ANIMATED MOTION CAPTURE: AN EXAMINATION OF CARTOON-STYLISED HUMAN MOVEMENT FOR THE CAPTURE OF ANIMATED PERFORMANCES

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Abstract

Animation functions as an expression of movement for artists and, since its formation, has been flexible in how it is produced at the artist's discretion. Walt Disney Animation Studios favoured manual frame-by-frame animation methods to craft the stylised movements of their characters' performances. Motion capture offers an alternative method for animating characters by reconstructing movement from a recorded pro-filmic event. Traditional frame-by-frame animation and motion capture are not isolated methods of character animation; however, an unspoken divide exists within the industry that silos realistic movement to motion capture and cartoon-style movement to traditional animation methods. Some have described this divide as a general rule of thumb, that motion capture should not be used to animate cartoon-style motion. This indicates the formation of a disciplinary boundary within the field of character animation between frame-by-frame stylised movement and realistic motion.

This study challenges this apparent boundary. It examines the capture stage of a typical motion capture pipeline and uses animation reference materials from popular training manuals to test the recorded actions of performers with cartoon-style movement at the time of capture. This research has revealed that motion capture can, in fact, be an effective tool in creating cartoon-style motion as long as the conditions of the production meet the requirements detailed in this thesis. A specific outcome of this study is that the more knowledge a motion capture performer has of physical acting and cartoon motion, the easier the process of shaping captured movement qualities to bring them closer to a finished cartoon-style result.

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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: QUT Verified Signature

Date: 25/07/2019

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Chapter 1: Introduction

1.1 BACKGROUND TO THE RESEARCH

Animation practitioners readily adapt their production methods to make use of new emergent technologies in order to push creative outcomes, make processes more efficient and reduce production costs. This has enabled growth for the animation discipline; as filmmaker John Lasseter famously stated, "the art challenges technology, and the technology inspires the art" (Iwerks 2007). Motion capture is one such technology that has pushed the animation discipline.

Animator Norman McLaren advocates that "animation is not the art of drawing-that-move, but rather the art of movements-that-are-drawn. What happens between each frame is more important than what happens on each frame" (Solomon 1987, 11). As such, the tools and methods of animating become subservient to the animator who is crafting the movements. This can, of course, be extrapolated to various technologies, like computer graphics (CG), where the animation is processed digitally. The ways in which these movements are constructed include manual frame-by-frame manipulation (traditional animation), procedural generation and mechanically reconstructed movement from a recorded pro-filmic event, such as rotoscoping or motion capture. During Walt Disney Productions' formative years, animators made use of the Rotoscope during productions to study human movement by tracing over live-action film onto paper (Bratt 2011). As a descendant of rotoscoping, modern motion capture also offers animators a realistic portrayal of movement to bring their characters to life. This operates as an alternative to an

animator's artistic interpretations of movement using traditional frame-by-frame animation methods.

Disney animators noticed during their human movement studies that a direct copy of movement from a recorded live performance resulted in a breakdown in the illusion of life (Thomas & Johnston 1981). The implications of process were described by two of Disney's animators, Frank Thomas and Ollie Johnston, that while the movements had authority "it was impossible to become emotionally involved with this eerie, shadowy creature who was never a real inhabitant of our fantasy world" (Thomas & Johnston 1981, 323). These characters lacked the essence of believability, which is the audience's willingness to suspend disbelief and sacrifice objective reality for the sake of enjoying the surreal to engage with the character (Bishko 2007). Motion capture inherits this issue of believability when recorded realistic movements are applied to stylised characters; therefore, a frame-by-frame manual method of animation is favoured to achieve stylised movement.

To achieve these stylised artistically interpreted movement patterns, Disney studio defined and developed the 12 Principles of Animation, which, as Bishko explains (2007, 24), "are known by all animators and used as a benchmark for good animation". Detailed in *Disney Animation: The Illusion of Life* (Thomas & Johnston 1981), these principles are:

1. Squash and Stretch
2. Anticipation
3. Staging
4. Straight Ahead Action and Pose to Pose
5. Follow Through and Overlapping Action
6. Slow In and Slow Out

7. Arcs

8. Secondary Action

9. Timing

10. Exaggeration

11. Solid Drawing

12. Appeal

These principles have been added to, redeveloped and redefined by many practitioners but have ultimately remained the same since their inception. Stylistic variations of animated movement emerged as practitioners took liberties with the methods of animation production. Some of these variations are the result of selective or emphasised use of particular animation principles. Webster (2005) describes some of these stylistic executions as 'naturalistic', 'cartoon' and 'limited' animation. However, these terms and other classifications are interpreted differently between practitioners. For example, Webster (2005, 8) refers to cartoon-style as "stretching the boundaries of the believable" as seen in Tex Avery's Bugs Bunny and Daffy Duck cartoons, where the animation principles are taken to their extreme. Animation theorist Leslie Bishko offers an alternate classification, stating cartoon-style "broadly refers to animation design and movement that adheres to the 12 Principles of Animation" (2007, 24). Regardless of style, these practitioners have expressed that above all else, believability is a consistent objective for quality character-based animation. Disney animators Frank Thomas and Ollie Johnston express their views on believability in character animation this way: "there is a special ingredient in our [Disney's] type of animation that produces drawings that appear to think and make decisions and act of their own volition; it is what creates the illusion of life" (Bates 1994, 1). The animation principles can, therefore, be used to create the illusion of thinking beings through

movement; however, the design of these characters is also a major factor in creating the illusion of life.

When a clear dissonance exists between an animated character's designed form and how they move, the character's believability is broken along with the audience's suspension of disbelief. There is an examined, neural link that triggers a person's positive emotional response to anthropomorphic characters that demonstrate human characteristics and intent through actions (Chaminade 2007). Conversely, "a breach from expectations of the combined motion and form cues would result in motions being perceived as atypical and less natural" (Chaminade 2007, 213). Therefore, a person will readily accept a stylised character moving in a stylised manner such as those seen in popular 3D computer generated (CG) animations from Disney-Pixar. Bouwer and Human (2017, 185) express this notion, stating "when animating 3D CG characters, the design of the character does have an impact on the audiences' perception level of immersion and emotional bonding with the CG characters as audiences are more sensitive to any imperfections in the applied animation to realistic CG characters than to the stylized characters". The realistic CG character designs referred to are live-action emulating characters such as those seen in *Beowulf* (Zemeckis 2007). Thus, regardless of style, character design and animated movement operate in a mutual relationship and will affect an audience's believability of the animated character.

As a production tool for animating characters, motion capture enables practitioners to reconstruct movement from a recorded pro-filmic event. Through modern motion capture, recorded movements of live-action performances can be applied to 3D CG characters in real-time: effectively, a mechanical process of animation. Characters animated through motion capture, however, typically require a

form of post-production processing by editing the recorded movements, which is usually done by an animator (Liverman 2004, 224). Post-capture processing of motion captured movements is required for multiple reasons including re-use of the movement for other actions, adding secondary motion or changing the intent of an action (Gleicher 2000, 4). An animator's involvement in a production that has used motion capture to animate CG characters will vary in the amount of recorded, realistic movement to traditional, frame-by-frame animation. According to director Steven Spielberg, the completely CG motion capture animation *The Adventures of Tintin* (2011) is "85 per cent animation to 15 per cent live-action" (Lyttelton 2011). Animators and their traditionally based skills are an important part of motion capture productions to ensure believability carries through in the animated performances. Animator and teacher Richard Williams (2009, 20) reiterates this, stating "the old [animation] knowledge applies to any style or approach to the medium no matter what the advances in technology". Traditional animation methods remain as relevant as ever, even with motion capture as part of the modern animator's production toolkit.

Just like the earliest animators, the modern animation practitioner is only limited by their imagination for the ways in which production tools, like motion capture, can be used to create the illusion of life. Traditionally animated films—such as those by Disney and Pixar Animation Studios—maintain categorical distinction from animations that have used motion capture. *Ratatouille* (Bird & Pinkava 2007) even boasts a label with "100% Pure Animation—No Motion Capture" during the credits. This was during the same period of the Oscar-winning motion capture animation, *Happy Feet* (Miller 2006). Some maintain an open outlook for motion capture and its potential as a tool for animation. In reference to *Monster House* (Kenan 2006), animation supervisor Thomas Hofstedt states, "There are still many other ways

to use the technology for stylized animation and storytelling […] I think the use of motion capture will evolve and expand. It doesn't have to be limited to only attempting to emulate photographic reality. It has a lot of potential to be used in new and different ways" (Bielik 2006). As Hofstedt suggests, the uses and applications of motion capture as a production tool for animating movement beyond being objectively realistic have yet to be completely explored. Applying John Lasseter's previously mentioned quote, animation productions challenge motion capture technology and motion capture inspires the continued expansion of expressed movement within the animation discipline.

1.2 RESEARCH PROBLEM

This thesis challenges the apparent disciplinary boundary within the field of character animation between frame-by-frame stylised movement and realistic motion. This is based on the discipline's presumption that suggests frame-by-frame stylised movement is not achievable with motion capture. Some practitioners, such as Alberto Menache (2011, 64) and Matt Liverman (2004, 22), suggest that animations requiring cartoon-style motion should not consider motion capture as a production method. Menache (2011, 81) argues, "Why would you want to capture realistic data if you want a cartoony look?" This assumes a motion capture performer is incapable of recording any movement beyond a traditionally trained actor's scope of knowledge and that motion capture is unsuitable to create a movement that is not based strictly on realism. This thesis examines a typical motion capture pipeline and uses reference materials from popular animation training manuals, such as *The Animator's Survival Kit* (Williams 2009), to test recorded actions of performers at the time of capture with cartoon-style movement.

1.3 RESEARCH QUESTIONS, AIM AND OBJECTIVES

This thesis responded to a key research question and two sub-questions:

- Can cartoon-style movement qualities be achieved through a typical motion capture pipeline for 3D CG character animation?
    - What challenges occur in attempting to achieve this and how might these challenges be overcome?
    - Through the tensions and ruptures that occur in this process, what opportunities exist for producing new movement aesthetics?

The aim of this research project has been to practically demonstrate motion capture as a viable tool for animating cartoon-style movement by reconciling traditional animation and motion capture practice.

This aim was achieved through the following objectives:

- Examining the typical production approach for 3D CG motion capture animations and identifying the pitfalls and conditions that practitioners encounter.
- Investigating the capture and post-capture stages of a 3D CG motion capture animation and what conditions enable cartoon-style forms of movement to emerge.
- Investigating the application of cartoon-style motion to a motion capture of the performer's movement through a lexicon of movement qualities built from the 12 Principles of Animation and expressed through the use of traditional animation texts and resources such as *The Animator's Survival Kit* (Williams 2009).

- Synthesising the research findings from the previous three objectives to define or develop production conditions that assist a 3D CG animation practitioner to create cartoon-style movement with motion capture.

1.4 RESEARCH APPROACH

The methodology of this research was a practice-led, action research model where iterative research cycles produced questions to inform proceeding practice cycles, i.e. a process of continuous refinement and learning (Gray 1996; Schön 1984). The practice cycles were devised to begin with a broader scope of motion capture animations before gradually refining the production conditions (participants and goals), which led to more specific, detailed testing of animated movement with motion capture. The first three practice cycles define the preliminary knowledge acquired before the fourth practice cycle. Various projects and collaborations were conducted to inform and contribute to each of the practice cycles. The outcomes from each cycle of practice serve as documented proof of the practical experimentation throughout this study. Figure 1 shows a breakdown of this research approach and how each cycle of practice and associated project/collaboration eventuated in digital outcomes:

Cycles of Practice	Projects / Collaborations	Digital Outcomes
1. Benchmark Practices for Motion Capture Animation	1. *Powers Above* Project	3D CG Animation & Behind-the-scenes Video
	2. VIMMA Project	Behind-the-scenes Video
	3. QUT 2015 Robotronica Project	3D CG Animation
2. Animated Actions with Motion Capture	4. Collaboration with Circus Artist Marianna Joslin	Comparative Video - Motion Capture Animations
3. Animation Techniques with Motion Capture	5. Collaborations with QUT Acting Students Liam Soden and Maeve Hook	Comparative Video - Motion Capture Animations
4. Cartoon-style Animated Movement with Motion Capture	6. Collaboration with Mime Artist Lorin Eric Salm	Comparative Videos: 1. Overlapping Action and Breaking Joints 2. Breakdown Positions 3. Weight and Anticipation 4. Line of Action 5. Referenced Actions 6. Pose-to-pose 7. Stylistic Animation Pulls 8. Characterisation 9. Perform to Character 10. Evolving Walk

Figure 1 - Table detailing the research approach of this study

The first cycle of practice laid the groundwork for animation motion capture production methods that informed the next practice cycles. This cycle included three projects: a motion capture animation called *Powers Above*, an international collaboration focused on digital puppetry called 'Virtual, Intermedial and Mixed Reality Performance in Live Production and Creative Contexts' (or VIMMA Project) and an experimental motion capture production with musicians and circus artists from Queensland University of Technology's (QUT's) Robotronica event in 2015. The cycle's digital outcomes included a behind-the-scenes video of the VIMMA project

showing what took place and a 3D CG animation for the *Powers Above* and Robotronica projects, with each showing an application of their respective production-specific areas of focus.

The second cycle of practice was a singular collaboration with circus artist Marianna Joslin that investigated animated movement and actions within the capture stage of a motion capture production as well as in the post-production editing stage. The digital outcome is a comparative video showing animation-sourced actions, footage of the recorded motion capture session and unedited/edited actions of the recorded data applied onto a 3D CG character.

The third cycle of practice involved collaboration with two novice (student) actors from QUT: Liam Soden and Maeve Hook. This cycle focused on approaches to animated movements in a more refined manner. Only the capture stage of a motion capture production was investigated for this cycle. The resultant digital outcome is a comparative video showing only the recorded motion capture session beside a video with the 'raw' motion capture data applied to 3D CG characters.

The fourth and final cycle of practice involved collaboration with professional mime artist Lorin Eric Salm. Like the previous cycle, this cycle focused on the application of animated movements within the capture stage of a motion capture production. The fourth cycle addresses more specifically stylisation and cartoon movement in a motion capture production setting, with adjustment made from the previous cycles' acquired knowledge. This collaboration was the most involved and resulted in 10 digital outcomes, each demonstrating applications of various experiments in the pursuit of animated, cartoon-style movement with motion capture.

1.5 RESEARCH SIGNIFICANCE AND CONTRIBUTION TO KNOWLEDGE

This study contributes to the field of animation through the expansion of production tools and techniques available to practitioners, as well as the yet unknown, future benefits these could enable through artistic experimentation and outcomes. In the same fashion that 3D CG was an innovative technological expansion of the animation discipline and allowed animators to define it as the now most dominant medium (Carter 2016), this study is significant as it too expands upon the animation discipline through the use of motion capture technology. Once feared as a replacement for animators during the high-tech hype period of the 1990′s, as well as a 'technical cheat' likened to limited animation and rotoscoping, motion capture held a negative association within the animation community (Failes 2018, para. 10; Furniss 1999; Sito 2013, 208). During this period, there were those who predicted a shift, as Greg Pair of AMPnyc said in correspondence with animation historian and theorist Maureen Furniss (1999), "when technology and output improve[s], motion capture will be seen as yet another new medium and not a replacement for the traditional media". On the motion capture animation *Monster House* (Kenan 2006), Disney animator Thomas Hofstedt stated, "there are still many other ways to use [motion capture] for stylised animation and storytelling" (Bielik 2006). The Netflix anthology animation series *Love, Death & Robots* (Miller 2019) is a contemporary example demonstrating this idea. Motion capture was used in seven episodes of this series, most of which aimed for a photorealistic outcome; however, the episode *Fish Night* (Nenow 2019) is a noteworthy example with a distinctly stylised visual aesthetic to accompany the realistic character movements. This series has garnered favour with audiences, being described as "a celebration of animation as an art form", "stunning visuals on display"

and “a plethora of [animation] styles developed over the past century” (Power 2019, para. 23). Through such experimental applications of animation tools, new production methods and techniques could expand the discipline as a whole and provide a fresh and innovative brand of animated movie-making (Webster 2005, 132). This research expands on the expressive possibilities of the animation discipline through artistic experimentation by investigating motion capture as a production tool for creating cartoon-style movement in a 3D CG animation.

Ed Catmull, Pixar’s co-founder, expresses a succinct view of creative-based research and its contributory value to knowledge in *Creativity, Inc.* (2014). He states that the current culture of research is based on fear of failure, where “researchers should know before they do their research whether or not the results of the research would have value” (Catmull 2014, 110). He argues that this misguided understanding of failure has now distorted how researchers choose their projects. He continues, “Failure is a manifestation of learning and exploration” and that “while we don’t want too many failures, we must think of the cost of failure as an investment in the future” (2014, 109–111). Catmull’s views on research are directly aligned this research’s contribution, whereby failure in reconciling motion capture with stylised movement is just as important as success. In investigating motion capture animation production methods, failure to achieve believable animated motion from human-derived motion is still a valid contribution to research as it establishes tangible proof (or disproof) of what has so far been speculation and assumption.

This research maintains a focus on applications to 3D CG animated films with stylised characters such as those seen Disney-Pixar films like *Frozen* (Buck & Lee 2013). This study has the potential to contribute to areas such as mocap game productions like *The Last of Us Part II* (Sony Interactive Entertainment 2019) or

contemporary applications such as live streaming 3D avatars through online platforms such as Twitch (Twitch Interactive Inc. 2019) and Holotech Studios' *Facerig* (2019). However, these forms of mocap are beyond the scope of this study. Detailed further in the Methods section, this research takes a technology agnostic approach, meaning the tools available at the time of the study are not a hindrance to the outcomes of the research or where these outcomes can be applied. This study serves to assess the application of cartoon-style movement to a mocap performer during the capture stage of a mocap animation.

1.6 THESIS STRUCTURE

Following this introduction, Chapter 2 details the literature review of this study in three categories. The first outlines animation, its developmental history and various components of the medium's productions and stylisations. The second pertains to motion capture and its historical relevance to animation practice, the types of productions in which it is typically used and the participants involved in such productions. The third category details motion capture animation production and variations of such productions. Here, the importance of believability in character animation is established as well as the definite qualities of form and movement. This chapter details relevant literature and research that closely aligns with this study to contextualise this research within the animation discipline.

Chapter 3 details the methodology and methods of this study, particularly the research processes, examination tools and approach for reviewing the digital outcomes. This chapter expands on the research approach presented in Chapter 1.

Chapter 4 discloses the first three cycles of practice of this research. The planning stage and specific aims associated with the over-arching research aims are detailed at the beginning of each practice cycle: the first cycle is a broader examination

of motion capture animation production practises; the second is an attempt at creating cartoon-style movement with motion capture; and, lastly, the third is a specific application of animation techniques to the capture stage of a motion capture animation production. These three cycles of practice collectively provide preliminary knowledge regarding motion capture animation production methods before the in-depth examination in Chapter 5.

Chapter 5 details the fourth cycle of practice. Here, methods of rendering cartoon-style movement in a motion capture animation production setting are documented through 10 practical experiments.

Chapter 6 is an evaluation of the digital outcomes of this study. Using Webster's (2012) 'Action Analysis' method of motion analysis, each outcome is examined through digital annotations. This chapter contributes as proof of application and informs the final discussion in Chapter 7.

Chapter 7 details the overarching research discussion, bringing together all cycles of practice, tying them to relevant literature and the research objectives. Among other items, this discussion discloses production conditions found during the study for creating cartoon-style movement for 3D CG motion capture animations.

Chapter 8 concludes this thesis by summarising the production conditions detailed in Chapter 7 while also regarding future research opportunities.

Chapter 2: Literature Review

Paul Wells describes ‘animation’ as meaning ‘to give life to’, which for the cinematic context means creating the illusion of movement with inanimate lines and forms (1998, 10). Animation effectively embodies a multitude of artistic solutions and outcomes to express movement. This definition is suitable for a film context, as it is not beholden to any particular aesthetic style or process of production and encompasses a large portion of an incredibly diverse discipline. Rather than defining process, the importance is redirected towards the individual artist and their choices of storytelling and expression for whichever style or production method they use. In the face of commercialisation and a global consumer market for animation, the creative outcomes of animation practitioners sway towards media based on popularity, something seen with 3D CG, the most dominant form of animation (Carter 2016). While the 2D form, established by Walt Disney Animation Studios, has reigned since animation became a mainstream of cinema and television, 3D CG has since become the more popular medium (Wells, Hardstaff & Clifton 2008). Shilo McClean (2007, 98) even titles 3D animators as ‘new traditionalists’ who still use narrative traditions of the long-form animation, but in this new, dominant medium. Self-trained animator Don Hertzfeldt urges that animators should be expanding their toolbox with new technologies and not subtracting at the same time (Wells, Hardstaff & Clifton 2008, 60). This refers to a tendency within the animation discipline for practitioners to use technological production tools and methods based on mainstream aesthetics, rather than exploring new methods with these new tools, informed by a longstanding animation history and, ultimately, expanding on animation’s artistic scope (Wells, Hardstaff & Clifton 2008).

In contextualising the current landscape of animation in relation to this study, this literature and contextual review assesses three key areas: (1) animation's history and the development of various forms and styles, particularly in relation to movement; (2) the influences of motion capture, the evolving technology and the impact of implementing motion capture into film productions, particularly for key participants; and (3) the area of cross-over between animation and motion capture, looking at the context of key films that have used motion capture as a method of character animation. In reviewing these areas, it is clear that technology such as motion capture enables the expanding nature of the animation discipline. More importantly, however, is that it requires the animation practitioner's inquisitive nature to push the artistic scope of the discipline.

2.1 ANIMATION

Animation History

Animation has a multitude of aesthetic forms developed from a long history of practitioner experimentation. These include, but are not limited to, 3D CG, 2D cell, stop motion and silhouette animation. Through a broader lens, animation is "the artificial creation of the illusion of movement in inanimate lines and forms" (Wells 1998, 10). Regarding film, animation must be broken down to its simplest state: the frame. For animation practice, "is it a film made by hand, frame-by-frame, providing an illusion of movement" (Wells 1998, 10). Wells' definitions are suitable for the discipline as they are unbiased towards any particular form. These forms each represent not only stylistically different aesthetic outcomes of animation but involve different production approaches in their development. Regardless of form, the character-based animator's goal has remained the same: to create an authentic and

believable performance, much in the same form as an actor on a stage. However, where the actor uses their body to perform, the animator breathes life into inanimate objects, creating movement through the manipulation of images (Hooks 2011). While similarities have been drawn between these two crafts—animator and actor—animation production remains a comparatively modern art form of storytelling.

While the history of animation practice stems from an artistic desire to visually represent stories, a pinnacle stage in its development was its rise to mainstream consumption during the mid-20th century, an era known as the 'Golden Age' of animation, and dominated by Walt Disney Studios (Williams 2009, 19). Since that time, digital technology has enabled a multitude of alternate animated mediums to emerge, with 3D CG as the current dominant form (Carter 2016). As Carter (2016, 36) states, "CG animation is something of a hybrid technique that uses key-frame and pose-to-pose methods of the 2D animator". Regardless of medium or technological influence, John Lasseter—former Disney-Pixar Chief Creative Officer and a driving force in the development of 3D CG animation—advocates the necessary understanding and incorporation of the traditional 2D animation principles to produce good 3D computer animation (Lasseter 1987). In discussing his first developed 3D animation, he states that "it was not the software that gave life to the characters, it was these principles of animation, these tricks of the trade that animators had developed over 50 years" (Lasseter 2001: 45). Lasseter alludes to the notion that the artist is the key determinant in their animated works, technological tools simple enable their production.

Traditional 'cel' was among the earliest methods of animation, where forms and figures were painted onto celluloid and then photographed (Wells 1998, 7). During this same period of the early 20th century, New York animation house Fleischer

Studios was responsible for the development of the Rotoscope (Bratt 2011). This device allowed animators to trace over live-action film footage frame-by-frame, which would capture all the subtleties of human movement and allow the animator to emulate them in their animations (Bratt 2011, 1). As Bratt (2011, 1) continues, "The innovation of the Rotoscope was the opportunity to study human movement within the medium of cel animation. Before this device was invented, animators would take great care to accumulate references for their shots. These references ranged from photographs and projected film footage to acting out the movements themselves in front of a mirror". This frame-by-frame motion analysis was a key method in the development of the 12 Principles of Animation. Mostly related to character motion, these principles were developed at Disney studios and taught to new animators "as if they were the rules of the trade" (Thomas & Johnston 1981, 45). Detailed in Thomas and Johnston's *Disney Animation: The Illusion of Life* (1981), these principles comprise:

1. Squash and Stretch: Giving weight and volume to a shape as it moves.
2. Anticipation: A motion which precedes a major action.
3. Staging: Presentation of an idea so it is clearly communicated.
4. Straight Ahead Action and Pose to Pose: Different methods of animation process, the former is likely to be more spontaneous and the later has a clear plan.
5. Follow Through and Overlapping Action: Nothing stops all at once, the main body will stop and the remainder will 'catch up'.
6. Slow In and Slow Out: Controlling the spacing of images to give an object the appearance of accelerating and decelerating.
7. Arcs: Adhering to naturalistic movements that travel through space along an arc.

8. Secondary Action: An additional, supplementary action used to reinforce and add dimension to the main action.
9. Timing: Adds meaning, interest and texture to movement.
10. Exaggeration: A caricature of character actions to emphasise and punctuate motion.
11. Solid Drawing: Drawings which appear to have form, weight and volume solidity.
12. Appeal: A charismatic representation of design and motion that appeals to the audience.

These principles have stood the test of time, being used by animation practitioners across an assortment of various forms, regardless of technological advances. Taught and examined worldwide, some have since proposed additional or replacement animation principles such as Walt Stanchfield's (2007) expanded 28 principles of animation. Ultimately, however, Disney's principles are the more widely accepted standards of animation practice in creating the illusion of life and are advocated by experienced animators like Richard Williams (2009, 20) who states, "the old knowledge applies to any style or approach to the medium no matter what the advances in technology". This affirms the importance of the principles and their continued use in all animated forms, particularly the now dominant 3D.

During the same period as Disney's principles were being established, Rudolf Laban—a dance artist and theorist—was instituting a notation system for human movement through expressionist dance, called 'Labanotation' and commonly known today as Laban Movement Analysis, or LMA (Bishko 2007). Leslie Bishko, an animation scholar and Laban Movement Analyst, favours the contemporary dance conceptual framework that (like the animation principles) observes, describes and

interprets the intentionality of movement. Bishko (2007, 27) believes the animation principles lack a key attribute, namely, "the link between how people move and what their movement communicates to others". Bishko (2007) uses LMA to critically address the authenticity and believability of cartoon-style animation and while it could be an applicable approach to analyse animated movement, practically speaking for animation practitioners, it is unlikely. It would be a disservice for a truly in-depth investigation dedicated to this topic as it would extensively broaden the scope of this research.

Animation Styles

The animation principles serve to create an illusion of movement and, moreover, an authentic and believable performance for story-driven character animation. Using these principles, practitioners have developed stylistic variations of animated movement. Two distinct examples are UPA's (United Productions of America) 'limited' animation and Disney's 'naturalistic' animation from the 1940s (Webster 2005, 132), where the former recycles frames, thereby reducing completely re-drawn frames. Even qualities of animated characters' timing can distinguish variations of cartoon animation or naturalism, both quite different approaches for an animator (Webster 2005, 6).

Before jumping into styles of animated movement, however, it is important to understand some of the classifications that practitioners have placed on animation as an art form. In the context of film, theorist and historian Maureen Furniss (2007), suggests that animation is more appropriately placed on a continuum with live-action, between 'abstraction' and 'mimesis', where one reproduces reality and the other suggests a concept instead of mimicking real life, respectively. Within animation, Paul

Wells (1998, 35) offers a potential model for theorising what he calls a "textual apparatus of different forms of animation". This encompasses three related forms of animation, which he tentatively labels 'orthodox', 'developmental' and 'experimental' (Wells, 1998). Wells suggests that the abstract short film *A Colour Box* (Lye 1935) lies at the experimental animation end of this apparatus and that more conventional, story-driven works, such as Disney's *Bambi* (Hand et al. 1946), lie at the orthodox animation end. Furniss and Wells' definitions of each encapsulate qualities of an animated production's final outcome, distinguishing itself as an art form.

Chris Webster's *Action Analysis for Animators* (2012) dives more specifically into classifying approaches to animated motion. First, there is 'simulation', which replicates naturalistic actions with a high degree of accuracy and what would be expected of animation within a live-action film such as the digital recreation of Grand Moff Tarkin in *Rogue One: A Star Wars Story* (Edwards 2016) once played by the late Peter Cushing. 'Representation' is another state that favours believability and passes for real in such cases where it cannot be proven with evidence such as the dragons in *How to Train Your Dragon* (Sanders & DeBlois 2010). Lastly, 'interpretation' is classified by an animator's personal expression, ranging from the completely abstract to well-known cartoon characters such as Daffy Duck and Bugs Bunny (Webster 2012, 32–34). Beyond these definitions, Webster continues by placing animated movement into a hierarchy titled "The Four A's of Animation: Activity, Action, Animation and Acting", each of which is a level to "identify the nature of movement from the simplest to the most complex" (Webster 2012, 35). Webster builds on Wells and Furniss's classifications for animation forms and its various artistic states; however, categorisation of this nature is still quite broad, particularly when considering the more mainstream states of character animation that studios have developed.

In relation to alternate animation styles, particularly for movement, some practitioners have made connections to film examples from particular studios. Leslie Bishko (2007) defines the broad range of animation styles as either Disney's 1930 'full animation' style, Warner Bros.'s 'cartoon animation' or Hanna-Barbera Productions' 'limited animation'. Christopher Carter (2016) builds on this further, referring to the 'Disney aesthetic' as naturalistic animation, conforming to the principles of animation. Another he identifies is the 'pushed cartoon' in reference to work from Sony Pictures Animation, such as *Cloudy with a Chance of Meatballs* (Lord & Miller 2009) and *Hotel Transylvania* (Tartakovsky 2012), both of which are derived from the Warner Bros. extreme cartoon style of motion (Carter 2016). Method Studios' animator, Tim Rudder (2015), refers to various styles of animation with 3D CG examples. These associations include 'realistic with motion capture' aligned with Caesar in *Dawn of the Planet of the Apes* (Reeves 2014), 'realistic without motion capture' exemplified by Rocket Raccoon in *Guardians of the Galaxy* (Gunn 2014), 'highly nuanced' with *How to Train Your Dragon* (DeBlois & Sanders 2010), 'Disney/Pixar' with *Frozen* (Buck & Lee 2013), 'cartoony' with *Rio 2* (Saldanha 2014), 'exaggerated cartoony' with *Cloudy With a Chance of Meatballs 2* (Cameron & Pearn 2013), 'limited animation' with *Teenage Mutant Ninja Turtles* (Middleton 2012–2017) and 'very limited animation' with *Pocoyo* (Carsi et al. 2005–2018) (Rudder 2015). With such a variety of terminology, it is difficult to clarify the 'cartoon-style' on which this research is focused, particularly in a practical sense. Fortunately, Leslie Bishko (2007) establishes a suitable circumvention through a categorical description wherein the animated movements adhere to the principles of animation and the intended depiction of characters within a dramatic context is believable. This provides a suitable lens in which this study views cartoon-style animation.

2.2 MOTION CAPTURE

Motion capture (or mocap) has a wide range of associated terminology, including ‘digital puppetry’, ‘virtual theatre’, ‘real-time animation’, ‘3D rotoscoping’ and ‘performance capture’ (or pecap) (Furniss 2007). In a technical capacity, mocap refers to the process of recording the position and orientation of a moving entity as computer-useable data that is then digitally mapped to CG objects. The most commonly captured objects include humans, non-human bodies, facial expressions and camera positions (Dyer, Martin & Zulauf 1995). This overall process typically involves the following: plan a capture shoot and setup of a capture space, record the movement/performance, clean up the recorded data, edit the data and map the data to the CG characters (Furniss 2007; Gleicher 2000, 2). For film productions, mocap is used to digitally record an actor’s performance from a pro-filmic event and then apply the actor’s captured movements to a CG character. The live-action visual effects (VFX) film *Avatar* (Cameron 2009) is often associated with this technology, which director James Cameron suggests empowers and enables actors (Motion Capture Society 2014). For animation practitioners, Weta animator Kevin Estey suggests that the technology “is a great additional tool to the already robust arsenal of tools that modern animators have at their disposal” (Animation College 2014). Modern mocap is an influential technology for film production and will continue to evolve to further enable its users.

If simply defined as ‘the capturing of motion’, then photography remains the earliest likeness to mocap, specifically, Eadweard Muybridge’s and Etienne-Jules Marey’s rudimentary photographic system (Brookman et al. 1981). In the development of modern mocap, rotoscoping represents a primitive form and ancestor, where motion is ‘captured’ by hand (Liverman 2004; Sturman 1999). Like the tools of animation production, mocap systems were developed independently, the most prominent of

which are currently optical and inertial-based systems. While definitions and terminology between such systems vary, they serve similar purposes, including not only the entertainment industries but also for medical purposes, specifically helping to analyse human movement (Liverman (2004, 2–3). Animation teacher and historian Tom Sito (2013, 222) suggests the context of the technology's use determines its categorisation. As such, for scientific purposes and understanding locomotion, the process would be 'mocap' and for theatrical productions it would be labelled as 'pecap'. This study focuses only on recording body movements to be applied in theatrical contexts because both terms are applicable. Ed Hooks, author of the *Acting for Animators* (2011), states in an interview that "[mocap and pecap] is an animator's medium to me and […] are heading us toward something that looks quite different than regular animation" (Animation World Network 2017). Hooks' statement echoes the values of this study, the belief that modern mocap, as an expansion of the animation discipline, provides not simply a means of recreating what we recognise from live-action, but perhaps something new, visually and creatively.

Motion Capture Participants

Modern mocap requires several roles to effectively process and implement the technology into a film production (Dagognet 1992). These roles include the director, the performer and the motion editor. The mocap director operates as a 'motion coordinator'; they understand how the performer's motions correlate with their mapped digital character and how they should interact within the virtual space (Liverman 2004; Menache 2011). The theatrical qualities of mocap allow actors to perform entire scenes in one take, without cuts. The technology maps the performance and allows the actor to become immersed in the role and to then see that performance

come to life in a digital character. The motion editor, usually an animator, 'cleans' and 'edits' the recorded movements by altering the timing and look of an animation file, and then "maps the motions to the animated characters" (Liverman 2004; Gleicher 2000, 2). The first two roles are typically associated with the capture stage of a mocap production, whereas the motion editor plays their role during post-capture.

While acting for the stage or the screen focuses on the actor's performance visually, mocap emphasises an actor's movements and how they are applied to a character in a virtual setting (Gomide 2013). As a purely theatrical experience, in the mocap setting, the actor must imagine their world entirely, down to their own props and costumes. Andy Serkis, a notable advocate of lessening the stigma associated with the technology, states that "It's nothing more than acting, pure acting. I think the perception is shifting" (Alexander 2017, para. 16). Workshops and specialty training courses, such as The Mocap Vaults (2019), have become a prominent resource for actors and focus on teaching the essential skills for working on mocap productions.

Although it is a relatively new medium for actors, mocap is presented as an unencumbered art form similar to theatre acting, only with the added benefit of unlimited casting choices (DeMott 2009). This is evident in *A Christmas Carol* (Zemeckis 2009), where Jim Carrey performs for several characters, including Scrooge and the three Christmas ghosts, and also in *The Polar Express* (Zemeckis 2004), where Tom Hanks performs the roles of the Hero Boy, the Hero Boy's father, the Conductor, the Hobo and Santa Claus. Speaking about his role in *A Christmas Carol* (Zemeckis 2009), Jim Carrey states "you can use everything you got […] it's like puppeteering in a way" (DeMott 2009).

The animator is an important part of the mocap production: they are unlikely to be redundant to the process of creating a digital performance. Charlie Bonifacio

states in an interview, "just as Disney animators only use rotoscope as a first draft of the animation, "mocap" works best when the captured material is interpreted by an animator with a trained eye who can reconnect those arbitrary points to emotional and physical meaning" (Besen, 2005). This is reiterated by director Brad Bird, who states "The best mocap I have seen has all been mucked with by animators. Much the same way the best rotoscope in Disney's time was mucked with. I'm not against Mo-Cap. But I think it has limitations if you don't mess with it" (The Animation Empire 2008). In a mocap production, an animator applies their understanding of motion through traditional animation methods to process the 'raw data' of the mocap performer and retarget the motions onto a digital character (Dyer, Martin & Zulauf 1995). Two methods can be used to process this data—destructive and non-destructive editing—either of which the animator applies at their discretion based on the intended style of movement (Liverman 2004). The more closely the raw, recorded motion aligns with the animator's vision before they begin processing it, the less involved the animator is likely to be. Liverman (2004) notes a common saying of 'garbage in, garbage out', which relates to the quality of the motion a performer provides for the animator. If the recorded movements are unsuitable, then the animator will apply more traditional animation methods to the digital performance.

Motion Capture Productions

Within the entertainment industries, the applications of mocap are as varied as the artists who apply it to their productions. For example, mocap easily assimilates into live-action VFX films aimed to complement photorealistic CG characters with realistic movement. Mocap is likewise used to animate hyper-realistic performances in video games. Dimensional Imaging founder Colin Urquhart suggests, "People see

how effective this technology is in movies and as a result want – or indeed expect – the same effect in a video game" (Batchelor 2016). Production houses, like The Third Floor, even specialise in pre/post-production visualisations that make use of mocap to accelerate their output. CG animations that have used mocap to animate their characters are yet another application of the technology and the focus area for this study.

Within the film category of CG mocap animations, outcomes range from attempts at realism, like the "Lucky 13" episode of *Love, Death & Robots* (Chen 2019; Miller 2019), to more stylised works such as *The Adventures of Tintin* (Spielberg 2011) and *Tarzan* (Kloss 2013). Applications of mocap to a level of stylisation similar to a Disney-Pixar film, like *Frozen* (Buck & Lee 2013), is something still yet to be explored and the focus of this study. Animation Mentor Co-Founder and senior animator at Industrial Light & Magic (ILM), Shawn Kelly (2008), states that "trying to push and pull Motion Capture around to turn it into something very stylised would be incredibly frustrating and time-consuming for any artist". Visual effects supervisor Alberto Menache explicitly advises against using mocap as a production method for cartoon-style animations, even referring to it as a "rule of thumb" (2011, 78). In giving a summary of potential mocap projects, Kelly (2008) speculates that if Pixar's hand-keyed animation *WALL-E* (Stanton 2008) had been motion captured, it would be an "ugly shadow...no matter how much an animator tried to augment the captured performances". He concludes that ultimately, the value of using mocap weighs upon the intended style of the project. Confronted with rising hybrid methods of production, 'purist' animators need to embrace the change no matter the circumstance; if characters are being brought to life, then the artist still holds sway over the tools they use (Kelly 2008). The most relevant, contextualising agents for this research, however, are

previous animated feature films that have used mocap to animate their CG characters. Assessing such films and ways in which cartoon-style movement could be achieved will contextualise this research.

2.3 MOTION CAPTURE ANIMATIONS

In assessing 3D CG mocap animation films, four types emerge. The first is seen in productions like *The Polar Express* (Zemeckis 2004) and *Beowulf* (Zemeckis 2007), where the director has sought to emulate a photorealistic world through both character form and movement. Referring to the character movement in *The Polar Express* (Zemeckis 2004), animation supervisor David Schaub (2005) commented that Zemeckis was adamant about keeping the mocap performances intact and that the film was not to be reinterpreted by animators, with a final result of 70–80% performance capture. The second type is seen in Gil Kenan's *Monster House* (2006), Steven Spielberg's *The Adventures of Tintin* (2011) and Disney's *Mars Needs Moms* (Wells 2011), which all used mocap during production, but where the final animations do not emulate realism. Visual effects supervisor Jay Redd stated that for *Monster House* (Kenan 2006), they purposefully created stylised characters with disproportionate body parts and that photorealistic details were disregarded (Bielik 2006). Additionally, animation supervisor Thomas Hofstedt indicated that key-frame animation brought the pecap footage to the next level and that animators were free to key-frame if they could create a performance that would work better in a scene (Creative Planet Network 2012). However, like *The Polar Express* (Zemeckis 2004), most of the film utilised mocap in the final production, with an estimated 75–90% of the body movement being mocap and 50–70% for the facial performances (Bielik 2006). *The Adventures of Tintin* (Spielberg 2011) represents a mocap animation production that almost entirely

dismisses the mocap, where 85% was animation and the remainder live-action according to the director (Lyttelton 2011). Spielberg desired a unique hybrid design of caricature and photorealism (Desowitz 2011). For *Mars Needs Moms* (2011), director Simon Wells stated, "I wanted to have a level of caricature that stepped you away from being completely real" (Murphy 2011). Another example in this second category is seen in the 3D CG animated TV series *Sid the Science Kid* (Finn 2008). This series used mocap suit augmentation where the performers would wear large prosthetics to emulate their digital counterparts' physical proportions (Figure 2). This series represents a unique hybrid animation combining puppeteers and animators through the Henson Digital Puppeteering System at Jim Henson Productions (Strike 2008). Using this production format, a puppeteer would animate the faces and the body would be mocap, all in real time (Seymour 2008). While standard post-capture procedures of motion editing were used for this production, it is one of the few industry-level examples of stylised mocap animation where the capture stage was a large emphasis in the production process. *Sid the Science Kid* (Finn 2008) and its production methods closely relate to this study.

Figure 2 - Misty Rosas (mocap suit), Sid (digital character) and Drew Massey (puppeteer)

The third mocap animation category alludes to the practice of mocap without using the technology directly to animate the CG characters. This is seen in DreamWorks Animation's *Rise of the Guardians* (Ramsey 2012), which was entirely animated; however, it reduced the cartoony aspect of character form and movement in place of more realistic qualities by using mocap as reference material in creating the characters' performances (Zahed 2012). The fourth and last CG mocap animation category is seen in the film *Rango* (Verbinski 2011), which used filmed acting as reference to animate its characters, emulating the intent of mocap. Johnny Depp comments on the production, stating "instead of motion capture, it's kind've 'emotion capture', using the actors as reference for the emotion of the animated character" (Pursuitist 2010).

The films discussed here, while dated, are widely accepted industry examples with commentary on their productions methods from industry and academic sources.

These older references are consistently used as examples in research materials relevant to this study. Contemporary examples such as *Tarzan* (Klooss 2013), Kochadaiiyaan (Ashwin 2014) and *Love, Death & Robots* (Miller 2019) suffer from limited research for the purposes of this study; however, they demonstrate a continuation of identified problems in the earlier references, despite improved mocap production technologies. These problems relate to their conveyed believability which is discussed further in the next section.

Even with the existence of stylised mocap animation productions, there is still a belief within the animation industry that mocap should not be used in productions with a stylised outcome. "Pixar have never been great fans of [mocap], preferring instead to let their animators use instincts to inform their art instead of raw data. The credits for 2007's Ratatouille proudly featured the claim '100% Pure Animation—No Motion Capture!'" (Gray 2014). While dated, the results of an industry survey on the perceptions of mocap versus traditional animation lean heavily towards favouring key-frame animation methods for animating cartoony/exaggerated movement (Izani et al. 2003). This research addresses this industry's perception and segregation of mocap as anything other than a production method for animating realistic movements.

Believability: Form and Movement

The two characteristics that determine the overall style and aesthetic of an animation are form and movement. As Gleicher (2000, 1) explains, "Animation is a uniquely expressive art form: it provides the creator with control over both the appearance and the movement of characters and objects. This gives artists tremendous freedom, which when well used can create works with tremendous impact". These two qualities—an animated character's design and their movement qualities—share a

unique relationship that can determine the overall believability of a character. This relationship has been noted by animation practitioners from an early stage. During studies of human movement at Disney Studios, animators noticed that when copying the realistic frame-by-frame movements from a live-action film onto the stylistic character designs, there was a breakdown in the illusion of life. As Thomas and Johnston (1981, 323) state, "there was a certain authority in the movement and a presence that came out of the whole action, but it was impossible to become emotionally involved with this eerie, shadowy creature who was never a real inhabitant of our fantasy world" and that "the actor's movements had to be reinterpreted in the world of our designs and shapes and forms". The relationship between character form and movement is directly linked to a character's believability.

Believability, in the context of mocap productions, is often associated with the 'Uncanny Valley Effect'. Originally, this effect was in reference to a person's emotional response to robot design and other non-human entities, visualised within a graph of familiarity against human likeness (Mori 1970). The graph in Figure 3 illustrates that a person's engagement with an entity increases the closer it appears to a realistic human, until a point just before a 'healthy person', where an opposite, distancing effect occurs. Mori (1970) observed that this effect is amplified when movement is added to the equation.

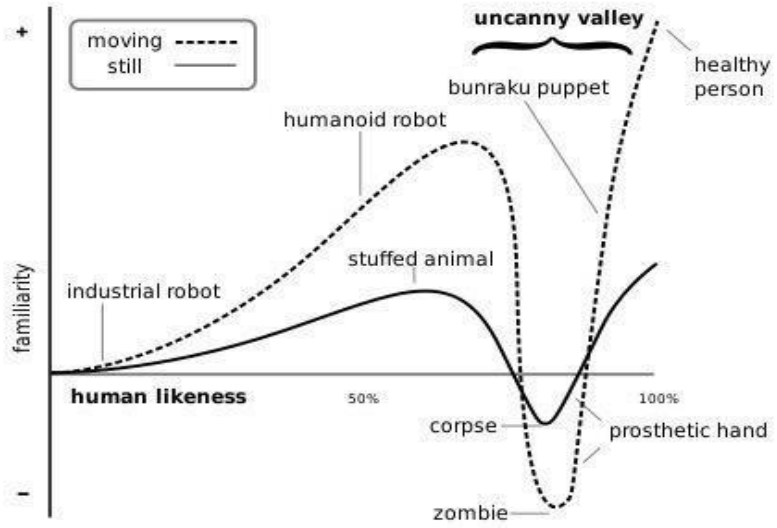

Figure 3 - Uncanny Valley Effect (Autodesk 2009, 9)

With this understanding, film productions that attempt hyper-realistic CG characters can fall into the uncanny valley. A fully realistic digital human is a goal for VFX filmmakers but, as Disney research scientist Dr Derek Bradley (2017) stated, "the trouble is no-one knows exactly what it is or how to fix it". Mocap is often a starting point for animating such characters, such as Caesar in *Dawn of the Planet of the Apes* (Reeves 2014) or entirely CG animations that attempt to emulate objective reality such as *A Christmas Carol* (Zemeckis 2009). While having used a realistic source of movement, these characters can still fall into the uncanny valley. This effect can also be seen in traditionally animated CG films such as Brad Bird's *The Incredibles* (2004). He states, "The character design was difficult … CGI looks plastic without detail, but beyond a certain point with the stylised deformed people, it starts to look creepy" (Butler & Joschko 2007). While this effect has been widely accepted, it fails to visually demonstrate the qualities of form and movement for 3D CG characters across a wide array of animation production methods, particularly for hybrid production methods that use mocap to animate stylised characters such as those seen in *The Adventures of Tintin* (Spielberg 2011) and *Tarzan* (Klooss 2013).

A suitable alternative in visualising and mapping CG characters' form and movement is Barbara Flueckiger's (2008) proposed 'model of distance' (Figure 4). This model allows "every feature of a digital character to be projected onto this matrix" (Flueckiger 2008, 43).

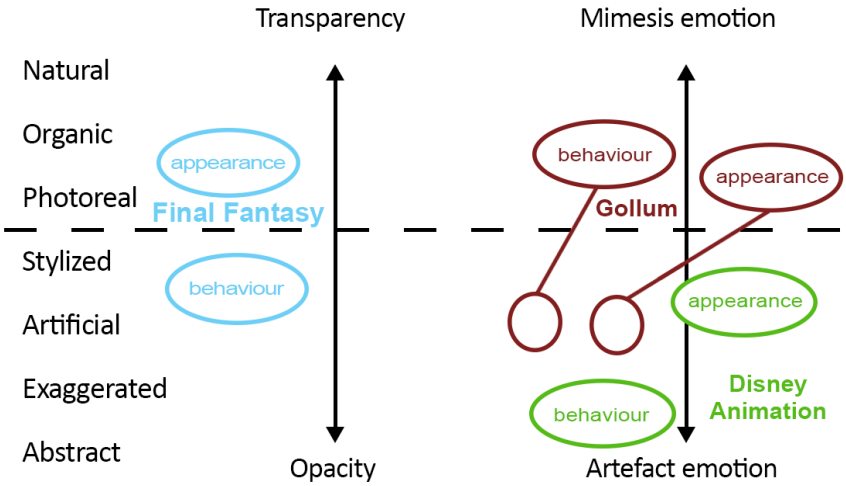

Figure 4 - Flueckiger's (2008) model of distance

The matrix ranges between the hypothetical, transparent forms of representation–showing an accurate depiction of reality–to opaque forms that accentuates a deviation from reality (Flueckiger 2008). Plotting both the appearance (character form) and behaviour (qualities of movement) of a digital character, Flueckiger explains the importance of character consistency and how a significant separation of either entity (in particular on either side of the 'essential line' between photorealism and stylisation) can result in an imbalanced character representation that becomes unfavourable with an audience. With reference to a plotted example, namely, *Final Fantasy* (Sakaguchi & Sakakibara 2001), Flueckiger (2008) states that the film's intentional photorealistic character design and motion captured movement demonstrates a characterisation failure, with a divided character appearance and behavioural representation on either side of the essential line. Butler and Joschko (2007) highlight this failure, stating the breakdown in the audience's empathetic

connection is evident in the film's critical reaction and commercial result. Flueckiger (2008) has also plotted generalised Disney stylisation of characters into exaggeration/abstraction for their behaviour and a stylised/artificial appearance, a culminated characterisation that emulates reality in an exaggerated manner, but still appeals to audiences. A cartoon-style outcome, which is the form of animation sought through this research, would appear in the same vicinity as Disney's animation: effectively an 'exaggerated' aesthetic engagement. While Flueckiger's model does not pinpoint the level of empathy an audience might have for a CG character, it does reinforce that character form and movement should be indicative of one another and, thereby, create a more believable characterisation. That is to say that a stylised character should move in a stylised manner and a realistic character in a realistic manner. The challenge remains in using mocap, which renders realistic movement qualities to achieve stylised movements, a result which has relied heavily upon the post-production animator.

Relevant Research

Literature that directly informs this research remains elusive. Four texts have been identified that provide instructional material for animators producing a mocap animation including Ricardo Tobon's *The Mocap Book: A Practical Guide to the Art of Motion Capture* (2010), Midori Kitagawa and Brian Windsor's *MoCap for Artists: Workflow and Techniques for Motion Capture* (2012), Matt Liverman's *The Animator's Motion Capture Guide: Organizing, Managing, and Editing* (2004) and Alberto Menache's *Understanding Motion Capture for Computer Animation* (2011). Only the last two give some indication towards achieving stylised movement in a mocap animation. The first two—Tobon's (2010) and Kitagawa and Windsor's (2012)

texts—are quite literal in providing technical direction for mocap productions, but lack in presenting methods or means of contribution an animator or performer might bring. Kitagawa and Windsor (2012, 167) invite some alternative mocap animation methods through 'puppetry capture', wherein a puppeteer controls an object much in the same way that an animator has complete influence over their character without the presence of another performer. This gives some credence to the notion of treating the mocap performer like a puppet as the potential for introducing the qualities of an animator into the mocap environment; however, this would need to be explored in a dedicated study.

Liverman (2004) and Menache (2011) are key informants of the presupposed nature of mocap, giving a direction of challenge in this study. Specifically, both have provided instructions in their texts that limit the opportunities for a stylised movement using mocap: given as a forewarning by Liverman and an outright dismissal by Menache. Liverman does not outright claim cartoon-like motion cannot be achieved but does suggest it might not be the best choice with mocap (2004, 22). He does introduce generic mocap production concepts that are transferrable to this research, including the importance of physicality, as he refers to Charlie Chaplin as a "good example of a live performer who uses his movements, action and reactions to brilliantly define his character's personality" (2004, 14). This gives some direction in the capture stage for imposing animated characters through a performer's physicality. Liverman does impose limitations, however, stating "It is possible to get a motion performer who can add more personality to your character, but they can only do so much as they're affected by the laws of physics" (2004, 30). During the post-capture phase, Liverman suggests that if quality data has been collected, then an animator should "animate the data as little as possible" (2004, 18). This notion can be applied

to this study also, reinforcing the importance of capturing animated movements to enable the animator. Relating directly to the animation principles, Liverman does advocate for keeping the animation principles in mind when animating a character, regardless of traditional animation or mocap but, most interestingly, he segregates the principles into three phases, 'preparation', 'capture' and 'post-capture', to indicate where a mocap animator might use them (2004, 12; 15–18). Menache (2011, 78) provides a stronger point of view than Liverman in the context of this research, as previously mentioned, labelling the premise of this study as a rule of thumb of what not to do. Like Liverman, Menache also separates out the animation principles, but instead has them labelled across: "cannot be accomplished with mocap", "natural to live performance" and "require work whether animated or performed" (2011, 81). Menache (2011) maintains that squash and stretch, anticipation beyond physical boundaries, follow-through beyond physical boundaries and exaggeration beyond physical boundaries cannot be accomplished with mocap, overlapping action, straight-ahead action, ease-in/ease-out, arcs and secondary motion are naturally occurring and, lastly, that the principles of timing, appeal and personality work whether traditionally animated or motion captured. While both texts provide useful insights into mocap production, they give little information for practitioners producing stylised mocap animations.

A thesis by Rafi Sengupta (2011) observed the production pipeline of a creative project that utilised mocap data to generate movement for stylised characters. While the study imposes a typical mocap animation pipeline, Sengupta made reference to attempting stylisation of movement during the capture or post-capture stages (Sengupta 2011). As such, the document resembles a similar method as *Monster House* (Kenan 2006). Another thesis by João Paiva (2014) takes a very similar premise to this

research in that it "explores the possibility of creating non-realistic animation through the use of motion capture" (2014, ii). However, it too, does not explore new processes of achieving cartoon-style movement through either the capture or post-capture stage. A Master's thesis by Kelly Christophers (2012, 67) successfully identifies the tensions of traditional animation as an 'artistic abstraction' and mocap as a 'mechanical transcription', but still places limitations on mocap for animations seeking movement beyond realism as did Menache (2011). As Christophers states, "Art in animation lies in the fact that characters exaggerate their movements, which is not successful when rotoscoped or motion captured" (Christophers 2012, 21). Unlike the previous two dissertations, Christophers' also has no practical component, limiting its relevance to this research.

A Pixar Animation Studios' paper titled "Stylizing Animation by Example" (Bénard et al. 2013) illustrates a "method for automatically inbetweening 2D painted key-frames based on 3D character animation" (2013, 9). This combined artistic and technological innovation provides a method for animators to expand their creativity, branching into visual stylisations of 2D. While the paper is referring to the visual texture style of the final outcome and not the character movement (as this research is), it offers a unique quality of placing the control of the outcome back into the hands of the artist. They are not limited by tools, but rather supported and encouraged to experiment. This is something that procedurally based solutions lack. The Pixar paper explicitly states, "Our goal is to create an example-based stylization method that supports a broad range of styles and provides artists with direct control over the result" (Bénard et al. 2013, 9). This method of enabling the artist to determine the style and not be dictated by the limitations of their production tools directly relates to the methods of this study.

A large portion of academic research can be found in stylising mocap data during the post-capture stage. Here, an animator can adapt and modify the realistic movements of a mocap performance, which as Menache (2011) states, would be more expensive than a traditional animation approach. The alternative is applying procedural methods of stylising mocap data through filters and algorithms to simulate cartoon movement. These algorithmic methods are typically devised as automatic applications of lacking animation qualities, such as squash and stretch. These motion editing tools can be useful in synthesising animated qualities in otherwise 'unanimated' mocap. *A Pose Space for Squash and Stretch Deformation* (Roberts & Mallett 2013) offers a mixed automated and artist-control character manipulation to imbue squash and stretch, which could be beneficial as a post-capture motion editing process. *Guided Time Warping for Motion Editing (*Hsu et al. 2007) employs automated time warping via an algorithm that can be used to refine motions, meet new timing constraints or modify intent of an action without affecting poses. This too, could be useful for post-capture motion editing for a cartoon-style aesthetic. *The Cartoon Animation Filter* (Wang et al. 2006) presents a post-capture motion filter algorithm that can simultaneously add the animation principles of exaggeration, anticipation, follow-through, and squash and stretch. *Adding Cartoon-Like Motion to Realistic Animations* (Ansara 2015) is a Master's thesis that proposes a post-capture algorithmic tool to add cartoon-like qualities to realistic mocap animations. *The Squash-and-Stretch Stylization for Character Motions* (Kwon & Lee 2012) and *Simulating Cartoon Style Animation* (Chenney et al. 2002) both present algorithmic methods that automatically enhance the squash and stretch for a given realistic motion, such as mocap data. *Motion Retiming by Using Bilateral Time Control Surfaces* (Yoo et al. 2015) presents an algorithm for re-timing character animations. *Motion Capture-*

assisted Animation: texturing and synthesis (Pullen & Bregler 2002) presents an interesting case of an inverse process whereby the key-framed animation is completed and then amended with mocap data to create nuanced movements. While not a representation of stylised movement, as they express that they are using the realistic movement of mocap to disrupt the roughly animated key-poses, it does represent an alteration of mocap from strictly realistic applications, enabling animators (to a degree) while utilising mocap. *Turning to the Masters: Motion Capturing Cartoons* (Bregler et al. 2002) is an appropriate paper to compare with this research as it demonstrates similar ideals through a new technique that can capture the motion style of cartoons and retarget the same style to a different domain such as a new medium. Bregler et al.'s (2002) paper embodies many of the qualities of this research, specifically, the use of cartoon-style movements from animated references as an informative base for applying a new animation context. Additionally, the paper includes a relatively simple diagram that illustrates similar ideals to Flueckiger's (2008) model of distance. As described by Bregler et al. (2002, 1), Figure 5 represents that "Animation has both a visual style and a motion style. Motion capture works within the green area of this figure. The pink area represents the realm of cartoon capture." Unfortunately, the authors' solution is primarily an algorithmic approach to an artistic area that transforms digitised cartoons into representations of cartoon motion.

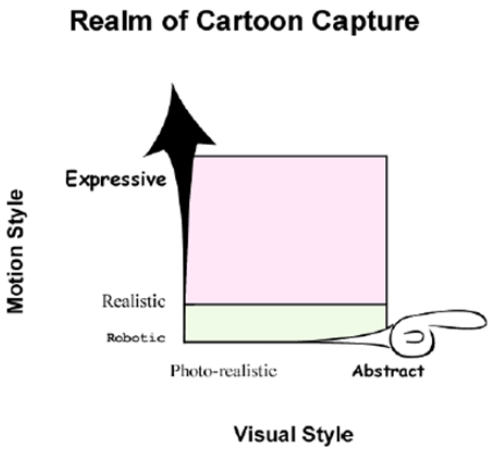

Figure 5 - 'Realm of Cartoon Capture' (Bregler et al. 2002, 1)

While animation is mediated by technology, it strongly remains as an art form. Joe Letteri, senior visual effects artist at Weta Digital concisely states "performance capture is not a mechanical process; it's still an artistic process" (Desowitz 2011). A pitfall in automated approaches to stylising mocap movement is that it takes artistic control away from the animator and can yield unexpected, unengaged performances without an animator's intuitive input. Senior animator Shawn Kelly advocates for mocap productions, but insists animators are a necessity in bringing any digital characters to life. He states that "no matter what, animators will always need to do some amount of reworking the mocap data, almost regardless of the intended style" (Kelly 2008).

In a mocap animation setting, the performer and animator share control over a character's movement. In consideration of a stylised, cartoon-motion outcome for a mocap animation, the shift of emphasis from post-capture to the capture stage represents a new perspective for this production. Ensuring animated qualities within the 'raw' mocap data from the performer's actions during capture enables a more fluid workflow for the animator in post-production. While there is ample research to inform the post-capture stage, there is limited research to inform the capture stage for stylising

movements of the actor. The most relevant literature relates to resources for actors and how they can best perform in a mocap production.

Acting for mocap is a specialised and very new area compared with theatrical acting. There are few dedicated texts to guide actors from a traditional stage acting background towards the even more specialised area of stylised movement for mocap. *Towards Stanislavski-based Principles for Motion Capture Acting in Animation and Computer Games* (Kade et al. 2014) discusses several topics related to adapting major acting techniques to mocap actor training. Through a series of interviews and questionnaires with mocap actors, directors and academic acting teachers, it concludes that while there are some technical and environmental differences, mocap acting might not be considered a separate style of acting (Kade et al. 2014). Generally, the mocap director desires a mocap performer who has good imagination, improvisational skills, is physically fit, can evoke emotion through their body and has some understanding of mocap. In supporting the mocap actor's new environment, a director should allow sufficient preparation for the actor's character, the scene they are playing, as well as their imagination preparation (Kade et al. 2014). Ultimately, the mocap performer need only bring their skill set to the mocap setting; it remains the director's responsibility to cast the optimal performer and "have a very clear vision of the performer's motion as filtered in the final character" (Menache 2011, 131). In the search for a performer suited to creating stylised movements in a mocap animation, the question of what qualities such a person would have remains unanswered but could reside in physically based acting.

Kitagawa and Windsor (2008, 131) undercut the actor's role in attaining cartoon-style movement in a mocap animation, stating "motion capture works great for human motion but people usually conserve motion and therefore do not have an

'animated' quality to their actions. Being able to change the motion data is one of the keys to getting what's wanted out of a performance" and "motion capture, at its best, is a tool for animators to build on". With this understanding, mocap is reliant upon post-production procedures to fix any lack of stylised motion in the recorded performance. This also shifts attention away from the capture stage and undercuts the notion of an actor performing with animated qualities. While the premise of Kitagawa and Windsor's (2008) argument is to empower the animator in a mocap production, the actor's contributions in providing animated qualities to their actions are downplayed.

Actors and Acting in Motion Capture (Pizzo 2016b) is a paper that explores the impact of mocap for performers, but it is not extensive. Pizzo (2016b) identifies the two alternate mocap performances between a life-like character for a live-action VFX film and a 'cartoonish' image such as Andy Serkis' Captain Haddock character in *The Adventures of Tintin* (Spielberg 2011). While Pizzo (2016b) does give a slight reference towards uses of a mocap performance in a different setting from the shoot environment with alternate pace of the movements or the length increased, he makes no mention of applications beyond performing for characters in objectively realistic mocap animations. In an interview (Pizzo 2016a), mocap director John Dower provides some excellent insights in working with performers in a mocap production that can translate to this research. He advocates that the "What matters in motion capture is physicality" and that "motion capture actors […] need to understand how their physicality, their gestures, and their whole body communicate[s], otherwise […] the actors become rigid" (Pizzo 2016a, para. 8; 18). Dower continues, explaining the importance of movement training for a mocap production, stating, "an actor cannot be successful in this area without having some theatrical training in the movement" and

"so, in motion capture, it is good that the actors have […] training that helps them to understand their own type of physicality and how it communicates to the public" (Pizzo 2016a, para. 18). Beyond simply instructing the mocap performer, Dower also stresses the importance of the animator and the actor working closely together in a mocap production. He states, "The actors must understand the animators" because "the animator sees the actor as a kind of puppet, and the actor must agree to be. But if the actor manages to make the animator understand what he needs to make that puppet better, then the result will be extraordinary" (Pizzo 2016a, para. 19). Dower demonstrates a clear understanding for the importance that the capture stage and the actor provide for expanding the potential of mocap as a tool for animation production beyond more realistic applications.

Considering more physically based acting art forms, such as mime, could provide a unique perspective in this research as it invites an alternative approach to mocap animation much in the same way as puppetry capture. Online blogs by Chantelle May (2017) and movement director Asha Jennings-Grant (2017) both mention physicality and general research preparation ahead of the capture stage, but are quite limited in terms of explicit methods of stylised movement for mocap performance. Corporeal mime presents similar qualities to animation and animated movement and could provide more explicit methods of stylised movement for mocap. Corporeal mime teacher Thomas Leabhart (2007, 81) describes the nature of a corporeal mime artist's movement, stating it is a "combination of three elements - trajectory of the movement; its speed, and its weight" and that "the corporeal mime constantly negotiates these difficulties, plays with these variable weights and resistances". Leabhart's (2007) description of mime resonates with animated movement that seeks to demonstrate believability through the illusion of movement,

whether realistic or highly stylised. While not the focus of this research, a dedicated study of stylised movement for mocap using mime practises could provide an additional dimension to this study through future research.

2.4 SUMMARY

Based on current literature and contextualising agents detailed in this chapter, it is evident that mocap remains an unexplored tool and method for cartoon-style movement. The methods of mocap animation are reliant upon the animator and it is evident that the capture stage of such productions does not facilitate the animator, particularly for stylised outcomes. Mocap will continue to provide a strong platform for live-action VFX films to animate realistic performances and movements for hyper-realistic characters. However, unexplored methods of mocap animation stunt potential growth for the discipline, which is becoming rapidly more accessible for smaller animation studios. Butler and Joschko (2007) express that we should not shun technical advancement in 3D animation but, instead, have consideration for aesthetic engagement and allow audiences the opportunity to use their imagination and generate emotional interactions with characters. This literature review serves as the contextual framework in which this study resides, detailing its position within the contemporary landscape of animated productions seeking a cartoon-style movement aesthetic and using mocap as a production tool.

Chapter 3: Methodology and Methods

3.1 METHODOLOGY

This study was a practice-led, qualitative research enquiry investigating stylised movement in 3D CG mocap animation. According to Carole Gray (1996, 1), practice-led research is initiated in and carried out through creative practice. Gray explains that this form of research is "validated 'naturalistic inquiry', which places the researcher firmly within the research process, often as participant" (1996, 4). Placing myself firmly within the mocap animation research process as a practitioner, my participation validates a naturalistic enquiry. By initiating and carrying out the research through a participatory role, the various projects exponentially initiated and developed the research practice. This aligns with Gray's epistemological stance whereby "the practitioner is the researcher; from this informed perspective, they identify researchable problems raised in practice, and respond through practice" (Gray 1996, 13). Through mocap animation production experimentation, this practice-led enquiry initiates questions, problems and challenges to continuously progress and evolve the research as a whole.

Defined by the Australian Bureau of Statistics (1998), one of the four types of Research and Experimental Development (R&D) includes 'strategic-basic research'. This type "is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of practical discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems" (Australian Bureau of Statistics 1998). This study assumes the role of strategic-basic research as it poses theoretical solutions to practical problems of

creating cartoon-style movement with mocap and is carried out through experimentation in an animation production context to provide new knowledge to the animation discipline. Enquiries through practical application stand as a firm approach for—and important part of—research within the field of animation (Furniss 2007). Expanding on this notion of animation practice as research, Paul Wells and Johnny Hardstaff (2008, 22) state "the creation of critically engaged material outcomes (animations) is part of the research necessary to inform provocative and developmental projects". The digital outcomes of this study serve as documented proof of practical applications of the outset research enquiry and provoke analysis through post-practice examination.

Just as Gray (1996, 13) describes, the practitioner within practice-led research has a multifaceted role, including research material generator, participant in the creative process, self-observer and more. Some of these roles include practises used in other methodologies. For this study, one such methodology is action research and the practice of self-observation by reflection-in-action and reflection-on-action, which is particularly applicable for collaborative projects (Gray 1996; Schön 1984). Valsa Koshy defines action research as "an enquiry, undertaken with rigour and understanding so as to constantly refine practice; the emerging evidence-based outcomes will then contribute to the researching practitioner's continuing professional development" (Koshy 2005, 2). Based on this understanding, the emergent evidence-based outcomes of this study continued my professional development as an animator. Like practice-led enquiries, action research is participatory in nature; Stephen Kemmis and Robin McTaggart take this further and re-label the methodology as 'participatory action research' (Koshy 2005). The Kemmis-McTaggart 'Action Plan Research Model' illustrated in Figure 6 is a visual representation of their reflective-based

research. Such a participatory action research model was applied to this study, with consistent reiteration and refinement through cycles of practice. This process of refinement was kept in check with reflective documentation throughout, providing a structured approach to this practice-led study alongside critical reflection and analysis. Each cycle of practice, indeed, even each digital outcome of this study, followed the Kemmis–McTaggart research model, which includes planning, taking action, making observations while acting and then reflecting on the outcomes before implementing newly acquired knowledge into the following cycle (McTaggart & Kemmis 1988). This iterative loop reaffirms the methodology and research output, providing evidence while informing the research project.

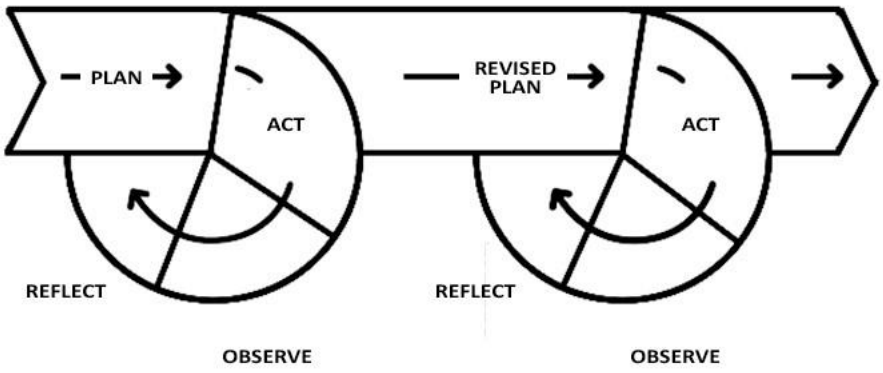

Figure 6 - Action Plan Research Model (McTaggart & Kemmis 1988)

Donald Schön's (1984) definitions of reflection-in-action and reflection-on-action were used during each practice cycle of this study. The former is a 'thinking on the spot' approach, continuously re-assessing the practice as it takes place, whereas the latter views the project in its entirety and draws conclusions from the combined results (Schön 1984). Reflecting-in-action during the production stages of the various animation mocap experiments meant re-assessing practical techniques and solutions being implemented, whereas reflection-on-action was implemented at the conclusion of each project and practice cycle while looking back retrospectively. While the

participants of this study, in particular the mocap performers, provided a perspective in their participation, the content and subject of reflection derived from my observations as a researcher and not the performers. Both forms of reflection were necessary to inform my actions and acquire new understanding of cartoon-style movement for 3D CG animations using mocap.

3.2 METHODS

3D CG Motion Capture Animation Production Environment

With a practice-led, action research methodology, this study included four cycles of practice and comprised six collaborative projects, resulting in a collection of digital outcomes including finalised 3D CG animations and documented experiments, which are detailed in Chapter 1.4. The methods of data collection and analysis for this study were consistent with a 3D CG animation production environment using mocap. The primary areas of this environment include the 'capture' and 'post-capture' stages (Liverman 2004, 15). For the purposes of this study, these two areas have been mapped to 'production' and 'post-production', respectively, which is consistent with industry practice for a mocap animation.

This study specifically focused on human, bipedal character animation. Additionally, an 18 camera s250e OptiTrack mocap system was primarily used with a 9x9 meter space (or mocap volume); excluding the VIMMA project, which took place at the LUME Media Centre at Aalto University, Helsinki, and used an alternate mocap system. Using these systems, body capture was the sole focus of this study, removing any technology requirements for facial capture. The native OptiTrack software, 'Motive', was also used while recording the performers. While industry standard software was used throughout this research, this study did not rely on any specific

software program and maintained a software-agnostic approach. Additionally, the primary 3D CG bipedal character rigs used during experiments were sourced through publicly accessible online channels. Any specific software or character rigs used in this study are identified throughout this exegesis.

Research Roles and Participants

Depending on the needs of the production, I was deployed where necessary to facilitate the production environment and adopted multiple roles as a practice-led researcher. While I am not a director, my knowledge and skills as an animator limited this study to directing movement style rather than focusing on emotive-based acting. As such, directing performers in the capture space resembled Matt Liverman's (2004, 16) definition of the role being a 'motion coordinator'. Additionally, using my animation background, I manipulated, edited and enhanced recorded movements as a motion editor during post-capture. These roles broadly cover the 'action' stage of each cycle of practice. This research maintained collaborative industry practises of animation by incorporating participants such as 3D CG modellers and riggers, puppeteers, dancers, mocap technicians, producers, musicians, actors and movement specialists. The mocap performers of this study were selected based on their physical skills or aptitude to perform but were not the primary focus of this study. The involvement of these specialist and generalist practitioners provided necessary data for this study.

Data Collection

Data collection throughout this study was multifaceted as it required documentation of practical processes and consistent reflection-in-action and

reflection-on-action to align with the adopted action research model. A literal approach was adopted, whereby the ‘plan’, ‘act’, ‘observe’ and ‘reflect’ portions of each cycle of practice were all documented extensively. From these documentations and reflections, the necessary information was extrapolated out and reconstructed as a critical investigation. This detailed account of what occurred and multi-pass approach of reflection enabled me to oversee all cycles of practice in retrospect and a seamless reflection-on-action during write-up.

The two predominant areas of the data collection can be sorted into the capture stage and post-capture stages of the four practice cycles. Reflection-in-action and reflection-on-action were enabled through both stages, allowing many opportunities where, as the practitioner, the experiments could be considered and adapted to improve as they occurred. Documenting the capture and post-capture stages of this study through these methods provided a comprehensive discussion based in practical experimentation. Both were critical for the digital outcomes of this study, demonstrating the practical application of mocap data and documentation of its collection.

The capture stage data collection involved:

- Video recorded mocap sessions, providing evidence and documentation of the mocap performers’ movements and actions, as well as the informal interactions between me and the mocap performers in the form of questions, suggestions and open discussions.
- Journal notes and written reflective statements on the observed discussions and events taking place.

- The data of the mocap performers recorded movements and actions via the native OptiTrack software (Motive) to apply to 3D CG characters during post-capture.

The post-capture stage data collection involved:

- Journal notes and written reflective statements on the raw form of the applied mocap data to 3D CG characters as well as notations of any manipulation of movements and actions as a motion editor.
- Video recorded interviews with mocap performers to reiterate and expand on their capture stage.
- Journal notes and written reflective statements through the digital outcomes, which took the form of side-by-side comparative videos.

Animation Resources

Various experiments in this study included the use of animated resources, both as reference for mocap performers during the capture stage and to include in digital outcomes. To remain relevant and accessible to practitioners, popular animation texts, manuals and resources were used. Richard Williams' *The Animator's Survival Kit* (2009) and Steve Roberts *Character Animation in 3D* (2004) are two such texts that provided consistent reference material in the form of animated videos and detailed frame-by-frame breakdowns of various actions and gestures, derived from Disney's 12 Principles of Animation. While both texts are informed by the 12 Principles of Animation, they are focused on animated movements and actions such as the 'double-bounce walk' and the 'cartoon take' and variations for animating such actions. Rather than being explicit exemplars of individual animation principles, both texts incorporate applications of the principles through specific scenarios and movements. For this

study, the mocap performers were tasked with emulating or simply observing the actions from these sources, which provided a consistent standard of animated, cartoon-style movement. Additional examples sourced from animated films and clips, such as *Toy Story* (Lasseter 1995) and *Road Runner* cartoons (Avery 1930–1969), were also utilised. Specific animation resources are indicated throughout this exegesis.

Analysis of Digital Outcomes

The digital outcomes provided comprehensive proof of documentation and application of this study's experiments; however, they were not at the point of completion. Analysing selected outcomes for their animated qualities through digital annotations gave additional rigour to this research. Based on Webster's (2012) 'Action Analysis' method of motion deconstruction, digital frame-by-frame annotations were implemented using the online collaborative media review website, SyncSketch. Appendix Items 5–7 incorporate the analysed digital outcomes. These outcomes are side-by-side, video comparisons of conducted experiments and include any combination of the following:

- Visuals (video or still-image) of an expressed animation idea or action.
- The video-recorded mocap session with the relevant experiment.
- Mocap data applied to a 3D CG character.
- Edited mocap data applied to a 3D CG character.

The details of each digital outcome and their analysis are detailed in Chapter 6. When reviewing SyncSketch items, a 'how to' guide is provided in the Appendix with brief instructions on navigating the website.

Selected criteria were used as part of the evaluation strategy during analysis. The stipulated 'animated qualities' are denoted as movements that demonstrate the

characteristics of Disney's 12 Principles of Animation as defined in Thomas and Johnston's *The Illusion of Life: Disney Animation* (1981). The terms 'style', 'stylistic' and 'stylisation' are used during this evaluation as pre-defined boundaries associated with animated movement. This refers to use of the animation principles in such a way that the animation outcome is a notable manipulation of emphasis over particular principles, whether through minimal use, maximum application or complete dismissal. This terminology is cohesively used alongside a point of reference in the form of an animated film. For example, 'classic 2D Disney style' would be in reference to Ferguson and Hee's *Pinocchio* (1940) and similar Golden Age Disney animation films. Refer to 'Animation Styles' in Chapter 2 for details on 'cartoon-style' in relation to this study. The criteria in analysing the digital outcomes vary slightly, depending on the intent of the experiment, but are all detailed in Chapter 6.

3.3 ETHICAL CONSIDERATIONS

Video documentation and creative contributions of this study's participants were given due consideration before beginning any collaborative projects. All participants provided written informed consent for their work, acknowledging their contribution served the purposes of this study and would not be taken out of context for any undisclosed ventures, whether financial or for alternate research. Mocap performers' physical participation during capture sessions was given particular attention. They were consulted on their levels of comfort throughout all productions so as not to risk stress, strain or injury while attempting difficult physical manoeuvres.

Chapter 4: Informing Motion Capture Animation Productions

This chapter addresses the first three cycles of practice, which collectively inform the fourth cycle, which is detailed in Chapter 5. These three cycles provide knowledge and understanding of mocap practises, the exploratory areas of a mocap animation and the role of the performer in the capture space. Each cycle presents actioned experiments, discussions of what took place and how each cycle informs the next.

4.1 BENCHMARK PRACTICES FOR MOTION CAPTURE ANIMATION

The first cycle of practice in this chapter addresses industry methods for a mocap animation and some experimental avenues of the technology through three projects. The *Powers Above* project acts as a benchmark for simply using mocap in a 3D CG animation, with no particular focus on animated movement. The second project (VIMMA) invited experimentation in the capture stage, specifically having mocap performers act for unorthodox creatures. The third project produced an abstract 3D CG animation for QUT's 2015 Robotronica event and experimented in the capture stage by introducing theatrical traits with a circus performer. Through these three projects, this inductive cycle of practice demonstrated the mocap production method groundwork necessary for the following practice cycles.

Project 1 | Powers Above

The *Powers Above* animation (see Appendix Item 1) was developed as a student- and research-based collaboration, utilising the mocap facilities at QUT,

Brisbane. The project was focused on assessing the overall mocap animation production process as well as beginning to look at character movement stylisation. The final outcome resembles a mix of semi-realistic and stylised design qualities and was not fixed on particular character stylisation through form or movement at this point in the research. Through the roles of a director and mocap technician, this project aimed to apply standard production methods of a 3D CG mocap animation. Throughout this project, these standard practices were questioned for their validity. By embedding experimental enquiry throughout the production, further areas of investigation presented themselves for proceeding practice cycles. The results were screened at the Logan Art Gallery in 2016 (Animation Fixation). Appendix Item 2 shows a behind-the-scenes documentation of the production practices, including story development, character design, capture session and post-capture stage.

The scope of this project was tied to a small number of artists (four) and a 12-week timeline; as such, both story and characters were placed under restrictions to allow completion while keeping within the boundaries of this study. The story was developed from an interest in visualising an epic sci-fi world of an unimagined space-based adventure, during which we follow an officer tracking down a troll-like convict in a space station. Figure 7 shows a portion of the set environment with an uncomplicated design, contextualising the story.

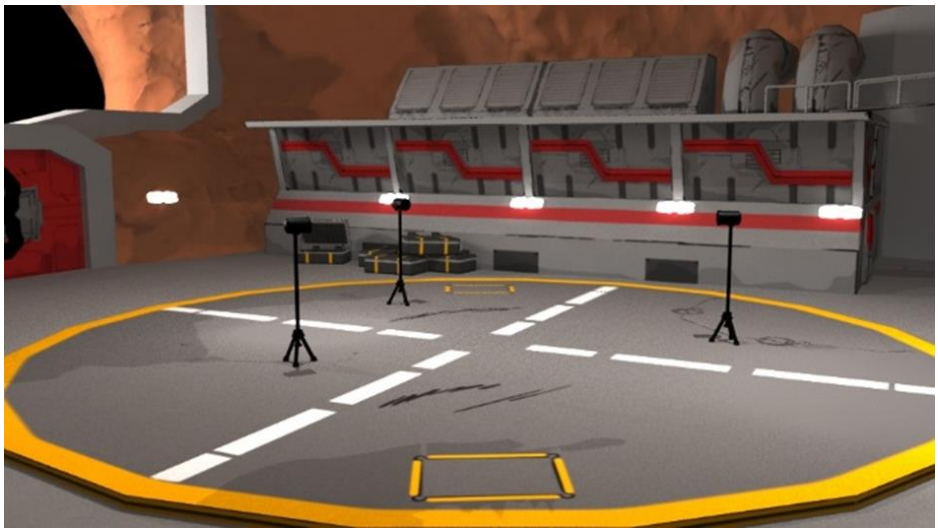

Figure 7 - Screenshot of *Powers Above* environment

Figure 8 - *Powers Above* characters: officer (left) and cyber-troll (right)

Figure 8 above shows the final design of the two 3D characters. Both were restricted to bi-pedal, human structures and designed without facial characteristics to keep the project scope small and ensure consistent body-only mocap throughout the study. The devised story produced a motion list recorded with mocap, seen in Figure 9. The project's artists were also utilised as the mocap performers for this production, who were directed through the devised motion list. The recorded movements were live-streamed from Motive to Autodesk's MotionBuilder and applied onto the

designed characters; this allowed all production members to see the characters animated in real time.

Figure 9 - *Powers Above* mocap recording session

During capture, the performers' movements were adjusted through their postures and gestures to embody characteristics I felt would suit the designed characters. The project's performers had no acting experience but did have backgrounds in animation, found to be a useful attribute when discussing animated qualities of weight while recording their actions. Mocap production texts are quick to establish that a mocap performer and their digital character counterpart require comparatively similar physiques for ideal mocap production results (Windsor & Kitagawa 2008, 32). As such, the disproportionate heights and lengths of the digital characters' to the performers', within this project, was a small obstacle. During capture, these disproportionate characteristics required the performers to make adjustments such as how far bent-over they were to allow for the cyber-troll's longer arms to touch the ground. The artists became quickly aware of this fact and accounted for it by integrating adjustments into their movements.

Having recorded the necessary movements, the raw data were processed with standard post-capture motion editing procedures using MotionBuilder. As seen in Figure 10, recorded mocap data were applied onto the *Powers Above* characters and

then refined, corrected and added to using the software's motion editing tools extensively. Generic motion filters, such as 'key reducing', were implemented to remove unnecessary animation or smooth-out movements. Destructive motion editing was used to remove large portions of movements and non-destructive editing through layered animation rebuilt or tweaked actions throughout.

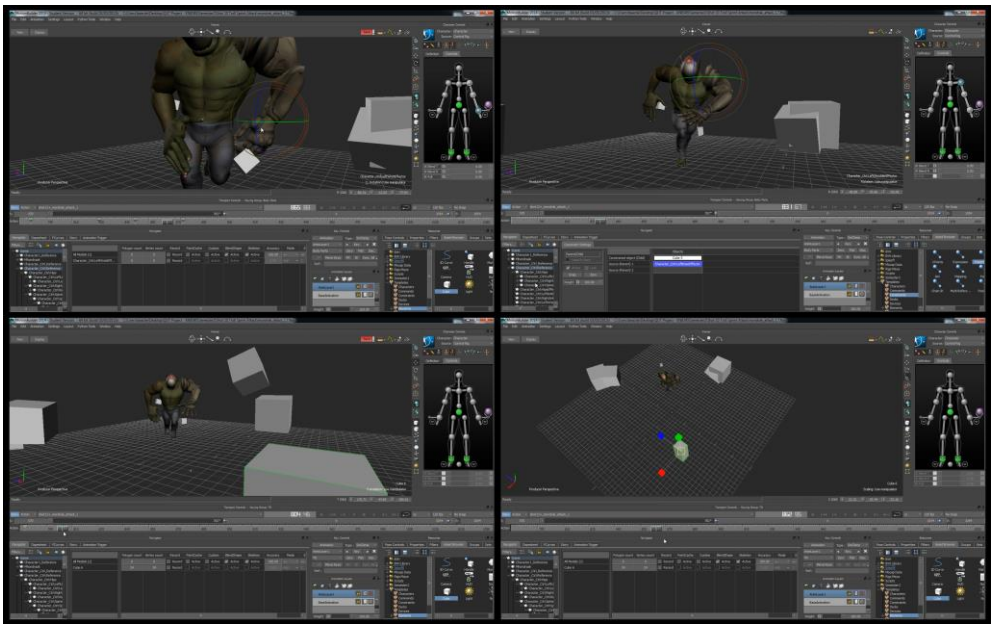

Figure 10 - *Powers Above* post-capture motion editing

The standard post-capture motion editing methods were found to be cumbersome and unintuitive, particularly for an animator who prefers the fluidity to adapt key-frames freely. Working between a combination of realistic frame-by-frame mocap movements and my own additional key-frames was complex and interfered with my adaptive instincts as a character animator. It was evident that to achieve a quality animated result, large portions of the original mocap data needed to be removed; the result shows a hybrid semi-realistic movement aesthetic in the final animation, seen in Appendix Item 1.

Project 1 | Results

As a 3D CG mocap animation that used standard production methods, the pitfalls as outlined in mocap texts such as Liverman's (2004) and Menache's (2011) were found in the affirmative. Specifically, the use of non-actor mocap performers resulted in minimal performance qualities and, as such, required moderate to heavy motion editing during post-capture. It was thought that directing with an understanding and background in animation would have compensated well enough for a trained performer, particularly considering the outcome was entirely 3D CG animation. While the perspective of multiple animator's during the capture stage was beneficial for discussions of movement quality and production process, this was a poor substitute for a trained performer. The post-capture motion editing stage was, as stated, a cumbersome approach, which ran against the traditional animation mindset. If the recorded movements did not satisfy the animator or simply did not have the required actions, then a traditional key-framing approach was implemented to meet the animation's motion list requirements. The disproportionate performer to digital character characteristics did not have a noticeable impact during post-capture due to the performers' adjustments during capture. Appendix Item 1 shows the final *Powers Above* animation that demonstrates some qualities of stylised, traditionally animated movement combined with 'mocap-animated' realistic movement but, overall, adheres to a standard mocap animation production.

Project 2 | VIMMA

The VIMMA project was a 2014 international research collaboration based in the Media Centre Lume at Aalto University in Helsinki that "develop[ed] and generate[d] genuinely new user-centred concepts and production solutions for mixed

reality, virtual and sensor-based performance in live productions" (Roihankorpi 2014a, para. 1). This project's experimentations investigated the psycho-physical cooperation that allows two or more performers to drive or puppeteer an individual virtual entity in live performance capture (Roihankorpi 2014b). Relating to this study, the project demonstrated experimental, unorthodox practices of mocap, specifically during the capture stage. As a director, mocap technician and 3D artist, I devised methods of having mocap performers animate various non-human character types such as a horse and a squid. Appendix Item 3 shows the digital outcome for this project as a behind-the-scenes video showing the production environment.

During the project, performers, including a mime/puppeteer and a theatrical dancer, were mapped to 3D CG entities and instructed to move around the large capture volume, looking at the projector screen for live-streamed feedback. The entities included a simple cube, a squid creature and a horse, which two performers had to manipulate simultaneously in an attempt to construct appropriate movement qualities for each. Examples of this can be seen in Figure 11. There was no post-capture motion editing for this project as the emphasis was solely placed on the capture stage.

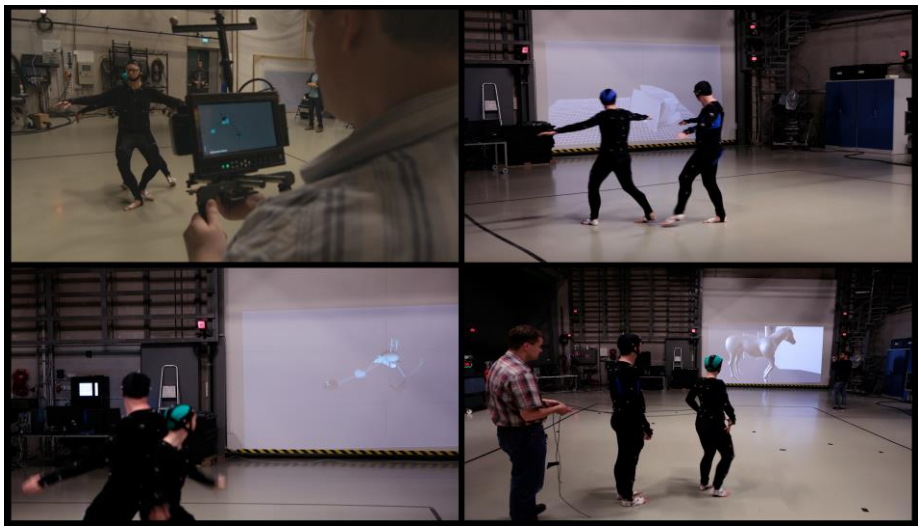

Figure 11 - VIMMA project mocap sessions

During this project's capture sessions, I directed the performers for their unconventional characters, the most notable being the squid and horse characters. For the squid movements, the performers were placed back-to-back, their arms acting as the squid's tentacles, creating fluid, dynamic gestures together in the mocap volume, aiming for a squid propelling through the water. The horse proved more difficult to create movements for as the performers' legs and torsos were mapped to the digital character and also needed to maintain a specific distance from one another, so the digital horse did not appear to stretch or compress half-way along its spine. Natural movements were devised based on their design (see a horse, act like a horse) to maintain Flueckiger's (2008) model of distance. However, devising even natural movements for these uniquely mapped human-to-non-human structures proved challenging, let alone stylising them further. This project did not provide room to examine movement beyond natural. Disproportionate character relationships—established in the previous project, where the performer does not anatomically align with their digital avatar—were not an impeding factor in the outcome of this project as the performers quickly became familiar with their non-human digital counterparts. This project's experimentations of multiple performers puppeteering a single creature with mocap resembled a traditional Chinese dragon dance and, overall, demonstrated some engaging characterisations, which could be the subject of future research.

A small experiment during this project included a variation of puppetry capture. This involved mapping a 3D sphere to a performer's hand, which the performer would then animate. Some stylised animation was introduced here in the form of varying the ball's properties, particularly weight. This proved effective as an exercise with the performer as it demonstrated a direct correlation of performer action to digital ball movement. A useful experiment in performer preparation included

demonstrating the boundaries of their digital character where the performer stood a standard t-pose and I traced the geometric edges of the digital character around their t-posed body. This gave a direct digital-to-physical correlation for the performer to remember. It was evident with these two experiments, that the more clearly a performer could distinguish how their body related to the virtual world, the more easily they could follow directions for devising a specific movement. The large projector screen also helped facilitate this, as it was an excellent live feedback of visualisations for all participants.

Project 2 | Results

This project investigated some experimental and unorthodox mocap production practices within the capture stage, seen in Appendix Item 3 as a behind-the-scenes video. The performers puppeteering their digital characters proved to be an engaging method of mocap animation. However, this experimental method would require extensive refinement to achieve a production-ready scenario. The performer would need to understand how to control an anatomically different character or object from themselves and the director to know how to coordinate their movements accordingly. While a puppeteer was one of the performers of this project, there were contextual differences in that here they were animating themselves rather than manipulating an inanimate object. As such, unlike the physical feedback of a real puppet, the mocap performers would be limited to visual feedback. This area is reserved for future research to investigate various character-type applications as the present study is limited to bipedal, humanoid characters.

Project 3 | Robotronica

The Robotronica project was the production of a 3D CG mocap animation based on a theatrical performance. This project introduced a circus performer in the capture stage and experimented with expressive, abstract forms of performance. Circus artist Marianna Joslin and violinist Richard Grantham were motion captured performing a routine. During this project, I facilitated Marianna as a director, worked as mocap technician and processed the recorded performance in post-production. The performance was processed with standard post-capture motion editing procedures for the final digital outcome and screened at the QUT 2015 Robotronica event's closing performance as presented in Appendix Item 4.

The capture stage was a large focus of this project as it invited complete experimentation for performance-based outcomes. Marianna's skills as a circus artist encouraged exploration of theatrical movement from ground-based performance through to aerial-based work. In addition, a large projector screen enabled Marianna to see her digital character—a simple 3D human—to consider and refine the final performance as seen in Figure 12. Musicians from the Robotronica event orchestra, DeepBlue, gave thematic resonance during the mocap session, specifically violinist Richard Grantham who played alongside Marianna's performance. Music had a noteworthy impact in providing rhythmic cues for various movements throughout the performance.

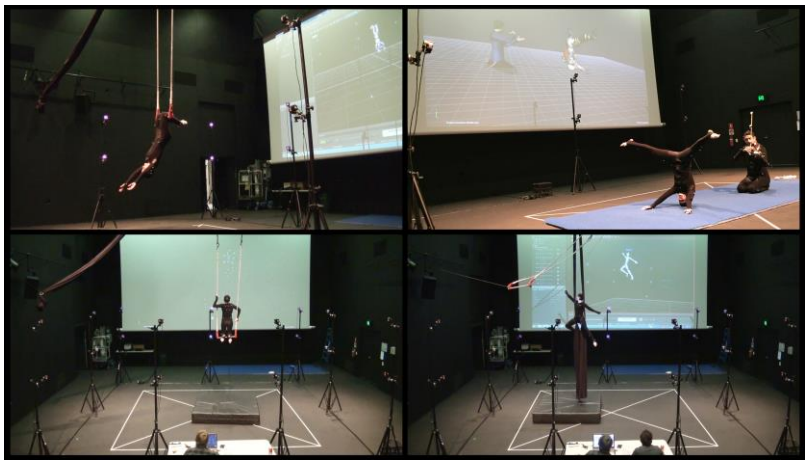

Figure 12 - Marianna practising trapeze, silks and ground-based mocap performances

During the capture session, Marianna performed with a trapeze, silks and a tumble mat as seen in Figure 12. The use of these props, particularly the silks, had an impact on the recorded movements due to occlusion (hiding of markers from the cameras). As such, Marianna had to adjust her movements to allow the system to record her performance. The placement of the mocap suit markers also impacted the performer. These caught on the silks or tore off with a forceful impact, making more strenuous manoeuvres difficult. The less-intrusive tumble mat provided a portable safety surface and gave a noticeable springy step when used.

The post-capture motion editing stage included the removal of outlier key-frames, the application of filters to smooth out gestures and movements and, lastly, some slight alterations of timing. These editing practices did not differ from the approach used during the *Powers Above* project.

Project 3 | Results

This project demonstrated some limitations of a particular mocap system but mostly invited a continuation of expressive movement in a mocap animation production. While again this project did not focus on stylisation of movement, the qualities of circus and theatrical performance were a noteworthy contribution to this

study, particularly with the inclusion of props such as a trapeze and silks. Although this project's production did not differ in process from the *Powers Above* project, the expanded application of and experimentation with mocap as a production tool directly aligns with the purposes of this study.

Discussion

The first practice cycle opened the discussion of mocap animation productions. Standard mocap production practices and experimentations of character movement set the stage for the proceeding practice cycles of this study. This cycle did not explicitly seek to explore stylised movement; however, it established an important precedent and contributes to the first two aims of this study. First, through a typical production approach for a 3D CG mocap animation, the pitfalls and conditions practitioners encounter have been identified and examined. Second, the capture and post-capture stages have been preliminarily investigated to assess the conditions of achieving cartoon-style movement.

During the *Powers Above* and VIMMA projects; the type of mocap performer used was a factor in the outcome of the movement and performance. This is an identified condition in standard mocap texts such as Liverman's (2004, 180), where he states that 'character motion performers' "should have an understanding of movement, timing and body expression", ideally being someone with an acting background. An understanding of animation—as was thought during the *Powers Above* project—was a poor substitute for a trained performer. The use of a puppeteer during the VIMMA project identified a unique production method that ties back to *Sid the Science Kid* (Finn 2008) mentioned in Chapter 2. This was also identified with Marianna during the Robotronica project, where her physical control over her movements and gestures

indicates a propensity to stylised movement; this will be further explored in the next practice cycle.

During the *Powers Above* and Robotronica projects, the unintuitive and complex nature of motion editing was identified during post-production. Again, standard mocap production texts for animators, such as Windsor and Kitagawa (2008), have detailed instructions for working with massive amount of key-frame mocap data. While applying such instructions did not highlight new information, it did solidify the premise of this study and placed emphasis on the capture stage to facilitate the animator during post-capture editing. Attempting to create stylised movement during post-capture while editing realistic mocap data proved to be ineffective. The post-capture motion editing practices and manipulation of mocap data will be a key area of exploration in the next practice cycle.

A condition found during this cycle of practice was the synergistic relationship between the performer and their digital character, specifically enabling the performer to understand how their movements correspond with those of their digital counterpart. Exercises related to puppetry capture were of surprising benefit in this area, showing a performer how their body can manipulate a single object or become immersed inside an entire digital entity. Directing a performer to digitally puppeteer a non-humanoid character with mocap proved too extensive to investigate further, but would be an engaging and complimentary area of research to this study. The standard optical mocap suit was found to be slightly restrictive for some performers of this cycle, particularly when they required a certain level of flexibility. The performer's movements were adjusted to combat this where it occurred. With a performer being comfortable in their mocap surroundings, the emphasis of stylised movement is directed to the motion coordinator, which will be explored in the next practice cycle.

During this cycle, three elements of the capture environment impacted the performer's immersion. First, a large performer-visible project screen enabled live feedback. Second, the tumble mat prop was a physical enhancement for the performer, giving their steps a bouncy quality. Third, music played during capture gave a notable experience, providing a rhythm to the performer's movements. Further research is required to properly examine the use of props and music as elements that impact the performer during capture.

Summary

This cycle of practice aimed to examine the standard production pipeline of a contemporary mocap animation while introducing some experimentation as part of a validation inquiry. Methods of capture and post-capture as described in mocap production texts, such as Menache (2011) and Liverman (2004), were successfully applied. While producing three digital outcomes in this cycle, the capture stages within all projects were identified as determining points of the mocap animations regarding how much of an impact would occur during post-capture for the animator. Relating to the first research objective detailed in Chapter 1.3, the pitfalls of a standard mocap animation production have been identified; principally, it is the over-reliance on post-production practices to remedy capture stage errors. Regarding the secondary research question, a variation of puppetry capture was identified as a new movement aesthetic opportunity to be explored through future research. The next practice cycle will benefit from the knowledge acquired from the *Powers Above*, VIMMA and Robotronica projects, with each contributing a valuable component in understanding industry-practised methods for mocap animations. Areas to be explored during the next cycle include immersing the performer in the recording experience to enable stylised

movement and the impact of specifically coordinating a performer's movements with animated gestures.

4.2 ANIMATED ACTIONS WITH MOTION CAPTURE

The second cycle of practice of this chapter directly explores a process of creating 3D CG cartoon-style movement with mocap through the production of several, short animated sequences. The process is primarily focused on the capture stage, working with a performer to achieve a cartoon-style movement aesthetic and identifying the impact for the animator during post-production. Standard post-capture motion editing was implemented to achieve the 3D CG animated characters seen in the Appendix Item 5 digital outcomes. The digital outcomes of this cycle are comparative videos that show animation reference footage, video documentation from the mocap recording session, an unprocessed version of the applied mocap data onto the 3D character and a motion-edited version. Carry-over elements of the previous practice cycle include creating an immersive recording experience for the performer and coordinating their movements but with an emphasis of animated qualities. This cycle attempts to directly address the key research question and, in doing so, identify challenges to overcome.

This practice cycle included a single collaboration with circus performer Marianna Joslin, who was directed through nine experiments, specifically recording a series of animated actions derived from *The Animator's Survival Kit* (Williams 2009) and *Character Animation in 3D* (Roberts 2004), with mocap. The chosen actions included a fist smash, heavy lift sequence and six variations of walks: depressed, angry, happy, tip-toe, sneak and double-bounce. These animated actions were processed with standard motion editing in Autodesk's MotionBuilder and Maya, where the data were applied to a stylised 3D CG character: the Stewart rig from

Animation Mentor. The post-production process varied for each experiment, but primarily involved destructive and non-destructive editing techniques to remove outliers in the datasets, make breakdown positions smoother, remove ground and body collisions and adjust pacing. The resultant animations for each action sequence aimed to be a close resemblance to the animation reference. Each action provides an opportunity to demonstrate animated qualities such as overlapping action, arcs, anticipation and convincing weight and, more specifically, cartoon-style movement as defined by Bishko (2007). As stated in Chapter 3 (Methods), the digital outcomes of this practice cycle's experiments are evaluated in Chapter 6.

Experiment 1

The first experiment of this collaboration was carried out by showing Marianna an example of the sequence seen in Figure 13. I provided some preliminary verbal explanations of animation principles and techniques. It was thought that a method of capture would be to fully immerse the performer in recording an animated action by giving them control. The performer was directed to recreate the walk based on her interpretation, with no breakdown or explanation of approach. This evolved into an attempted demonstration of the action to the performer and then directing the performer to attempt to match each drawn frame of the sequence. This proved far too complex to complete.

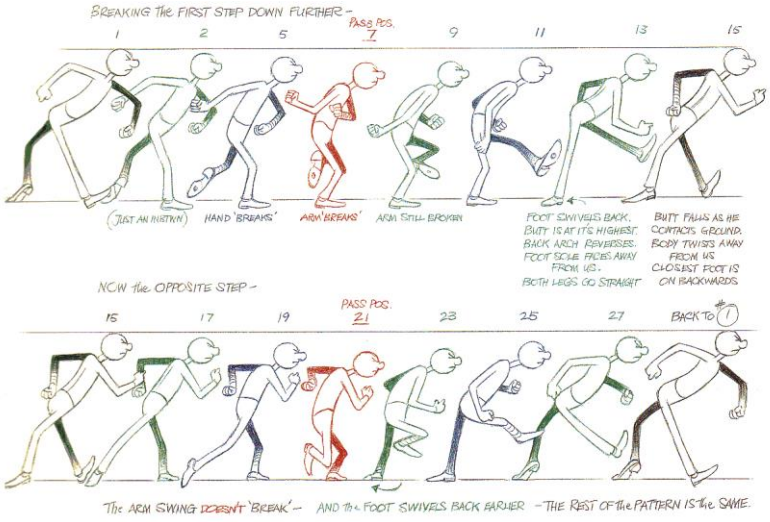

Figure 13 - Broken angry walk (Williams 2009, 126)

The physically demanding nature of the action itself, as well as the method I had taken, resulted in incomplete attempts of the sequence. Matching the drawn poses took an almost puppeteering approach to position the performer and worked for individual poses; however, when the performer was directed to combine the poses together at-speed, all detail was lost. The frame-by-frame breakdown of the action also had many contradictory gestures happening at once, with some physically impossible poses such as the angle of the pelvis or a reverse-bent knee. Attempted recordings for this action were not remotely close to resembling the reference footage and took a significant portion of time to even attempt. The complicated nature of this animated action implies similarly complex and performer-inept actions would require an alternative method with mocap.

Experiment 2

A simple fist smash action was chosen as the second experiment. This action focused on the animated technique of 'breaking the joint' by leading with the elbow, as seen in Figure 14, thereby showing arcs and curves. While the image indicates the use of a table, mocap marker occlusion was a concern while recording, resulting in the

action being performed in the air. After showing the animation reference, the performer was directed through the action with suggestions of keeping loose, allowing joints to succumb to gravity and the momentum of other joints, as well as my own demonstrations of the action.

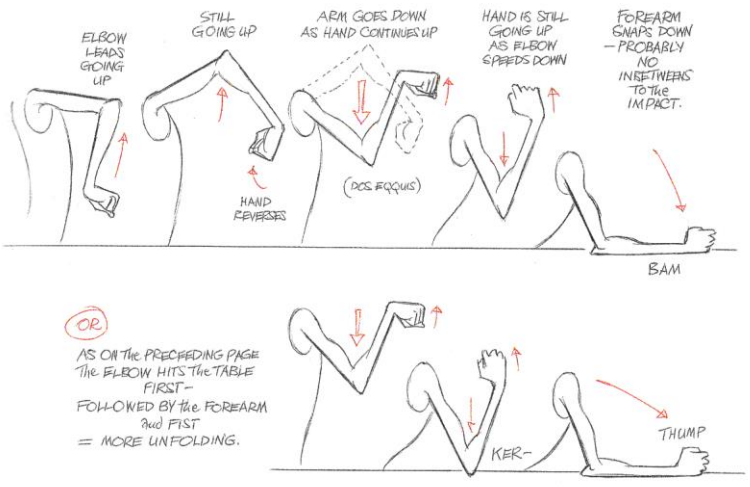

Figure 14 - Fist smash (Williams 2009, 237)

The raw mocap data were processed with standard motion editing methods (Appendix Item 5 @ frames 1477−1643). While processing the animation, the focus remained on 'leading with the elbow' to emphasise the fluidity of the action. Minor timing alterations were made to the extreme poses to help emphasise the power of the gesture. The data were easily processed in post-production, which was thought to be due to the specifically directed action given to the performer alongside an animation reference of the intended outcome. Compared with the previous experiment, the specificity of intent behind the fist smash action had a positive impact on the outcome.

Experiment 3

Following the idea of 'intent', the third experiment chosen was a character attempting to lift a heavy object as seen in Figure 15. This action involved a character-type (determined/curious character), a goal (lift object) and an obstacle (heavy object)

to assist with immersing the performer in the animated characteristics. During the capture, this approach brought more enthusiasm and focus from the performer, particularly compared with the first experiment, which was directed through a series of instructional poses. In addition to having a goal-driven action, the performer was also directed to mime the heavy characteristics of the object, using an actual light box during the mocap. This was intended to give more focus on movement rather than relying on real-world physics. A physical demonstration proceeded, showing the animation reference, including animated qualities of exaggerated motion, staging, concave and convex spine movements and the line of action concept. Through demonstrating the action, I aimed to help emphasise the intent from which Marianna could draw understanding and inspiration, which proved effective.

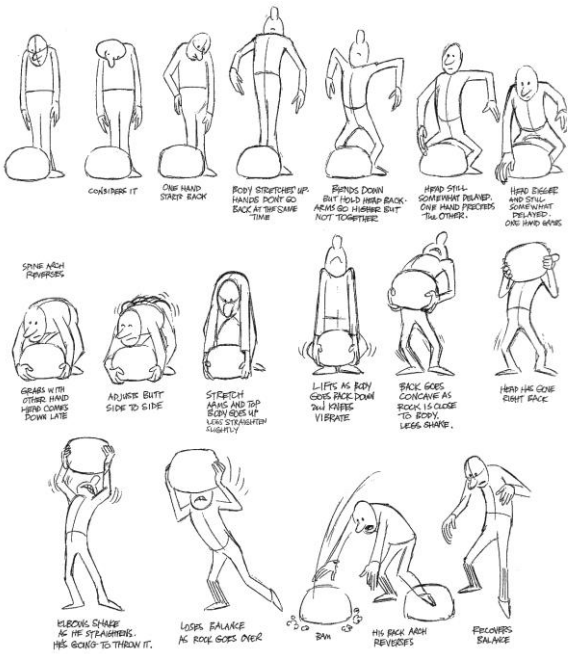

Figure 15 - Lifting a heavy object (Williams 2009, 267)

Two standard methods of processing the heavy-lift action were tested during post-production: a layered animation approach and destructive editing. Manipulating the action with the layered approach proved difficult. Creating animated movement by adding layers on top of the raw mocap data implies the original data would already

contain most of the intended animated qualities and places a strong emphasis on the capture stage; this was not the case for this action. The destructive editing approach removes large portions of the original data to be replaced with new key-frames. This approach was far more effective and the results (Appendix Item 5 @ frames 1034–1314) show that an action with more animated qualities was achieved. During this process, parts where the character was doing very little or repeating an action (like a balk) were removed; this emphasised the character's intent in the final result, ensuring the goal-driven nature of the action.

Experiment 4

In keeping with character motivation during the capture stage, the walks chosen for the remaining experiments of this cycle all derived from emotionally inspired ideas. This was intended to immerse the performer to create overt animated movements. A depressed walk was the first of these, during which the performer was directed to drag their feet, loosen their body and have large overlapping gestures with each step, which were performed well. The performer was assisted by a slow musical rhythm provided by a violinist during capture. The performer did not completely portray the animation reference (Figure 16) but added their own interpretation to the walk.

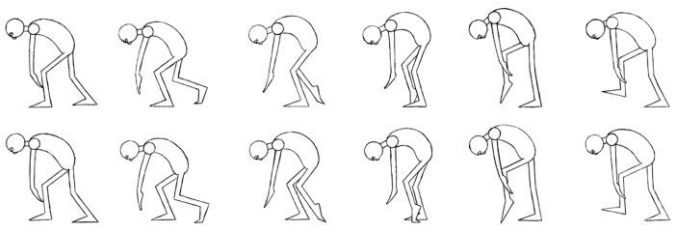

Figure 16 - Depressed walk (Roberts 2004, 111)

During the post-production, destructive motion editing was used, which meant removing outlier key-frames not suited to the intended action. The spine and neck were

curved for a more exaggerated pose and the arms and clavicles were positioned to dangle prominently, like pendulums. The legs and feet were reworked to have more flop with each step, which took the longest amount of processing time. The results of this walk can be seen in Appendix Item 5 @ frames 1−253.

Experiment 5

The angry walk used animation reference material (Figure 17) to depict a character stomping with a rigid upper body, which the performer was directed to emulate during capture. As a method of introducing the form of the walk, I suggested transitioning from a normal walk and gradually building in the angry characteristics. The main difficulty was demonstrating a strong, forceful line of action as opposed to focusing on a specific limb gesture.

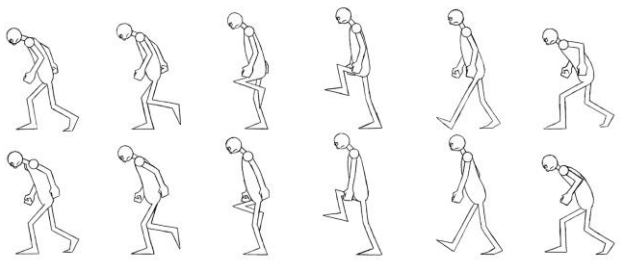

Figure 17 - Angry walk (Roberts 2004, 111)

Post-production motion editing of this action mostly involved destructive editing for anomalies such as ground intersection and jerky movements. Modifications included removing any major follow-through on the body (based on naturally occurring movements) in favour of a locked upper body with each step, as well as minimising arm-bounce. Appendix Item 5 @ frames 254−443 shows the results of this experiment.

Experiment 6

For the happy walk, the performer's own demeanour lent very well to this experiment. The performer felt engaged and comfortable as it exemplified an obvious emotion that resonated with her personality. The action (Figure 18) embraced follow-through and overlapping animation qualities. The mocap system setup did not allow enough space for the performer to have broader actions in their arm swings—something only seen momentarily in the last strides of the walk (Appendix Item 5 @ frames 444–623). In processing the mocap data, destructive editing was the main approach while keeping as much to the original data as necessary to maintain the large amount of character nuances. During the 2–3 hour post-production processing, a slight double-bounce quality was also noted in the data.

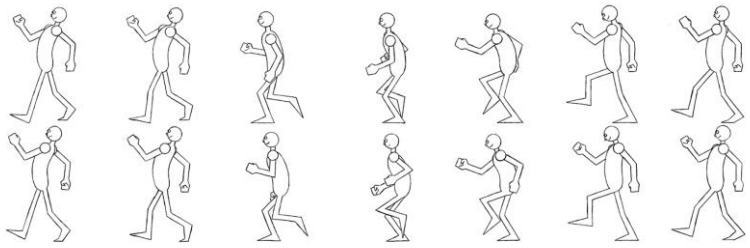

Figure 18 - Happy walk (Roberts 2004, 111)

Experiment 7

The tip-toe walk proved to be a relatively simple task for the performer to record. The results seen in Appendix Item 5 @ frames 624–795 show a walk that resembles any number of stylised cartoon characters based on the animation reference in Figure 19. The performer was assisted during the capture session with a tip-toe-inspired rhythm from a violinist.

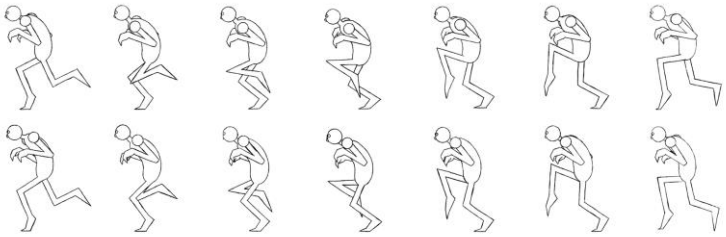

Figure 19 - Tip-toe walk (Roberts 2004, 112)

During standard motion editing processes, issues of ground intersection required fixing due to the toe-rise of the performer not being recorded and based on the chosen marker configuration. The character's light steps and stiff upper body were maintained and strengthened during post as well. The bend of the upper body was exaggerated slightly to amplify the overall nature of the walk.

Experiment 8

While having the same character intent as the tip-toe walk, the sneak walk had a completely different execution for both capture and post-capture. Of the walk-related experiments of this cycle, this proved the most difficult for the performer (although still achievable with practise). During capture, the performer found the action was difficult to sustain based on the reference material (Figure 20). This was due to an overly complicated explanation and demonstration given to the performer.

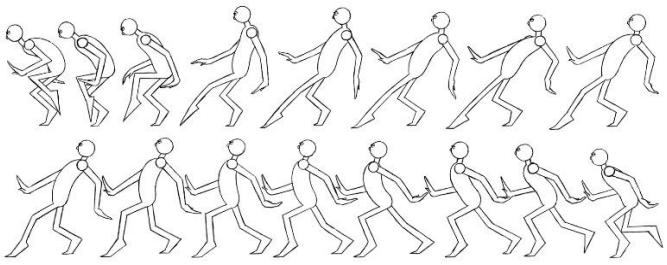

Figure 20 - Sneak walk (Roberts 2004, 112)

A 1–2 hour standard motion editing process, using mostly destructive editing, resulted in the digital outcome seen in Appendix Item 5 @ frames 796−1033. This

process included mass deletion of feet placement key-frames to ensure the character's feet appear to be locked on each step, whereas the remainder of the body's key-frames were mostly untouched. The edited walk is indicative of the animation reference, with an over-exaggerated movement and long, smooth strides on the balls of the feet.

Experiment 9

The double-bounce walk was the final experiment for this practice cycle and used the reference material seen in Figure 21. This action had a similar approach to the happy walk, where the performer brought a happy demeanour to their mocap recorded attempts. To attain the double-bounce effect of the walk, the performer skipped but without leaving the ground. An appropriate double-bounce rhythm was played while recording, informing the performer's pace.

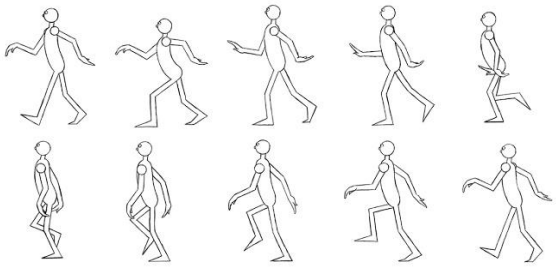

Figure 21 - Double-bounce walk (Roberts 2004, 113)

Through standard post-production motion editing, follow-through on the arm swings and a slightly greater bounce for the body were added to amplify the overall double-bounce effect. A tumbling mat, supplied by the performer, provided a slight spring and softness to the walk. Appendix Item 5 @ frames 1315−1476 shows the results of this walk.

Discussion

The second cycle of practice for this study examined a process of achieving cartoon-style movement in a typical mocap animation production. The capture stage was investigated specifically in an attempt to create cartoon-style movements with the performer and, if so, whether this would have a positive impact for the animator during post-production. During capture, actions were derived from animation texts such as *The Animator's Survival Kit* (Williams 2009). Standard post-production motion editing processed the recorded 'animated mocap' of the performer to demonstrate the movements applied to a stylised, non-realistic character. The digital outcomes (Appendix Item 5) demonstrate cartoon-style movement achieved using this production method and are evaluated in Chapter 6. This discussion serves to reflect upon the identified challenges of this practice cycle and how these challenges were overcome.

Prior to conducting this cycle's experiments, the performer was encouraged to familiarise herself in this production setting as this was a first-time experience with mocap. Maximising comfort was important to facilitate the performer's ability to conduct the experiments well. This included having a live-streamed view of the performer mapped onto the native 3D CG Motive avatar seen in Figure 22. This was an important contributory element identified from the previous cycle of practice and doing so helped the performer to consider her gestures and refine how she moved.

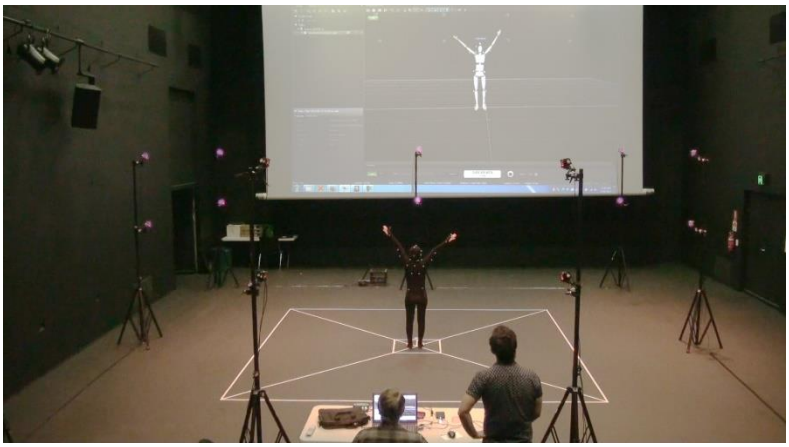

Figure 22 - Marianna testing her 3D CG avatar

The performer's immersion, in so far as their ability to easily and effectively create a cartoon-style movement based on the conditions of the capture environment, was an important production strategy of this cycle. Several factors came into play:

- The first was the performer's emotional state and personality, which determined how easily an action was to complete. This was evident with the happy walk that the performer was notably comfortable performing and resulted in an authentic and believable movement.
- The second was the intent of an action, something with a goal-driven nature. For example, a high level of immersion was apparent during the heavy-lift experiment, where a goal (lift object) and obstacle (heavy) created a drive for the character and thus motivated an energetic reaction.
- The third was the production-set elements of props, specifically the gymnastic tumbling mat, which was a safety feature left-over from the Robotronica project. It helped with certain walks to give a cushioning ground or elastic platform to have bouncier strides as well as a relief tool for the performer from impacting the hard ground. Props, such as the tumbling mat, could give the performer an advantage in attaining

stylised movement. However, a proper examination of this theory would require research beyond the scope of this study.

- The fourth was the use of music. DeepBlue violinist, Richard Grantham, provided off-the-cuff, spontaneous pieces of music played alongside some experiments. These were found to inform the performer's action choices through rhythm. While noteworthy, the extent to which music impacts a performer's ability to create stylised movement as an independent variable is outside the scope of this study and requires future research.
- The fifth was the projector screen used to review recorded actions, a benefit for all participants. The performer, however, found some difficulty in correlating her own movements to her digital counterpart's, which was commented as an in-between state of a mirror and a film. This tension came about due to her reliance upon what she felt physically when performing and not what was visibly transferred on the screen. While not executed, a suggestion of seeing a live-streamed character application would have been beneficial, rather than relying on the native 3D CG Motive avatar.
- The last was how each type of walk was introduced to the performer. Marianna was directed to build up to the intended action gradually by slowly incorporating elements and transitioning from a normal walk; this did not apply well to all walks but did provide a unique transition to understand animated movement qualities from the performer's perspective.

Marianna was able to achieve all the required actions with a relative cartoon-style aesthetic; the learning curve of this process, however, was reduced by immersive elements during the capture stage. These methods of immersion are investigated further in proceeding practice cycles.

While untested during this cycle, an alternate capture method would be having the performer purposefully recording their actions slowly. This would allow the animator to massage the performance to a certain movement aesthetic in post-production by adding stretch to a pose and manipulating the time of an action by making it faster or slower. Using such a method could take advantage of time-manipulative motion editing algorithms as mentioned in Chapter 2 (Literature Review). This would require testing the performer's capabilities during the capture stage, including how quickly they are able to move or hold a specific pose.

As part of the strategy of facilitating the performer to create cartoon-style movements, animation instructional materials were largely used. The use of frame-by-frame or pose-by-pose breakdowns of actions from *The Animator's Survival Kit* (Williams 2009) and *Character Animation in 3D* (Roberts 2004) were very helpful as they provided guides from which the motion coordinator/director could facilitate the performer and showed the performer what to emulate and strive for. These included still images and 2D animated videos that presented moving exemplars of the various actions. In addition to these resources, explanations of the animation principles and techniques within these actions and demonstrations of the actions themselves made them easier for Marianna to understand and achieve. My experience as an animator enabled this production method as it allowed a clear, direct and instructive nature to the capture stage. For complex actions, having a detailed breakdown in fact resulted in confusion for the performer. This was seen in the first experiment—a broken angry

walk—which failed due to the over-use of instructional posing. The performer focused on the movement of separate body parts rather than the action as a whole. However, this experiment did identify the idea of a pose-to-pose capture method or 'assisted blocking' where a performer would pose the individual key-frames of an animated action that might otherwise be difficult to achieve through real-time mocap. This would involve extracting key-frames of a mocap recorded performance during post-production. This method is tested in another cycle of practice later in the study. While the use of reference material proved effective for all the actions to directly inform Marianna's movements, she did not completely adapt her own natural movements to one with animated characteristics—a level where I could comfortably direct Marianna without the use of reference material. This may have been due to the process itself, relying upon reference of the actions, the skills of the performer to adapt her movements or simply the time-restricted nature of the capture stage during production. These qualities are tested further in the study.

During the capture stage, the level of involvement from the performer at times resembled that of a stunt-person, completing the actions as tasks rather than being a creative collaborator. When collaboration was at play, the results were immersed and fluid actions rather than a one-sided 'puppeteering' approach, where I dictated all the terms of movement. Critical feedback throughout the capture stage enabled a reflective and adaptive environment. For example, Marianna noted during this cycle's capture stage that as a performer, her understanding of the directed actions was clearer once I had explained the difference between a traditionally animated outcome and a mocap production where the performer creates the movements. The level of participation from the performer is explored further in proceeding practice cycles.

The post-capture stage is a requirement of mocap animations and, for this practice cycle, standard motion editing processes were applied to the animated mocap. Multiple 'takes' of each action were recorded to allow for selection of the most animated result. Editing the data generally averaged between 3–5 hours and included adjusting intersections and fixing any major alterations from the intended action. Even with the 'animated' mocap data, there was still a level of destructive editing involved. This implies that the recorded movements did not have all the qualities I felt were needed to be cartoony. An example was the removal of uneven steps to consistently make sure the character's feet were firmly planted on the ground, which was time-consuming. To ensure an effective post-capture process, the captured movements would need to closely resemble the required cartoony movements. Otherwise, the performer would need to make conscious adjustments while recording—such as the untested method mentioned previously—to account for an animator's input at a later stage. After some standard mocap editing, Marianna's animated mocap actions applied well to the stylised character and an acceptable, even quality result of animated actions was achieved (see Chapter 6 evaluation).

Summary

This cycle of practice has tested a production method to attain cartoon-style movement with the use of mocap. This cycle indicates that if cartoon-style movement qualities are present at the capture stage, an animator will have an easier time in their role as a motion editor. It was found that during the capture stage, the performer can be enabled to create cartoony movements through certain immersive qualities. These include the emotional state of the performer and their innate personality, the use of a projector screen as feedback of their recorded movements, an objective-type action

rather than an instructive motion list and, lastly, movement-enhancing set props and music. These last two qualities will not be explored further in this study as they expand the scope beyond the direct research subject. This cycle emphasised the use of specific animation reference materials to inform the performer during the capture stage, which was very useful. Other production methods explored during the capture stage of this cycle include pre-emptively encouraging the performer to become familiar with the production setting by exploring their physicality; transitioning into an animated style of a walk action sequence by beginning naturally and then slowly incorporating the animated traits; providing explanations and physical demonstrations to the performer to clarify animated actions; and the level of creative involvement from the performer versus my own level of involvement, which can reach a stage of puppeteering. These capture stage qualities enabled motion editing during the post-capture stage—using standard processes—to create cartoon-style movements for a stylised 3D CG character. This study will continue to investigate the capture stage of a mocap animation production and methods of attaining cartoon-style movement through this production.

4.3 ANIMATION TECHNIQUES WITH MOTION CAPTURE

The third cycle of practice of this study explores the application of specific animation techniques and concepts through a mocap animation production. The previous practice cycle began this process by creating a series of animated actions derived from instructional texts. Building on the learned outcomes, this cycle continues the investigation of cartoon-style movement within the capture stage of a mocap animation production. With acting students as the mocap performers, techniques associated with animation were applied to the capture stage through set actions to achieve a cartoon-

style movement quality. This practice cycle aligns with the third objective of this study and continues to build on the already established research outcomes.

During this cycle of practice, collaboration between two performers–Liam Soden and Maeve Hook (QUT acting students)–took place where the two were directed to complete several brief action sequences from a scripted animation called *Lost for Words* (Appendix Item 8) as part of a mocap animation production. Unlike the previous cycle, animation reference was minimised as part of the investigating variables for attaining cartoon-style movement during the capture stage. Recorded actions were applied to a 3D CG character (Y-bot and X-bot from Mixamo), with no post-capture motion editing taking place. These characters were chosen as they demonstrate the mocap data applied onto a digital model, in a raw form—a basic representation of the action with no correlation between the appearance of a character (proportions or texturing) and its movement. With actions derived from an animation script, this cycle of practice represents a simulated real-world production and investigation into applying animation techniques into a mocap animation during the capture stage. The digital works of this cycle (Appendix Item 6) are comparative videos that include video documentation from the mocap recording session beside an unprocessed version of the mocap data applied onto a 3D CG character. These digital outcomes are evaluated in Chapter 6 for the presence of animated qualities.

Experiment 1

The project's first experiment with Liam began with a brief introduction to the mocap system and an overview of the production method and basics of animation principles. During capture, the performer was limited to seeing only the 3D CG Motive avatar with no application to another more detailed character. Warm-up exercises

helped remove Liam's initially robotic movements before completing the first of two action sequences involving a cartoon take and a double-bounce walk. As shown in Figure 23, the cartoon take was chosen as both a well-defined animated action and scripted sequence in the aforementioned *Lost for Words* animation (Figure 24). After some verbal instruction on what the cartoon take looked like, three tests were conducted. The first, completing the action with no involvement from myself as a director, is seen in Appendix Item 6-1 @ frames 1–172. This established a baseline of the actor's own interpretation of the action, with no relation to stylised movement at this point.

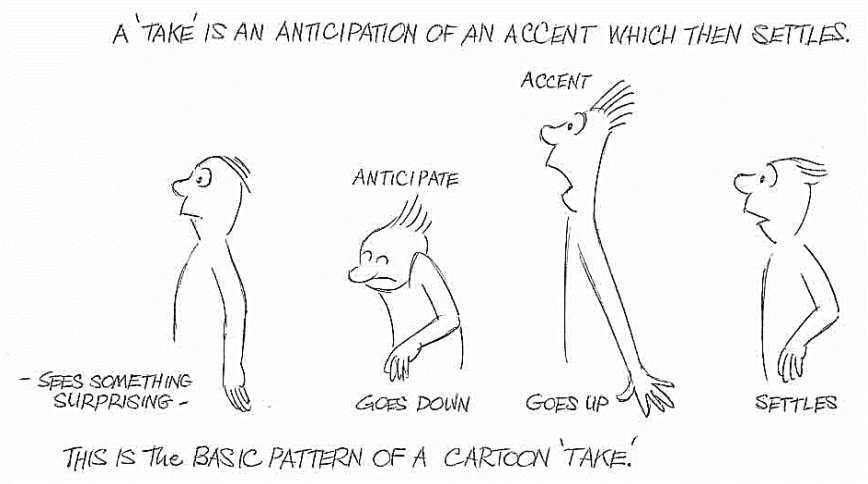

Figure 23 - Cartoon take (Williams 2009, 285)

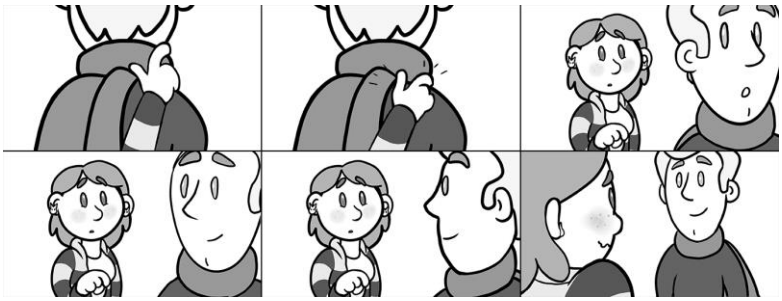

Figure 24 - Cartoon take sequence from *Lost for Words*

The second test involved completing the action with my involvement, where improvements were suggested. Here, the mechanics of the action were explained in

detail, with a physical demonstration before attempting the action with an assisted spoken cue of ‘tap on the shoulder’. No animation reference images or videos of the action were shown aside from the specific sequence from the *Lost for Words* animatic (Figure 24). An animatic is a timed video edit that contains the drawn frames of a storyboard. The results of this test are seen in Appendix Item 6-1 @ frames 173–346. The performer responded well to my involvement, showing an improved understanding of the action and how making his poses and gestures more overt would have them appear more clearly on the Motive 3D CG character.

The third test incorporated specific animation principles, such as exaggeration and anticipation, to embed more animated, cartoony movement. During this test, variations included attempting a ‘double-take’, having an asymmetrical starting pose for more contrast, adding more volume to gestures, leading the turn-around with different body parts, having great anticipation on the ‘down’, increasing overlapping action and follow-through and, lastly, varying the speed of the turn-around. To energize Liam’s actions throughout the capture session, it was suggested to continue walking around the capture space to infuse more life into his actions as he felt initially quite stagnant. The results of this test can be seen in Appendix Item 6-1 @ frames 347–828.

The second action sequence for this experiment included a double-bounce walk (Figure 25). This sequence, unlike the previous one, was dialog-driven, showing a confident character walking into shot, back-tracking slightly and turning to deliver the line “Well! … Ring-a-ding-ding” (see Appendix Item 8 @ 2.18 min for reference). Additionally, this sequence was an opportunity to include character qualities from the performer as a unique way to complete the action. The performer was shown a physical

demonstration of the sequence, animation reference of a double-bounce walk and the specific sequence in the *Lost for Words* animatic.

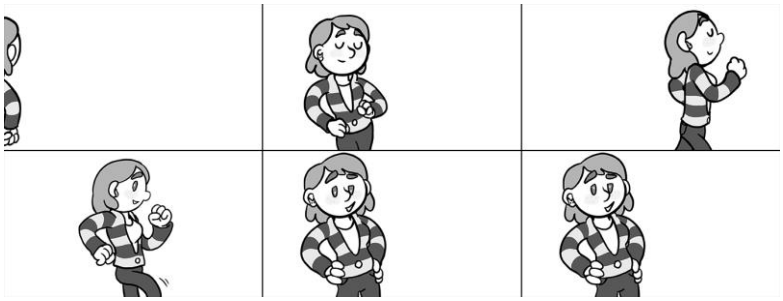

Figure 25 - Double-bounce sequence from *Lost for Words*

While recording this action sequence, Liam felt highly engaged and demonstrated as such with an energetic persona. This sequence had a particularly hands-on approach. This involved demonstrating the action to the performer myself and then assisting the performer's attempts, specifically removing any robotic movement qualities by maintaining a relaxed/loose upper body. During capture, the performer continued to improve, with two variations shown in the results (Appendix Item 6-1 @ frames 829−1047 and 1048−1284).

Experiment 2

Maeve's experiment began with additional time explaining key animation principles and showing clips from animated films with distinctly different movement styles alongside the introduction to the mocap production. This additional 'prep-time' aimed to identify if a holistic (if brief) understanding of animation practices would strengthen the performer's ability to incorporate animated qualities into their recorded actions. The last extra preparation with Maeve included live-streaming her character and applying it to a 3D CG character in MotionBuilder. This was well received as it enabled the performer to begin experimenting with body posture, weight and, all round, the qualities of movement between herself and her digital character.

Once fully prepped, Maeve was directed to complete a running-stop action sequence and the same double-bounce action sequence as Liam. The first action shows a character running to a stop and swinging their arms wildly (Figure 26 and Appendix Item 8 @ 3.21 min). The same three involvement-level tests from the previous experiment were conducted for this sequence. The performer's own interpretation of the action sequence was recorded before involving any stylisation of movement or director influence. The performer executed a high-energy action sequence, noticeably sliding to a stop slightly due to the shoes that were worn. The results can be seen in Appendix Item 6-2 @ frames 1–208.

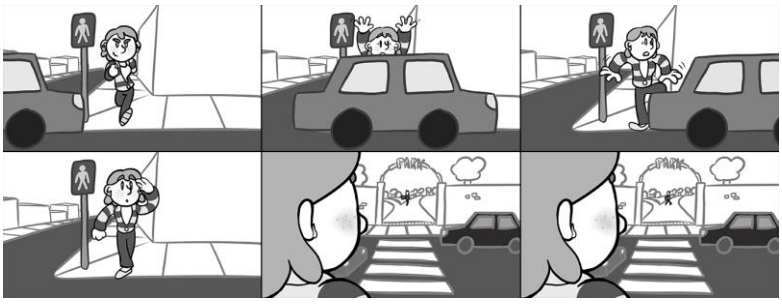

Figure 26 - Running-stop sequence from *Lost for Words*

The specifics of the action sequence were explained to the performer while showing the *Lost for Words* animatic before directing the second test. As character played an important role for this sequence, the performer was encouraged to embody the animated character's qualities and attempt being 'uncoordinated' while 'hurriedly trying to catch up to someone'. Coordinating the performer was broken down further to an instructional level of run, stop, and then look. While recording, I also placed myself as a physical barrier to have the performer stop more suddenly to reinforce the animation principle of overlapping action. After some further refinement, the results seen in Appendix Item 6-2 @ frames 209–475 were achieved.

The final involvement-level test of this sequence (Appendix Item 6-2 @ frames 476–765) shows animation principles and techniques were specifically applied. Here,

‘line of action’ was reinforced by considering the character’s contrasting spinal position throughout the sequence. During this attempt, the animation terminology I used was a point of contention with the performer and so the sequence was simplified to concentrating on ‘follow-through with exaggeration’.

After concluding the running-stop action sequence, the double-bounce action sequence was recorded with Maeve. Due to time restrictions, the technical qualities of the movement were explained straight away, after which several attempts were recorded. These too included the performer’s own interpretation of the sequence, the director’s assistance and then an animation-focused variation. During this capture session, the performer was given verbal cues such as ‘bob your head more’ to assist with the animated movement qualities. The results of this action sequence can be seen in Appendix Item 6-2 @ frames 766–1077.

Experiment 3

To conclude this cycle of practice, this third experiment brought the two (now informed) performers together for a final action sequence: carrying a heavy box (Figure 27 and Appendix Item 8 @ 3.17 min). The performers were given a cardboard box to direct hand placement and consistency of proximity to each other. During the capture of this action sequence, both performers were encouraged to demonstrate exaggeration and weight: the heaviness of the object would be mimed.

Figure 27 - Jumping over removal-men sequence from *Lost for Words*

Before recording, the sequence was demonstrated with a sideways crab-walk and backwards walking version for both characters. Explanations were also given on the appearance of shifting weight to make the object appear to be heavy. Both performers were posed in a partial-squat and were given verbal cues to narrate their actions throughout the sequence via their character's thoughts. Small adjustments were made to their attempts, including lowering their crouched positions and suggestions to sync their steps. Variations of this action sequence can be seen in Appendix Item 6-3.

Discussion

The third cycle of practice of this study examined the mocap animation production, specifically working with a performer during the capture stage to apply animation principles and techniques to action sequences from a pre-determined animation script. Unlike the previous cycle, which used animation reference material to derive cartoon-style movement for the performer, this cycle simulated a production environment that primarily used the animation experience of the director (myself) to determine the animated movement qualities. The post-production stage was removed in so far as the recorded mocap data was directly applied to a 3D CG character, with no motion editing. This kept to the basic, 'bare-bones' of animated movement to simply demonstrate the performer's actions and their ability to create cartoon-style movement. The results of this practice cycle are seen in Appendix Item 6 and are evaluated in Chapter 6. Observations during the capture stage inform the discussion and results of this cycle as well as interviews conducted with the performers to assess their learning curve and understandings of the production.

At the time of this practice cycle, acting students Liam (third year) and Maeve (first year) had no prior understanding of what takes place in a mocap production and

had limited to no understanding of animation production. Liam had been a part of several novice theatrical productions while Maeve brought physical training through a history of dance, gymnastics, circus, and theatre. These acting students broadened the discussion of this research and brought a new perspective to this study as novices in their field. However, it was evident that a degree of production breakdown was required for both performers prior to recording.

'Preparation' before beginning the performer's mocap sessions was an effort to pre-emptively train and immerse each performer within the animation aesthetic, specifically in terms of movement qualities. After prep, both performers could distinguish between the different animated movement styles as well as the relationship between character form and movement. They stated that explanations of animated styles, being shown varying animated forms through film examples and basic training in animation practices were valuable in helping them imitate and mimic animated actions. Maeve felt her additional prep-time was unwarranted and that for the purpose of saving time during a production, such detailed deconstruction might not be necessary. This could be reduced to simply showing references of the kinds of animated movement required before attempting the mocap recording. While Maeve agreed that an awareness of the animation process was useful to gain a holistic sense of the production, the post-production details could remain hidden from the performer. It was noted that Maeve was less inclined to accept the mocap animation production methods. This prep-time approach opened ideas of training performer's to be 'production ready'; overall, the approach demonstrated value and warrants further investigation as part of this study.

It was decided that animation reference material would be removed from this cycle of practice and minimised to the denoted still frames from the *Lost for Words*

animatic. This approach, in fact, aligned with the performers' learned acting practices, where they were taught to avoid character performances by other actors so as not to impede or influence their own interpretations. As a 'bare minimum' approach, the basic animatic reference material was found to be essential to cut down on production time by minimising explanations from a director. The lack of action/movement specific animation reference material—such as the previous practice cycle—proved to be minimally impactful; however, this was not comparatively tested during this cycle by giving the same level of reference materials. In addition, a largely hands-on approach from me was required in lieu of this reference material. A mocap animation production would be better served by having the reference materials of movement for scripted actions ready to supply to the performer, whether they are used or not.

While initially finding it difficult to navigate between natural and cartoony movement, the more time given to the process the more comfortable the performers felt trying to create the latter. This was found to be more effective when an energetic action sequence was taking place. Liam's first action—a cartoon take—was subtle compared with the overt double-bounce action sequence. He showed an immediate engagement for the animated form with the second, larger action, stating "the double-bounce really gets you in the right frame of mind". Maeve also felt it was easier to begin with a more energetic sequence as it was overtly physical. Such action sequences allowed the performers to disassociate from their natural states and immerse themselves into their animated character roles. Refining stylised, cartoony movement effectively in this manner could mean starting capture sessions with active, 'animated' actions before beginning subtler, more emotionally driven ones. This cannot be stated outright as the type of performer and level of understanding they have for animated movement is a large factor and would require further investigation.

Just as in the previous cycle, Liam and Maeve were able to see their movements mapped to the 3D CG Motive avatar on a large projector screen in the capture space for viewing movements in real-time and recorded performances afterward. Both performers referred to the screen before and after recording but ignored it while performing, seeing it as a distraction. The presence of the screen encouraged the performers to adjust their movements; the correlation of each performer's movements to their on-screen digital avatar was quickly understood and adapted. The impact of the projector screen, as a visual reference tool for the actors during this cycle, was notably positive.

Each performer applied their own unique qualities during this cycle. Liam found the use of his emotions helped him create animated movements that would have otherwise appeared very stilted. While performing, he also used his own sound effects to bring all his performative skills into play. Doing so was his attempt to imbue emotions into his body's actions and, therefore, physically show character intent. Liam commented that before doing an action, he would ask himself internally, what a cartoon movement would look like for this action and then try to replicate it with his body. Liam demonstrated an aptitude for this production. Maeve's prior physical training experience made her particularly aware of her body, offering clarity on weights and different qualities of movement. This also rendered her movements with the qualities of a dancer; although graceful, these qualities seemed imbedded in all her actions and, hence, limited the options for stylisation. Whether through internally generated motivations or an understanding of physicality in performance, both performers brought unique characteristics that were beneficial in the mocap animation production context.

I facilitated the performers during this cycle by physically demonstrating actions, explaining animation techniques where necessary and focusing on ensuring the character's objective and intent was read clearly through their actions. Whether for on-stage or for a mocap animation, character motivation through an objective remains key to engage the performer for authentic, believable actions, regardless of the performer's background or prior knowledge. From the previous cycle, there was some concern for over-controlling the performers to a degree of puppeteering and so I attempted to remain open to performer involvement. While Liam felt comfortable working to this structure format, Maeve still felt removed from any creative input in the process. Even with an understanding of the experimental nature of this production, Maeve still felt creatively restricted and more like a stunt person. By comparison, Liam felt his contributions were no different to a typical film set where the director would load up the performer with the requirements of the scene or shot, where this production was simply intensified on movement. He felt his creative contributions were never pushed aside to be a puppet and that "it's just me getting to know how my body works and how it reads". The dynamic between the director and actor for such a production is precarious as the director requires a level of manipulation and control over the recorded actions so that significant post-production is not required, whereas the actor wants their own creative input. For a mocap animation production seeking cartoon-style movement, this cycle has not resolved the issue of director control and will continue to be explored in the following practice cycle.

This cycle of practice tested an alternate approach to working with the mocap performers to create stylised movements by progressively layering more complexity into the recorded actions. First, the actors would record their interpretation of an action, then I would give my input to improve the appearance of character intent and then,

lastly, I applied my animation experience with specific techniques and terminology to the action to enhance its cartoon-style movement qualities. This approach slowly brought the performer up to speed with animated movement rather than directly going into cartoon-style movement qualities. The performers' preconceived limitations of mocap, being only useful for realistic movement, were gradually changed over the course of this cycle. For this cycle's digital outcomes, this method also demonstrates the distinct involvement of an animator as a director. After the performers were individually tested and informed of the mocap animation process, the third experiment brought them together to perform an action sequence. During this experiment, both performers portrayed a convincing weight and cohesive movements while mime-carrying a heavy box. This progressive layering production approach was effective for this cycle and will be utilised in the following cycle of practice.

A challenge found during this cycle with both Maeve and Liam was the use of animation-based terminology such as the animation principles. Specifically, the performers found it difficult to physically manifest my directions, which did not align with their understanding of movement. Repetition and explanation helped this issue and the actors stated that they would internally reinterpret what they heard into acting vocabulary they could understand. This is a known issue and by-product of communication breakdown between directors and actors from different backgrounds, and not limited to mocap productions. Such an issue could be the subject of a larger study to examine the boundaries of animation and acting terminology to determine a cross-over for a mocap animation production. For the purposes of this study, however, the language barrier could be overcome with standard industry conditions of a live-action production environment, where director and actor work in concert and maintain open communication to minimise production delays.

Summary

This cycle of practice concludes the preliminary knowledge set before continuing onto the final practice cycle. During this cycle, specific animation techniques were applied to performers' recorded actions during the capture stage of a mocap animation production. The results of this cycle show the continued benefits of previously established production qualities in creating cartoon-style movement for a mocap animation. These include, the benefits that emotion and character motivation play into a performer's immersion, the use of a visual screen as a resource for feedback and, lastly, physical demonstrations and explanations from the director when clarifying animation actions. Newly recognised outcomes from this cycle include the benefits of prepping a performer before a production, that either specific animation reference material or a hands-on directorial approach would be required to effectively work with a mocap performer, that energetic 'animated' actions help immerse a performer in animated movement qualities and a method of layering more complex animation qualities helps slowly immerse a performer in creating cartoon-style movement. The dynamic between the director and performer and communication-related production challenges will continue to be investigated in the proceeding practice cycle as well as already established research outcomes. The collective research outcomes and knowledge of this chapter informs the final cycle of practice, which continues to investigate the application of animation principles and techniques within a mocap animation production to create cartoon-style movement.

Chapter 5: Cartoon-style Animated Movement with Motion Capture

This chapter details the fourth and final cycle of practice of this study, which continues the investigation of creating cartoon-style movement in a mocap animation production. Using a single performer—mime artist, Lorin Eric Salm—10 experiments were conducted to explore methods for creating cartoon-style movement, including focusing on specific animation principles and techniques and building upon pre-established methods and challenges from previous cycles. This cycle encompasses the first three objectives and all research questions of this study as detailed in Chapter 1.3.

Lorin offered his skillset and experience as a mime artist, traditional actor, mocap performer and movement coach specialist. To establish the level of experience Lorin brought to this study, a baseline examination of his abilities and aptitude for a mocap animation production was conducted. The 10 experiments of this study were then carried out and, depending on the experiment, involved both the capture and post-capture stages of a mocap animation production. Appendix Items 7 and 8 show the digital outcomes of this practice cycle that are evaluated in Chapter 6.

5.1 CARTOON-STYLE ANIMATED MOVEMENT WITH MOTION CAPTURE

Baseline Testing

The performer was first introduced to the mocap production setting to familiarise himself with the capture processes. Using the motion list from the *Lost for Words* animation, I then established the extent of Lorin's ability in creating animated movement based on his pre-existing knowledge. The performer was directed to

interpret the actions based on his instincts while I gave minimal input other than providing cues from the motion list. The recorded actions were not intended to be applied to the developed 3D CG *Lost for Words* characters in post-production and neither motion edited. There are no digital outcomes from this baseline testing of Lorin's skills as it was only used to inform the final cycle's experiments.

Lorin immediately began testing the relationship between his movements and what appeared on the projector screen. The performer showed concerns about whether his movements would transfer well to the *Lost for Words* character's as their proportions were quite stylised. This concern came from the same place as the *Powers Above* animation and the difference of proportions between performer and digital characters. While initially limited to seeing the 3D CG Motive avatar, Lorin's character was live-streamed to MotionBuilder to test his movements against an intended *Lost for Words* 3D CG character (Figure 28). I reassured Lorin that any disproportionate relationship between his physical movements and those of the digital character should be disregarded in favour of genuine actions and a flow of gestures.

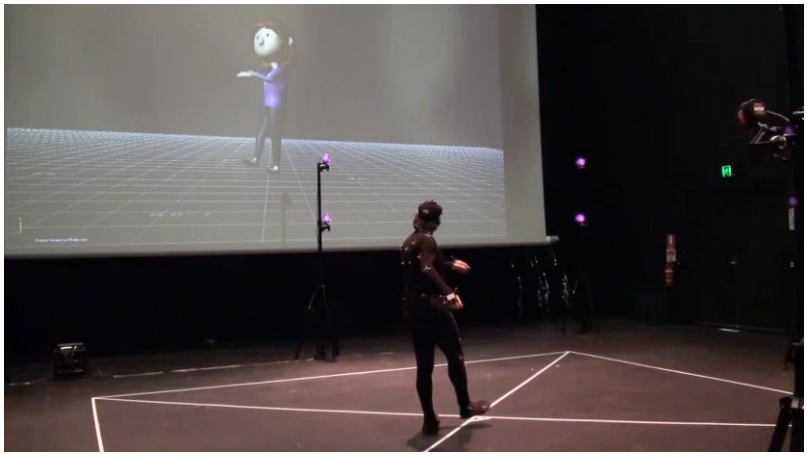

Figure 28 - Lorin testing a *Lost for Words* character

Lorin was taken through the motion list, using the *Lost for Words* animatic (Appendix Item 8) as an additional reference (Figure 29). I suggested beginning with more energetic actions in the motion list than going chronologically but Lorin felt it

was not necessary as he was visibly warmed up and felt confident in his knowledge of animation to apply to his movements. During this process, some character scenarios, such as ‘a person hurrying to work’ or ‘waiting for a bus’ were used to help immerse Lorin in the various character types. Longer, uninterrupted recordings were opted over shorter ones so as not to disrupt Lorin’s flow with the standard “t-pose–stop recording–t-pose–recording” mocap process. This approach is one of the recognised benefits of a mocap animation production, regardless of stylisation. While performing, Lorin stated aloud his character changes to again maintain a smooth production process.

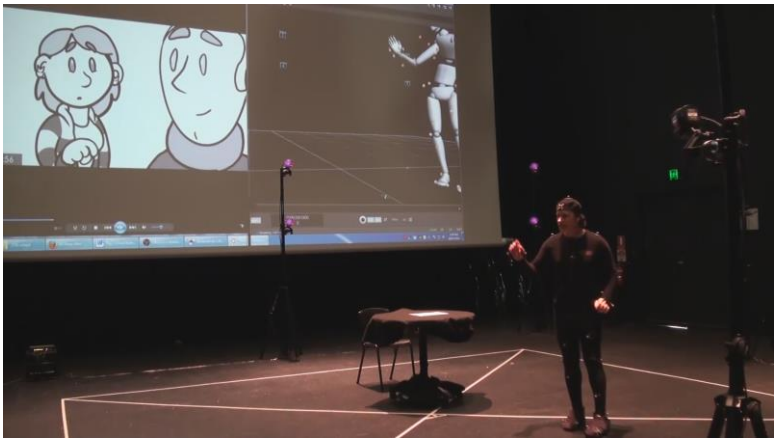

Figure 29 - Baseline recording mocap session with Lorin

Reviewing the actions after each recording ensured the performer’s movements read with a clear intent on the 3D CG Motive avatar. In instances when Lorin felt unsure if his actions were reading clearly enough, I momentarily streamed them onto the intended *Lost for Words* 3D CG character. This way, Lorin could gauge the size of his actions and how clearly they were coming across. During this review process, it was decided the actions needed to be larger. My observations of Lorin’s baseline understanding of a mocap animation production were recorded during this capture session and are detailed in the discussion section of this chapter.

Experiment 1 | Overlapping Action and Breaking Joints

The first experiment with Lorin assessed his ability to consciously demonstrate a common animation principle of 'overlapping action' through an animation flexibility technique of 'breaking the joint'. Using a breakdown of the technique from *The Animator's Survival Kit* (Williams 2009, 151), Lorin was directed to complete four actions: arm swings, raising and lowering arms, a fist smash on a table and a turn-around action. Once recorded, each action was applied directly (meaning no motion editing) onto a basic 3D CG character. Appendix Item 7-1 shows these results, which are evaluated in Chapter 6.

An arm swinging action was seen as an easy, low-level exercise to begin with Lorin. This demonstrated breaking the joint with a simple arm motion, which shows a fluid animated quality. In attaining the required 'flop' to this motion with the wrist, there was a slight restriction from the suit's hand/finger holding loops (only noticeable with such a particular action); this was resolved by having Lorin remove them from his hand. The animation reference from *The Animator's Survival Kit* (Williams 2009, 151) was used to show Lorin the animation technique and is seen in the digital outcome. Lorin was directed to imitate this action and shown how to achieve the desired outcome by creating the illusion of the break without physically breaking his elbow. In the same approach as a 2D animator, a momentary break through an outward positioning of the elbow, in combination with the camera's position would achieve the desired outcome. This was explained comparatively with the 'smeared frame' where a single frame would demonstrate a whip-like and fast movement. I used this idea to elaborate on another animation technique of demonstrating principles without being obvious, such as the use of a smeared frame. Lorin was directed to create the same effect with a singular arm, two arms and, finally, incorporating the joint-break arm

swing into a character walk; ultimately, he achieved a quality semblance for each. The results can be seen in Appendix Item 7-1 @ frames 1–525.

The joint-break animation technique was continued with another arm-based action where Lorin was directed to raise and lower his arm. Animation reference from *The Animator's Survival Kit* (Williams 2009, 233) was again shown before recording the action, the result of which is seen in Appendix Item 7-1 @ frames 526–715. This demonstrated the animation principle of overlapping action as well as a distinct skeletal structure with fluid, dynamic and flexible character movements.

A fist smash on a table was the last arm-based action of this experiment and emphasised intent. This gave some purpose behind the same joint-break technique. Here, Lorin was provided a table on which to perform the action and enhance the impact with a solid surface. A folded cloth was used to soften the physical impact on the table to prevent Lorin from harming himself. Just as with the previous two arm-based actions, Lorin was shown the animation reference from *The Animator's Survival Kit* (Williams 2009, 236) before executing a quality fist smash action as seen in Appendix Item 7-1 @ frames 716–876.

The last overlapping experiment was an exercise where Lorin was directed to turn on the spot. This demonstrated overlapping action through different parts of the body leading an action, with the remainder following afterward at different intervals. After showing Lorin an animated example from *The Animator's Survival Kit* (Williams 2009, 226), several variations of the action were recorded. The variations include turning the whole body robotically at once, turning the head>chest>foot, turning the foot>chest>head, turning the chest>foot>head and turning with two-steps>chest>head. Each demonstrated Lorin's use of overlapping action through a simple body turn. The results are seen in Appendix Item 7-1 @ frames 877–1286.

Experiment 2 | Breakdown Positions

The second experiment focused on the animation concept of the 'breakdown' or 'breakdown position', a determinant position between two key poses of an action. The aim was to illustrate how Lorin could construct variations of an action by applying this concept. Additionally, this experiment highlighted the exploratory path that mocap offers an animation pipeline. This experiment involved four actions, each of which looked at the ways in which a performer can decide on the transitional point between two key moments of a movement. These actions included a forward head movement, a walk with the focus on the 'passing pose', standing to sitting down on a chair and picking up a coffee cup. Each of these actions had the same relative start and end position. Just as with the previous experiment, all actions were directly applied to a basic 3D CG character, the results of which can be seen in Appendix Item 7-2. The recorded results of this experiment are analysed in Chapter 6, detailing how the performer constructed each variation of action and successfully applied the animation breakdown concept in a mocap setting.

The forward head movement was the first action for this experiment. The animation reference from *The Animator's Survival Kit* (Williams 2009, 223) was shown to demonstrate to Lorin this animation idea and is also seen in the digital outcome Appendix Item 7-2 @ frames 1–355. Lorin created several character intentions from this simple gesture, each beginning and ending with the same pose. By varying the breakdown between the start and end pose, these variations demonstrate motives through movement and there is consistency across the action. The variations Lorin recorded include forward>down, down>forward>up, up>forward>down and down>around head gestures. Even with this first action, Lorin stated he had a better understanding of the breakdown animation concept.

The ‘passing position’ of a walk was the second action of this experiment as seen in Figure 30. This action demonstrates variation of character through changes of this single position between two standard contact points. I expressed to Lorin the importance of the passing position as a character-defining pose within the walk and directed him to record as many variations as he could create, which resulted in seven outcomes in a single recorded take. These variations included a passing position resulting in a walk resembling a bob down, swinging-leg, half-skip, prancing, droopy, body side-swing and lean-back type walk as shown in Appendix Item 7-2 @ frames 356–1662. While recording this action, Lorin expressed that for his own work he would often concentrate on the contact position of a walk more than the passing position and discovered the value in the breakdown and its importance for his own future character development work.

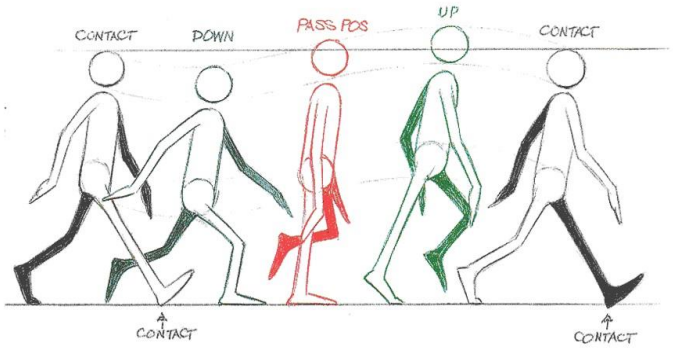

Figure 30 - Key positions of an animated walk (Williams 2009, 108)

A sit-down action was the third exercise of the breakdown experiment, where Lorin was directed to stand close to a chair, take a step and then sit down, altering the in-between state of standing and sitting with each attempt. Several variations of the action were recorded, which offered a selection of character types as well. These variations included a breakdown position that results in a sit-down resembling a regular version, wide-step, slumbered, slink, butt-first, stiff, jump, high-legs and an

over-chair leg-swing sit-down. These variations are seen in the digital outcome Appendix Item 7-2 @ frames 1663−2659.

The last exercise for this experiment involved Lorin picking up a coffee cup and varying his character type through the breakdown position. Lorin performed the whole action seated at a table but mimed the use of a cup. Prior to any recording, Lorin was shown a character study video (Wired, 2014) that exemplified this experiment. In this cup pick-up scenario, a wide selection of character types was recorded, each varying in the way they moved, but having the same setting of sitting and drinking from a cup. The results of this are seen in Appendix Item 7-2 @ frames 2660–5464 and include a regular version, a slow swoop, a swipe'n'gulp, slow with two hands, a slow pluck, gathering the cup, a grab'n'gulp with two hands, a swirling version, a pluck'n'toss and, lastly, a grab'n'wipe variation. While recording, Lorin was directed to consider characters like Scrooge or position his body to create a more defined silhouette. These characteristics were directed in order to slowly embed more animated qualities into the actions he performed.

Experiment 3 | Weight and Anticipation

The third experiment of this cycle focused on the animation concept of convincing weight and the principle of anticipation through two performed actions: a heavy-lift and a cartoon take. Both actions were performed in previous practice cycles. This experiment provided a comparative opportunity against previous performers to exemplify the physically expressive aptitude of a mime artist as well to demonstrate the application of two key animation ideas through well-recognised actions. Both the cartoon take and heavy-lift made use of 2D animation references from *The Animator's Survival Kit* (Williams 2009, 285; 257). The recorded actions of this experiment were

applied to the basic 3D CG character, the results of which can be seen in Appendix Item 7-3. This experiment's outcomes are evaluated in Chapter 6, showing how a performer can create overt anticipation through their actions and successfully mime the qualities of acting upon a heavy object.

The cartoon take primarily focused on the animation principle of anticipation. The animation reference shown to Lorin (Williams 2009, 285) showed a great deal of volume deformation through squash and stretch. This presented a challenge in the mocap animation production setting as Lorin was limited to the temporal and spatial difference of his body parts to demonstrate squash and stretch. Several variations of the action were recorded, adding slight differences to the length or amount of anticipation within the action. As Appendix Item 7-3 @ frames 1–252 shows, two variations were the results of Lorin's efforts: a moderate version and a full-body version. During this exercise, Lorin commented that this was, in fact, something he had studied under Marcel Marceau, specifically the double-take.

The second action for the experiment—the heavy-lift—was a clear demonstration of weight as well as anticipation. In previous practice cycles, performers had been given a physical object to lift. Lorin was directed to mime the entire action to emphasise the use of body posture to enforce weight. Once shown the animation reference (Figure 31), two variations of this action were recorded: tossing the object away and with the performer falling backwards. The second variation (Lorin falling backwards) was Lorin's own interpretation of the action as he was directed to implement his own creative ideas to the sequence. Additional mime techniques were referred to during this capture, specifically 'identification' and the use of counter-weight. This comparison and exchange of terminology will be discussed further in the discussion section of this chapter. During post-capture, a key-framed 3D box-object

was included to show the performer acting on an object rather than lifting nothing. Just as with the previous experiments to this point, no motion editing to the character's actions occurred. The results are seen in Appendix Item 7-3 @ frames 254–1979.

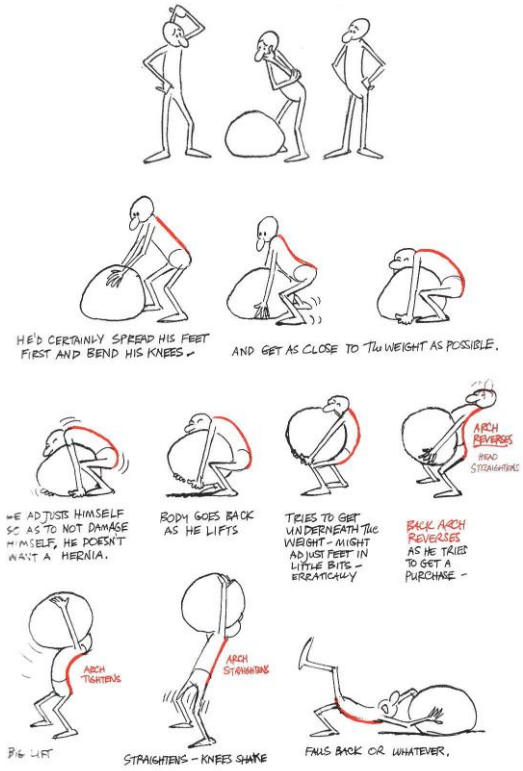

Figure 31 - Heavy-lift action sequence (Williams 2009, 257)

Experiment 4 | Line of Action

The fourth experiment for this cycle of practice focused on 'line of action' by recreating character actions from two animated scenes. As a guide of structuring a pose, line of action encourages the animator to concentrate on the essence of an action, strengthening a figure's dynamic flow (Webster 2005, 52). A clear line of action denotes a strong, movement-evoking pose. The animated scenarios chosen for this experiment were an interaction between Buzz and Woody from *Toy Story* (Lasseter 1995) and a clip with the title character from *Goofy's How to Play Baseball* (Kinney 1942). These scenes were chosen for their direct and easily comparable demonstration

of the line of action concept. For both outcomes, the data were applied to similarly represent 3D CG characters from the reference material and some motion editing did occur in during post-capture. The digital outcome of this experiment is seen in Appendix Item 7-4 and evaluated in Chapter 6 for the performer's ability to demonstrate this animation technique.

Figure 32 - Screenshot from *Toy Story* (Lasseter 1995)

After breaking down the line of action concept, Lorin was directed to perform as both Woody and Buzz. While performing the scene denoted in Figure 32, Lorin was directed to be parallel with the projector screen for an easier layout comparison. This was a useful alteration to performing typically straight-ahead, instead of mirroring the characters as seen on the projector screen. This was the first instance that dialogue was used to sync with Lorin's actions and used as a point of reference and gestural cue. For Buzz's action, some gestural suggestions were made to refine the similarity of Lorin's actions to the film's, which Lorin took on and performed well. Lorin felt engaged with this action and enjoyed playing out the scene. Woody's actions in the scene emphasised contrast in his poses, which I directed Lorin to duplicate. I explained how in this sequence Woody would use his whole body and even face as a pointing tool, making the intent and forward motion clear. I demonstrated the action myself before Lorin performed Woody's part of the scene. Lorin broke down the action specifically,

even asking to see the trajectory of Woody's arms as he exclaimed his lines. Motion editing during post-capture included varying the timing of the recorded data slightly to emulate the timing in the *Toy Story* (Lasseter 1995) clip. The outcome of this recording can be seen in Appendix Item 7-4 @ frames 1–218.

Figure 33 - Screenshot from *Goofy's How to Play Baseball* (Kinney 1942)

The Goofy baseball scenario (Figure 33) was shown to Lorin and broken down to address potential issues such as Lorin being left-handed as opposed to the character in the reference and the various posing extremities of Goofy. This was the first instance where Lorin was given a prop: a piece of plywood as a physical representation of a baseball bat. In rehearsing the scene, I demonstrated the action myself and made use of the reference video to direct Lorin through the sequential gestures frame-by-frame. Several variations of the sequence were recorded. During post-capture, some motion editing occurred that primarily altered any intersecting between the bat and the character. It was evident that the level of deformation in the 2D Goofy animation clip was difficult to replicate in mocap. The results of this are seen in Appendix Item 7-4 @ frames 219–497.

Experiment 5 | Referenced Actions

The fifth experiment of this cycle of practice used animation reference material to recreate the same cartoon-style actions in mocap, emulating the second cycle of practice. *The Animator's Survival Kit* (2009) and Steve Roberts' *Character Animation in 3D* (2004) were used to inform this experiment and included actions of a happy walk (or Disney strut), a sneak walk, a double-bounce walk, a jump, a push action and a pull. These actions were chosen as they represent a series of basic exercises an animator would typically construct when being taught about body mechanics and animation principles; as such, they suitably represent a level of scrutiny from an animator's perspective. In completing these actions to emulate their characteristics, the performer would demonstrate cartoon-style movements, without any post-capture motion editing. Recorded actions were directly applied to a basic 3D CG character as seen in the digital outcome in Appendix Item 7-5. The results of this experiment are evaluated in Chapter 6.

The happy walk resembled the title character's happy-style walk in *Pinocchio* (Ferguson & Hee 1940). Using the animation reference of the walk (Figure 34), Lorin immediately attempted what was on screen without any prompted ideas of execution. When directed through the action, he began at a slower pace and, with increased speed, improved the overlapping action and drag of his upper body. I directed the performer to bring even more contrast with each arm-swing. The results, seen in Appendix Item 7-5 @ frames 1–236, resemble a skip action. It was noted that the more extreme the posing the more difficult control of the action's speed. Playing the action at double-speed during the capture session showed it followed the animation reference quite closely.

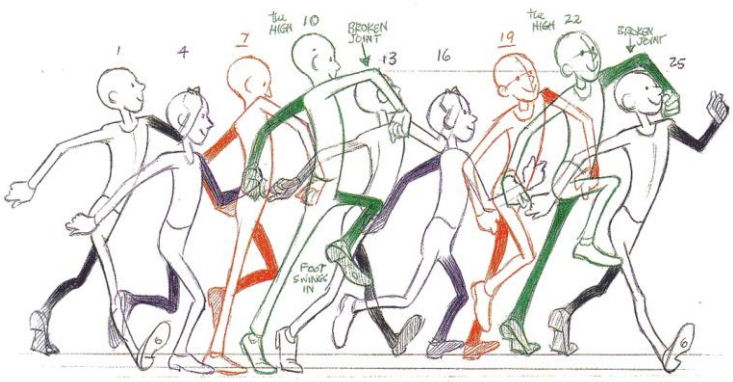

Figure 34 - Happy walk breakdown (Williams 2009, 166)

For the sneak action, Lorin first performed his own interpretation of the action (without any reference) as part of an exercise to comparatively review his own version against others. Lorin was then shown the animation reference (Figure 35) and a scene from *Snow White and the Seven Dwarfs* (Hand et al. 1937). The reference indicates minimal movement of the arms, which Lorin found difficult to achieve. I recommended he divert his attentions to the leg movements simply having the arms in a rest-position, which appeared to help. In a very short recording (three minutes) an accurate sneak action had been secured as seen in Appendix Item 7-5 @ frames 237–453.

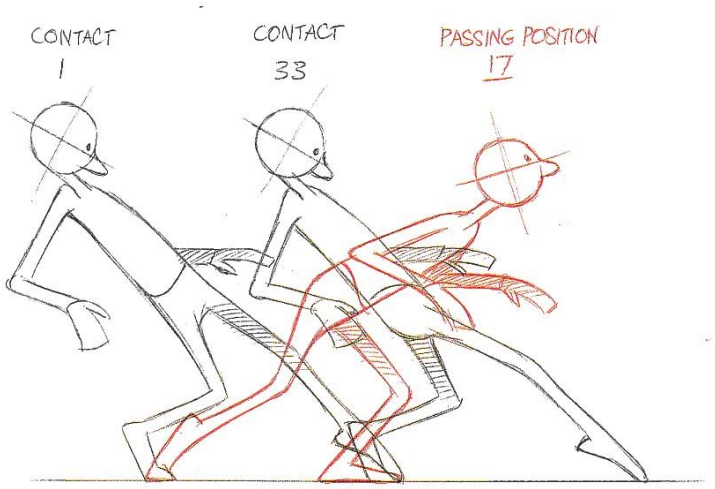

Figure 35 - Sneak breakdown (Williams 2009, 168)

For the double-bounce walk, the animation reference (Figure 36) was used to show Lorin details of the action. During capture, Lorin found going slower than the depicted reference helped him, but the particular rhythm and timing proved difficult, particularly while maintaining correct posing. I directed Lorin to alter his approach by simply doing a ‘bouncy-walk’ and maintaining the vertical movement in the upper body and keeping the legs relatively steady. When the performer was not concentrating solely on the individual components of the action and simply approached the overall impression of the walk, a better result was obtained. While reviewing recorded takes in slow-motion, a slight skip was evident. The digital outcome is seen in Appendix Item 7-5 @ frames 454–737.

Figure 36 - Double-bounce walk breakdown (Williams 2009, 119)

The jump action provided an opportunity to demonstrate animation principles of anticipation, follow-through and the line of action concept. While recording, there were physical difficulties due to the shoes of the capture suit providing less than an ideal grip on the floor, which was resolved by changing his shoes to sneakers. With several recorded takes, the action overall improved slightly but did not clearly demonstrate the extreme poses of the action as seen in Figure 37. The difficulty was attaining the extreme angles of the jump. The performer felt he was mostly trying to accommodate the physics of the overall action rather than trying to get specific poses; thus, it was not a lack of understanding but rather mere physical incapability. The results of can be seen in Appendix Item 7-5 @ frames 739–995.

A variation of capture method was attempted, whereby the key poses of the jump action were recorded through my assistance. Once recorded, the desired poses were then extracted during post-capture. The results of this method are seen in Appendix Item 7-5 @ frames 996–1355. This approach refers to a failed attempt at a broken angry walk during the second cycle of practice. This pose-to-pose capture method requires the director to be a puppeteer and to use of any means (including props) to achieve the required extreme poses. Progressing through each pose of the jump sequentially, this process relies upon post-capture motion editing and equates to 'blocking'. This method is explored further in the sixth experiment.

Figure 37 - Jump breakdown (Williams 2009, 213)

For the push action, Lorin's mime-based skills were significantly used as the performer was directed to not use any props. Animation reference for this action included *The Animator's Survival Kit* (2009, 263) and *Character Animation in 3D* (Roberts 2004); however, these were largely disregarded in favour of Lorin's understanding of the action. During capture, Lorin commented he felt as though he was not adding any animated qualities to his standard miming and yet they demonstrated weight, appeal, anticipation and many other animation principles, as seen in Appendix Item 7-5 @ frames 1356–1850.

The final action, a pull, again made significant use of Lorin's mime skills rather than relying on animation reference. Lorin devised an over-the-shoulder type of pull, which was executed by using his knees as a pivot point, trying to maintain or keep the momentum moving forward and never going backward, albeit with an adjusted spine

for a better line of action. Another variation of this action was using the pelvis as the power centre and anchoring the object on his shoulder to pull. Both variations are seen in Appendix Item 7-5 @ frames 1851–2417.

Experiment 6 | Pose-to-pose

The sixth experiment of this practice cycle investigated the pose-to-pose or 'speed-blocking' capture method briefly tested in the previous experiment. The performer devised a short scenario where a business-type character misses their bus while walking to the bus-stop. In executing this capture method, the performer was directed to pause momentarily for each key pose, something the performer was also tasked with identifying. Lorin was directed to focus on the storytelling and extreme poses, rather than breakdown positions. The pauses were aimed to assist with the post-capture stage, where the key poses were extracted and all other key-frames, deleted. Where the jump action from the fifth experiment required this capture method due to the physically demanding nature of the action, this experiment applied this same method to a less physically exhaustive action sequence. The children's animated television series *Pocoyo* (Carsi et al. 2005–2018) was referred to before conducting this experiment as it demonstrated some similar movement qualities with moments of completely stationary characters.

While recording the experiment, an alternate approach to this experiment presented itself. The pose–pause–pose approach was one method while another was simply performing the scenario without pausing. This approach would keep fluidity and inertia in mind, ensuring animation principles such as follow-through and overlapping action. Lorin admitted he had expected this fluid performance approach rather than integrating pauses into the performance. While in both attempts Lorin could

identify and apply the extreme posing of the sequence, he had difficulty in pausing for breakdowns using the first approach. Of these two approaches, the second was chosen in post-production. The post-capture process involved applying the recorded data to a basic 3D CG character, placing the character in a simple scene and then, at the animator's discretion, using destructive motion editing to extract extreme and breakdown poses while remaining key-frames were deleted. The digital outcome of this experiment is seen in Appendix Item 7-6 and is evaluated in Chapter 6.

Experiment 7 | Stylistic Animation Pulls

The cycle's seventh experiment focused on attempting five stylistic variations of animated movement within the capture stage of a mocap animation. With the same action—a sideways rope-pull—Lorin was directed to attempt a style of movement that emulated 'realistic', 'classic Disney', 'modern Disney', 'Sony' and 'Warner Bros'. As a complicated area of classification, these denoted styles were represented by specific animation film examples and were chosen as distinct categories of animation in the industry. These examples were shown to the performer as representing each movement style and aimed to encourage identifying the comparative qualities of movement from each style to emulate. Keeping to the same action during this experiment would maintain motivation and simply alter the 'how' for the action. Variations to this action would come from how Lorin would grab the rope and make the pulling motions. Each recorded action was applied to a basic 3D CG character with no motion editing. The results are seen in Appendix Item 7-7 and evaluated in Chapter 6.

The realistic movement style was first recorded as a baseline against the remaining animated movement styles. Video clips from *The Adventures of Tintin* (Spielberg 2011), *The Polar Express* (Zemeckis 2004) and *A Christmas Carol*

(Zemeckis 2009) were shown to the performer before attempting this movement style to illustrate the realistic-emulating, minimal stylisation of movement. During capture, an actual rope was used as a real-world representative to create realistic movement. The results are seen in Appendix Item 7-7 @ frames 1–181 and demonstrate a non-stylised form of animated movement.

The classic Disney movement style for this experiment used the film *Pinocchio* (Ferguson & Hee 1940) as a reference. The performer was directed to emulate this style using Pinocchio and Jiminy Cricket as the primary references for this style of movement. These characters demonstrated extreme posing, exaggerated line of action, moments of attitude (a mime term meaning paused posing), anticipation, overt gestures and actions: effectively, all the animation principles. For recording, the use of a prop was removed as it would have no control of stylised movement to complement Lorin's style. While performing, Lorin stated he would be thinking of the referenced characters and their noted movement qualities to inform his movement style. The results of this style are seen in Appendix Item 7-7 @ frames 182–494 and show a convincing classic Disney style of movement.

The modern Disney style of movement used in the films *Tangled* (Greno & Howard 2010) and *Frozen* (Buck & Lee 2013) were used as indicators of this style. Prior to showing these examples to Lorin, he was shown *One Hundred and One Dalmatians* (Reitherman et al. 1961) and *The Lion King* (Allers & Minkoff 1994) to demonstrate the transitional period from the classic Disney form as well as the change of medium from 2D to 3D. The modern Disney style of movement demonstrated qualities of not-so-obvious anticipation, fluid movement with slow-ins and slow-outs, occasional quick movements with short stops, strong attitudes, big facial expressions and overt silhouettes. During capture, no rope prop was used to favour Lorin's entirely

mimed actions. Compared with the previous style, the actions here were made subtler with the addition of smaller, natural movements such as backing off into a slight rest pose at the end of each pull. The results of this style can be seen in Appendix Item 7-7 @ frames 495–909.

The Sony style of movement was categorised with the animated films *Hotel Transylvania* (Tartakovsky 2012) and *Cloudy with a Chance of Meatballs 2* (Cameron & Pearn 2013). In these films, the movement qualities include very quick transitions, overt breakdowns, pushed extremes, frozen attitudes and, at times, a pose-to-pose form of animation. Before recording the pull action with this movement style, Lorin notably practised more than the previous styles to emulate the Sony style. To embody the characteristics of this style, Lorin aimed to have the extreme poses as still as possible, minimal to no ease-in or ease-out and wild hand and arm gestures. During capture, Lorin was affected by maintaining his balance and the extreme change of position between forward and back poses. The results can be seen in Appendix Item 7-7 @ frames 910–1299. Overall, the action would be even faster than Lorin's own physical capabilities to emulate the Sony style closer.

The Warner Bros. movement style was the last for this experiment. The 1930–1969 Looney Tunes (Avery) program with Wile E. Coyote and the Road Runner, and the more recently developed 3D CG version with the same content from the 2011–2014 *The Looney Tunes Show* (Register 2011) were used as examples for Lorin and establish the movement qualities. It was noted that the Warner Bros. style shared a lot with Sony's movement style, but was more fluid, showed more extreme posing, contained major anticipation and extreme squash and stretch. During capture, Lorin attempted to bring a curved line of action in the final pose and a fast pull-back motion.

The results are seen in Appendix Item 7-7 @ frames 1300–1804 and show a quality rendition of the Warner Bros. movement style.

Experiment 8 | Characterisation

The eighth experiment for this practice cycle focused on character portrayal by using a selected animation video clip and recreating a short character action with their associated movement qualities. Similar to the structure of the fourth experiment, the aim of this experiment was to identify and recreate the physical mannerisms of an animated character, specifically Daffy Duck and Wile E. Coyote. These two characters were chosen as they exhibit overt characteristics through their body movements. Once recorded, the mocap data were applied onto 3D CG characters that resemble the inferred characters of each scenario and placed into basic 3D scenes. Post-production processing was applied minimally for each scenario. The results of this experiment are seen in Appendix Item 7-8 and evaluated in Chapter 6.

Figure 38 - Screenshot from *Rabbit Fire* (Jones 1951)

Lorin was shown the animated scene (Figure 38) with Daffy Duck from *Rabbit Fire* (Jones 1951) multiple times before attempting to record the action. During his

recording attempts, minimal directing assistance was provided as the performer was required to deconstruct the character movements himself. While performing, Lorin stomped across the capture volume, emulating the character. While the performer appeared to have little difficulty recreating Daffy's posture, the fast-paced up and down motion of the character's legs in combination with the posture was difficult to maintain. During post-production, the action was overall sped-up slightly to more closely emulate the animation reference. The results of this sequence are seen in Appendix Item 7-8 @ frames 1–304.

Figure 39 - Screenshot from *Bubble Trouble* (Register 2011)

For the second characterisation sequence, Lorin was again shown the animation reference (Figure 39) prior to his recording attempts. During this Wile E. Coyote sequence, the character is seen constructing a trap for the Road Runner with an invisible rope. While the animation reference indicated the use of a rope, during the experiment, the use of an actual rope would have hindered Lorin's style of movement due to its physical properties and so it was discarded. This was the only suggestion from a directorial perspective. Again, Lorin was instructed to complete the sequence on his own during capture. Lorin recorded several takes of the sequence, miming the properties of holding an object and interacting with the scenery around him. During post-production and applied to the 3D CG Wile E. Coyote character, some

modifications were made, specifically location-based jumps between camera cuts and speeding-up select actions to emulate the animation reference more closely. The results of this sequence are seen in Appendix Item 7-8 @ frames 305–953.

Experiment 9 | Perform to Character

The ninth experiment for this cycle of practice, built on some of qualities of the previous experiment of examining the performer's ability to identify movement qualities of an animation character and then performing them in a mocap setting. This involved live-streaming five different 3D CG characters, each with varying stylistic qualities of their form, onto Lorin during a capture session. With each character and using the projector screen as a point of reference, the performer was instructed to explore and 'find' the movement he felt suited its form as seen in Figure 40. This experiment directly correlates to Flueckiger's (2008) model of distance. To complete this experiment, Lorin's insights and knowledge so far gained from this cycle's experimentations were required. Lorin categorised the characters into the previously mentioned animation styles: 'realistic', 'classic Disney', 'modern Disney', 'Sony' and 'Warner Bros.'. After deciding on a character's movement qualities, Lorin was directed to perform a short scenario of walking into a café and sitting down. This would provide a consistent basis for evaluation in Chapter 6 from the digital outcomes of this experiment seen in Appendix Item 7-9. The purpose of this experiment was to examine the benefits of integrating the performer into the mocap animation pipeline, specifically the performer's insights for character movement at an early stage of such a production.

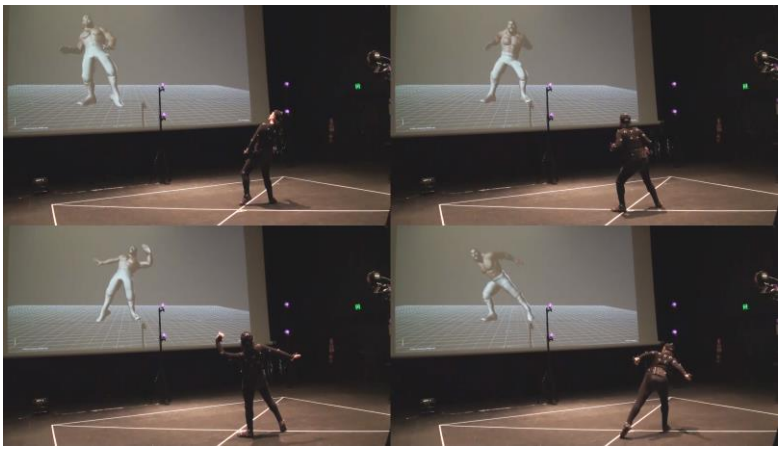

Figure 40 - Lorin testing movements for a character

The first character for this experiment was ‘Carl’ from Mixamo.com, for which Lorin assumed a natural movement aesthetic while exploring. He stated the character would fit into the world of *The Polar Express* (Zemeckis 2004) or *The Adventures of Tintin* (Spielberg 2011). Lorin briefly attempted an energetic Sony-style movement that showed too much expression for Carl’s design and concluded that he could not have made it cartoonish even if he had tried. The results of the café scenario (with Carl) are presented in Appendix Item 7-9 @ frames 1–709.

The next character for this experiment was ‘Stewart’ from Animation Mentor, previously used during the second cycle of practice. After exploring the character form to identify a movement he felt would suit the character design, Lorin stated he would place the character from modern Disney such as *Frozen* (Buck & Lee 2013) to Sony-style such as *Cloudy with a Chance of Meatballs* (Lord & Miller 2009). The performer noted that the character’s emotions are easily read and, regarding movement style, felt it would suit something with suspended, overt silhouettes and gestures, overall adhering to stylistic movement. Two variations of the café scenario were captured with this character, the results of which are seen in Appendix Item 7-9 @ frames 710–1842.

Animschool’s ‘Malcolm’ character was next used in this experiment. Proportionally, this character matched Lorin more closely than Stewart. Lorin

attempted to make the character appear naive, stupid and dopey but, due to its standard facial expression, it appeared more aware and intelligent. Lorin stated he was influenced by what the character wore and felt his demeanour and attitude would be quite casual. Regarding movement, Lorin felt the character aligned more with Sony than modern or classic Disney, the elongated proportions suggesting similarly extreme posing and overall quick movements. The café scenario recorded with this character is seen in Appendix Item 7-9 @ frames 1843–2762.

The next character of this experiment was 'Ty' from Mixamo.com. After exploring the style of movement, Lorin determined that this character suited a happy demeanour. He felt he could not imagine the character with a Sony movement style, but rather modern Disney. The recorded café scenario with this character can be seen in Appendix Item 7-9 @ frames 2763–3264.

The last character Lorin embodied for this experiment was one called 'Brute' from Mixamo.com. He felt this character did not look cartoony enough for a Sony style of movement and confirmed this while exploring the character's style as seen in Figure 40. Using a walk cycle test, Lorin attempted to push the exaggeration of the character's movement and demonstrated a believable, heavy weight with each step. Lorin determined the character aligned with a Disney movement aesthetic, such as one of the bad guys from *Tangled* (Greno & Howard 2010). The recorded café scenario with Brute can be seen in Appendix Item 7-9 @ frames 3267–3924.

Experiment 10 | Evolving Walk

The final experiment for this cycle of practice required the performer to create movements for a series of different characters, but with no directorial input, no reference from a live-streamed 3D CG character and no animation reference material.

For this experiment, the performer was recorded completing a continuous walk cycle around the perimeter of the mocap volume while periodically changing his character type and overall style of movement. During post-production, I assessed the recorded mocap data of various styles of walk and applied a different 3D CG character that I felt would suit each walk. Lorin designed his styles in an off-the-cuff manner during capture, culminating his own skills of mime practice with the knowledge and experience of this cycle of practice. This experiment serves as a demonstration of Lorin's skills and, also, an example of a performer creating a collection of character types and movement styles for a mocap animation in a short span of time. The digital outcome of this experiment is seen in Appendix Item 7-10 and evaluated in Chapter 6.

Once the premise was established, I simply observed Lorin conduct himself through this task, creating nine characters and associated walks. In reviewing these during post-production, I have labelled them (in order of their appearance) as 'plain', 'happy', 'depressed', 'Brute', 'nervous/skittish', 'easy-going', 'Disney-glide', 'old-man shuffle', 'Daffy Duck' and, again, another 'plain' walk. Lorin expressed that in generating the walks he did not specifically have characters in mind but used a combination of elements to see what character would come out of the experiment. This experiment demonstrates a mocap performer creating stylised movement from which a character form was applied in post-production.

Discussion

The fourth and final cycle of practice for this study was an in-depth exploration of the mocap animation production methods used to create cartoon-style movement with a mocap performer. Through a series of experiments, this cycle has culminated the research up until this point and responds to the key research question and sub-

questions equally. My observations and notations throughout this cycle, the experimental results and the contributions of the mocap performer inform the key discussion points of this chapter.

Lorin Eric Salm was selected for this study for his notable professional experience, training as a theatrical mime artist and experience as a character movement instructor. Schooled under mime artist Marcel Marceau, Lorin also has professional acting experience in live theatre, live-action film, TV programmes and animated TV programmes *Care Bears: Welcome to Care-a-Lot* (Gordon 2012) and *Strawberry Shortcake's Berry Bitty Adventures* (2010–2015) where he created movement references for animators to work from, similarly to *Rango's* (Verbinski 2011) production method. Lorin's skills allow for multi-disciplinary applications. His prior experience on mocap productions meant he knew how his skills as an actor and mime artist could apply to pecap, which minimised technical explanations of the mocap system. Lorin's methods of performance focus heavily on the physical expressivity of the body and, overall, applied very well to this research of creating cartoon-style movement during the capture stage of a mocap animation. Lorin felt that while some actions of this cycle were outside of his capabilities, certain individuals trained in other types of physical movement might be more adept at accomplishing them. Additionally, the time-restrictions of the mocap sessions played a factor in perfecting the cartoon-style results. Any action that was not satisfactorily achieved during the sessions would not be disregarded outright, but as a by-product of the limited experimentation time. With enough rehearsal time, a performer could emulate cartoon-style movement well.

As an instructor, Lorin provides workshops and coaching for performers who want to maximise their physical expression, including singers, dancers, magicians, circus artists, jugglers, actors and, also, animators (Salm 2017). He is of the opinion

that mime lends itself well to animation. Through his 'Character Movement for Animation' workshop series, Lorin has taught at Disney, DreamWorks Animation, Sony Pictures Imageworks, Rhythm and Hues and several animation schools (Salm 2017). He noted even animators at Disney had never approached character expression using mime-based solutions. During these workshops, Lorin provides training for animators to understand the expressive potential of the body and ways in which body can be used to express the personality of a character or what they think and feel at any given moment. It was thought that based on Lorin's ability to apply mime practices to the animation practitioner's methods, a rigorous examination of cartoon-style movement with mocap could be achieved.

The mocap performer is a niche acting area in and of itself; the specialty of animation mocap performer remains unknown. The capabilities of the performer play a large role in this form of production and this cycle has indicated what training background would be beneficial. The skills required for such a role far exceed a typical actor's training in movement. Any actor who wants to perform for this kind of medium would require movement skills, mime skills, physical acting skills, awareness of using the entire body and projecting their movements to be overt; all together, abilities that are much broader than an actor whose focus is on-camera for film and television. Lorin agreed that a mocap performer for a cartoony animation would require a whole new set of skills. There could be room for a new acting technique or at least an extension of an acting technique as it applies to mocap.

Over the course of this practice cycle, mime and animation were found to share multiple similarities, from the practitioners to their practices. Both the animator and mime actor emphasise the physical expression of a performance, using variables of movement to denote character. Lorin stated that the mime actor understands the

possibilities of movement, whereas the traditional stage actor often does not learn how far they can take a movement or the physical expression of an idea because it is not appropriate in most traditional styles of acting to take a physical expression that far. Both the mime actor and animator can take a physical performance beyond what a traditional actor is willing or capable of achieving. What this implies is that in the pursuit of cartoon-style movement with mocap, a mime could be a good candidate as a performer, bridging the physical performance to the animator's digitally reconstructed performance. Mime-based movement, according to Lorin, is always stylised in some way, whether by adding, removing, refining or directly changing natural movement for an artistic interpretation. With the mime artist already working in the world of stylised movement, their involvement in a cartoon-style mocap animation is not far from their field of expertise. Their degree of control over movement enables them to use their body to easily to show character, or what that character is thinking or feeling, as well as in a stylised manner. A distinct difference in skills of animated movement analysis and execution was noted between Lorin and previous performers. Where an exercise may have taken up to an hour to achieve previously, with Lorin, the recording was attained much faster and more accurately. Mime is a unique performative craft that lends itself well to the process of creating cartoon-style mocap.

The baseline testing, prior to this cycle's experiments, encouraged Lorin to perform based on his instincts, prior experience and only using the *Lost for Words* animatic (Appendix Item 8) as reference. With his skills as a mime artist, Lorin instinctively began to stylise his movements rather than moving in a natural manner. He demonstrated the character's emotions and intent of actions through chosen posture, qualities of stillness and suspension and, lastly, by isolating certain parts of

his body to move singularly. These movements derived from Lorin's skills as a mime artist and demonstrate animated movement qualities. These were not naturally considered with previous performers, but rather something I had introduced to during their experiments. Lorin demonstrated excellent articulation in refined movement, as well as having a move–hold–move–hold rhythm to his gestures. Lorin, himself, felt his movements and acting choices provided a good, accurate representation of the animatic. This pre-production examination did, in fact, provide a good proving ground for the performer's skills and comprehension of the mocap animation production and stylised movement for such a production. From the baseline testing, it was clear Lorin brought a very distinguished and transferrable style of movement to the study and would make the experiments of mocap cartoon-style movement profound.

The large projector screen during this cycle was a valuable tool, just as it had been in previous cycles. Lorin indicated it was a great training tool and reference for personification, posing and movement based on what he was trying to achieve and how it came through in 3D. The ability to test certain movements and immediately see how they are being read allow performers to make modifications in real-time. Additionally, throughout this cycle, movements were mostly recorded and reviewed on the basic 3D CG Motive avatar, which removed any interfering character design elements that might impede on how the character's movements were perceived.

At the beginning of this cycle of practice, I ensured that a progressive build in difficulty would occur. Introducing animated movement qualities to the performer's action began slowly with the 'overlapping action and breaking joints' experiment. These allowed the performer to get into the mind-set of animated movements and—in combination with the use of the projector screen—encouraged the performer to understand the relationship of his own movements to his digital avatar's as well as how

to shift into an alternate form of moving. This proved to be effective. It was also noted through this approach that the larger movements helped draw out a stylistic movement pattern from the performer more than smaller, nuanced gestures. Lorin agreed that as part of a process to slowly bring a performer into the mocap animation setting—particularly one with stylised movement—such exercises would be very useful on the first day of production.

The 'breakdown', 'perform to character' and 'evolving walk' experiments were opportunities to examine character movement as a determinant of personality, where the performer was directed to complete the same action but change how he moved. The development and exploration of a character's movement are important components of animation production. Designing unique action choices and stylisation through movement are part of an animator's decisions. For the mocap animation, the performer shares this responsibility. As part of Lorin's process of character development, he indicated that for a walk action, he would typically look at how the character's feet hit the ground, how their knees move, how far apart their legs are and the angle of their feet. He described how the function often would follow form; for example, for a walk, the contact pose would indicate the way to get into that pose. As such, demonstrating the potential of the breakdown position of an action was a key teaching moment for Lorin as was exploring the types of movements suited for whichever 3D CG character was applied to Lorin during the ninth experiment. The exemplar video, *Big Hero 6 Character Studies* (Wired 2014), resonated well with the performer, showing how the same action can be performed in different ways to signify the personality of a character by how they differ in completing that action. Particularly within the 'breakdown' and 'evolving walk' experiments, using the basic 3D CG

Motive avatar and having the performer record variations of the same action or variation truly demonstrated the importance of personification through movement.

The third experiments' 'weight and anticipation' exercises were an expressive opportunity for Lorin's skills as a mime actor. The physical exertion required to mime heavy objects is almost the same as lifting an actual heavy object. This is due to the required similar muscular tension in the former, which if not used, does not make the action look real. Lorin stated that anticipation was a technique taught directly to him and stated that it is even referred to as 'opposition', which is also mentioned in *Towards a Theory of Mime* (Iliev 2014). To create the effect of convincing weight, Lorin employed what he called 'counter-weights', which is a mime technique of exerting force by going one way to go another. He exemplified this with a demonstration of carrying something heavy on his shoulder and explained in that situation, a performer would go down, to go up. Weight and anticipation were not difficult animated qualities for Lorin to demonstrate; his mastery over them could be further proof to the case of the physical performance required for cartoon-style mocap animation.

The use of animation reference materials was a large component of this cycle of practice. These were particularly necessary for the 'overlapping action and breaking joints', 'weight and anticipation', 'line of action', 'referenced actions' and 'characterisation' experiments. As a method of production, Lorin found he would not have been able to accurately portray the directed actions if he had merely had verbal directions. While very useful as guides of overall animated action, Lorin noted that the instructional breakdowns, such as those from *The Animator's Survival Kit* (Williams 2009), lacked an indication of the transfer of weight and momentum, or at least did not indicate where it was happening in order to make use of it in the mocap setting. As

texts dedicated for animator's, these are not considered performance guides; thus, it remained Lorin's task to interpret the references with his best estimate for these qualities. A performer who has not done body movement analysis or similar training may not be able to understand what these animation references mean, much less replicate them. While for traditional animation productions these factors would not necessarily be considered as heavily and still appear plausible, they would need to be considered when brought into the physical space. Even so, the use of animation reference materials outweighs its absence for cartoon-style mocap animation productions. For the purposes of cartoon-style mocap animation, a 'movement package' with the required actions, animation references and informational breakdowns could be sent to all performers to prepare them prior to the mocap session. This could be complemented with a rehearsal period to ensure they can achieve the desired results. This can be compared with Andy Serkis' 'ape camps' that were used as a physical preparation school for mocap performers to immerse themselves in their roles as non-human mocap performers (Xposé Entertainment 2017). Overall, the animation reference materials—whether still images with pose breakdowns, exemplar 2D animated video clips or animated films—were an important tool for the director and performer during this cycle of practice, enabling communication for otherwise complex animation concepts.

Communication between the director and performer in terms of the language used was an issue broached within this cycle. Lorin made it clear that he was not aware of any common language within physical acting theatre or mime because there is no one unifying technique. As such, any instance of miscommunication during this cycle was rectified through verbal or visual explanations to help bridge any lack of understanding from the performer about the animation. This solution aligns with

industry practices, where participants' communication issues lessen over the course of the production. Further research would be required to properly implement a collective production language in a mocap animation and it would need to incorporate multiple participants, including directors, performers and animators, all of whom would have varying background knowledge of performance.

The pose-to-pose capture method examined during the fifth and sixth experiments invited new approaches of cartoon-style mocap. The jump action of experiment five demonstrated that for actions exerting speeds, angles, forces and extreme momentum beyond the capabilities of the performer there would need to be preparation ahead of the capture stage to identify what actions might require 'assisted posing' as a means of 'speed-blocking'. The pose–pause–pose–pause approach from the performer during the sixth experiment's bus-stop scenario did not indicate overly animated qualities of movement because unlike the jump action, there was no specific pose references for which the performer to emulate. The bus-stop scenario was devised in the moment and dictated by the performer, which made it difficult to account for more extreme posing and animation principles that might otherwise be affected when recorded in real time, without the pauses. The second 'fluid' approach with the use of pose-extraction during post-capture proved to be a better method. While not completely explored, both would warrant further investigation to properly examine their legitimacy as a means of mocap animation production. The children's TV series *Pocoyo* (Carsi et al. 2005–2018) was shown during this experiment but was untested as a style of movement. This series has fast, popping movements with direct gestures and long-held, static posing. The application of the pose-to-pose capture method during this cycle, limited as it was, is a demonstration of the expanse for which mocap can be utilised for animation productions.

The ‘stylistic animation pulls’ was a valuable experiment for this study as it identified a certain method of restricting the movement patterns of a mocap performer. Each style of animated movement—realistic, classic Disney, modern Disney, Sony and Warner Bros.—was established with certain rules and derived from selected animated films. Such rules would govern the movement of the performers for the mocap animation and establish the aesthetic the director required. A Sony-style outcome, for example, might call for the performer to hit extreme poses, have high speed actions and render still, dynamic posing. Relating to the experiment, an established manoeuvre was the fast hand-flourish that Lorin included for the Sony-style pull action. For a production, this might be given to the performer as a rule of: “quickly flourish/frenzy your arms when transitioning between two extreme poses” or “whenever doing X type of movement, embellish it with movement Y”. Setting parameters such as these could establish the conditions for movement in a mocap animation. This also directs attention to the approach of language a director might be required to consider. During this experiment, Lorin successfully identified and executed each animation style under this study’s definition of cartoon-style movement, which were greatly dependent on the skills of the performer. Lorin felt that the hardest movement style, based on what he had achieved, was the subtle movement nuances of the modern Disney style and the easiest was the broader actions of the Sony/Warner Bros. styles. Future research could use this method to bring stylised mocap animation into more refined animated movement styles such as those used during this experiment.

The ninth ‘characterisation’ experiment provided an opportunity for the performer to creatively participate and decide on the movement qualities of a denoted character’s form. This effectively assessed Lorin’s ability to align ‘behaviour’ and

‘appearance’ according to Flueckiger’s (2008) model of distance, which he was able. While untested during this study, this experiment also invited an alternate approach to the mocap animation production. Specifically, using an unfinished 3D CG character for a production and during a mocap session—such as in the characterisation experiments—exploring the character’s movements to pre-emptively create a movement study from which the character’s design could be adjusted to optimise readability. This was found when Lorin was applied to two character’s that—with the same pose—showed different silhouettes as seen in Figure 41. This refers to the similarly disproportionate characters in the *Powers Above* project. Through pre-production, this issue could be minimised by adapting the digital characters’ physical design after a pre-capture exploration, where the mocap performer has assisted in strengthening the character’s movement readability. In instances where the performer’s and digital character’s proportions are different, another solution could use capture-suit fixtures such as those used in the *Sid the Science Kid* (Finn 2008) TV series seen in Figure 2.

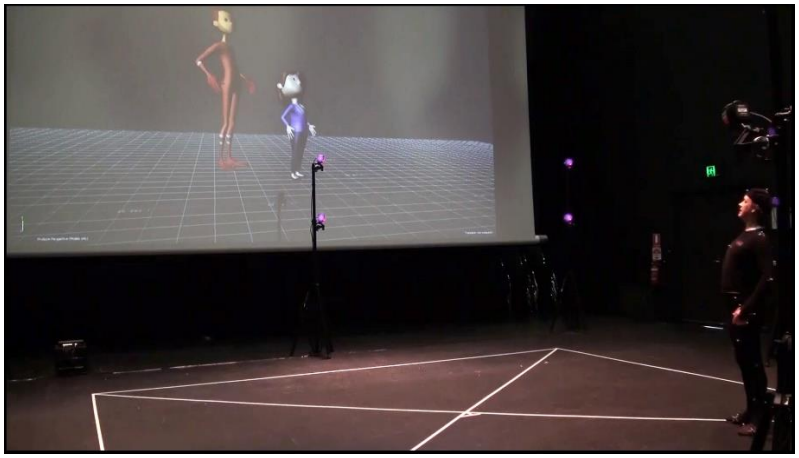

Figure 41 - Lorin comparing the Stewart character with a *Lost for Words* character

This pre-capture exploration could otherwise be used to illustrate the digital avatar to the mocap performer, so the performer can begin to create a movement style

for them. While minimally tested in this study, further research could use this method to refine a production process for a cartoon-style mocap animation.

Control over the movements between the director and performer was a consideration of this cycle of practice. Initially, it was believed that having a measure of control over the movements of the performer would denote the best results for this production. Instead, the movements become stilted and the performer plays no participatory role and their skills become mute. During this cycle, I would often physically demonstrate the various actions when explaining their execution which, for Lorin, was too restrictive. Lorin felt this was hindering as he had little creative rights to the actions. He still required the freedom to decide the rhythms and timing of the movements. Additionally, when shown an action in detail, he found his instincts as an actor would be disregarded and require simply copying what was shown. This interfered with his sense of spontaneity and ability to explore a moment that might arise naturally, as well as not having to think about a series of tasks to complete for an action. Based on the limited range of range of participants within this study, the control over the movements between the director and performer would need to be shared. This dynamic requires further investigation for the unique production environment of cartoon-style mocap animation.

Summary

This chapter addressed the fourth and final cycle of practice for this study, closing the investigation of cartoon-style mocap animation. Through the participation of an experienced mime actor—Lorin Eric Salm—multiple experiments were conducted to reconcile traditional animation and mocap practices. Lorin was selected for this study for his professional experience of applying his skills as a mime artist to

animation practice; moreover, he demonstrated aptitude for creating cartoon-style movements for a mocap animation. This cycle of practice has found that mime and animation practice share many similarities through mocap, indicating a strong connection that could be explored through further research. Previously acquired knowledge was further examined through this cycle, specifically the use of a projector screen, progressively increasing the difficulty of animated actions, using animation reference materials and the dynamic between director and performer over control of movement during the cartoon-style mocap animation production. Of these researched areas, the last item was the only one that was not successfully resolved. In addition, newly investigated areas of this cycle included character movement as a determinant of personality, weight and anticipation as prominent mime-based qualities, the use of a new pose-to-pose capture method and establishing restrictions of a mocap performer's movement patterns to create varying styles of animation. This cycle of practice produced several digital outcomes, all visualising the experiments evaluated in Chapter 6 of this exegesis. The results of this cycle of practice will be discussed with respect to this study's questions, aim and objectives during Chapter 7.

Chapter 6: Evaluation of Digital Outcomes

This chapter critically evaluates the digital outcomes as a result of the second, third and fourth cycles of practice. Through an evaluation of these outcomes, the effectiveness of the various experiments carried out through each cycle's projects is illustrated. These are reviewed for the presence of animated qualities, whether by animation principle or technique. While practically informative, the digital outcomes of the first cycle of practice do not require evaluation as they indicate benchmark practices for mocap animation.

6.1 EVALUATION OF SECOND CYCLE OF PRACTICE

The second cycle of practice resulted in a collection of comparative videos, demonstrating applied animated actions from collected mocap data. Appendix Item 5 shows all of these comparative videos together. Each video is titled and includes animation reference as 'animation footage', video capture of the mocap session as 'Motion Capture Recording', the collected mocap data applied to Stewart character rig from Animation Mentor in an unmodified 'Applied Dirty Data' version and an edited 'Cleaned-up Data' version. It should be noted that the animation reference was not necessarily the reference material shown to the performer during the capture session, but demonstrates the intent and execution of the idea from a traditionally animated method. The purpose of this cycle's digital outcome is to visually compare the qualities of cartoon-style movement through several animated actions and select those that suit the stylised character.

Action, Animation Reference, Frames, Figure	**Review**	**Result**
Depressed walk Flint from *Cloudy with a Chance of Meatballs 2* (Cameron & Pearn 2013) 1–253 Figure 42	• Reference shows an extreme version of walk and has rhythmic slaps of the feet and minimal up/down movement of the upper body • Exaggerated bent-over posture and loose upper body • Quite naturalistic; emulates the appeal of flint • No consideration of overlapping action or timing • Over-acted walk • Steps of the mocap movement slower than the animation reference • Does not adhere to a fluid overlapping motion of the upper body with each step • Natural timing is still indicative of mocap animation compared with minimalist animation of Flint	• Movements do not emulate the animation reference precisely • Actions suit the stylised character (Stewart) • Overall intention of movement is clear
Angry walk Hook Hand from *Tangled* (Howard & Greno 2010) 254–443 Figure 43	• Reference shows large, domineering character with a directed force towards another character • Slumped posture closely resembles Hook Hand's • Emphasis of each step's impact in animated mocap versions does not demonstrate weight as well as Hook Hand • Recorded action demonstrates angry pacing Upper body bent forward and impact of each step exaggerated during clean-up to emphasise intent of action	• Imperfect comparison to animation reference • Quality application of animated action to a stylised character • Fast-paced nature of the walk lends well to the intent of the action

Happy walk Mowgli from *The Jungle Book* (Reitherman 1967) 444–623 Figure 44	• Reference shows rhythmic timing and foot-slaps to the ground • Captured action is over-acted • More closely resembles the character walk of *Pinocchio* (Ferguson & Hee 1940); particularly last few steps of the walk • Large arm-swings and indication of skip with each step • Broadened the posture with an open chest during clean-up and incorporated overlapping action into the arm-swings; shows a better silhouette and overall character appeal	• Animated outcome differs from reference, but still evident representation of an animated and exaggerated happy walk • Overall timing of the action would need considerable anticipation and overlapping to render an even closer look • Actions suit the stylised character (Stewart)
Tip-toe walk *Shrek* (Adamson & Jenson 2001) 624–795 Figure 45	• Reference shows large character build with complementary movements • Difficult for the performer to replicate • Performer's build closely resembles her digital character Stewart • Over-acted nature from performer • Exaggerated upper body compression by lowering the head and showing a pressing down motion with the arms during clean-up; lends well to the character intent of tip-toeing	• Could be sped-up slightly overall as well as doubling the speed the leg up and down movement for a more conducive animated result • An overly cartoony result would mean minimal to no vertical movement of the body and the legs simply going up and down • Actions suit the stylised character (Stewart)
Sneak walk Seven dwarfs from *Snow White and the Seven Dwarfs* (Hand et al. 1937) 796–1033 Figure 46	• Reference shows fluidity seen through arcs, giving the appearance of an almost weightless step as well as a pose-to-pose animated approach • Recorded action lacks fluidity; broken up due to balancing nature of walk-through weight distribution as well as the offset arm actions	• Overall animated characteristics for a quality result • Actions suit the stylised character (Stewart)

	• Performer had more concern for leaning back than use of arcs • Exaggerated posing during capture • Slight revisions during clean-up such as adding hand-splay • Animation reference shows use of props, these would alter the weighting of the walk considerably	
Heavy-lift action *The Animator's Survival Kit* (Williams 2009) lecture series 1034–1314 Figure 47	• Object-interaction • Squash and stretch qualities are visibly bound to the physical limitations of the performer • Relaxed final pose–gives appearance of deflated character • Subtleties of anticipation and follow-through evident but could be pushed further Attempt to re-introduce stretch and exaggerated posing during clean-up	• Results are good approximation and demonstrate the ideas of a heavy lift • Animated qualities present • Does not directly copy the animation reference • Staggering effect would require immense strain to realistically re-create during capture stage
Double-bounce walk *The Animator's Survival Kit* (Williams 2009) lecture series 1315–1476 Figure 48	Typical cartoon action • Demonstrated well with animated characteristics • Foot-plant of each step made while maintaining the loose timing of the upper body • Minimal overlapping action of the head Revisions during clean-up to add overlapping action of the arm-swing and a slight skip	• Well-timed double-bounce action • Animation reference and outcome compare well • Overall character intent and happy nature evident
Fist smash action Ralph from *Wreck-It Ralph* (Moore 2012) 1477–1643 Figure 49	• Evident elbow-break technique but awkward • Obvious lack of object-interaction • Lack of force behind the action, leads to weak silhouette at times • Minimal action intent shown • Revisions during clean-up to add exaggerated drag with the	• Evident animated qualities of an elbow-break, anticipation, overlapping action and follow-through • Animation reference and capture show different executions of the same action

	shoulder to emphasise overlapping action and adjusted timing to emphasise anticipation with a longer hold on the ‘up’ pose ; obtained passable result	• Minimal action intent shown

Figure 42 - Depressed walk with Marianna comparative video

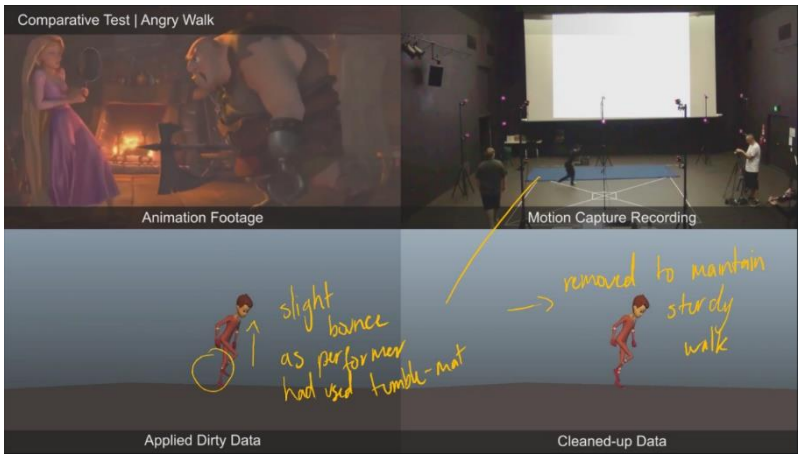

Figure 43 - Angry walk with Marianna comparative video

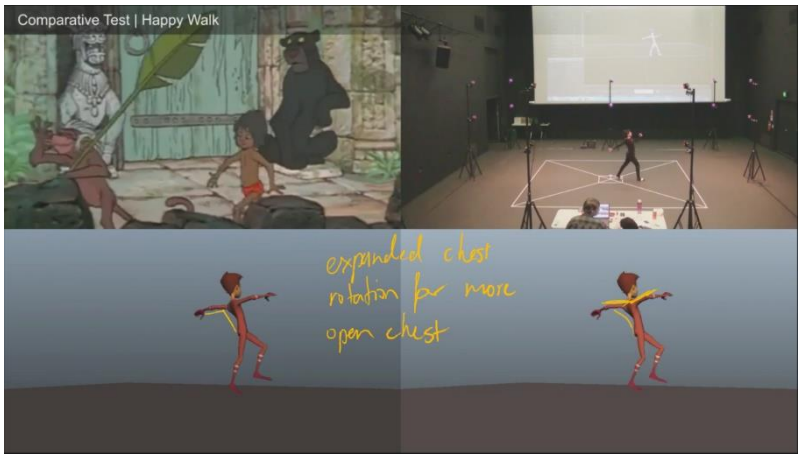

Figure 44 - Happy walk with Marianna comparative video

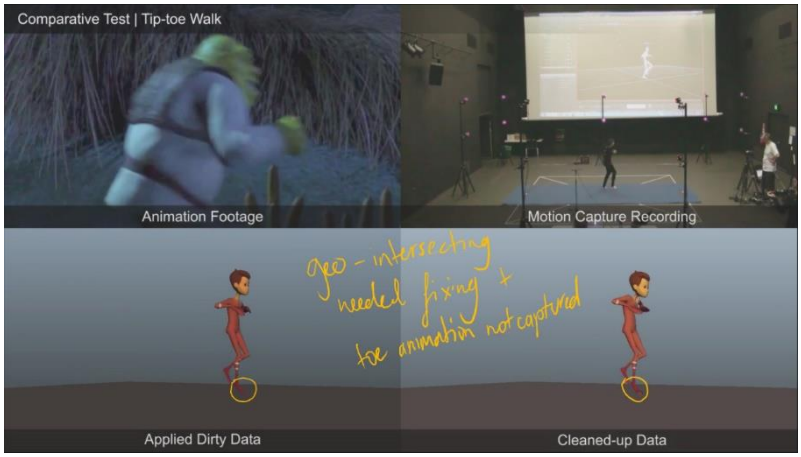

Figure 45 - Tip-toe walk with Marianna comparative video

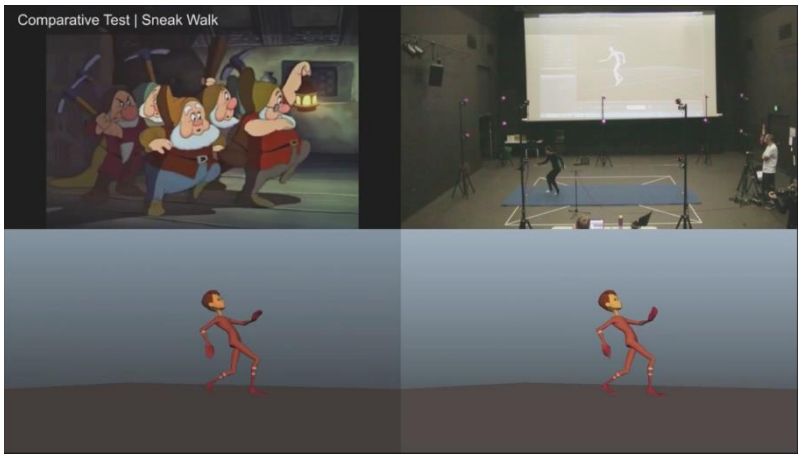

Figure 46 - Sneak walk with Marianna comparative video

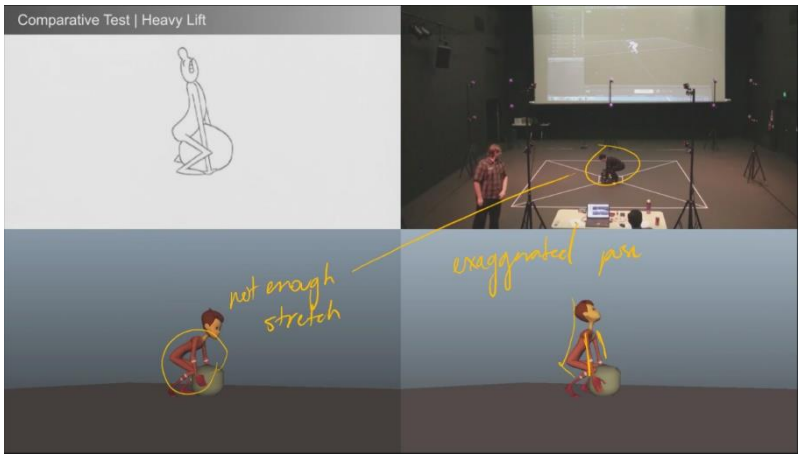

Figure 47 - Heavy-lift action with Marianna comparative video

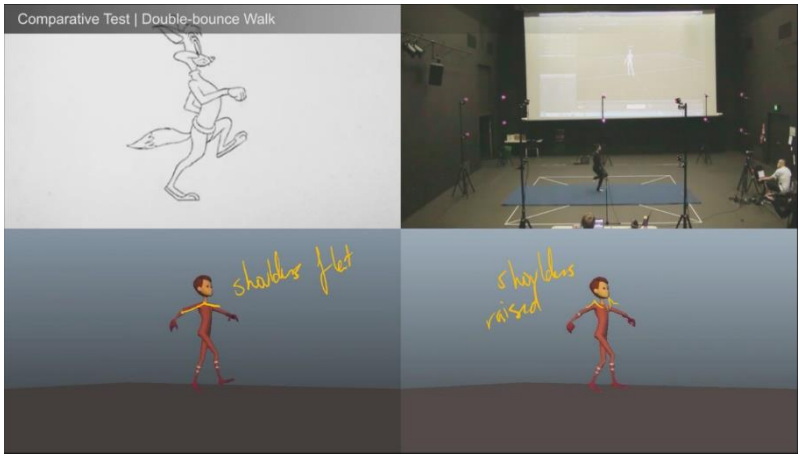

Figure 48 - Double-bounce walk with Marianna comparative video

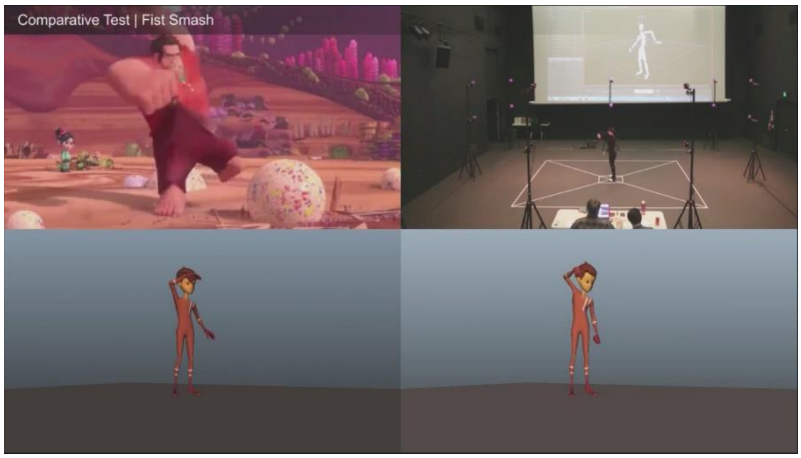

Figure 49 - Fist smash action with Marianna comparative video

The results of this evaluation indicate the presence of animated qualities in each of the mocap actions beyond simple movement but demonstrating character intent. With amendments to each action during post-production—to the extent of standard

mocap editing techniques—the results demonstrate the potential for this method of production, imbuing animated actions during the capture stage.

6.2 EVALUATION OF THIRD CYCLE OF PRACTICE

The third cycle of practice resulted in comparative videos with performers Liam Soden and Maeve Hook as seen in Appendix Item 6. Each digital outcome is titled and annotated, and contains a side-by-side comparison of (1) the recorded mocap data applied to a 3D CG character─Y-bot or X-bot from Mixamo.com─called 'Applied to 3D Base' and (2) video capture of the mocap session titled 'Motion Capture Recording'. These digital outcomes demonstrate the progressive refinement and addition of animation qualities and techniques to a mocap performer's movements during the capture stage of a mocap animation. They also indicate whether or not the performers could achieve cartoon-style movement through this process.

Action, Frames & Figure	**Review**	**Result**
Cartoon take 1-828 Figure 50	**Actor's Interpretation of Action** • Naturalistic, with no discernible animation characteristics • Initial profile stance of the character shows disengaged staging and all parts of the body move together with minimal to no distinctive offset **Director's Involvement to Improve Action Intent** • Better starting pose • Slight offset with the head leading the action and arcs in the turn-around, particularly the head going down and around	• Shows progressive implementation of animation techniques • Overall action has been infused with stylised, animated qualities

	• Improved animation characteristics, nothing specific to the cartoon take **Applied Animation Techniques to Emphasise the Animated Characteristics 1** • Anticipation as body goes down, then up in surprise to create accurate cartoon take • Momentary hold to show what the character is thinking before then turning around • Head emphasises arcs and leads the turn-around with the arms being dragged behind with an offset • Ease-in and ease-out arc action visible **Applied Animation Techniques to Emphasise the Animated Characteristics 2** • Adjusted stance with weight leaning lean to one side (relaxed pose) • Better character silhouette • Alteration to the 'take' before turning • Minimal anticipated down motion and emphasis on the up motion to indicate the direction of the shoulder-tap cue • Increased volume of the down motion as well, with a knee-bend to incorporate the whole body	
Double-bounce walk 829–1047 Figure 51	• Shows actor infusing characteristics and performance into an action (with some understanding of animation practices) • Momentary hold at the end of the stride before back-tracking is an	• Reintroduced character into an animated action • Double-bounce walk is evident • Demonstrates animated qualities

	exaggerated gesture and complements the intent of the action well • Spin-around shows a great deal of drag, anticipation and overlap when the actor delivers the line	
Running-stop sequence 1–765 Figure 52	**Actor's Interpretation of Action** • A lot of energy behind the run, results in a sliding-stop at the end • Force and speed of the action show physically based body overlap, minimal control over the animation qualities **Director's Involvement to Improve Action Intent** • Action is slower and demonstrates slightly more control with overlapping action and follow-through • Sliding still present • An invisible pull-back force in the action at the point of impact **Applied Animation Techniques to Emphasise the Animated Characteristics 1** Performer has control, results are a desired effect of rhythmic arm-circles stopping her run	• Well-executed animated-style of action, improved from the first instance
Double-bounce walk 766−1077 Figure 53	• Fluid, dancer-like motions, indicative of the actor's background • Double-bounce walk is evident but more of a stride • Movements lack the characteristic 'pop' of small, fast, yet discernible gestures • Feminine looking turn-around action strikes a strong final pose and silhouette	• Re-introduction of character into an animated action • Demonstrates character intent • Does not completely embody animated qualities but does show the performer has some understanding of animation characteristics
Box-carry sequence	• Two performers involved	• Each sequence progressively shows improved

1–525 Figure 54	• Crab-walk variation (350–525) is the best outcome; shows quality exaggeration with each step, anticipating with their bodies leaning over and follow-through with a swaying action • Imperfect sequence	demonstration of mimed weight and cohesive movement • Shows consideration and refinement from both performers' to move with animated qualities

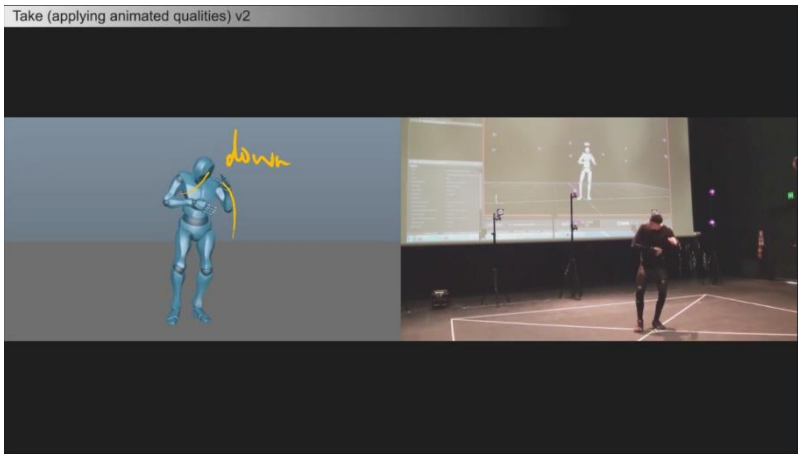

Figure 50 - Cartoon take with Liam comparative video

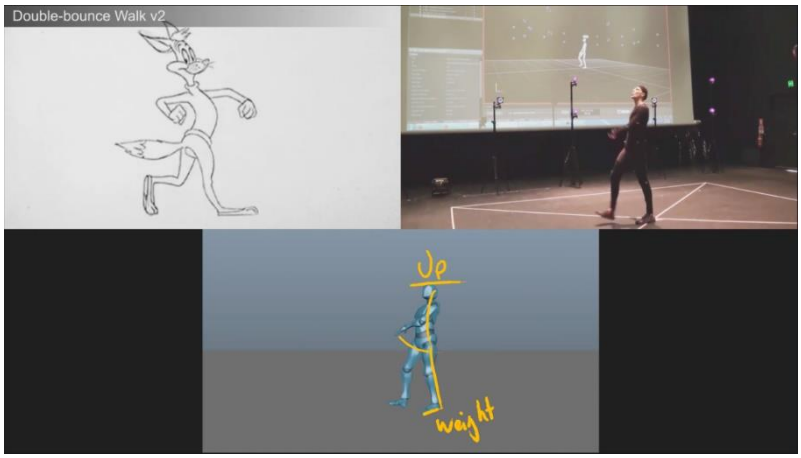

Figure 51 - Double-bounce walk sequence with Liam comparative video

Figure 52 - Running-stop sequence with Maeve comparative video

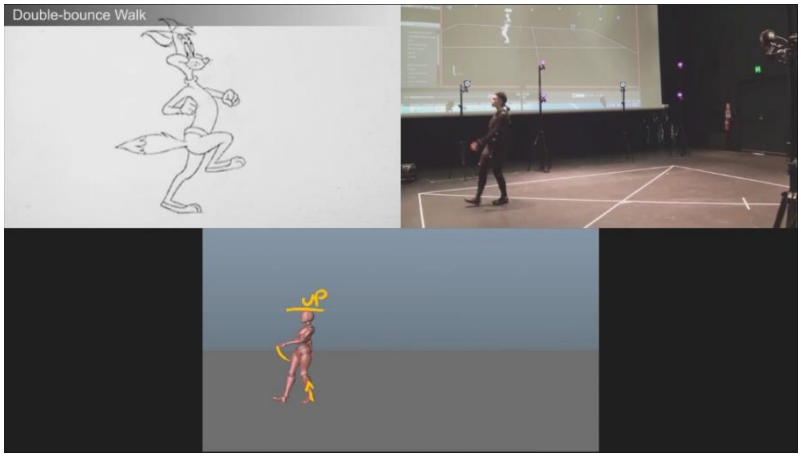

Figure 53 - Double-bounce walk sequence with Maeve comparative video

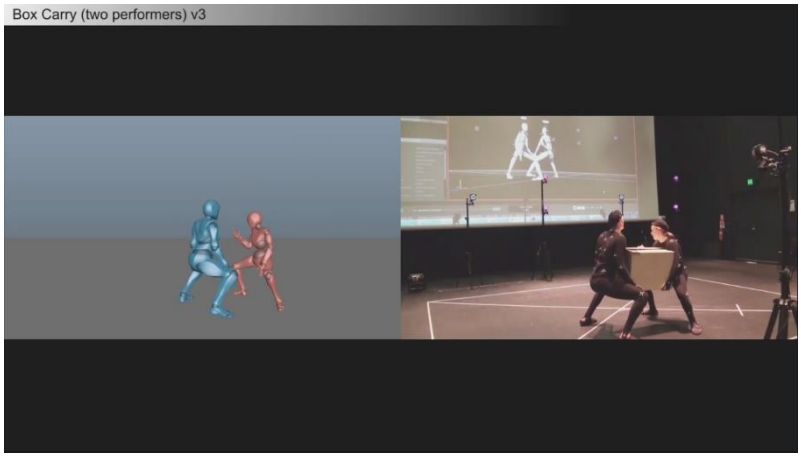

Figure 54 - Box-carry sequence with Liam and Maeve comparative video

The evaluated results of this cycle's digital outcomes demonstrate the capabilities of two actors to render animated performances with the assistance of a director. Through progressive implementation of animation principles and techniques,

it is evident that even within the short period of time to which these sessions were limited, these performers could create animated actions. The application of unprocessed mocap data to 3D CG characters emphasises the qualities of animated movement within the capture stage of a mocap animation production. It is evident that although both students were given a relatively similar mocap setting, Liam demonstrated a better understanding and capability to create cartoon-style movements. A natural affinity for such a production could be a test factor to consider. Through mocap sessions such as these, a performer could be found to have a natural inclination or ability to adapt their skills for a cartoon-style mocap animation.

6.3 EVALUATION OF FOURTH CYCLE OF PRACTICE

The fourth cycle of practice resulted in ten digital outcomes, each a comparative video visualising the results of the experiments detailed in Chapter 5 and listed under Appendix Item 7. Each outcome includes a combination of a video recording of the collected mocap data, the mocap data applied to a 3D CG digital character and animation reference footage. Collectively titled 'Cartoon-style Animated Movement with Motion Capture', each comparative video is titled and digitally annotated (where necessary) for the purposes of this evaluation. A side-by-side comparison is used together with these annotations to analyse and review the effectiveness of each experimental outcome. The aim of each experiment and its resultant digital outcome will be detailed throughout this evaluation.

Experiment 1 | Overlapping Action and Breaking Joints

The first digital outcome (Appendix Item 7-1) contains a 2D animation reference from *The Animator's Survival Kit* (Williams 2009) lecture series, a video

recording of the mocap session and the collected mocap data from this recorded session directly applied onto a 3D CG character (Y-bot character from Mixamo.com) and unedited (Figure 55). The digital outcome illustrates four action sets. The experiment demonstrates the performer's successful execution of the animation principle of overlapping action through a joint-break technique.

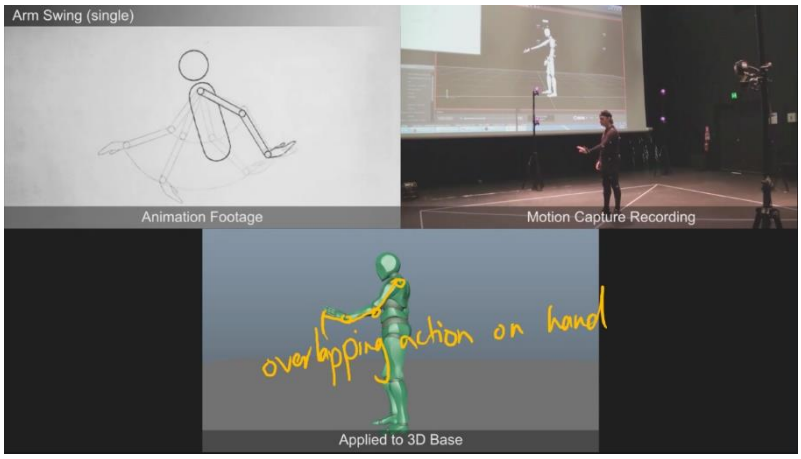

Figure 55 - Experiment 1 digital outcome comparative video

Action, Frames	**Review**	**Result**
Single arm swing 1–266	• Shoulder/upper torso twists for exaggeration, elbow leads the swing forward, hand drags behind and overlaps at the front-end • An apparent push motion with the wrist is required to achieve this result	• Demonstrates the technique
Two arm swing 267–407	• Shows a physical limitation attempting to maximise technique impact • Less shoulder-exaggerated movement as both arms are in motion	• Evident but not as prominent
Two arm swing during walk 408–525	• Would require further practise to execute with more distinction	• Does not completely satisfy technique

Raise and lower arm action 526–715	• During the ‘up’, the leading elbow is evident, and a nice hand-overlapping action concludes the gesture • During the ‘down’, the elbow easily leads the action again, with the hand following through afterward	• Consistent overlapping action and drag throughout this outcome and clear application of technique
Fist smash action on a table joint break 716–978	• Elbow leads the action with a raised shoulder • Hand overlaps on the ‘up’ and drags behind on the ‘down’ • Elbow locks onto the table at point of impact • Hand arrives last and a two-frame apparent bounce • Emphasis of weight and force (like a dropped bowling bowl: slight, but still apparent)	• Clear indication of technique with a forceful impact • Character and emotionally driven action • Performative quality rather than simply an exercise
Turning on spot: all-together, no overlap 877–960	• Even timing and spacing with low appeal	• Focus on full-body overlapping action • The order of head, chest and feet overlapping action during turn determine variety of situational and characteristic possibilities • Variances of timing were disregarded in favour of overlapping action • Demonstrates different characters through change of action state
Turning on spot: head, chest, then foot 961–1060	• Attention drawn away	
Turning on spot: foot, chest, then head 1061–1149	• Shoulder raised up and back to indicate the chest turning first; leaning to the side to bring foot around • Defiant / confident turn-away gesture	
Turning on spot: chest, foot, then head 1150–1239	• More deliberate, exaggerated version of previous	
Turning on spot: High	• Guard standing to attention	

steps with both legs, chest, then head 1239–1286		

Experiment 2 | Breakdown Positions

The digital outcome of this experiment reviews the in-between state of a set start and end position or a character and includes four individual actions (see Appendix Item 7-2). This outcome contains the same structure as the experiment one digital outcome as seen in Figure 56. This digital outcome also contains four action sets and illustrates the performer's ability to apply the animation technique of 'the breakdown' and, in turn, render variations to the same action.

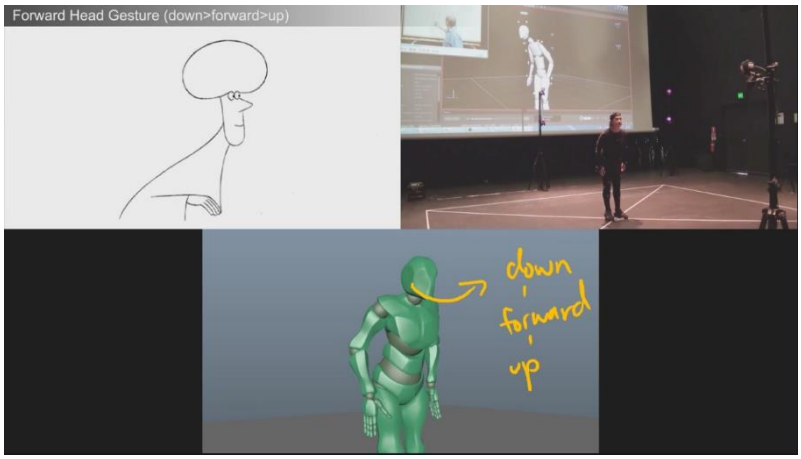

Figure 56 - Experiment 2 digital outcome comparative video

Action, Frames	**Variations, Perception of Action**	**Result**
Forward head gesture Start pose = looking	• Forward-to-down movement • Giving a bow / exasperated sigh	• Performer had little difficulty in creating variations of each action and showed the ability to accommodate this
	• Curious / inquisitive • Character going directly down before moving forward and up	
	• Clear sigh gesture	

straight-ahead End pose = leaning forward 1–355	• Chest rises slightly, followed by the head, before both leaning forward and down	animation technique during the capture stage • Demonstrates the potential of varied characters through a simply by changing the equivalent of the breakdown position • Progressively more complex manoeuvres • Animation reference materials not used during capture of these all actions • Each variation does not strictly adhere to a character-type
	• Passive sign of aggression / equivalent eye-roll with the head • Head goes downward, then left in a circular motion	
'Passing position' of a walk Start pose = foot contact position End pose = foot contact position 356–1662	• Rhythmic bobbing action • Passing position is the lowest pose between the two contacts	
	• Stiff-legged strut • Sweeping leg around the passing position in an arcing motion; resultant shift of weight over the opposing leg to compensate.	
	• Half-skip • Springing upward with each step but with no jump, the pressure being on the ball of the behind foot. • Like previous walk but in a forward gesture.	
	• Prancing • Raised leg high and the opposing leg pressure on the ball of his foot as well; here, however, there is a slightly forceful impact on the down of each step.	
	• Droopy • Leg positioned at a steady height through the passing position, the head appears to drag, and the chest leads the action.	
	• Cool, suave • Twists entire body with each step and holds that 'twisted pose', the body leaning outward to compensate.	
	• Awkward character • Uses force from a kick action to lean back as far as possible, with arms held out for balance.	

Sit-down action Start pose = standing beside the chair End pose = being seated 1663–2659	• Standard, generic timing and spacing • Used as a comparison for other variations.	
	• Raised arms with a step to the side, breakdown pose resembles exasperation	
	• Slumbered, tired character • Dragged head and leans body outward, anticipating the step, which overlaps as it is dragged across.	
	• Crumpled body-state and slinking, weak character • Overall lower posture where the head arcs downward and the outside foot holds the weight while the other repositions	
	• Lazy • Leads with pelvis and the entire body dragging behind	
	• Stiff and robotic • Leg-first step and then the pelvis leading straight back	
	• Excitable character • Anticipates the action with a slight crouch before jumping in the air with a circular arm-arc	
	• Mocking/defiant character response • Performer steps over an obstacle with high legs to sit-down	
	• Exuberant character action • Dancer-like arc of the inner leg swinging out over the back of the chair and the body following-through to the sitting position	
Picking up and drinking from a cup, while seated	• Standard and low appeal • Direct and efficient action	

Start pose = seated with hands in lap End pose = holding a cup in one hand 2660–5461	• Appreciating drink • Raising the elbow, delayed hand overlapping with the head arriving last in a drooping manner before bringing the cup up and leaning backward with the whole body as a moving hold	
	• Energetic • Anticipates the action by moving back and bringing the arm up and out in a wide sweeping arc motion, anticipating the drinking action by bringing the body forward and leaning back with an outstretched arm	
	• Pondering / absent minded • Minimalistic action • All parts moving with even timing and spacing	
	• Someone being warned that what they are drinking could be in some way dangerous • Consistent pausing, with apparent moving holds and moments of minimal movement such as only one arm moving	
	• Tired and in need of coffee • Low/slumped pose, collects cup with both hands meeting together and moving back in a slow, deliberate gesture	
	• Faster and exaggerated version of previous • Offset arms with two-hand cup grab, body leans back further to drink faster	
	• Taking time / appreciating drink • Interesting silhouette with side-lean and head in the opposing direction • Appealing overlapping action of the wrist as the cup is swirled	

	around before drinking with a moving hold	
	• Plucks cup up and tosses drink back • Appreciating drink a lot • Many animated characteristics with elbow drag, gestural flourishes, arcs, anticipation, slow-ins and slow outs and appealing silhouettes	
	• Dissatisfied and defiant • Swipes up cup, hunched over and wipes mouth off	

Experiment 3 | Weight and Anticipation

The digital outcome of this experiment (Appendix Item 7-3) shows the performer's ability to demonstrate a clear emphasis of weight and the animation principle of anticipation through an action. Weight plays an important part in animation for believability and, likewise, anticipation shows distinct intention behind an action. This video includes an animation reference from *The Animator's Survival Kit* (Williams 2009) lecture series for each action, forensic video capture recording of the mocap session and the collected mocap data from this session applied directly to a 3D CG character (Y-bot character from Mixamo.com) as seen in Figure 57. The results show that the performer convincingly portrays these animated characteristics through each action, beyond standard movement and into cartoon-style movement.

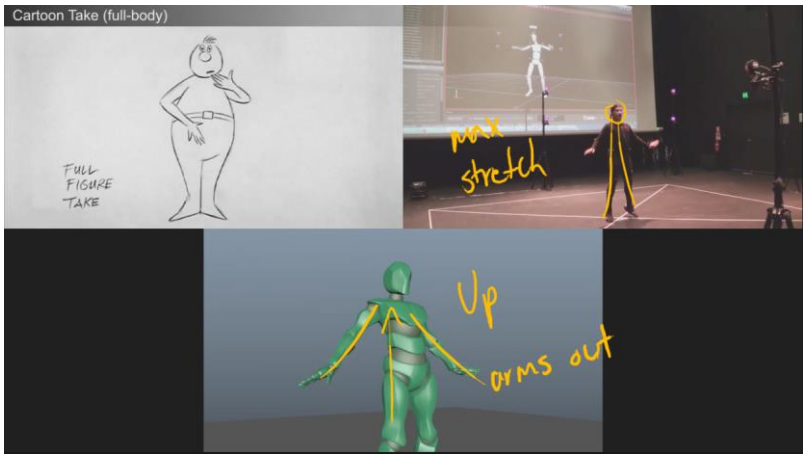

Figure 57 - Experiment 3 digital outcome comparative video

Action, Frames	**Review**	**Result**
Cartoon take (moderate form - from shoulders up) 1–118	• Compresses body down by slumping the shoulders and head and raising the elbows in contrast before stretching the neck and head upwards, and finally settling slightly down from the up position	• Performer can expressively show cartoon-style anticipation as well as key aspects of timing, squash and stretch
Cartoon take (full-bodied) 119–252	• More exaggerated version of previous, more volume at each stage	
Picking up a heavy, box-shaped object (tossing object to the side) 254–1183	• Shown as a series of smaller tasks inspecting the object, anticipating before doing down, re-positioning and then picking the object up onto the chest • Contrast of the spine for a better silhouette while inspecting object • Anticipation before the ‘down’ - shoulders and elbows go up, bringing the arms out and the head down (as a contrast) - appearance of taking in a deep breath • On the down, the head overlaps by first going back, the arms go out in a fluid arc and the chest leads the downward direction, with the arms coming to a rest beside the object	• Animation reference included as a demonstration of the weighted characteristics when acting on an object • Completely mimed action • Shows weight and anticipation convincingly • A quality example of a caricatured mocap performance

	• Side-to-side swaying during re-positioning, before raising the pelvis and lowering the head to anticipate the pick-up • Arcing motion, using the pelvis as a pendulum, sweeps the object up in the characters arms and settles slightly again, showing the weight of the object • Several manoeuvres brings object to the chest, showing anticipation and perceived weight through the concave/convex repositioning of the spine, a strong line of action, bent knees and follow-through in balancing the object	
Picking up a heavy, box-shaped object (fall over) 1184–1979	• Similar sequence to previous • Convincing weight through a combination of locked limbs, bending of the spine and knees toward the end of the sequence • Ends with character falling over from imbalance - evident follow-through and overlapping action with the limbs and a jostling bounce as the body comes to rest	• An impressively mimed action of attempting to contain the weight of a heavy object • Demonstrated weight and incorporated many other cartoon-style qualities of timing, anticipation, squash and stretch and arcs

Experiment 4 | Line of Action

The digital outcome of this experiment (Appendix Item 7-4) focuses on the 'line of action' concept through a recreation of two selected, traditionally animated scenes. Line of action refers to an imaginary line extending through a posed character that when used can show a clear, dynamic pose or stance with visual appeal. The outcome includes the animation reference of the indicated animated scene, a forensic video recording of the mocap session, the collected mocap data from this session applied directly to basic a 3D CG character (Y-bot character from Mixamo.com) and

a motion edited version applied to 3D CG characters that resemble the original animation reference (Figure 58). The results show the performer Lorin successfully replicating the character's denoted lines of action. Although the recreations are not perfect, the performer demonstrates his attempts to emulate the traditionally animated characters and embody their characteristics.

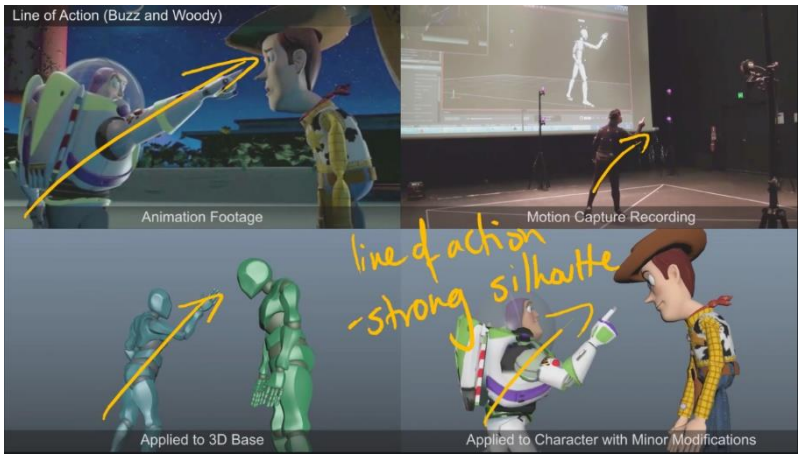

Figure 58 - Experiment 4 digital outcome comparative video

The first scenario from *Toy Story* (Lasseter 1995) (frames 1–218) demonstrates that the collected mocap data incorporate many of the qualities in the referenced scene and, in some respects, build on them further. The modified data, applied to Buzz's character model, shows the performer held a strong line of action and a consistent pose-to-pose form with each gesture, ensuring each statement and silhouette was strong in his attempt to be intimidating, thus emulating the referenced animation scene. The mocap version of Woody similarly demonstrates a strong line of action through his exaggerated posing; however, the timing of gestures and some of the posing are not matched completely to the referenced character in the animation footage. The difficult and contrasted posing is an evident factor in attaining the correct pacing and poses. While difficult, the results appear to be attainable and, overall, still denote two characters arguing and demonstrating strong characterisation through gesture and

posing, particularly in their profile view. Overall, the performer captured a well-synced action sequence, proving the effectiveness of this applied animation technique.

The second scenario from *Goofy's How to Play Baseball* (Kinney 1942) (frames 219–487) shows an attempt to recreate the overtly exaggerated and loose-limbed nature of the well-known character in this baseball sketch. The mocap does indicate a resembled match-up of poses, line of action and weight and follow-through within the action sequence but suffers from the distinctive physical restrictions imposed in the capture setting. The extreme nature of the 2D animation reference and pushed poses indicate that significant adjustment in post-production would be required on the 3D CG mocap character to completely match the animated reference. While the performer used a prop in the capture space, the physical embodiment of the prop in the reference does not completely evoke the same effect. Weighting of the object is a noticeably absent characteristic; although there is evident follow-through and arcing motion, the physical weight is not as prevalent. Further attempts would be required to improve the outcome in the comparative video to incorporate additional animated qualities more effectively.

Experiment 5 | Referenced Actions

The digital outcome of this experiment (Appendix Item 7-5) shows recreated actions from animation references. This experiment is a demonstration of the performer's ability to replicate the cartoon-style movement from a selected traditionally animated action. The outcome includes six actions: a happy walk, a sneak walk, a double-bounce walk, a jump, a push and a pull. The comparative video includes references of each action (some animated and some static images), a forensic video recording of the mocap session and the collected mocap data applied directly onto a

3D CG character (Y-bot character from Mixamo.com) as seen in Figure 59. The reference material for each action is sourced from *The Animator's Survival Kit* (Williams 2009) lecture series and *Character Animation in 3D* (Roberts 2004). While the accuracy to the reference material plays a factor in this evaluation, the cartoon-style movement qualities, particularly those that enhance the intent of the action, are a larger consideration to demonstrate the overall effectiveness of this method. The results show the performer successfully carrying out each action accurately, except for the jump.

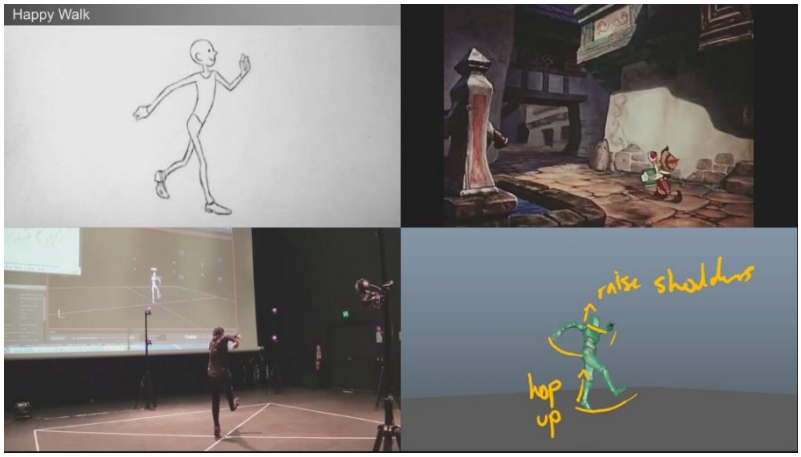

Figure 59 - Experiment 5 digital outcome comparative video

Action, Animation Reference, Frames	**Review**	**Result**
Happy walk *The Animator's Survival Kit* (Williams 2009) *Pinocchio* (Ferguson & Hee 1940) 1–236	• Performer's walk mixes the reference animations: contains all the elements of first reference, minus the harder impacts of the feet to the ground and has a slight skip in the walk without any actual air-time (Pinocchio) • Very high passing position, with a leg swinging action and maximum arm-swing arcs, a slight hopping action and emphasis of overlap from the arms	• A very close recreation of the referenced action in both the mocap space with Lorin and the 3D CG character with the applied mocap data • Minor amendments and further practise during capture would result in a

		more accurate outcome
Sneak *Character Animation in 3D* (Roberts 2004) *Snow White and the Seven Dwarfs* (Hand et al. 1937) 237–453	• Shows rocking motion with the pivot at the pelvis, the legs catching each step in an overall level passing, and a consistent height throughout • Contact points (extreme poses) could be pushed further • Timing deviations from reference animation, be refined with further practise during capture	• Demonstrates the correct action intent • Sneak characteristics all present in recorded action
Double-bounce walk *The Animator's Survival Kit* (Williams 2009) 454–737	• Recorded action has signature up and down movement twice as often as a standard walk and does not affect the arm-swing or head movement • Performer's up and down motion is prompted, makes walk appear awkward and unnatural • Reference shows character's lower-half operating at double-bounce speed, with the upper-half showing only secondary actions - difficult to maintain in the mocap action	• Recorded action demonstrates moderately assembled version of walk's characteristics • Further practise required to attain a natural state walk during capture
Jump *The Animator's Survival Kit* (Williams 2009) 739–995	• Key positions - initial contact, the down movement in anticipation, an arced motion upward, momentarily air bound and landing with a follow-though motion; most positions present in recorded action • Performer was greatly affected by real-world physics and disabled his ability to accelerate to a speed that allowed for extreme angles, a significant jump height and landing without overbalancing; missing qualities evident in outcome	• Jump action is present overall, but the extreme qualities are not • Action would be difficult to obtain through this production method
	• Alternate method of production with second jump variation (996–1355)	• Alternate method results in a far

	• Outcome shows sped-up video footage and extracted poses of the applied data, representing each pose from the reference image	more accurate representation of the extreme angles and posing from reference
Push *Character Animation in 3D* (Roberts 2004) 1356–1850	• Animation reference has low appeal; recorded action has far more appeal • Front leg used as an anchor to lean as far forward as possible to give the appearance of pushing off the back leg • Chest leads the action leads and flows out through the arms in a dynamic manoeuvre • Slow-in at the end of each push demonstrates realistic resistance of a weighted object being pushed	• Excellent rendition of a push action with a quality line of action and a solid, rhythmic nature to each step • Demonstrates cartoon-style movement qualities • performer invoked skills well during capture
Pull *Character Animation in 3D* (Roberts 2004) 1851–2417	• Pulling with the shoulder • Animation reference has low appeal • Recorded action demonstrates the propensity of force, weight, drag and pull • Concentration of the • Appearance of heavy weight being drag - maintained by concentrating centre of weight directly over front foot • Strong pull action shown with consistent lean forward, almost falling onto each step; exaggeration could be improved with anticipation of each step • Strong line of action, demonstrates a high; more opportunities to implement additional animated principles such as anticipation and overlapping action for a more cartoon-style outcome	• Completely mimed action • Strays from the animation reference • Convincing portrayal of a pull sequence from the performer • Maximises performer's mime skills during capture
	• Alternate pull variation (2084–2417) was not recorded • Pull powered through the pelvis • More upright pull • Weight being pulled appears lighter due to the lack of exaggerated stagger • Weaker line of action than previous pull	• Well-executed as a demonstration of performative variation

Experiment 6 | Pose-to-pose

The digital outcome of this experiment shows both an application of the devised pose-to-pose production method and breakdown of its various stages (Appendix Item 7-6). This outcome includes a forensic video recording of the mocap, the collected mocap data from this session applied directly to a 3D CG character (Y-bot character from Mixamo.com), a sped-up screen-capture of the post-capture process where extreme poses and breakdown positions were extracted and lastly, the motion edited data applied to the same 3D CG character (Figure 60).

Figure 60 - Experiment 6 digital outcome comparative video

The results of this experiment show a blocked stage of animation that could benefit from key-framing animation to create a cartoon-style outcome. As a method of 'speed-blocking', this experiment proved effective. The destructive editing method used attempts to breakdown any realistic timing or spacing qualities to enable an animator to rebuild with the desired stylisation. In terms of viability as a production method for animation, even if a polished level of animation was not reached with this method, a high-quality level of 'blocked' animation is possible.

Experiment 7 | Stylistic Animation Pulls

The digital outcome of this experiment (Appendix Item 7-7) shows five variations of animated movement with the same pull action. This outcome includes forensic video capture of the mocap session and the collected mocap data from this session applied directly to a 3D CG character (Y-bot character from Mixamo.com) as seen in Figure 61. The digital annotations throughout this video highlight characteristics of the action, noting how they distinguish from one another in their animated qualities. This creative outcome demonstrates that a performer can create variations of animation-inspired movement for a singular action by identifying and physically demonstrating these various, stylistic movement types. These variations were made as a result of the performer's movement choices made during capture and not explicitly given as directions. The results show the performer successfully achieving a stylistic rendition of each denoted style of animated movement.

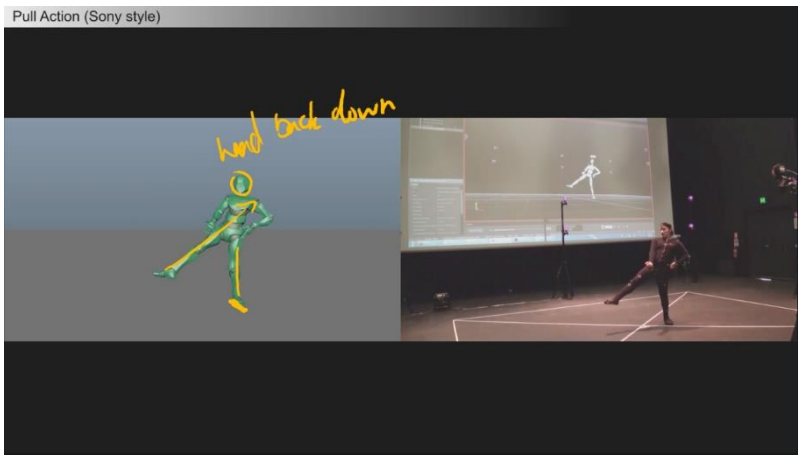

Figure 61 - Experiment 7 digital outcome comparative video

Type of Pull, Frames	Review	Result
Regular 1–181	• Standard, naturalistic action • Use of a rope as a prop • Replicates a production method used to create realistic data collection • Slight lean and even weight distribution at the start position and an evenly timed pull back of the body • Line of action is quite straight and unappealing • Minimal overlapping action	• Successfully rendition of an un-animated action • Stark contrast to the remaining stylistic pulls
Classic Disney style 182–494	• The second 'classic Disney style' pull (frames 182–494). As the annotations in the video indicate, • All movements show clear anticipation, evidence of arcs motions are evident, a solid contrast exists between the forward and back positions and the arms have large gestures • Pull-back is punctuated slightly, giving strain to the pull, but not so quickly that it does not suit the fluidity of the classic Disney style	• Aimed to demonstrate qualities of movement reminiscent of early Disney animated films, which the outcome successfully shows • Performer successfully achieve this style of movement
Modern Disney/Pixar style 495–909	• Many similarities to previous • Slower moments, goes less directly into the action, shows moments of thought and reflection	• Less concrete as a solid demonstration of Disney's modern style of animated movement qualities • An interpretation/subjective view of the denoted style

	• Less exaggerated than the classic Disney style • Slightly reduced extreme poses – overt pull-back, but less dramatic timing and a slight forward moving hold into a relaxed pose after each pull-back	• A definitive confirmation as a successful rendition would require significant further research and an assertive clarification of Disney's contemporary animated movement style
Sony style 910–1299	• Extreme posing at both ends of the rope pull • Quick movements to grab the rope • Anticipation of the pull slightly • Very fast backwards motion before reverting to starting pose • Strong line of action in the forward and back positions by maximising the lean and using the leg as a direct influence • Multiple held poses and somewhat straight-line actions - impression of a pose-to-pose movement	• Engaging cartoon-style movement qualities • Approach to this style would require further practise and refinement • Performer physical limitations
Chuck Jones/Warner Bros. style 1300–1804	• More fluidity compared with Sony's sharper movement • Greater volume on the extreme poses, major anticipation, extreme squash and stretch • Characteristic exaggeration evident in the dramatic posing change • Unique silhouettes throughout action • Performer leans further forward for each rope	• Demonstrates a categorically different form of movement through the choice of actions and implemented animation techniques, rendering a successful result • Suffers from the physical limitations set through timing and spacing of gestures • Maintaining balance while maximising extreme posing is an evident limitation • Contrast of timing through fast, snappy gestures–such as the pull-back of the rope–would benefit this style

	grab and action reset to anticipate the next pull	

Experiment 8 | Characterisation

The digital outcome of this experiment (Appendix Item 7-8) is a demonstration of the mocap performer's ability to recreate the characteristic movement qualities of an animated character from a selected, traditionally animated scene. This outcome includes two characters, namely, Daffy Duck in a scene from *Rabbit Fire* (Jones 1951) and Wile E. Coyote in a scene from *Bubble Trouble* (Register 2011). Included in the video is an animation reference of the selected scene, a forensic video recording of the mocap session, the recorded data from this capture session applied directly to a 3D CG character (Y-bot from Mixamo.com) and, lastly, this same data applied to a 3D CG character that resembles the animation reference with some minor post-capture modifications (Figure 62). The results of this experiment demonstrate the performer successfully embodied the qualities of the chosen characters to a level of 'rough blocking'. The inaccuracy of the rendered movement derives from the extreme cartoon-style animation style.

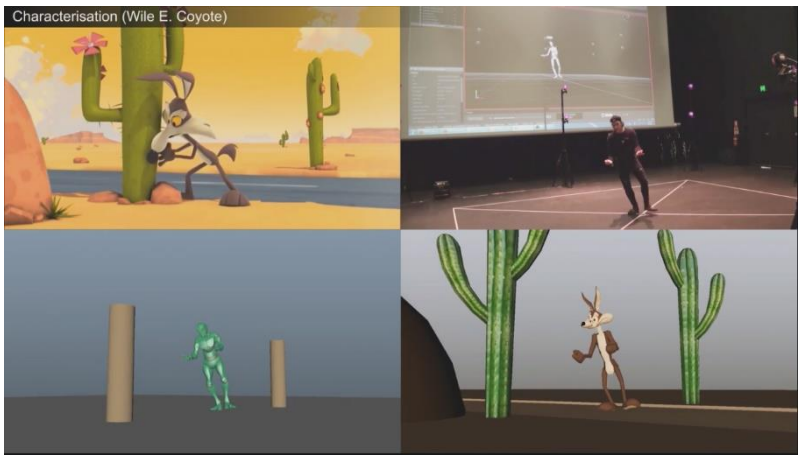

Figure 62 - Experiment 8 digital outcome comparative video

The first ‘Daffy Duck’ scenario (frames 1–304) shows a basic resemblance of the animation reference, whereas the ‘modified’ result shows the posture and overall temperament of Daffy Duck. The characteristics of the walk are determined to include forceful pounding with each step while maintaining a relatively level body posture. The performer’s attempt shows the correct posture but is missing the more extreme elements of the walk, particularly the anatomically difficult, fast-paced leg movements.

The second ‘Wile E. Coyote’ scenario (frames 305–953) shows the broad strokes of the animation reference with punctuated actions and large-volume poses. The similar issues were identified during experiment seven’s Warner Bros. style pull are evident in this outcome. The character’s fast steps taken across the road in the reference have minimal movement of the body, whereas the mocap version requires a balanced side-to-side sway of the whole character to show the same exaggerated steps. Another found issue was the exaggerated quick dash around the rock the referenced animation shows; this does not transfer well to mocap in reality due to the physically restrictive nature of the capture setting. While the finite characteristics of the sequence are incomplete or missing in the final mocap version, the performer demonstrates moderate abilities to recreate the character accurately. Neither sequence is completed, but a level of animation is achieved that demonstrates the intent of the characters in each sequence. This could be utilised at a blocking level of a production, showing the animator the overall goals and layout of a sequence.

Experiment 9 | Perform to Character

The digital outcome of this experiment (Appendix Item 7-9) visualises the constructed animated movements from a mocap performer for various 3D CG

characters. This outcome shows short scenarios of five different characters walking into a café and sitting down, each with their own defined characteristics as designed by the mocap performer. This outcome includes forensic video capture of the mocap session and the collected mocap data from this session applied directly to the 3D CG character used during the capture stage (Figure 63). During this experiment, the performer assessed the visible characteristics of a 3D CG character and then designed movements to complement their level of stylisation. The results show the performer successfully interpreting and creating unique movement qualities based on each character's design. While subjective, I feel the movement qualities appear somewhat inconsistent with what the character's apparent forms are.

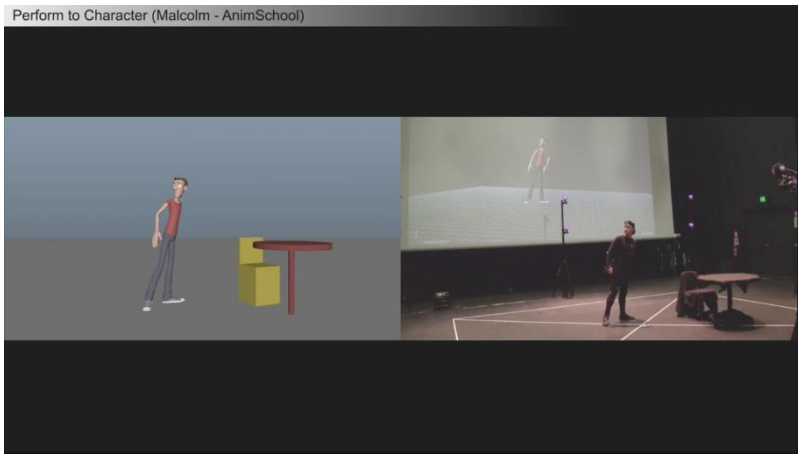

Figure 63 - Experiment 9 digital outcome comparative video

Character, Frames	**Review**	**Result**
Carl 1–709	• Walks into the space, curiously looking around the room, walking over to the chair and taking a seat • Realistic choice of actions from performer • Pacing and overall timing are largely realistic, with no exaggerated qualities of posing, temporal and spatial adjustment, animated anticipation or any significant indicators	• Style of movement matches the apparent aesthetic qualities of the character (realistic geometric proportions)

Stewart 710–1842	• Two variations: 1) character walks in slowly and peers around the café before excitedly spotting the table and sitting down and 2) character paces in a more definitive manner, coming to the table to find no one there and then sitting down • Both variations show emphasised pauses, anticipation and overlapping action	• Style of movement and performer's choices do not complement well with the character's design • The realistic action qualities detract from the impact of the sketch • More stylised actions–such as a Sony style–would apply better to this character
Malcolm 1843–2762	• Character frantically dashes about the café with exaggerated movements. • The performer's movements show evidence of animated anticipation but little follow-through and overlapping action, making the gestures appear direct and punctuated, with quick, sporadic shifts, interspersed with paused poses	• Outcome leans more towards a Sony style movement aesthetic • Movements do appear to complement the 3D CG character; the character's form could also suggest a modern Disney style over a Sony style
Ty 2763–3264	• Character strolls into the café, gesturing over to someone and then sitting at a table • Performer's style of movement appears to be a modern Disney style with a toned-down version of the animation principles, favouring fluid motions over sharp, overt actions and overall, large gestures and distinct posing	• Apparent movement style suits the aesthetic design of the character, primarily due to its larger, disproportionate head • The large character head would need fluid movements–with minimised jolting–which would otherwise be unappealing
Brute	• Character strides into the café, peering about the room, stomping	• Performer's choice of movements well

Burly character, some realistic design and styled proportions (similar to Carl) 3267–3924	over to a table, picking up a chair and placing it down, shoving the table forward and aside and squatting down onto the chair • Could be pushed further into a modern Disney style of movement, embracing traits of fluid movement, arcs and anticipation while still imposing the heavier traits	suited for character - denotes mixture of modern Disney and realistic • Character form and movement match well with weight and timing

Overall, the performer has expressed his movement interpretations for each character. Such a result could be part of a character exploration during the early stages of a production and could invite further discussion for both the design of the character's form and movement.

Experiment 10 | Evolving Walk

The digital outcome for this final experiment (Appendix Item 7-10) shows a myriad of walk types for various characters. This outcome is a demonstration of the mocap performer's ability to devise a range of animated walks and character types from a single mocap recording. The outcome shows nine character types and includes a forensic video recording of the mocap session, the collected mocap data from this session applied directly onto a 3D CG character (Y-bot from Mixamo.com) and, lastly, this same data applied directly to a range of 3D CG characters selected during post-capture (Figure 64). Throughout this sequence, nine characters were applied to the recorded mocap data and, during post-capture, I chose each 3D CG character to complement the displayed walk.

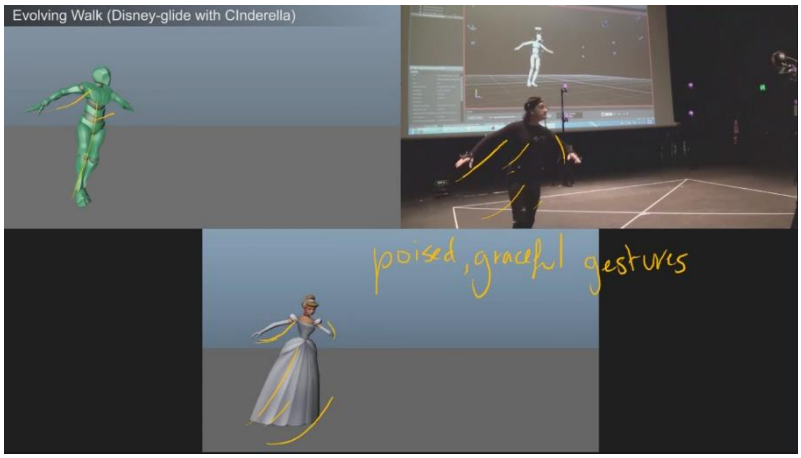

Figure 64 - Experiment 10 digital outcome comparative video

Walk Type, Character, Frames	**Review**
Plain Realistic character - standard proportions 0–91; 3573–4099	• Realistic movement characteristics, with limited and minimal gestures of stylisation
Happy Ty - over-exaggerated body proportions - large head, skinny body and big feet 129–433	• Large gestures, strong posing, clear silhouettes, rhythmic pacing and bouncy steps
Depressed Manny from *Cloudy with a Chance of Meatballs* (Lord & Miller 2009) 459–940	• Bent-over, minimal upper body movement and subdued movements
Big'n'Burly Brute 969–1483	• Overt heavy qualities through large, lumbering steps and overlapping upper body movement • Created with over-exaggeration, obvious weight transfer, a wide-stance, slow deliberate steps and a slightly pulled-back posture
Nervous / skittish	• Awkward walk with a variety of steps from full foot to only the balls of the feet, raised posture/balls of

Stewart – skinny 1510–1728	feet, minimal upper body movement, rigidity, quick and sharp bounce-steps
Easy-going stroll Malcolm - Disney-type features and exaggerated proportions 1761–2156	• Leaning back posture, wide-swinging arms, the use of arcs giving fluidity and each step leading with a kick and soft contact/landing
Gliding Cinderella - character-specific 2180–2486	• Arcing movement in series of steps, poised graceful gestures, sways from side-to-side with small steps to accommodate a gown and the removed leg animation to maintain a fluid and graceful manner
Slow Shuffle Old-man Morpheus rig (from Josh Burton) with skinny appendages 2512–3241	• Small, calculated steps, stiff movements, bent-over posture, awkward neck and the whole body shifting in rigid steps
Angry Pacing Daffy Duck -character-specific 3274–3544	• High legs, arm-swings locked in front of body, a steady head/neck and a stiff spine

This experiment's creative outcome demonstrates a character and movement sample from which a director might choose when designing their mocap animation. This is, in effect, a reversal of standard production methods, where a character design would take place ahead of the animating process. From the director's perspective, this experiment could also be a training exercise as part of a performer's rehearsal or audition procedure to encourage exploration of movement for animated characters and immersion in a cartoon-style mocap animation production environment.

Chapter 7: Discussion

This chapter contains a full discussion, interpretation and evaluation of the results with reference to the literature of this study. Each of four cycles of practice is summarised for their contributions before then reviewing the study as a whole. This includes a justified examination approach used throughout study, the various participants who contributed to the study's collected data and derived variables of the pertinent production conditions that were found throughout this research. This chapter is framed around the study's objectives, namely:

- Examine the typical production approach for 3D CG mocap animations and identify the pitfalls and conditions that practitioners encounter.
- Investigate the capture and post-capture stages of a 3D CG mocap animation and what conditions enable cartoon-style forms of movement to emerge.
- Investigate the application of cartoon-style motion to a mocap performer's movements through a lexicon of movement qualities built from the 12 Principles of Animation and expressed through the use of traditional animation texts and resources, such as *The Animator's Survival Kit* (Williams 2009).
- Synthesise the research findings from the previous three objectives to define or develop production conditions that would assist a 3D CG animation practitioner to create cartoon-style movement with mocap.

DISCUSSION

This study applied four cycles of practice, each building a practically informed examination of mocap animation productions and the pursuit of cartoon-style movement. The first practice cycle examined the standard production approach to a

mocap animation, during which the capture and post-capture stages were examined. This cycle confirmed that an over-reliance on post-capture practices to rectify capture stage errors inherently devalues the capture stage. During three projects of this cycle, the capture stages of each were a determining point for the impact that would occur during post-production. This confirms notations from Matt Liverman who suggests that as the director, "one of your main goals during a capture session should not only be to capture the motions that you need, but also to capture them in a way that will help save your animators time in the post capture process" (2004, 211). Doing so will inherently save time on the overall production because "if you have to do damage control after the fact, it is always more difficult than doing it correctly the first time" (Liverman 2004, 32). The challenges of inaccurately recorded mocap movement are to reinforce the capture environment of a mocap animation production, ensuring that the original data adheres to a cartoon-style movement aesthetic. During this cycle, experimentations during the VIMMA project showed that a variation of puppetry capture could provide a new method of mocap animation, whereby the performer manipulates a virtual object within the context of a capture environment. As a new movement aesthetic opportunity, it aligns with the intentions of this study to examine new animation practices.

The second cycle of practice was a direct attempt to answer the key research question; applying a method of creating cartoon-style movement through a typical mocap animation production, albeit with experimentation during the capture stage. This cycle provided a valuable shift in focus towards the capture stage and attaining stylised movement with the performer to assist the animator during post-capture. Through applied qualities of immersion, the performer can assist with creating cartoon-style movement. This cycle found that from the perspective of the performer,

their state of emotion, innate personality and being given objective-driven actions as opposed to a set motion list all encouraged an immersive quality in their movements and, in-turn, more believable animated actions. Such qualities would naturally immerse a performer in their role, regardless of the production's sought movement style. In addition, during this cycle I included a bouncy tumbling mat as a prop and impromptu musical ambiance to help enhance their cartoon-style movements and further immerse the performer, respectively. The results of each, while seemingly positive in this instance, would require a dedicated study to examine properly. Another form of immersive assistance I provided was slowly introducing animated forms of a walk by having the performer begin by walking naturally and (while they are walking) bringing animated traits into their action. This ease-in transition helped the performer's challenges of understanding the animated qualities of movement and how they differed from their natural movements. The use of a projector screen as a means of feedback for performer actions was utilised from this cycle onward and was consistently positive. While not set out to be tested, I naturally explained and physically demonstrated various actions to the performer when queries of clarification arose. This challenge of performer enquiry into how to construct an animated action brought about a larger issue of control within the mocap setting. Specifically, the performer's creative involvement versus my level of assistance or control of actions and how they were to be perceived in their final state. This will be discussed later as a study-wide challenge. Lastly, the emphasis of animation reference materials—such as those seen in *The Animator's Survival Kit* (Williams 2009)—during this cycle as a method of creating cartoon-style movement resulted in an over-reliance and 'repeat what's shown' approach that (like a standard mocap animation) also relied upon post-production motion editing to fix any mistakes during capture. Although Appendix 5 results show

some quality animated actions, this seemingly logical approach would not encourage collaboration from mocap performers in a real production context as their contributions are minimised.

The third cycle of practice derived specific animated actions such as the 'double-bounce walk' and the 'cartoon take' from an animation script to bring the study closer to a production context, working specifically in the capture stage. This cycle attempted to rectify the mistakes of the previous; this included minimal reference (only relying on an animatic) and devising more involvement from the performers by providing opportunities during capture. These opportunities included prepping the performers prior to the capture session with a brief understanding of animation principles, techniques and productions. The performers (Liam and Maeve) lacked an understanding of animation practices and so prepping them intended to enable them to create animated movements as well as make the production process more efficient during recording. While beneficial in the context of animation-naive mocap performers, a more effective method would ensure that the performer was not ignorant of such practices. Like the previous cycle, this cycle engaged practices that immersed the performers in their roles as animated-mocap performers. The first was providing them with actions that overtly demonstrated animated qualities, such as the double-bounce walk. An initial challenge was having the performer's movements denote animated qualities, i.e. the more energetic actions enabled their immersion in the production context. The second was creating a three-stage, progressively more involved system of creating the cartoon-style actions: 1) the actors' interpretation, 2) bringing my input as an outside observer and 3) focusing on animation techniques to enhance the cartoon-style movement qualities. This layering approach gave the performer an opportunity to learn the production context and to bring their creative

contribution to the setting, and proved successful as a means of immersion. This cycle was designed with minimal animation reference—a stark contrast to the previous cycle's reference-heavy approach—and so to compensate in cases of movement clarification, my role increased in explaining and demonstrating actions. A balance must be struck between these approaches as the over-reliance of reference will remove the performer as a key participant and the lack of animation reference will require compensation on the motion coordinator/director's part to demonstrate and explain actions, again to the point of the mocap performer contributing very little creatively. This cycle brought attention to the dynamic between director and performer during the capture stage, specifically the level of control over the production's performance and specific actions. In the context of creating cartoon-style movements, the director is concerned with minimising the degree of post-capture motion editing and the performer wants to feel like their role is more than marionette puppet. This challenge was brought across to the final cycle of practice.

The fourth cycle of practice was the most comprehensive examination in this study as it consolidated acquired knowledge of the previous practice cycles and introduced multiple new experiments and methods of cartoon-style mocap. This cycle experimented extensively within the capture stage of a mocap production, applying animation principles and techniques to achieve cartoon-style movement for a 3D CG mocap animation. A single performer—a mime artist—participated in 10 experiments, each providing a new dimension to the study. This cycle uniquely applied animation reference to the cartoon-style mocap production (the same as second cycle of practice) while allowing the performer to contribute their skills (like the third cycle of practice). This cycle was pivotal to this study in that it advocated for applying mime-based practices to the cartoon mocap animation production, examined a pose-to-pose method

of capture and observed an expansion of movement styles for a mocap animation such as the Sony style. This cycle also uniquely tested methods of pre-production exploration during experiments nine and ten, which, if integrated into a mocap animation pipeline, could provide opportunities for the director to creatively explore the character form and movement style of their production. This cycle introduced a myriad of new methods of approaching cartoon-style movement for a mocap animation, but also presented challenges, specifically physically difficult actions and communication breakdowns (principally, the dynamic between director and performer over control of movement), which were challenges found in previous cycles.

The lack of documented approaches or methods for creating cartoon-style movement in a mocap animation led to a study-wide challenge: finding a consistent examination approach. As stated in the literature review, cartoon-style is defined by Leslie Bishko (2007) as animated movements that adhere to the principles of animation and, in doing so, depicts character believability in a dramatic context. Rather than an approach of applying singular animation principles to a mocap production, animated character actions—which inherently use the principles of animation in their design—were the channel of this study's approach. A key strategy of this study was imbuing animated qualities into a mocap performer's actions through a lexicon of animated character actions from relevant animation sources such as *The Animator's Survival Kit* (Williams 2009) and *Character Animation In 3D* (Roberts 2004). The breakdown of actions and execution of animation techniques from these texts were supplemented with an array of well-known animated feature films and on-screen animated characters such as Buzz and Woody in *Toy Story* (Lasseter 1995). The second cycle of practice was the first production solution, which emphasised the use of animation reference material and on-hand assistance during the capture stage. The third cycle of practice

altered this approach and minimised reference material to an animatic and tested a progressively more involved approach through assisting the performer. The fourth cycle of practice applied multiple approaches while incorporating knowledge from the previous cycles. Of the 10 experiments in the fourth cycle, six used such animation reference materials to directly inform the performer's actions. Showing the animation reference during productions enabled ease of communication between the production participants. Menache (2011, 81) and Liverman (2004, 12; 15–18) detail the uses and limitations of the animation principles in a mocap production; however, they lack a reference of applied practice, as this study has done. The use of animated, action-specific reference material—closely approximating the required action (both in style and execution)—notably improved performer immersion and would be a near-crucial component for all participants in such a production. Taking this premise further, prior to the capture session(s), a 'movement package' containing animated reference of the production's animated actions and denoted style could be pre-emptively sent to the performer, as well as reference materials being on-hand during the capture stage. This would ensure an efficient process at the time of capture. This study's devised approach would require an application to a larger animation production context if the derived solutions are to be completely confirmed.

The variation of performers used throughout this study presented a unique challenge, specifically because while their role of mocap performer was consistent across practice cycles, their contributions and experience created a variable in the research data. Each performer saw and interpreted movement differently: the *Powers Above* mocap performers are traditionally trained animators; the VIMMA performers are a trained mime/puppeteer and a theatrical dancer; Marianna is a circus artist with a background in Suzuki theatre, unspecified clown training and acrobatics; Liam is a

traditionally trained stage and TV actor; Maeve is also a traditionally trained stage and TV actor but with a dancing, gymnastics and circus background; and Lorin is a mime artist with training in traditional acting for stage and TV. Each performer provided equal weighting to this study as they added a new dimension of collaboration to which the production conditions of a cartoon-style mocap animation could apply. To optimise these collaborations, this research has pursued a translatable movement lexicon, meaning solutions were derived that were neither non-specific to the participants involved nor limited through an alternate mocap system or software. As such, non-specific solutions were developed for two-way communication across various participants and stakeholders; for example, when the performer and/or director had an alternate training or background to those examined during this study. While this study certainly does not contain enough of a performer spectrum to firmly state any one performer as a preference over another, the skills to which certain individuals brought to this research were notably categorised. The acting students brought a perspective to this study of traditionally trained stage actors. Their involvement was beneficial as it ensured a non-specific approach to creating cartoon-style movement during the mocap animation. Their opinions on the vocabulary used in the capture space were particularly open and reinforced the required flexibility of production approach as the motion coordinator, director and animator. The mime artist, Lorin, brought great depth of understanding to the characteristic traits of animated movement while successfully demonstrating such traits. Animation practices, such as overlapping action, convincing weight and anticipation, timing and spacing, a strong line of action, breakdown positions, were particularly strong qualities found in the mime artist's cycle of practice. Additionally, the accurate recreation of actions from referenced materials likewise indicated his aptitude. While Lorin specifically demonstrated talent for creating

cartoon-style movement, further research would be required to ascertain if this was due to his own abilities or something all mime artists would be capable. While Liverman (2004, 192) would state "there are four basic types of performers: animal, athletic, character and stunt"; I would suggest that a fifth be added: the 'animation performer'. Lorin stood out against previous participants, with the high-degree of control he demonstrated over his own actions. While not strictly examined during this study, Lorin's skills indicate that a performer with training in physically based performance and with such capability of movement control could potentially be a preferred candidate for a cartoon-style mocap animation production. Future research into optimal performer-specific qualities would be required.

Mime practices were found to have a strong relationship to cartoon-style mocap animation, particularly with Lorin's contributions, which brought experience of teaching movement to animators. Several connective traits were found between mime practice and animation. Mime's 'digressive' and 'progressive' movements can be equated to exhibited flexibility in animated actions. In the first, the largest part (like the upper arm) moves first, then the next smallest (forearm/hand), where the second acts in the reverse. Both help mime artists explore the full range of movement vocabulary and ways to move the body in a segmented way. These mime movements also equate to ways of animating a CG character rig, specifically forward kinematics (FK) and inverse kinematics (IK). Overlapping action is another shared quality between mime and animation. The arm-swing and fist smash actions of the fourth cycle were compared with a corporeal mime technique where a mime actor would exaggerate an articulated movement and lead an arm action with the elbow, just as with an animated joint-break. This is done for the same reason, where it accentuates those articulations and allows character expression. Corporeal mime segmentation of

the ‘trunk’ brings out key expression for a character by changing the relative positioning of the head, neck, chest, waist and pelvis—all the pieces that make up the trunk. The turn-around action during the fourth practice cycle was a demonstration of this mime technique while also equating to animation’s overlapping action to distinguish character by the way they turn. ‘Attitudes’—where a mime poses as a statue to convey a specific emotion—equated to clear silhouettes and animation principle of solid drawing, which are practices suggesting clarity of action and intent. Lorin’s use of attitudes was prevalent, stating an action in mime is not always continuous movement; that is, there are moments when an attitude is held to allow it to register with the audience before continuing. This mime technique naturally lent itself to this study. An application of mime practice to animation was not the focus of this study, but these qualities naturally emerged through an examination of cartoon-style mocap animation. Future research into this relationship could build on this study and potentially identify mime as the conductive practice between cartoon-style animation and mocap.

Communication between production participants (mocap performers/director), like all mocap production environments, requires a level of efficiency that allows everyone to contribute in their roles effectively. The unique parameter of this study—attaining cartoon-style movement from mocap performers—presented a unique language barrier challenge. Even with the denoted instructions of animated actions through reference material, the performers still required further clarification. The difficulty was explaining animation principles and techniques to the performers in such a way for them to understand and then re-interpret these to physically execute the actions with animated, cartoony qualities. This language barrier—as a by-product of

the beginning stages of a production—was reduced the longer participants worked together; for an animation production, this would be minimised during rehearsal time.

The dynamic of control over the mocap animation actions was a challenge within the productions of this study. From the coordinator/director perspective, I intended to create movements that would require minimal post-capture motion editing. In doing so, I found myself controlling the actions of the performer by physically demonstrating the animated actions to the performer in addition to providing lengthy, technical explanations. Dictating too many conditions of the performer's actions and movements were found to be creatively stifling for the performers. In such cases, their contributions were minimised to little more than a stunt-role or likened to a marionette puppet, their movements, in turn, becoming conserved and un-animated. The solution was to enable the performer's emotional capacity and invite them to become immersed within the capture setting. The performer's immersion would, in turn, create authentic, believable cartoony actions during capture.

Creating an immersive mocap environment to render cartoon-style movement requires creative solutions as listed below:

- A mocap production with a realistic character aesthetic would have the subtle, nuanced expressions and gestures of the mocap data apply well to a realistic CG character. Cartoon-style animation, however, typically shows overt expressions of character intent. As such, the cartoon-style mocap performer requires a different performer approach to movement and that demonstrates their character's intent through overt actions and gestures. The animation principle 'exaggeration' lends to this idea well. Menache states that the animation principle of exaggeration cannot be accomplished with mocap beyond physical boundaries (2011, 81).

However, as detailed by animator Tim Rudd (2015), this principle is not always dictated by large, grand movements; indeed, this principle can be defined through contrast, specifically a performer's smaller movements compared with their largest, their fastest movements to their slowest or a lot of movement to very little movement. This was seen during the fourth cycle of practice where the performer showed a capacity for moments of almost complete stillness before then changing into quick, sharp movements. Overall, creating an animated movement aesthetic.

- In addition to this approach, the benefits of beginning the cartoon-capture session with more energetic actions was seen across all cycles. In Marianna's cycle, the energetic happy walk—while notably aligning with her temperament—brought out exaggerated qualities to the action. The other performers likewise drew out stylistic, animated qualities when starting with energetic actions to perform rather than subtler ones.
- The most direct example of facilitating the performer's cartoon-capture immersion was providing them with character-driven, goal-oriented actions rather than simply a set of motions. This was an effective method across all practice cycles. For example, during the fourth practice cycle, Lorin shows a somewhat generic turn-around action in one experiment (Appendix Item 7-1) and then an animated, character-driven heavy-lift action in another (Appendix Item 7-3). This is part of an actor's instinctive role and would occur naturally in a larger production context with scenes and character performances.

- A brief inclusion of live music during the second practice cycle, while noteworthy, could not be brought into the scope of the study and would require further research to properly examine.
- Another effective method of enabling the mocap performer was providing a real-time feedback channel of their digital performance via a large projector screen. While not a novel idea for mocap productions, it was unclear as to whether displaying a performer's movements would have inadvertent affects; however, this proved to have a positive impact as a tool to review captured actions.
- An intentional scaffolding of actions was proven as an effective strategy to gently bring the performer into a cartoon-style of movement and mind-set of an animated character. This was done by initially giving simple gestures, then progressively more complex actions using the performer's entire body. Doing so in a progressive manner addressed movements without confusion and allowed the performers time to adjust. This is seen when comparing the second and third cycles of practice; in the former, Marianna appeared unguided and, in the latter, a methodical approach brought comfort to the performers.

The following were found to be greatly beneficial to immerse the mocap performer in the capture stage of the cartoon-style animation production: performing overt/exaggerated movements, beginning with energetic movements over subtler ones, having goal-driven actions, using a projector screen and scaffolding actions. As such, the motion coordinator's role for such a production extends beyond simply understanding the correlation between the mocap performer and their digital character;

rather, their role is one of facilitating the performer through methods such as those listed above.

This study has instigated many production stage solutions, but many of these solutions would benefit from an emphasis on the pre-production stage. During this time, the mocap performers would be selected and the 3D CG character's forms and movements designed. Motion design, like a character model sheet, involves selecting the movement characteristics of a 3D CG character; for example, this can be seen in *Big Hero 6 Character Studies* (Wired 2014). The ninth and tenth experiments of the fourth cycle of practice would be particularly well-suited to the pre-production stage of a cartoon-style mocap animation. The methods denoted in these two experiments could be used as a means of making a pre-production 'movement library' from which a director could choose their characters or movement qualities such as the character improvisations of Jim Carrey in *Lemony Snicket's A Series of Unfortunate Events* (Silberling 2004; Zeta Omega Omega 2017). Additionally, the 3D CG animation's character designs could be modified at this point to better suit the denoted character movements, maximising the stylisation of the final outcome. An example of a modification might be to create a slightly larger character head so as to emphasise any head movements. Such pre-production preparation would make the production capture stage far more efficient.

Cartoon-style movement often denotes physically implausible actions. This was a challenge in this study, particularly for animation styles that tended towards a Warner Bros. or Sony animation style. This is noted by Menache (2011) who accurately suggests that movements beyond physical boundaries are not possible with mocap. This was documented during the second cycle of practice, where the very first action (a broken angry walk) was very difficult for the performer to even attempt, the

car-stop action sequence during the third cycle of practice required extreme poses with precise control at a fast pace and, lastly, the fourth practice cycle hosted multiple actions that were physically demanding, including the jump action and characterisation experiment. A pose-to-pose capture method was tested during the fourth practice cycle and was found as a successful means of overcoming physical limitations. This type of production method has already been alluded to with Italian studio MAD Entertainment, stating they "rarely [use] the motion capture as-is, but as a rough blocking process, where the animators pick and tweak a selection of key poses, and then manually animate the in-betweens. Walk cycles are made within a few hours this way" (Vollenbroek 2017, para. 14). As documented during Chapter 5-1, this method could readily be implemented into an animated production for the benefit of blocking out actions which can take an inordinate about of time through traditional key-framing. The results (Appendix Item 7-6) demonstrate an industry-practised technique and way in which it can be applied to a cartoon-style mocap animation.

Beyond the catch-all term of 'cartoon-style', new movement aesthetics in the form of a classic Disney, modern Disney, Sony and Warner Bros. animated movement styles were found to be accessible when examined during the fourth practice cycle (Appendix Item 7-7). Here, to enable such movement qualities, artistic guidelines would be required to maintain the performer's form of movement. Aesthetic movement rules would govern the performer's movement throughout the capture stage and establish the movement aesthetic the director required. Such rules might be: 'ensuring all extreme posing holds its position momentarily before another action', or 'any head motion should be conveyed with arcs and never linear movements', or 'whenever going between one extreme pose and another, the breakdown position needs to be a downward arc', or 'always display overt emotional characteristics, for example,

a depressed body expression would be completely slumped over'. Such parameters would be set at the beginning of the production to ensure a consistent style of movement. Providing such parameters to the performer would restrict the performer's method of movement; however, the over-arching consideration would be final outcomes' movement aesthetic, something the motion coordinator/director would know explicitly. This style might emulate an established artistic direction used in animated films such as Sony's style in *Cloudy with a Chance of Meatballs 2* (Cameron & Pearn 2013). The strongest animation techniques and principles evident in the referenced film or source would need to be identified, such as attaining the extremes, arc-type movements and a strong line of action. With an established movement aesthetic, the difficulty would then fall to the performer to recognise the need for them and to the director to ensure there is an open line of communication with the performer to understand the set movement aesthetic. While not extensively examined during this study, there is proof that there remains an opportunity for producing new movement aesthetics.

Additional new movement aesthetics include a variation of puppetry capture from the first cycle of practice and the disproportionate relationship of mocap performer to digital character found at various points during this study. A mocap performer whose proportions match their digital character's proportions would have their recorded movements correlate to the final animation. In the context of a stylised mocap animation, where characters are similarly stylised through disproportionate body characteristics, it would difficult to recruit performers with similarly disproportionate characteristics. While a performer might be able to portray characteristics that do not strictly befit their build—such as Lorin's ability to walk like heavy-set character during the final experiment of the fourth practice cycle —an issue

of intersection is likely to occur if proportions are mismatched. A performer might be able to compensate for such an instant by miming their digital character's proportions, but a better solution would be implementing the production method developed through *Sid the Science Kid* (Finn 2008). Using an augmented capture suit with prosthetics (Figure 2), the mocap performer would be free to create their stylised movements, knowing that intersection would not be an issue. The variation of puppetry capture came about through the first cycle of practice and represents an alternate approach to this study, where a performer could manipulate a digital entity outside of themselves such as a ball mapped to their hand. This would give the performer a puppeteer's role and a great deal of control of their movements. Such methods would require further examination beyond the scope of this study.

Chapter 8: Conclusion

Traditional animation refers to an artist's interpretation of motion as manually constructed frame-by-frame, whereas motion capture is a mechanical reconstruction of motion from a digitally recorded pro-filmic event. As an expansion of animation practices, this study represents an attempt to bring these two processes together by using motion capture to create a cartoon-style movement aesthetic, typically produced through traditional animation methods. This research directly challenges presumptions made on the limitations of motion capture as a method of creating cartoon-style movement for a 3D CG animation. In their published texts on motion capture, Alberto Menache (video game developer/technical director) and Matt Liverman (independent motion capture coordinator) both openly state that animations requiring a cartoon or stylised form of movement should not consider motion capture as a production method (Menache 2011, 64; Liverman 2004, 22). This study hypothesised that motion capture can be used as a production tool to attain cartoon-style, animated movement for a 3D CG motion capture animation production, specifically during the capture stage. In pursuit of this hypothesis, the aim of this research project has been to practically demonstrate motion capture as a viable tool for animating cartoon-style movement and has done this by reconciling traditional animation and motion capture practices. The following research questions have been held throughout this research:

- Can cartoon-style movement qualities be achieved through a typical motion capture pipeline for 3D CG character animation?
    - What challenges occur in attempting to achieve this and how might these challenges be overcome?

- Through the tensions and ruptures that occur in this process, what opportunities exist for producing new movement aesthetics?

This research has tested the tensions between motion capture and animation practices and found that motion capture can, in fact, be used to create cartoon-style movement; however, there are still limiting factors. Based on the results of this research, a number of production conditions are proposed which alleviate a large portion of the limiting factors and aesthetic problems that come about during a 3D CG cartoon-style motion capture animation. Listed below are these production conditions:

1. Animation Performer
    - In preparation of the animation production, a performer would be selected who, ideally, demonstrates understanding or knowledge of animation and motion capture practices but, most importantly, has movement training and/or minute control of their physical actions. While Liverman (2004, 192) states "there are four basic types of performers: animal, athletic, character and stunt", I would suggest that a fifth be added: the 'animation performer'. The character performer Liverman classifies is someone simply with an acting background and/or physical characteristics resembling the intended 3D CG character, this study suggests a performer with a more specific understanding of movement and knowledge of animation practices would be of benefit.

2. Curated Animation Visuals

    - Animation materials—videos and images—would be collected prior to the capture stage of the production. These materials would show breakdowns of the movements and actions to be recorded (derived from a motion list, script or animatic). These curated animation visuals would be sent to all motion capture performers prior to the production's capture stage so they can familiarise themselves with the production's movement aesthetic and to physically prepare.
    - This package would represent the production's movement aesthetic that the director has already determined, such as a 'classic 2D Disney style', meaning the reference of actions would most likely reference such examples. During the capture, these same materials would be visible for all production participants via a large display.

3. Pre-production Capture

    - In the case that the director is undecided on the aesthetics of character form and movement, a pre-production capture session would occur during which the performer would provide a sample of movement stylisations while using a work-in-progress 3D CG character as their digitally mapped entity. These would offer options to the director to choose their movement stylisations. The design of the production's character(s) would optionally adapt at this pre-production stage

and modifications to their design would accentuate the chosen movement aesthetic.

4. Gestural Warm-ups and Scaffolded Actions
    - While the animation performer would come to the capture stage with an understanding of the production's movement aesthetic, the director would begin the production's capture session by giving the performer actions that are overt gestures with clear emotional states and directives. These actions may not be explicitly part of the motion list, but would be important to embed the performer into the stylistic movement conditions of the animated world of the production.
    - In a progressively more complex manner, the director would scaffold actions, allowing the motion capture performer to demonstrate their understanding of the production's animated aesthetic: first by moving in a 'natural' state and then in the production's 'animated' state. With any distinct lack of gestural boundary from the performer, the director would then provide corrective solutions to adhere to the required animated quality of the production.

While these are not intended to be an ultimate list or guide, they are a summary of the parameters found during this study. They are recommended when pursuing a cartoon-style movement aesthetic in a motion capture animation production, specifically, the parameters leading up to, but not including, the post-capture motion editing stage. This study has not examined the post-capture stage in so far as introducing new, algorithmic-based solutions such as those described in Chapter 2.

Provided that the capture stage of a motion capture animation is not treated as an isolated part of the production, a stylised movement aesthetic can be achieved. If the motion capture performer being recorded understands how characters move in animation, then they can embed that same type of motion at the time of capture. Doing so results in 'cartoon-style motion capture' and, therefore, reduces the amount of modification required by an animator during post-capture. The over-reliance of post-capture motion editing for such productions, with a 'fix it in post' mentality, reduces opportunities of achieving new movement aesthetics. Cartoon-style motion capture represents a new movement aesthetic to animation practice. It does not strictly adhere to an aesthetic of manual frame-by-frame animation construction nor does it adhere to objective reality; instead, it demonstrates a new stylistic variation that remains on Maureen Furniss's (2007) continuum between abstraction and mimesis. This study has contributed to the expansion of the animation discipline's expressive possibilities through artistic experimentation. It has also provided an artist-accessible solution in bridging the unspoken divide within the industry, which silos realistic movement to motion capture and cartoon-style movement to traditional animation methods.

FUTURE RESEARCH

This study brought together an array of disciplines and interesting insights came about in this process that could provide opportunities for future research. The production conditions detailed above came through experimentation of the motion capture animation production process. As such, they have yet to be applied to an animation production to identify their effectiveness. Doing so would establish the benefits of this research in a larger animation production context. By extension, the results of this study could be used in a production alongside the production methods of the children's

TV programme *Sid the Science Kid* (Finn 2008)—with augmented motion capture suits—or, the 'rough blocking process' used by animation studio MAD Entertainment (Vollenbroek 2017). Such applications would demonstrate a comprehensive and integrated animation production approach to add to the animation discipline. Props and ambient music were minimally applied through this study as a means of enhancing the performer's immersion in their role as a cartoon-style motion capture performer. Both the use of props and music could be investigated further to identify if—as independent variables—they would have an application in this type of production or, in fact, any motion capture production. This study was limited to directing movement style which leaves the opportunity for future research of directing motion capture performers in such a production with an emphasis of emotionally driven actions. The performers of this study were valuable in their participation for ensuring an inclusive demographic for the cartoon-style motion capture animation. Future research into optimal performer-specific qualities would refine the type of participants who would maximise the production conditions found during this study. Why or how the use of actor training can influence the movement qualities of motion capture would similarly complement such research. There is a strong indication that mime practice could apply specifically to this type of production. Future research into this relationship (mime-animation) could build on this study and potentially identify mime as the conductive practice between cartoon-style animation and motion capture. The mime artist from this study demonstrated a particular aptitude for creating cartoon-style movement. Further research would be required to determine if this was due to his own abilities or whether someone with similar training would also be capable. The outcomes of this study could have benefits to productions and platforms beyond 3D CG animated films. These include video games utilising mocap such as *The Last of Us Part II* (Sony Interactive

Entertainment 2019) and webcam-based tracking games such as Holotech Studios' *Facerig* (2019) and their 3D avatar live-streaming applications through services such as Twitch (Twitch Interactive Inc. 2019). While this study has large benefits toward assisting the post-capture stage of a mocap animation production by minimising the differentiation between capture and post-capture stages, this research could be applied to a real-time production context. This study could be used as a foundation for designing a comprehensive production guide or framework for creating cartoon-style motion capture animation and, further, more refined animated movement styles as found in the Warner Bros., Sony and classic Disney styles.

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Appendices

Item 1 - *Powers Above* Animation

- https://vimeo.com/119204511

Item 2 - *Powers Above* Animation Behind-the-scenes

- https://vimeo.com/298295205

Item 3 - VIMMA Project Behind-the-scenes

- https://vimeo.com/122004899

Item 4 - *Robotronica* Animation

- https://vimeo.com/279030500

Item 5 - Animated Actions

- https://syncsketch.com/sketch/4431b3fae9b3/#399447/325245

Item 6 - Animation Techniques with Motion Capture

- 1 Liam - https://syncsketch.com/sketch/f9d2b8c3b079/#400500/326325
- 2 Maeve - https://syncsketch.com/sketch/f9d2b8c3b079/#400499/326324
- 3 Liam and Maeve - https://syncsketch.com/sketch/f9d2b8c3b079/#400498/326323

Item 7 - Cartoon-style Animated Movement with Motion Capture

- 1 Overlapping Action and Breaking Joints - https://syncsketch.com/sketch/c7a23f582b3a/#400488/326313
- 2 Breakdown Positions - https://syncsketch.com/sketch/c7a23f582b3a/#400489/326314

- 3 Weight and Anticipation - https://syncsketch.com/sketch/c7a23f582b3a/#402477/328367
- 4 Line of Action - https://syncsketch.com/sketch/c7a23f582b3a/#400492/326317
- 5 Referenced Actions - https://syncsketch.com/sketch/c7a23f582b3a/#400507/326332
- 6 Pose-to-pose - https://syncsketch.com/sketch/c7a23f582b3a/#400493/326318
- 7 Stylistic Animation Pulls - https://syncsketch.com/sketch/c7a23f582b3a/#400503/326328
- 8 Characterisation - https://syncsketch.com/sketch/c7a23f582b3a/#400502/326327
- 9 Perform to Character - https://syncsketch.com/sketch/c7a23f582b3a/#400508/326333
- 10 Evolving Walk - https://syncsketch.com/sketch/c7a23f582b3a/#400491/326316

Item 8 - *Lost for Words* Animatic

- *Lost for Words* | Animatic (ambient audio) - https://youtu.be/_D9sib8TYGY

SyncSketch - How to

1. Select a SyncSketch link from the Appendix Items list.
2. To play a loop of a specific action, follow the instructions below.
3. In the opened browser, select an 'Out' value near [1].
4. Lock the value range of 'Out' value by selecting the bracket icons near [2] and select the looping icon, also near [2].

- Reselect the bracket to clear the locked value range.

5. Hit the play icon near [3].

6. Optionally turn annotations off with the eyeball icon near [4].

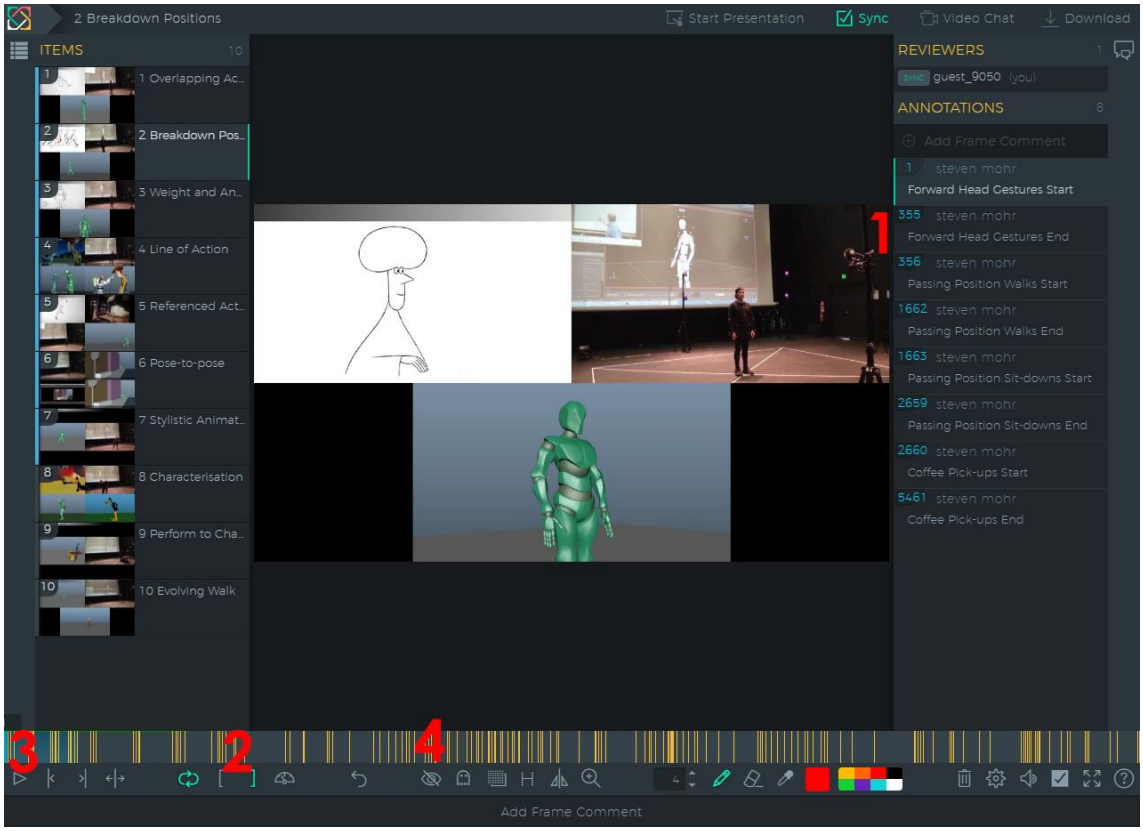

Figure 65 - Screenshot of online SyncSketch page with digital outcome