Research Paper Snare Drumming Preliminary Results

Preprint · April 2022

DOI: 10.13140/RG.2.2.24690.79045

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Abstract:

The focus of this paper is to present an analysis for snare drumming technique via motion capture. This method of analysis includes motion capture data, reconstructed key frames from the data, and the expression of concepts analogous with phenomena found in snare drumming through mathematical comparison. This paper merely examines one portion of the entire experiment in an attempt to preview the full capabilities of this type of analysis in snare drum pedagogy and practice.

Introduction:

This experiment is to improve upon the current educational material found in the drumming market through analyzing technique for the purpose of creating a self-instruction manual. This approach combines the historical production of snare drum manuals with the technology of motion capture and acoustic analysis in order to meld the new and the old. To understand the historical progression of these systems, several elements must be taken into account: the use of rudiments in pedagogy, the history of rudiments, how rudiments are dissected in pedagogy, and the how rudiments and technique are taught currently.

For snare drumming, the traditional system of a book with visual and musical examples is still widely used. However, the most recent pedagogical tool for teaching the Moeller technique (military technique) has been through a DVD which incorporated a computer based model of drumming along with a video of the technique (Mayer 2007). The purpose of this paper is to present an adjustment to the tradition of snare drum pedagogy through motion capture data, artistic representation of that data, slow-motion and real time videos, and mathematical concepts through acoustic and kinematic analysis. The experiment is performed by one professional snare drummer over the course of one year (three experiments). This allows for a range of improvements over time and a range of motion for rest position, basic strokes, and selected rudiments in the Moeller style of rudimental snare drumming.

Literary Review

The purpose of this literature review is to understand the current trends in motion capture technology as it applies to snare drumming technique and if any system of analysis captures the specifics of a technique like the Moeller Technique. This review also includes articles on current motion capture trends that pertain to the arts in general, mainly dancing. Also, there is a portion devoted to what technology is used for these experiments. The review begins with the earliest forms of motion capture drumming and then progresses to the most current application of motion capture in drumming and dancing.

The first example of motion capture study was performed in the late 19th century by Eadweard Muybridge (Lanska, 2016) (Horvath, 2012). Muybridge and Francis Dercum produced the first ever gait study which analyzed the gait of both humans and animals utilizing sequentially triggered cameras and tracings based on the footage collected (Lanska, 2016). Harry Bower produced a document that illustrated techniques pertaining to percussion which utilized the photo as well (Bower, 1912). There were no "moving pictures" as there was with Muybrdige, but Bower's guide to drumming detailed grip technique, set up of the drum, and exercises in order to "keep [the body] in the proper position." (Bower, 1912). While Bower was among the first drummers to publish a work utilizing the technology of the day, Sanford Moeller began to work with this technology as well. Moeller produced a "self-instruction" manual on the snare drumming technique used by snare drum veterans of the Civil War (Moeller, 1925). Moeller used a camera to capture the Civil War technique by performing the strokes in reverse in order to show the stroke at a reduced speed (Moeller, 1925). As the Great Depression rolled around, the United States Marine Corps produced a reference Manual for drummers and trumpeters (USMC,

1935). This Marine Corps Manual provided images (both photography and illustrated images) for the drummer and trumpeter to reference for field duty (USMC, 1935). Photography began to be commonplace in self-instruction manuals in snare drumming technique, allowing for drummers to sell their technique to a wide audience outside of their immediate surroundings. Approaching the 21st century, snare drumming technique had not moved from photography as its most useful source of displaying technique (Logozzo, 1992). The specificity of technique in regards to human anatomy began to progress rapidly at the turn of the century (Strain, 2002). Motion capture technology began to be more widely used at the turn of the century in the areas of both dance and snare drumming (Dahl, 2004) (Meador, 2004) (Hachimura, 2004).

Even though both fields of study use a form of motion capture, they both utilize various art along side motion capture. In the field of dance and motion capture, novel methods of motion capture were used in dance training in evaluating dancers in an interactive mixed-reality environment (Hachimura, 2004). This availability of software allowed for dance productions to utilize a virtual environment so dancers can interact with a 3D model of a dancer on stage (Meador, 2004). As technology progressed, the interface between dancer and digital instructor improved which allowed for the analysis of a dancer's technique in a distance-learning environment (Chan, 2011). In recent studies, there has been development of "home-based" practices in the area of dance training through the use of the Kinect system (O'Conner, 2011). This practice of Kinect-based live dance analysis has continued up until recently with advancement being made on algorithmic applications and effectiveness of the 3D interaction in relation to the dancers being analyzed (Marquardt, 2012) (Anderson, 2013) (Kim, 2017). Some research in the field of dance

and motion capture has been on exploring the home-based method of virtual teachers in a dancer's learning.

In drumming, analysis of the upper body in regards to snare drumming performance began to be analyzed via motion capture, force plates, and acoustic analysis (Dahl, 2004) (Kawakami, 2008). In more recent years, a geometric approach to the representation of the human body has been used via motion capture data (Miura et al, 2011) (Miura et al, 2012) (Miura, 2012). There was also an incorporation of EMGs, or electromyography, into the framework of motion capture analysis for the snare drum (Miura, 2012). Some researchers use a simple RGB camera with markers on the stick to gain access to motion capture data and drumming (Rooyen, 2015) (Rooyen et al., 2016).

However, the purpose of this paper is not to provide evidence of a home-based vitural reality system for snare drum, but to provide evidence on mathematical correlations between different movement events pertaining to drum pedagogy. The example that will be studied in this paper is the bouncing ball phenomenon with the buzz stroke phenomenon as played with the Moeller technique. The motion capture system used for this experiment is the Vicon Motis system with 4-synced cameras. There is a sound recording for the experiment trail used in order to compare the correlation between the sound of a bouncing ball and the sound of a buzz stroke.

Brief History of Snare Drum Pedagogy:

The current model of rudimental snare drumming was developed in Switzerland in the 16th century (USMC, 1935). The practice of fife and drumming continued through employment of Swiss troups by the British, and came over to the Colonies by the time of the Revolutionary War (USMC, 1935). Now, snare drumming can be found in school programs as the basis of learning modern percussion. The practice of rudimental drumming began to fade out of a military field and into a military camp practice by the time of the First World War (USMC, 1935). However, the Civil War marked the last war drummer boys were used in the battlefield (USMC, 1935). After the military need for drummers and fifers ended, the American Legion developed groups for drummers and fifers, or trumpeters, to gather and perform the art form of military music (USMC, 1935). In addition to the privatization of rudimental snare drumming practices, the popularity of snare drumming increased, and survived, through the World Wars and the depression (This lead to the popularization of rudimental snare drumming as a competition instead of a field practice (Mazur, 2005).

Documentation surrounding rudimental drumming had been limited prior to Sanford Moeller's publication in 1925. This book detailed many of the rudiments used by the Civil War drummer boys as well as the basic components of the rudiments which are called basic strokes (Moeller, 1925). The Moeller book was a catalog of a specific technique as well as a pedagogical tool for the snare drummer. The Moeller book allowed for drummers to approach this cataloging of Civil War snare drumming technique from home. In a sense, the Moeller Book operated as one of the first motion capture (via photography) self-instruction manuals in any field (Moeller, 1925). The Moeller Book provided frame by frame analysis of basic strokes and rudiments. Prior to Sanford

Moeller, percussionists like Henry Bower provided technical assistance through prose and music notation (Bower, 1912). However, there were no sequential frames to reference, only still images with a key to sort through (Bower, 1912). While helpful, the Bower system of pedagogy wasn't as detailed as Sanford Moeller's. This method of expressing snare drumming technique changed with the invention of the motion camera and resulting video tape and DVD technologies. While there were many products between 1925 and the current day, Jojo Mayer's DVD built upon the Moeller Book's style of slow-motion and motion capture analysis of drumming via the camera (Mayer, 2007).

Experiment

The experiment could not be done without the help of Dr. Liza Shapiro, the graduate students (Amber Heard-Booth, Allison McNamara, Emma Curtis) and undergraduate students (Meagan Obrien, Samantha Rice).

There were small (14 mm and 19 mm) spherical reflective markers (Mocap Solutions, Huntington Beach, CA, USA) attached to the experimentee at 9 joint locations on both arms (18 total anatomical markers), 2 strips of reflective tape at either end of both sticks (4 stick markers), and 2 strips of reflective tape on the snare drum. All anatomical markers were attached directly to the skin of the subject using small strips of sticky-back Velcro (Velcro®, Manchester, NH, USA) while reflective tape was used on the drums and sticks. The subjects performed the experiment while being filmed with five Basler 602f monochrome cameras (Basler Vision Technologies, Ahrensburg, Germany) at 150 Hz. The 3D coordinates of the reflective markers were generated using Peak Motus (v. 9.2) software (Vicon Motion Systems, Oxford, UK), and displacement of shoulder, elbow, wrist, and stick tip were calculated. The equipment used by the snare drummer was a 10 inch Firecracker snare drum (Pearl) and a pair of Vic Firth 5B Barrel Tip sticks. For the experiment, the coordinate plane has the orientation of z (vertical), y (front/back), and x (side/side).

The drummer performed 5 seconds on basic strokes (full, up, down, tap, buzz) and a selection of the 40 rudiments (Percussive International Society) in the Moeller technical framework. The following data is of the buzz stroke as it pertains to the right shoulder, elbow, wrist, and stick. For American Rudimental Snare Drumming, the practice of rudiments is approached as different

combinations of basic strokes. The basic strokes are basic movement ideas that enable a snare drummer to develop the technique needed for rudiments. The rudiments allow the snare drummer to apply the technique developed from the basic strokes. This is similar to basketball fundamentals like the layup and jump-shot which have individual elements that composite the entire movement.

The Buzz Stroke is the stroke used for all multiple bounce strokes. In other words, the double stroke (or diddle) is included in the Buzz Stroke. This is the case because the Buzz Stroke shows the relationship between number of bounces and the rate in which the most relaxed grip (di erent for each player) produces each bounce. The buzz stroke is considered a basic stroke because the technique used for a double stoke roll, a three bounce roll, and a buzz stoke utilize the same motion. For every bounce after the initial stroke, the elbow contains that stroke until the stick dissipates and the stroke reaches rest position. The elbow contains each stroke. The body is relaxed enough to allow transfer of weight from the shoulder to the tip of the stick. Here's the sequencing of the buzz stroke by stroke type: Rest->Up->Down->Tap->Tap->Tap->Tap->Tap->Rest.

The buzz stroke can be viewed as a fundamental stroke because the double stroke is contained inside of the buzz stroke movement. From rest to upstroke, the elbow moves in close to the body while the hands reach the farthest place from the head of the drum.

This is one stroke sequence based on sequencing of movement by stroke type: From upstroke to down stroke, the elbow moves further away from the body as the hands move toward the drum in order to strike the head of the drum. from Down to tap, the elbow reaches its furthest point as the second stroke is performed. Note: this is the sequence for the Double Stroke Roll. The elbow

continues to move closer to the body through each subsequent tap until the body reachers rest position. This completes one stroke sequence.

Results

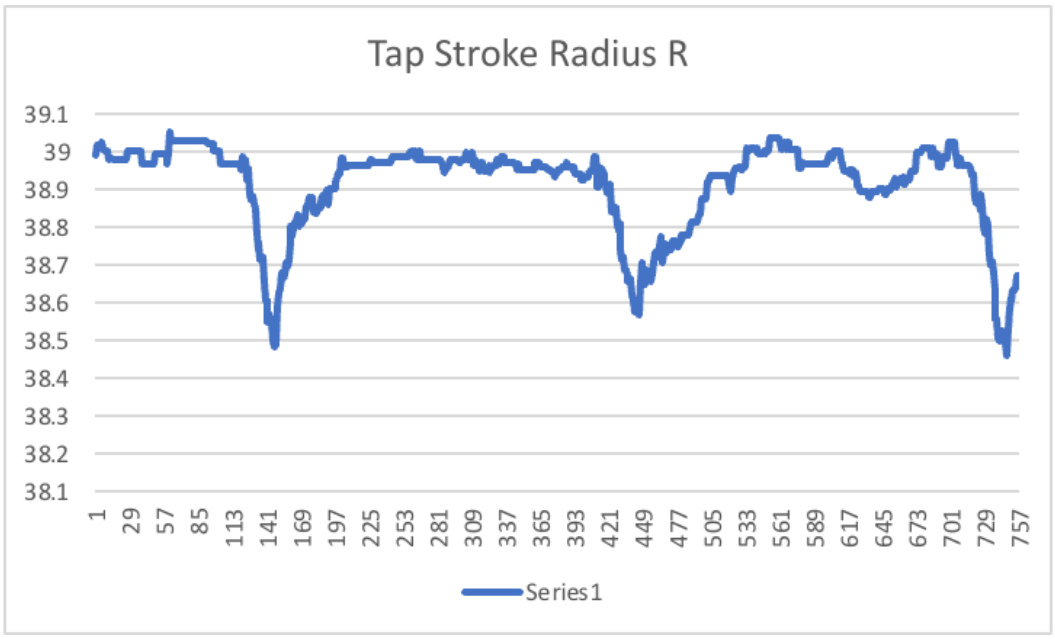
The snare drumming data can be analyzed using local maxima and minima for all trails. These points (x,y,z) and limb sections (i.e. ulna left, ulna right, etc.) refer to the following position: rest position, tap position, and up position. Each position is defined as follows: the rest position is when all limbs change in position is or approaches zero; the tap position is when the arms are configuration to where the stick touches the snare drum membrane; and the up position is the highest the ulna and radius are in the z plane relative to the rest and tap position for each trail. These positions mapped to an existing delineation of snare drum technique. For instance, the rest position in this experiment will refer to the common use of the rest position in snare drumming; same for all positions. A list of rudimental breakdowns will be provided in the annex section.

The data presented in the results section will be categorized into their ranges. For instance: range of positions, range of rudiments, range of basic strokes, and range of basic strokes in the rudiments.

The data has been partitioned into maximum and minimum values for selected trails as well as averages of those values along with standard deviation values. The data is composed of basic strokes, drag rudiments, flam rudiments, and selected single and double rudiments. The logic behind this separation is due to the nature of snare drumming. The basic strokes, as their name suggests, are the underpinnings of all of the rudiments: full stroke, down stroke, tap stroke, up stroke, and the buzz stroke. Each rudiment has a combination of basic strokes which lends to the different triggering of the kinetic chain of the upper body. Since the upper body determines the stroke performed, only the upper body will be analyzed for this preliminary analysis.

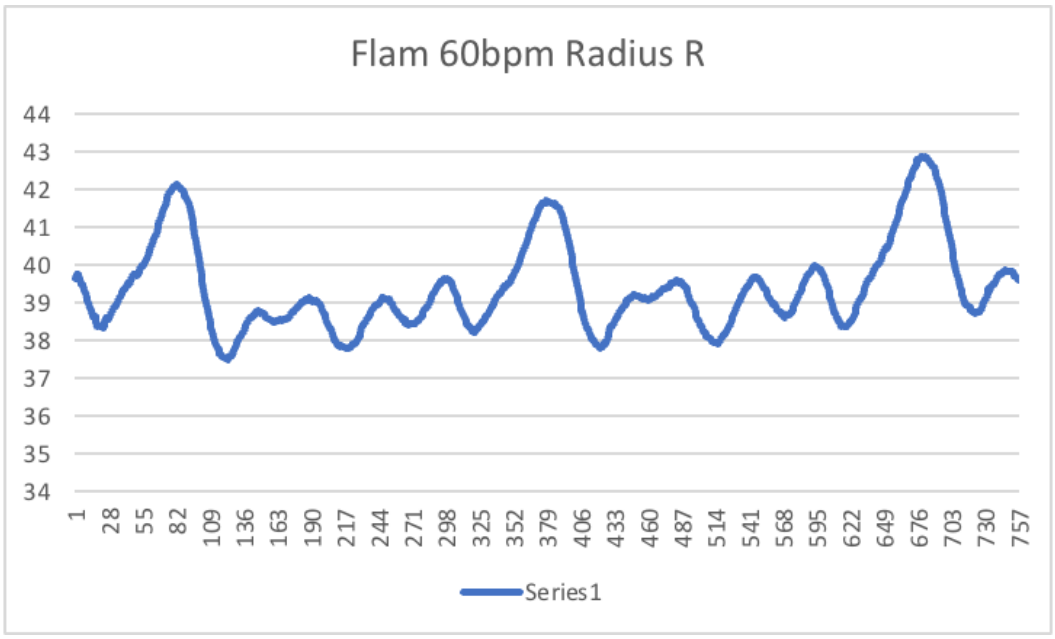
Furthermore, only the right side of the body will be analyzed for this preliminary analysis using algebraic geometry. Among capturing the essence of the basic strokes, another phenomenon has been discovered. The idea of the position can be found through the averages of these phenomena. The positions are the up position, tap position, and rest position. While the up position and tap position can be defined through Cartesian coordinates, the rest position seems to be a range of positions across all trials. The following analysis will be presented in the following order: basic strokes, roll rudiments, flam rudiments, and drag rudiments.

The first basic stroke to be analyzed is the tap stroke. The tap stroke has a range for its tap position at 38.4822cm in the resultant vector and 38.5686cm in the resultant vector. The up position for the tap stroke is difficult to analyze due to the nature of the stroke. For the tap stroke, the drummer performs the motion through dropping the stick. This phenomenon lends itself to be difficult to pinpoint accurately; meaning the up position for the tap stroke is defined as the maximum displacement in the resultant vector.



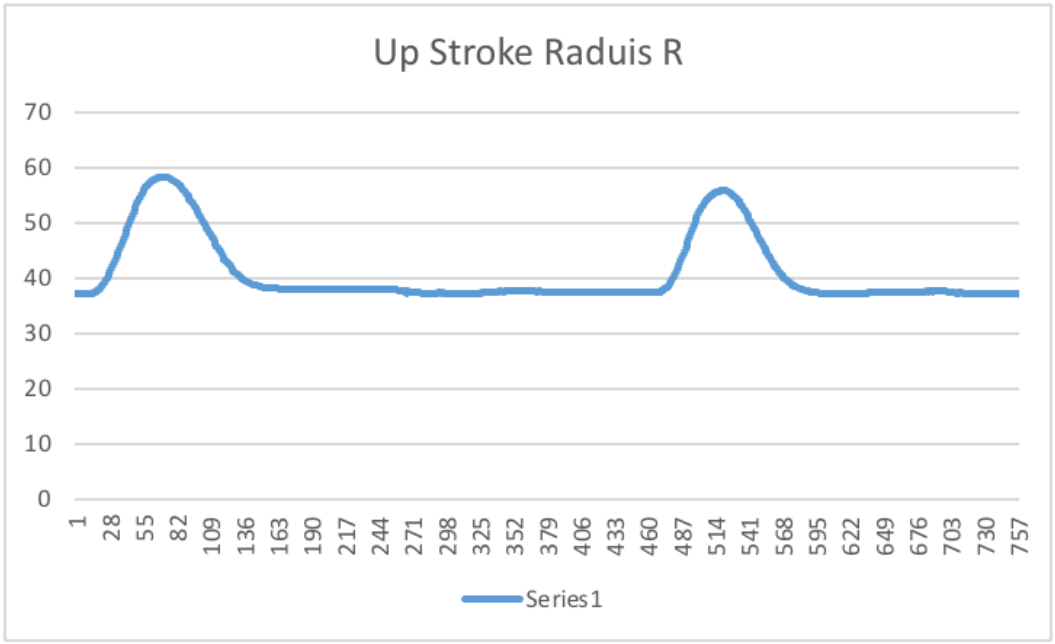
As seen in the chart, the Radius in the resultant vector has a rest position through a range of values. While the movement isn't numerically equivalent throughout the tap stroke sequence, one can average the displacement of the Radius in the resultant vector to lend an idea of the numerical displacement of the Radius in the rest position. With this average of displacements, one can take this value and cross reference other basic strokes and rudiments. The average of the rest position is 38.9689cm in the resultant vector for the Radius. This phenomenon of the rest position will be visited on every basic stroke and every rudiment.

This phenomenon can be seen in the rudiments that contain the tap stroke in its sequence of strokes. For instance, the flam accent is a flam followed by a tap stroke on the alternate hand. In the resultant vector for the ulna, there are two distinct tap strokes in the data. (See below)

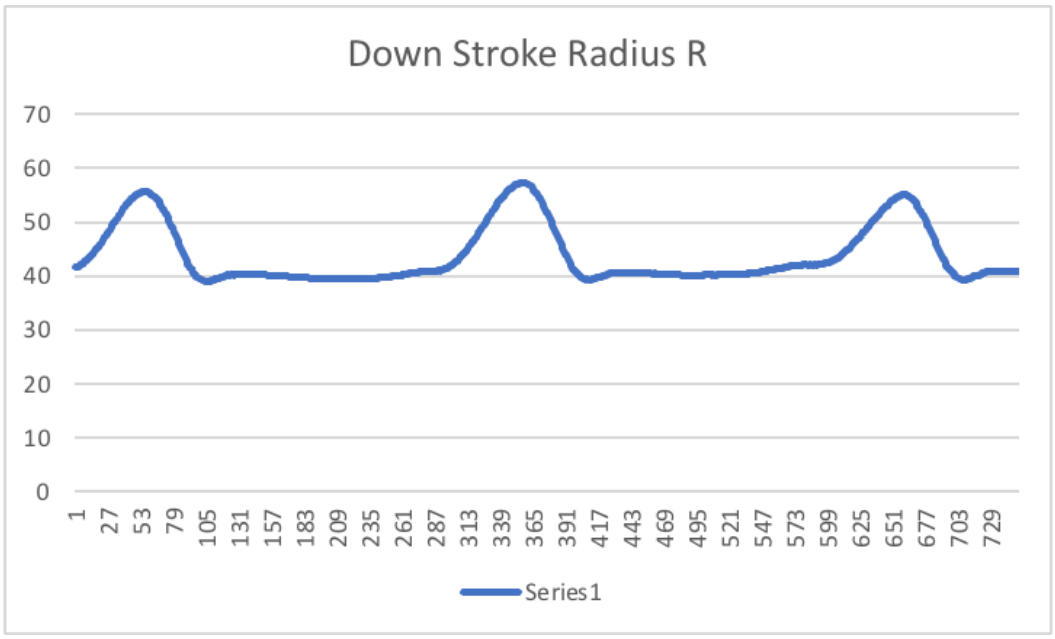


The chart displays how the tap stroke morphs to produce this particular sequence of basic strokes called the Flam Accent which was recorded at 60 beats per minute.

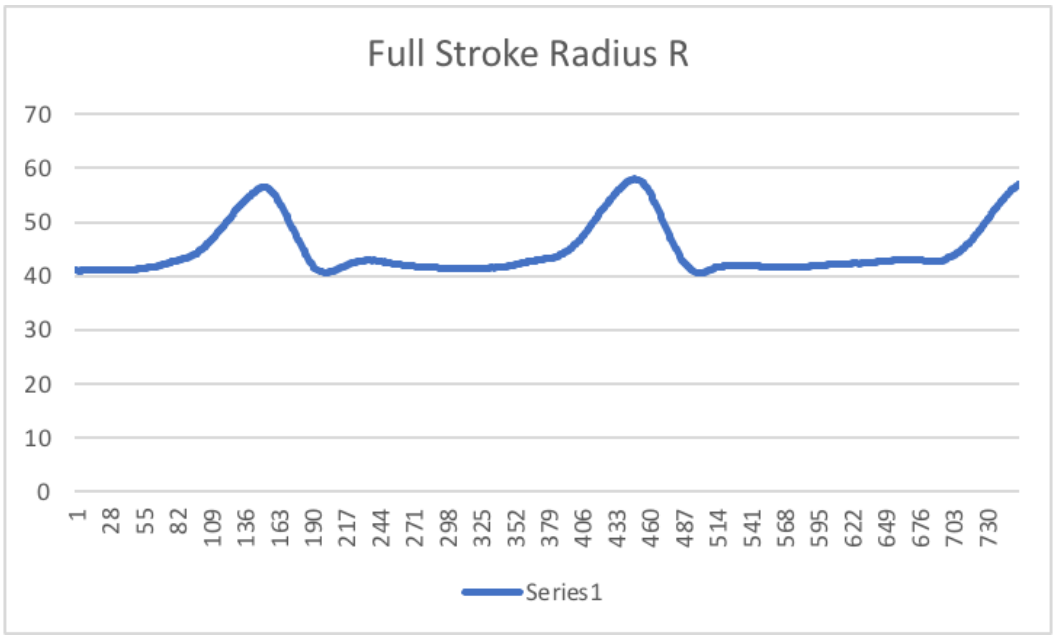
The Up stroke is a basic stroke that performs a strike on the drum head from the rest position. Immediately following the strike of the drum, the arm is lifted to the up position then returned to the rest position. The range of values for the tap position for the up stroke in the Resultant vector for the radius is 37.392cm. The up position average for the Radius R is 57.0952cm. The rest position average is 37.6534cm. These values can be seen in the table below.



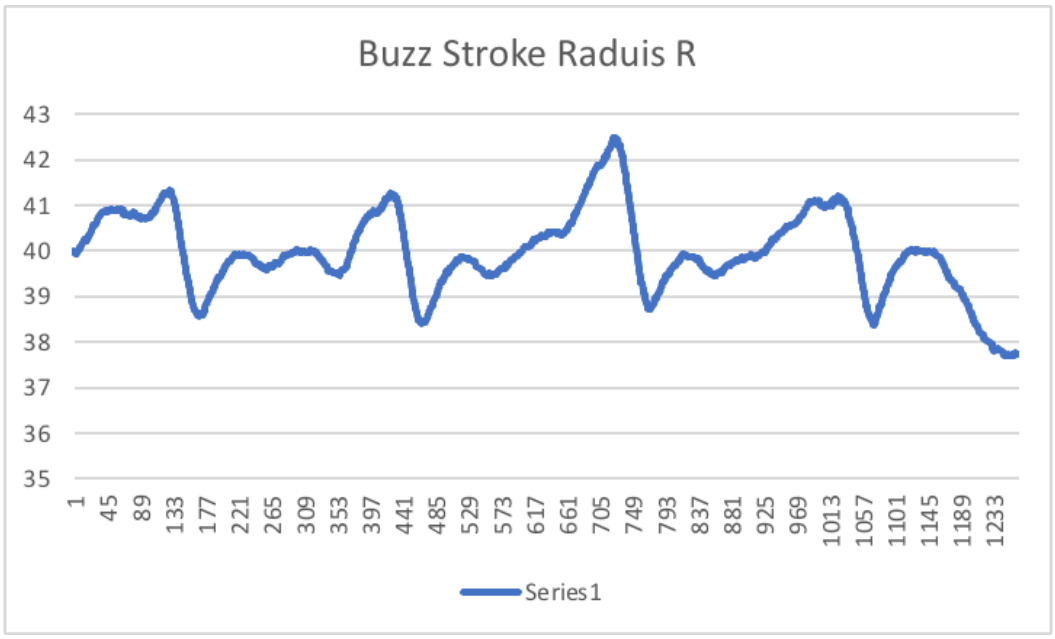
The Down stroke is a basic stroke with the following sequence: rest position, up position, tap position, and rest position. At the tap position, the movement after the strike of the drum is minimized to allow the stick to return to the rest position directly after the strike of the drum. The average of the tap position in the resultant vector for the radius is 39.1348cm; for the up position 56.0281cm; for the rest position 40.091cm. The values can be seen in the table below.



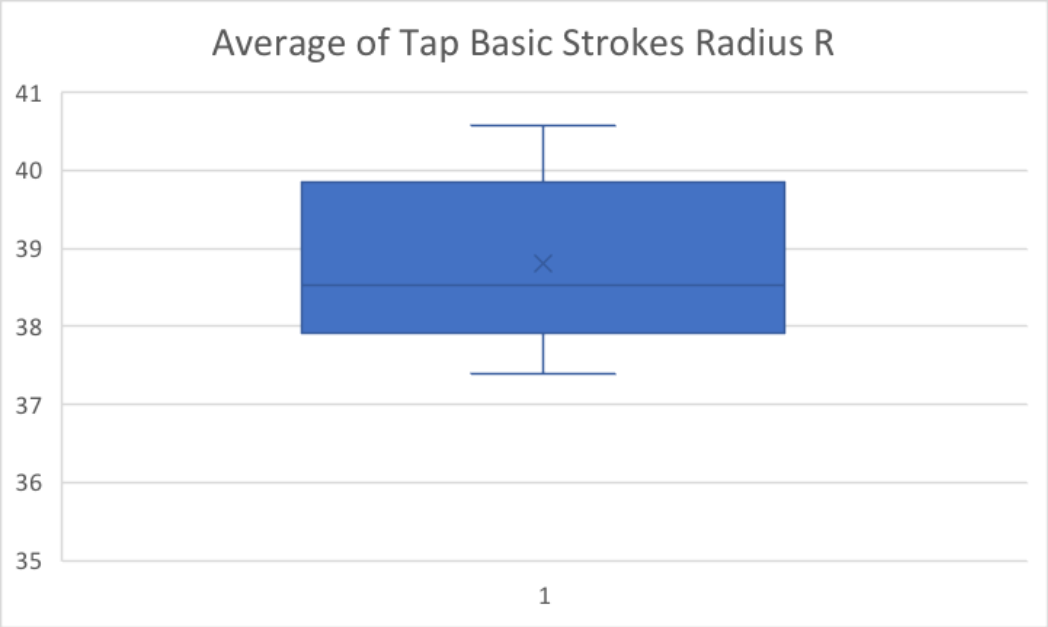
The Full stroke is a basic stroke with the following sequence: rest position, up position, tap position, rest position. At the tap position, the movement after the stroke follows the rebound of the stick allowing the return to the rest position with as little resistance as possible. The average for the tap position in the resultant vector for the radius is 40.5677cm; for the up position 57.0993; for the rest position 42.0125. The values can be seen in the table below.



The buzz stroke is a basic stroke with the following sequence: rest position, up position, tap position, rest position. At the position, the drummer performs three sequential taps from that position which is similar to the double stroke. The average for the tap position is 39.6796cm in the resultant vector for the Radius; for the up position 41.5793cm. The values for the radius resultant vector can be seen in the table below.

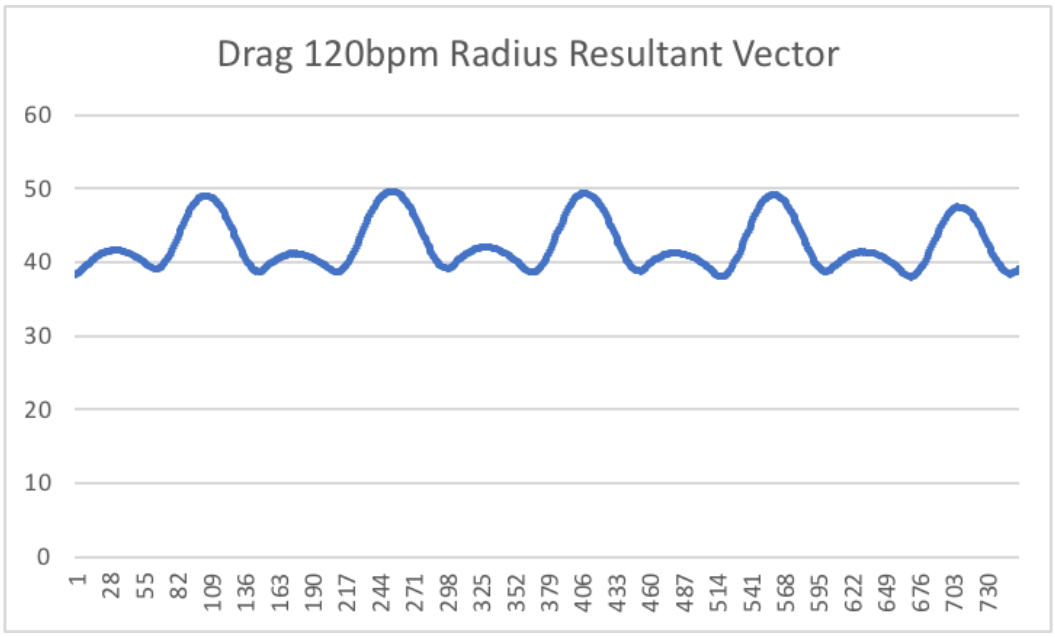


The basic strokes have their particular sequence when performed in isolation. In the performance of sequential basic strokes known as snare drum rudiments, the displacement values for the shoulder, elbow, and wrist change due to the rapid nature of performing basic stroke sequences. However, certain phenomena can be analyzed through the same lens in which the basic strokes themselves are analyzed. The following box plots display the average displacement of each basic stroke for the tap position, up position, and rest position.



The previous box plot contains the averages of displacement for the radius R for the tap stroke. This representation will be used to analyze the positions for the remainder of the selected trails.

Even though the drag rudiment is the foundation of the drag rudiment family, the drag rudiment will be grouped with the basic strokes for this preliminary analysis. The drag rudiment has a stroke sequence as follows: left hand tap, left hand tap+right hand down stroke. The following values are based on the drag rudiment at 120bpm. The value for the tap position in the resultant vector for the radius is 38.6132cm; for the up position for the tap stroke 41.5058; for the up position for the down stroke 48.9278. The values can be seen in the chart below. The drag at 60 bpm will not be analyzed for this preliminary analysis.

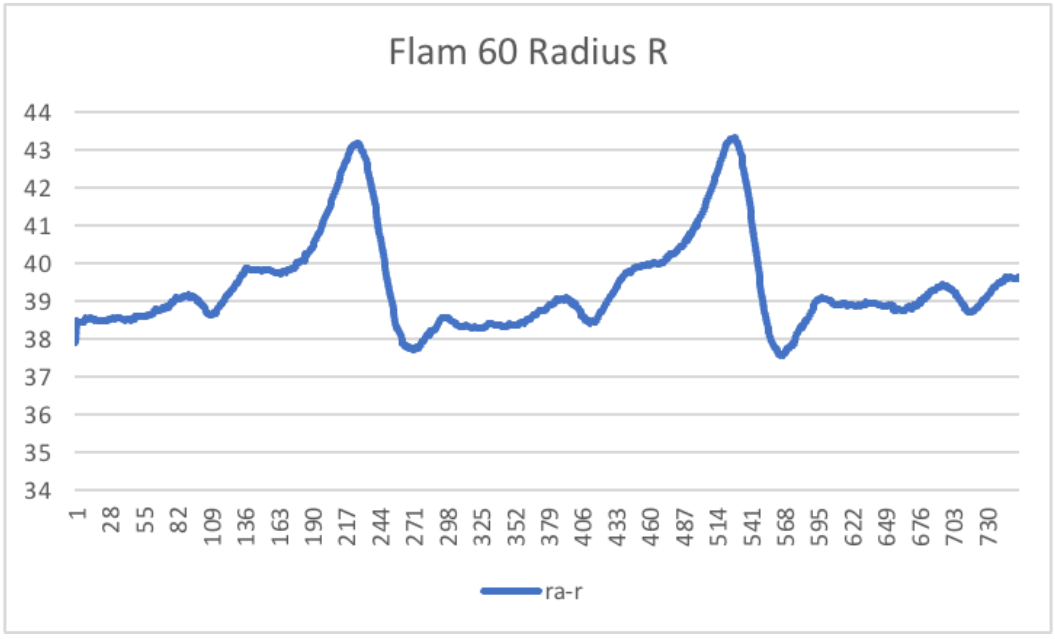

Drag 120bpm Radius Resultant Vector
60
50
40
30
20
10
0
1
28
55
82
109
136
163
190
217
244
271
298
325
352
379
406
433
460
487
514
541
568
595
622
649
676
703
730

B. Rudiments

I. Flam rudiment positions

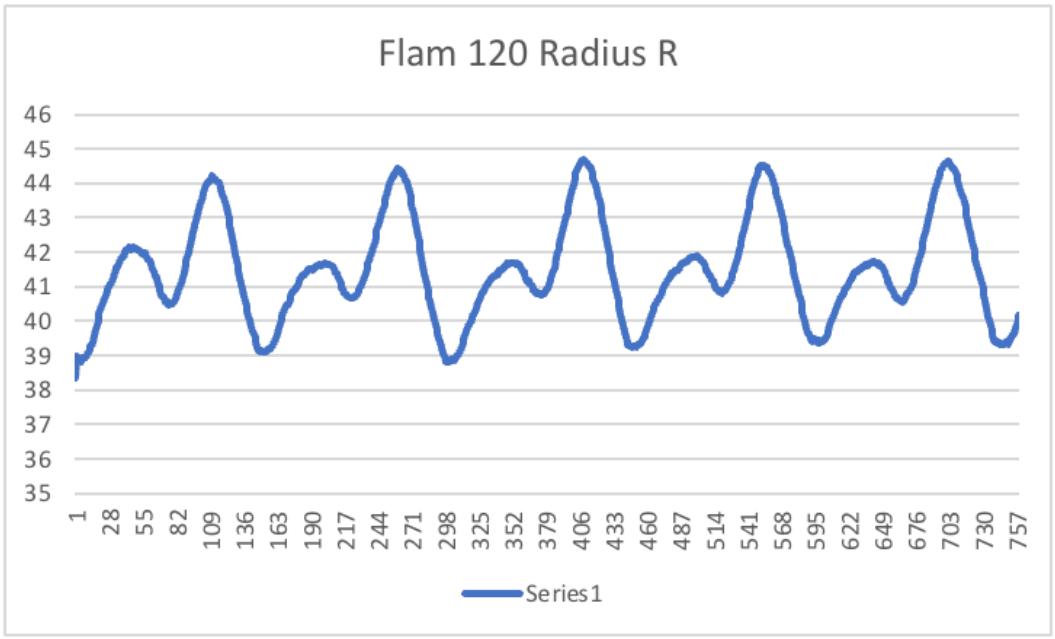
II. Roll rudiments positions

The Flam rudiments are selected combinations of basic strokes that produce a certain triggering of the kinetic chain. The first rudiment to be analyzed is the Flam at 60 beats per minute and 120 beats per minute. The basic stroke sequence for the flam is a tap stroke on one hand and a simultaneous full stroke on the other hand. This is an alternating rudiment: Right full stroke and left tap stroke, left full stroke and right tap stroke. The flam trial for 60 beats per minute has an average tap position in the radius R of 37.6384cm; for the up position 43.2551cm; for the rest position 38.6624cm. These values can be seen in the following chart.



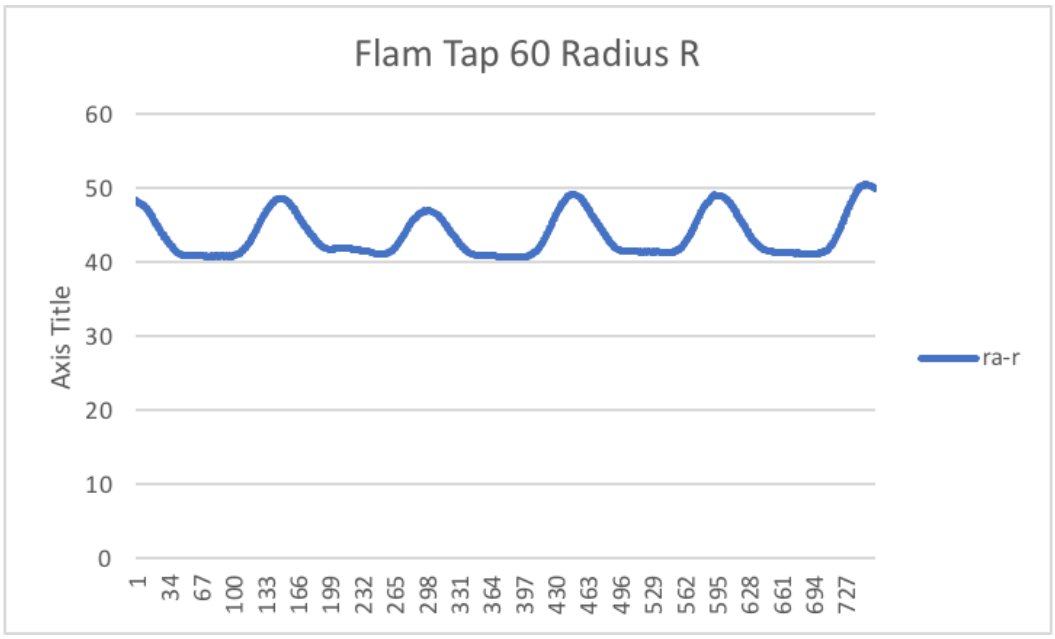
For the flam at 120 beats per minute, the basic stroke sequence remains the same. However, since the overall timing of the rudiment is halved, the movement in the kinetic chain is morphed

due to this time constraint. The average tap position in the resultant vector for the radius is 39.9071cm; for the up position 44.5053cm. There are not any quantitative markers of the rest position for this trail as the right radius is in continuous motion as seen in the chart below.

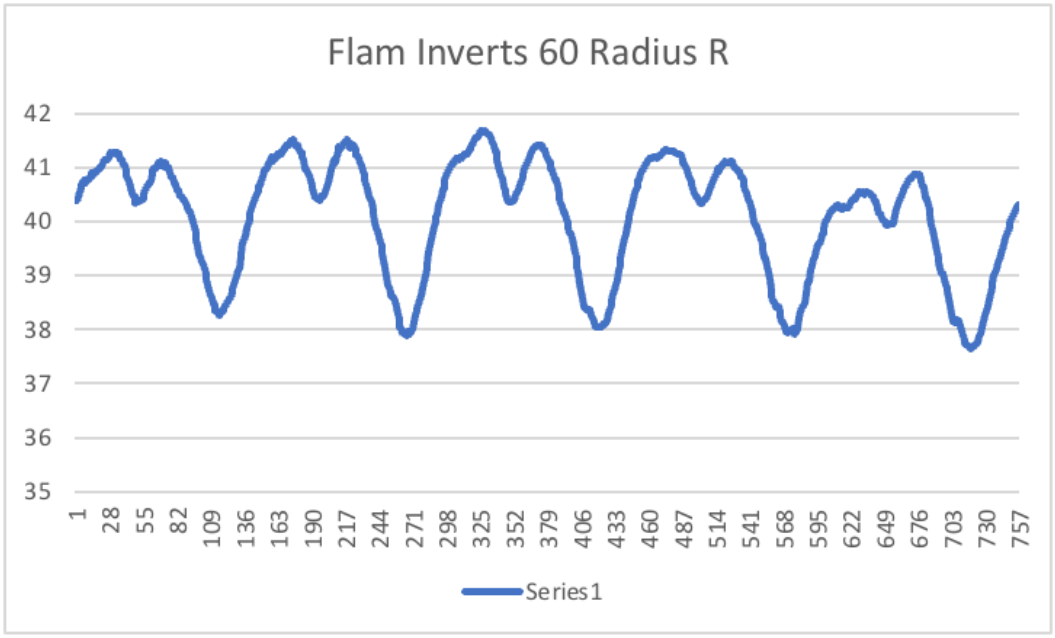


From the analysis of the basic strokes, one can ascertain that the average rest position of the radius in the resultant vector is 39.6815cm. This is about a .3cm difference between the flam 120 rest position average and the basic stroke rest average.

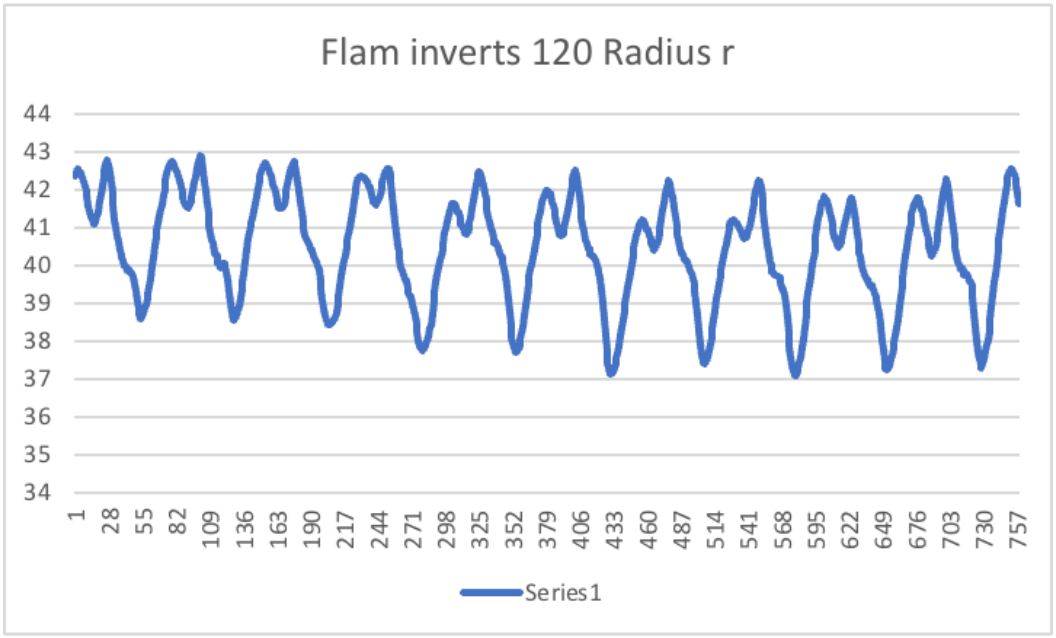
The next rudiment to be analyzed is the Flam tap at 60 beats per minute. The basic stroke sequencing for the flam tap are as follows: Right hand down stroke and left hand tap stroke, right hand tap stroke, left hand down stroke and right hand tap, left hand tap stroke. The average tap position for the right hand radius in the resultant vector is 40.9515cm; for the up position 48.6502. There is not an average of rest position for the flam at 60 beats per minute because the right radius is in perpetual motion.



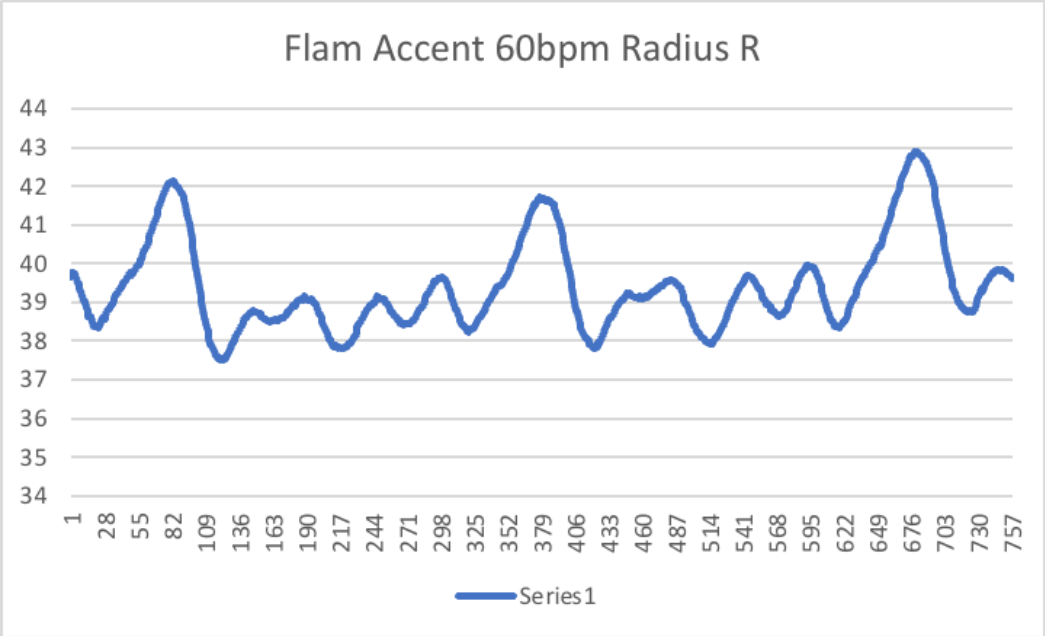
The next rudiment to be analyzed is the Flam Inverts at 60 bpm and 120 bpm. The basic stroke sequencing for the flam inverts are as follows: down stroke right hand and tap stroke left hand, left hand tap, down stroke left hand and tap stroke right hand, right hand tap. The average of the tap stroke for the radius in the resultant vector is 38.8856cm; for the up position 41.2393cm. There is no definitive value for the rest position as the radius in the resultant vector is in perpetual motion. The values can be seen in the chart below.



The flam inverts at 120 bpm has the same sequence of basic strokes as its 60 bpm counterpart. However, twice the amount of strokes are executed in the same time frame. The average of the tap stroke for the radius in the resultant vector is 37.7587cm; for the up position 42.4375cm. These values can be seen in the chart below.

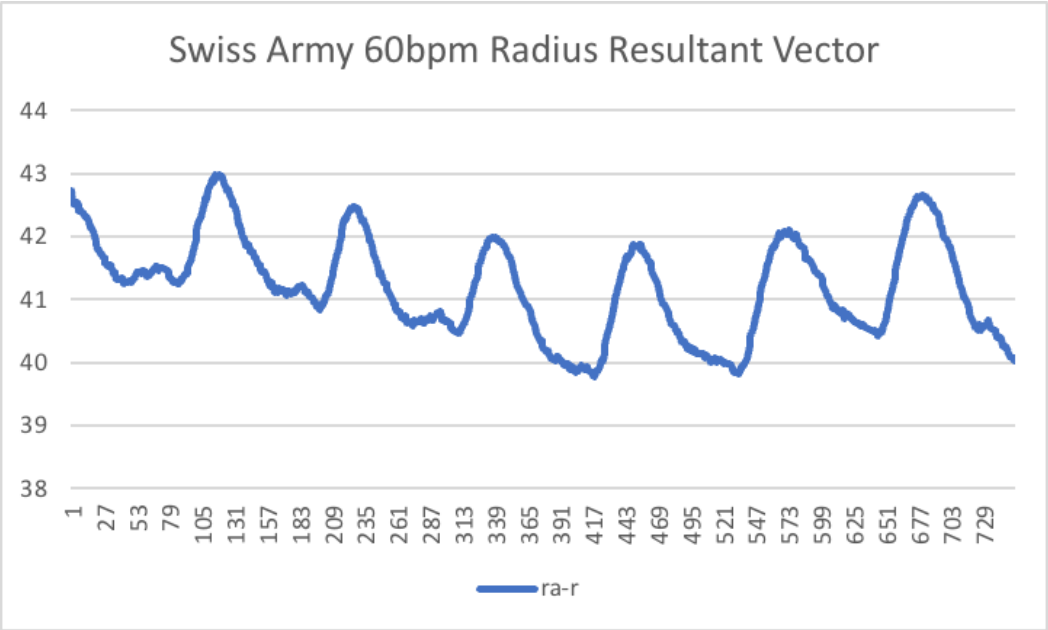


The next rudiment to be analyzed is the Flam Accent 60 bpm and 120 bpm. The basic stroke sequencing for the flam accent is as follows: (left tap+Right down stroke, left tap, right tap, left hand down stroke+right tap, right tap, left tap). The average tap position for the radius in the resulting vector is 38.0335cm; for the up position 40.437cm. The value for the up position is an average of two types of up position based on the sequencing of the basic strokes. This difference is the up position of the down stroke and the up position of the tap stroke; which average to 42.8824cm and 39.5325cm respectively. The values can be seen in the chart below.

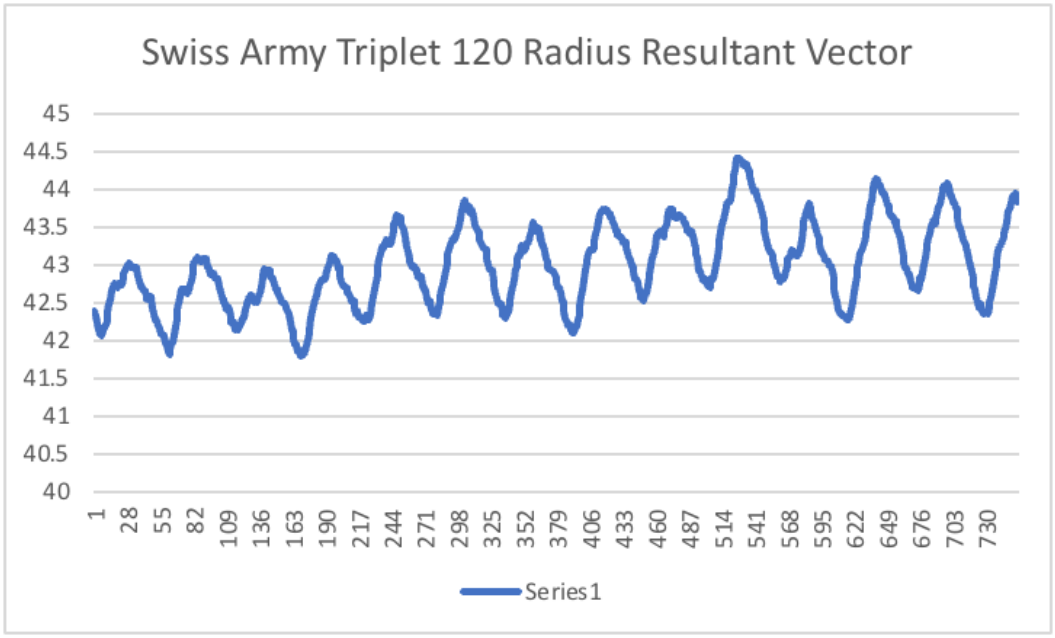


The flam accent at 120 bpm has the same basic stroke sequence as the flam accent at 60 bpm. However, twice the amount of strokes are performed within the same time period. The average value for the tap position in the resultant vector for the radius is 38.2733cm. The up position was not analyzed for this trail due to the complexity of the data. It was difficult to ascertain when the up position was executed based on the data alone.

The next rudiment to be analyzed is the Swiss Army Triplet at 60 bpm and 120 bpm. The basic stroke sequencing for the Swiss Army Triplet are as follows: left tap+right down stroke, right up stroke, left tap. The average value for the tap position in the resultant vector for the radius is 40.4253cm; for the up position 42.3423cm. The values can be seen in the chart below.



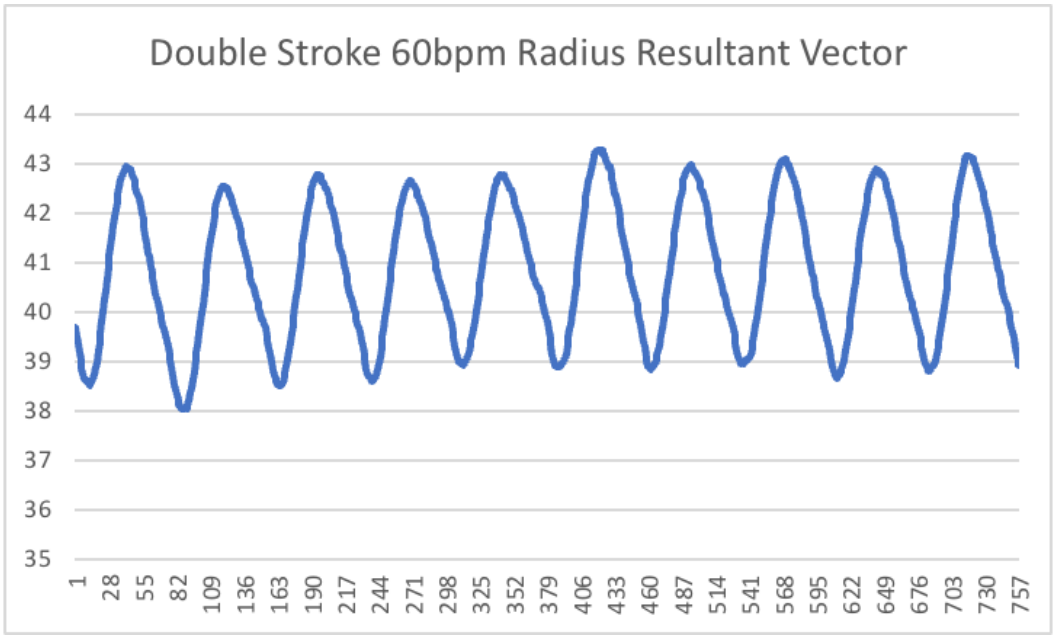
The Swiss Army Triplet at 120 bpm has the same basic stroke sequencing as the Swiss Army Triplet at 60cpm. However, twice the amount of strokes are performed within the same time period. The average value for the tap position in the resultant vector for the radius is 42.2902cm; for the up position 43.649cm. The values can be seen in the chart below.


Swiss Army Triplet 120 Radius Resultant Vector
45
44.5
44
43.5
43
42.5
42
41.5
41
40.5
40
1
28
55
82
109
136
163
190
217
244
271
298
325
352
379
406
433
460
487
514
541
568
595
622
649
676
703
730
Series1

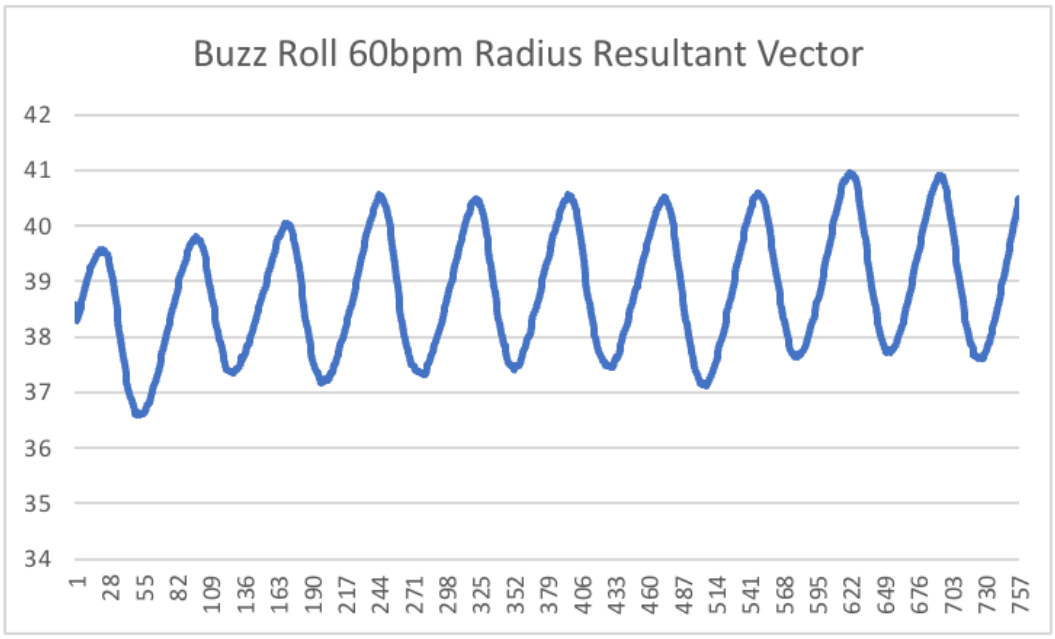
Roll Rudiments

- Buzz Roll
- Double Stroke

The Double Stroke roll is a sequence of alternating full strokes which produce two taps per full stroke. The double bounce roll at 60 will be analyzed for this preliminary analysis. The average value for the tap position in the resultant vector for the radius is 38.8868cm; for the up position 42.9033cm. The values can be seen in the chart below.



The buzz roll is a sequence of alternating full strokes that produces three or more bounces. The buzz roll at 60 bpm will be analyzed for this preliminary analysis. The average tap position in the resultant vector for the radius is 37.3335cm; for the up position 40.3945cm. The results can be seen in the chart below.



This concludes the charting of selected experiment trails as well as detailing the maximum and minimum values for the radius in the resultant vector of each trail. Next, the comparisons of all trials will be expressed.

Conclusion

There seems to be a direct correlation between the consistency of the positions for snare drumming and the execution of the strokes or sequences of strokes found in this experiment. Also, it seems that there is a morphing of the movement pattern for the basic strokes in isolation and the basic strokes in the respective sequencing found in the rudiments. Further analysis is needed to express these phenomena in detail. However, this preliminary analysis shows the utility of motion capture data on snare drumming as a means to not only understand the physical nature of drumming, but also the continual practice of drumming and mastery of bodily movement in general. Furthermore, there seems to be an educational application of such a practice. In theory, one can present this information to a group of students who struggle with math and its place in the world. With some guidance, one could see how mathematics is present in something as artistic as rudimentary snare drumming; and by extension, music technique and human movement in general. Speculations aside, this preliminary analysis will be followed by a complete analysis of the snare drum trials for this experiment which includes: analysis across six different drummers, full upper body analysis of positions and movement through space, and the complete trials for the snare drumming experiment. At the end of this paper are the charts and data mentioned in the text.

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