In the same week I performed *Minutiae* (2017) (Chapter 7), my composition for solo valve rotating trumpet, further solidifying the potential for the valve rotation technique to be the main focus of an improvised set.

When it came to the improvisation the clarity of the idea in my mind an hour before the performance was, ‘20 minute valve rotation exploration, with long textures that project the detail through the airstream effects’. The result is more or less this concept, over 22.5 minutes.

Analysis

The clear focus on the valve rotation material makes this improvisation a perfect source for the analysis of the valve rotation in my playing, and how these techniques may be utilised in performance. An audio spectrogram of the performance has been created and analysed (Appendix 2B). In general many of the findings from the *Minutiae* (O’Connor, 2017b) analysis (Chapter 7) are reflected in the analysis of *iMprov #13* (O’Connor, 2017a) (in this chapter) and as such I will present a summary below. For detailed observations consult Appendix 2B.

The most interesting moments of the improvisation are when two or more sounds are occurring simultaneously. Often this is a squeal or gurgle within air noise or a consistent whistling amongst rapid valve movements. Furthermore the ability for one sound to evolve whilst another remains the same I find particularly interesting, and I was not quite aware of the extent to which this was happening as I performed. The best examples being (i) at E. (Figure 39) where an unstable whistling remains as airstream noise moves between a lower to higher frequency band and back again, and (ii) at B. (Figure 40) where a frequency band of airstream noise fades in

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26 ‘Trumpet notes’ meaning pitched tones that one may expect to hear from a trumpet.
behind a gurgling moisture tone, with no audible change to the moisture tone. The realisation of the, seemingly independent, multi-sound possibilities that trumpet valve rotation allows provides direction for further exploration.

Figure 39. Excerpt E. from *iMprov #13 (2017)* spectrogram, x: Time, y: Frequency (Hz).

Figure 40. Excerpt B. from *iMprov #13 (2017)* spectrogram, x: Time, y: Frequency (Hz).
I have also defined thematic development within this performance and find that I often explore a small subset of available textures for a time before moving to another subset in the next section. This is most evident in Section 1 of the spectrographic analysis (Appendix 2B) where duration of a noise is the subset and I move between extremely short sounds, surrounded by silence, to longer, sustained airstream noise. Finding a balance between the two, letting my ears guide the transitions between two extremes of duration.

**Future practice directions**

This improvised performance and subsequent analysis have made me increasingly concerned with the meaning of preparation and practice when approaching improvised performance. I wonder whether the analysis of past improvisation could be the biggest instigator of change in future improvisations. Thus, through looking at the iMprov #13 (O'Connor, 2017a) performance I have identified a subset of valve rotation techniques that I can focus on during my next period of practice.

As mentioned earlier, the premeditation involved in this performance may be at odds with some definitions of improvisation. Hence, I am currently re-negotiating the term ‘improvisation’ within my own practice. This is perhaps a turning point in my improvisational practice, which was predominantly about being open and alert in order to react in the moment. But now I find myself more concerned with developing a defined vocabulary or language, as well as deciding whether this is at the heart of improvised practice or this is a different kind of practice that requires a new term. These are topics for future research.
Chapter 9: Ongoing exploration

To the best of my knowledge this thesis presents the first scholarly investigation into trumpet valve rotation. It is hoped that this is a starting point for the discovery and use of the technique by composers and performers alike. A number of the gaps in current knowledge have been addressed through my practice-based research: documentation of trumpet valve rotation; investigation into the application of trumpet valve rotation in improvisation and composition; and methods for the effective communication (both aural and written) of the technique. I have applied and validated the new knowledge by creating two original works for solo trumpet, and developed both static and animated notation. My dissertation also includes detailed description of the physical parameters and sonic characteristics of the trumpet valve rotation as well as notes on best practice for composers and performers.

In developing a unique notation for trumpet valve rotation performers and composer now have a communication tool with which they can discuss valve rotation and create new work. The notated form is by no means universally codified and the continued assessment and development by third parties is welcomed by the author — hopefully creative people will take this notation, develop and refine it, and create interesting music.

The works presented in this dissertation are a snapshot of my creative practice during the middle of 2017. Appendix 7A lists other performances in which I have incorporation valve rotation techniques, these are much a part of the exploration and research as the creative work presented above.

This research is of course ongoing and throughout this thesis I have stated directions and intentions for further practice-based research. In particular the refinement of instrument modifications will push my practice forward. Specifically, raised or engraved valve markings, notched valve guides and an apparatus to hold the trumpet. The Valverotator app requires further development to incorporate a greater abundance of instrument techniques in conjunction with valve rotation and consideration of performance possibilities in the ensemble setting. As well as looking at my own use of valve rotation it is of the utmost importance to search out composers and performers who are engaged with the technique in order to push the music and research forward.
Scores, Recordings, and Audiovisual

Cassidy, A. (2008). *What then renders these forces visible is a strange smile (or, First Study for Figures at the Base of a Crucifixion)* [Score]. Augenmusik (ASCAP).


Reilly, K. J. (2016). *Charmaine Lee, Nate Wooley @ Gallery 456 11-20-16 1/3* [Video file]. Retrieved from https://www.youtube.com/watch?v=H0OHEAtpNQ


Journal articles, books, chapters, and webpages


Appendices

Appendix 1

Appendix 1A: *Minutiae* (O’Connor, 2017b), audio recording. (USB)

Appendix 1B: *States* (5/8/17)
Appendix 1C: States (31/8/17)
Appendix 1E: *Minutiae (2017)* — score for solo trumpet.

Appendix 1F: Analysis of *Minutiae (2017)* performance, PDF format. (USB)
Appendix 2

Appendix 2A: *iMprov #13* (2017), audio recording. (USB)

Appendix 2B: Analysis of *iMprov #13* (2017), PDF format. (USB)
Appendix 3

Appendix 3A: 360° valve rotation spectrograms

Spectrogram of 360° valve rotation over approximately 10 seconds with medium air velocity. Rotational position is marked and lettered for discussion purposes.
Appendix 3B: 1st valve 360° rotation, audio recording. (USB)

Appendix 3C: 2nd valve 360° rotation, audio recording. (USB)

Appendix 3D: 3rd valve 360° rotation, audio recording. (USB)
Appendix 4

Appendix 4A: Progression Sketch #1

Appendix 4B: Progression Sketch #2
Appendix 4C: Progression Sketch #3
Appendix 5

Appendix 5A: Valverotator Test Score 1
Appendix 5B: Valverotator Test Score 2
Appendix 5C: Valverotator Test Score 2 Explanation of symbols

1. **Arched line from top, clockwise rotation**
   - This example shows 90 degree rotation.

2. **Arched line from bottom, anti-clockwise rotation**
   - This example shows 270 degree rotation.

3. **Slide removed**

4. **Slide in place**

5. **Dotted line: change slide before next frame**

6. **Air velocity**
   - Low.
   - High.
   - Gradually increasing.
Appendix 6

Appendix 6A: Valverotator Progress Notes

Test Score 1

For the effective testing of the Valverotator maxpatch I’ve created a “test score” in order to test the ease of inputing compositions and the effectiveness at performing a given score. I first sketched the score on a piece of paper and then replicated this in Adobe Illustrator. Although producing a slick result, working in this way makes the scoring process long and tedious.

Valverotator 2

Taking the test score and inputing into the line graphs wasn’t as efficient as it could be due to the “current position step thru” displayed as a part of the total timeframe. This made necessary an intermediate step converting the time codes on the test score into “current position” numbers. It was significantly quicker to draw out the score in the line graphs than using Adobe Illustrator in the way that created the Test Score. An advantage for the animated score system. In giving the value for the degree of valve rotation I was forced to use a decimal amount with zero being no rotation and one implying a fully rotated. After acclimatising to this it was intuitive enough. In playing the Test Score via Valverotator 2 overall it made sense and the was able to get through the piece.

Room for improvement:
- The piece starts immediately upon pressing go, the performer needs more time than this to prepare.
- The “air volume” colour change is fairly ambiguous. The performer has to take in 4 streams of information, I found that when my focus shifted from the changing colour, and then I returned, I had lost the direction of the change. Was it still becoming more opaque or more solid?
- In general it felt like I was playing catchup with the score. This is potentially not a bad thing. In the way some orchestras plays slightly behind it's conductor, if the sounds relative to themselves remain the same the performance will be solid. However I do think it could be good to give the performer a heads using a scrolling element to the score, like in the Decibel ScorePlayer.

Valverotator 3

Inputing the composition remained the same here as the previous version, including the intermediate step of time conversion, which I will remove in the next version. Valverotator 3 scrolls the line graphs past a playhead that aligns with the centre of the valve diagrams. This is gives the performer a lot of foresight into the the piece. I found keeping my focus on the valve diagrams and the scrolling information in the periphery was most effective. The air volume is now expressed by a vertically filling multislider bar. I found this far more intuitive. In listening back to the performances using Valverotator 3 it is obvious that the result is time accurate and sonically accurate. It should be noted that some of this could be related to playing the same score a number of times by now in the testing sessions.

Room for improvement:
- Some hangover remain from Valverotator 2 such as the opacity change and the “current position” indicator is still not displaying seconds.
- There could be some refinement of object alignment and timing to the play head. Particularly the air volume line graph progress bar, which currently are a hair out of sync.

Some adjustment to the test score should be made at this point to push the program further. Particularly with regard to anticlockwise rotation. To this point the scores have only involved clockwise rotation.

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Valverotator 4

We’ve also added a 4 second delay on all key commands in order to more effectively prepare for performance. The performer can now press ‘space bar’ then assume the correct posture ready to play before the piece begins. A piece only plays through once now, whereas previously it kept playing over and over.

Valverotator 4 adds some key commands.

- ‘esc’ sets the play position to zero. Making for an easy preparation for starting the piece.
- ‘enter’ pause the piece at a given position.
- ‘space bar’ is still the start button.

Room for improvement:

- Thinking about the playhead and accurate alignment of the scrolling elements.
- removing the opaque changing background.
- Think about the aesthetic presentation of the patch. Behind the scenes and the product.

Valverotator 6

When inputing Test Score 2 into Valverotator 6 a few deficiencies in the system became apparent. It is very difficult to judge the degree of rotation when manipulating the line graphs, particularly when moving to the end of a piece, where the x, y coordinates of the line graph are no longer visible. For Valverotator 7 I will add a scale to the left of the playhead so this can be done more intuitively by eye. This is also the same for the volume line graph.

I had to change the dimensions of the line graph for this composition. Movements of one second were too cramped within the graph.

Also, the sequence of steps that must be followed in order to keep time information accurate. First you must set the duration of the entire composition. As I discovered if this is changed after the fact the timing of all information is not accurate when playing the patch. I had set the duration to 226 seconds, due to an absent minded miscalculation, when the composition was actually 80sec long. when this was discovered, partway through, it was impossible to change without have my inputed information reframed with the new total duration. You can however keep this the same and play the patch with a large “nothingness” at the end.

This also got me thinking about the dimensions of the graphs relative to the duration of the composition. A longer composition requires a longer graph in order to be effectual in letting the performer know what is coming. Potential the patch could be changed such that the compositional duration entered can influence the x dimension of the graphs.

Then you move through playing the patch and pausing at any point that a change occurs. I found it best to place a node on every line graph at any pause in the process. This is because changing a point can affect large areas unless bounded by another point. With the volume graph it was important to consider the past and future trajectory at any pause point, due to needing vertical lines to achieve instantaneous volume change, or air stops.

Performing Test Score 2 via VR6

As with any new piece of music it seems to take a few play throughs to coordinate the events. Particularly when things are very close together. At approx. 39 seconds the air velocity increases, the 1st valve finishes a rotation and the 3rd valve starts a rotation, all within 2 seconds. Again at 60 seconds the 3rd slide is removed, the 3rd valve begins a rotation and the air goes from nothing to 100% velocity all within a second duration. By the third take I am getting the hang of coordinating these movements.

Generally there still is a sense that when a single gesture is required I loose focus of all other parameters. And it is still feeling impossible to keep track of the actual position of the valves with the inscribes marks. My background as a
trumpet player and improviser probably doesn’t make me the perfect player for a score like this, including so many parameters.

Other problems include deciphering when zero air flow is required, there is still a thin blue line at the bottom of the graph and thus it looks like there should be air. Perhaps a grid behind the graphs would make it more visible as to what is happening next.

Composing straight into Valverotator

The magic of Valverotator is the immediacy with which one can compose. My thought process is first find a sound and then slot it into the piece, considering duration and position. The ability to compose a portion of the piece and then play it straight away, then adjust the durations and rotational position is handy. A floor in the application is that play-through always starts from the beginning. When I was working on the ending of this short piece it was frustrating to play from the start when trying to assess the end. This is functionality that the Decibel ScorePlayer has for rehearsal purposes, and this would be good to have here.

Appendix 6B: Valverotator 3 Test Score 1, video recording. (USB)

Appendix 6C: Valverotator 6 Test Score 2, video recording. (USB)

Appendix 6D: Valverotator app, video recording. (USB)

Appendix 6E: Valverotator maxpatch (USB)

Appendix 6F: Valverotator app (USB)
Appendix 7

Appendix 7A: 2017 Performances Incorporating Trumpet Valve Rotation.

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