EXPLORING THE INFLUENCE OF A DANCING VIRTUAL AGENT ON THE EVOCATION ON HUMAN EMOTIONS

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Abstract

Dance has been the universal language of humans for thousands of years. It has been used as a form of expression and therapy. It is only natural then that virtual humans, often known as Intelligent Virtual Agents (IVAs), should also be able to dance and help humans to express themselves through dance. This thesis presents a study investigating the impact of dancing IVAs on human emotions. The experiment was based on a 'repeated measures' design with one within subjects factor (dancing character) and one between-subjects factor (display order). The study analysed the responses of 55 participants comprised of dancers and non-dancers watching a dancing IVA perform three different dances that represent anger, sadness and happiness in different display orders. Analysis of the study data showed statistically significant results confirming a number of hypotheses that watching a dancing IVA depicting different emotions can influence human emotions. The participants' anger, sadness and happiness were significantly dependent on which dancing character's emotion they watched. The results of the study also showed that the participants can recognize the emotions depicted by the dancing IVA. Moreover, correct recognition was not a factor for the influence of the dancing IVAs on human emotions except for the happy dancing IVA. These results suggest that IVAs could be useful for dance therapy.

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Chapter 1: Introduction

1.1 Motivation

Since the beginning of time, humans from all cultures have expressed themselves through dance. It has been identified that dance can unify humans' physical, mental and emotional wellbeing (Levy, 1988). Dance improves health and coordination, enhances cognitive skills and motivation, helps people express and explore emotions (Aktas and Ogce, 2005) and influences humans' emotions based on the nature of movements they perceive when they watch a dancer (Hagendoorn, 2004). It is only natural then that virtual humans, often known as Intelligent Virtual Agents (IVAs), should also be able to dance and help humans to express themselves through dance. Research in IVAs and dance is slowly growing as technology develops, new technology emerges and its benefits are realized.

Dance has been mainly studied as the subject for the development of realism and believability of IVA behaviour and animation. Dance has been analysed for emotion recognition (Camurri et al., 2003) and modelled for behaviour expressivity (Pelachaud, 2009) of IVAs. There is a growing interest in virtual trainers for improving human physical fitness and providing therapeutic exercises (Ruttkay et al., 2006). This has been applied to the context of dance instructors and has been investigated with ballroom dance.

Despite some research involving IVAs and dance, there is little research concerning the influence of dancing IVAs on human emotions. Integrating emotion into a dancing IVA has the potential of helping humans to express themselves and increase their capacity for communication, as has been found in Dance Movement Therapy (DMT) (Jeong et al., 2005). It may also contribute to research efforts to increase the believability and humanlike capabilities of IVAs.

1.2 Research Aims

The aim of this project is to research whether a dancing IVA can evoke or influence human emotions. This project seeks to explore and contribute towards addressing the current research gap with respect to dance in the domain of IVAs. Current and previous research related to dance and IVAs mainly revolves around the concept of a virtual trainer or instructor, exploring whether an IVA can teach a human to dance (Huang et al., 2012). There has also

been research in recognition of emotions from dance (Camurri et al., 2003) and expression of emotions through arm movements (ADA et al., 2003). Though there are established works in observing emotions from facial expressions which is relevant to dance, there is still a lack of research in observing emotions from dance movements and its relation with IVAs and humans. Therefore, the goal of this project is to explore the evocation and influence of a dancing IVA on human emotions.

1.3 Research Question

Little research has studied the development of a dancing IVA and its relationship with human emotions. Moreover, to the best of my knowledge, there is no study that investigated the influence of full body movements of a dancing IVA on human emotions. The research reported in this thesis seeks to address this gap. In order to understand the relationship between a dancing IVA that portrays emotions through movements and human emotions, the following research question is proposed:

RQ1. *Can a dancing IVA influence human emotions?*

To determine if it is essential for the humans to recognize the emotion the IVA depicts in order to be influenced emotionally, the following additional research question is proposed:

RQ2. *Can humans recognize the emotions portrayed in the IVAs dance movements?*

1.4 Research Approach

To answer the research question, this project will investigate the responses of humans watching a dancing IVA perform three different dances that represent three different emotions. This project will investigate humans watching the dancing IVA, which involves eliciting the humans' emotional response to an IVA expressing three different emotions through dancing. This project will identify what movement characteristics of the body indicate an angry, sad and happy dance. These emotions will be modelled in the IVA.

1.5 Outline

The thesis is organised as follows. Chapter 2 provides the background information on the work conducted in this thesis and reviews previous research in IVA and dance. Chapter 3 outlines the repeated measures design employed for the study and describes how the dancing character was created. Chapter 4 presents the detailed analysis of the results from the data that

was collected from the study involving 55 participants. Chapter 5 revisits the research questions, summarises the findings and outcomes, describes the future work and limitations, and offers final remarks.

Chapter 2: Literature Review

Research into the influence of a dancing IVA on the evocation on human emotions draws on multidisciplinary literature from psychology and computer science. From psychology it includes studies and theories concerning emotion and/or dance, and from computer science it draws literature from artificial intelligence and the subarea of intelligent virtual agents. This chapter will review the literature from these related fields, identify their relationships, and further describe how it forms the basis of the hypothesis. We will define the different aspects of human emotion and explain its importance of expression for human well-being and believability of IVAs (section 2.1). Following an introduction to IVAs (section 2.2), dance will be introduced (section 2.3) highlighting the benefits of dance and DMT. Next, we will review the current and previous research and applications of IVA and dance (section 2.4) and identify the research gap that the present study will cover. Before we can establish this, we have to understand the role of our emotions.

2.1 Human Emotions

Emotion is an essential element of human life that brings meaning, character and connection to people. It is “the apparent desires of a character and the way the character feels about what happens in the world with respect to those desires, are what make us care about that character” (Bates, 1994, p.2) . Researchers frequently study emotion to understand human nature. For example, De Melo et al. (2010) explains that anger can communicate to a person to stop another person's actions as it might be a disturbance to their goals, shame can portray regret for a person's actions and happiness or sadness can influence a positive or negative appraisal of a certain situation. Emotions play a central role in human social interaction (Keltner and Haidt, 1999) and behaviour (Van Dyke Parunak et al., 2006). Gratch and Marsella (2004) explain that emotions are manifested across a wide range of levels and modalities via facial expressions, body language and speech. For example, when eye brows are lowered and drawn together indicates anger (Ekman and Friesen, 2003), raised arms above shoulder level and straightened elbow characterise happiness (Coulson, 2004) and slow speech with little high frequency energy signals sadness (Nwe et al., 2003).

The power of emotions to communicate through different modes and influence human behaviour forms a crucial part of our research. In the following paragraphs we will provide a definition of human emotion and further explain the importance of expression of emotions for human well-being and believability of IVAs.

Emotion is comprised of five components including the cognitive processing, the subjective feeling, the action tendencies, the physiological changes, and the motor expression (Scherer, 2000). These five components form the psychological construct (Becker-Asano and Wachsmuth, 2008) or definition of emotion. Emotion is defined as an occurrence of interconnected, synchronized changes in the states of all or most of the five components in response to an event of major significance (Scherer, 2000). In neurobiology, emotions can be defined into two classes, namely, primary and secondary emotions. Primary emotions refers to emotions that are presumably innate that directly influences facial expressions. It is the immediate feeling or response to a certain situation. Secondary emotions are what leads from primary emotions such as ‘hope’ or ‘relief’ that emerge from higher cognitive processes, based on the evaluation of experiences against outcomes and expectations (Becker-Asano and Wachsmuth, 2008). Another definition from cognitive appraisal theories describes emotions as a response to subjective interpretation of an event. This interpretation is based on the evaluation of appraisal variables that determines the type and intensity of the triggered emotion (Scherer, 2000). Among all the provided definitions of emotions(Gratch and Marsella, 2001, Courgeon et al., 2009), the commonality of all is that they identify the ability of emotions to communicate information and impact human behaviour.

2.2 Intelligent Virtual Agents (IVA)

IVAs allow humans to interact with a computer using a human-like character. Depending on the focus of the research, they are also known as animated pedagogical agents and embodied conversational agents. Research into IVAs emerged from the convergence of various areas including artificial intelligence, computer graphics, computer animation, human-computer interaction, cognitive science and robotics (Kasap and Magnenat-Thalmann, 2008).

An IVA is a type of agent. According to Wooldridge and Jennings (1995) an agent can be defined into two notions of weak and strong.

The weak notion of agents refers to hardware or software-based (i.e. more common) computer systems that have the attributes of autonomy, social ability, reactivity and pro-activeness. Autonomy defines that agents should be able to operate without the need of human

intervention (Castelfranchi, 1995) and have "control over its own actions and internal state" (Jennings and Wooldridge, 1998, p.4). Social ability in the agent-to-agent context identifies that agents should interact with other agents through a certain agent-communication language (Genesereth and Ketchpel, 1994). Reactivity describes that agents should perceive their environment (e.g. physical world or user via a Graphical User Interface) and respond in a timely fashion to changes that occur in it (Wooldridge and Jennings, 1995). Pro-activeness specifies that agents do not simply just react to their environment but are able to initiate and exhibit behaviour driven by goal (Wooldridge and Jennings, 1995). There are other attributes of agents that other researchers discuss including mobility, veracity, benevolence and rationality. For certain applications, some attributes may be more important than others, but the key attributes of an agent that are widely accepted and is relevant to the present study is autonomy, social ability, reactivity, pro-activeness and situated-ness (i.e. agents should interact with its environment receiving sensory input and performing responses that can change its environment) (Jennings et al., 1998).

The strong notion of agents extends on the weak notion of agents which is more specific towards its definition of a computer system that applies human concepts (i.e. mentality, emotion, face) (Wooldridge and Jennings, 1995) or as the Proceedings of the Thirteenth International Conference on Intelligent Virtual Agents (2013) defines it:

> "Intelligent virtual agents (IVAs) are interactive characters that exhibit human-like qualities and communicate with humans or with each other using natural human modalities such as facial expressions, speech and gesture. They are capable of real-time perception, cognition and action that allow them to participate in dynamic social environments" (p.5)

This closely supports the subject of the thesis, namely IVAs that apply human forms of expressive movements or IVAs that can dance. IVAs have been used for many different purposes. The use of IVAs by other researchers as fitness coaches (Ruttkay and van Welbergen, 2008, Ruttkay et al., 2006) or teacher/instructor (Huang et al., 2012, Uejou et al., 2011, Leyzberg et al., 2011, Chan et al., 2011, Magnenat-Thalmann et al., 2008) could also be useful in the dance domain. While we do not report any IVA work for fitness via dancing, we do present some work on the use of IVAs as dancing instructors (section 2.4.1). The usefulness of IVAs in these, and other roles, is largely related to their ability to express emotion as described in the following subsection.

2.2.1 IVA Emotion

Researchers have observed that the importance of emotions in IVAs is their potential to enhance human-machine interaction (De Melo et al., 2010, Gratch and Marsella, 2004, Ochs et al., 2008) in a way that takes into account the emotional state of the human user (Lisetti and Schiano, 2000, Picard, 2003) and the believability of IVAs (Leite et al., 2008). The expression of emotion in IVAs can enhance user satisfaction (Klein et al., 1999, Prendinger et al., 2005), user engagement (Klein et al., 1999), user performance in tasks (Partala and Surakka, 2004), and the perception of IVAs (Brave et al., 2005). As Bates (1994) states "If the character does not react emotionally to events, if they don't care then neither will we. The emotionless character is lifeless as a machine" (p.2). Emotions bring life to IVAs.

The emotions of an IVA are communicated and expressed through verbal and non-verbal communication. Verbal communication refers to voice or speech and non-verbal communication refers to facial expressions, body gestures/postures, and eye gaze. Research in IVA and emotions has mainly focused on recognition and analysis of facial expressions and the relationship between emotions and body gestures has not been adequately explored yet (Gunes and Pantic, 2010). Wallbott (1998) investigated certain parts of the body and qualities of movement that distinguish specific emotions. For example, they found that the crossing arms in front of the chest represent pride. Similarly, Coulson (2004) studied the attribution of emotions to different static body postures. They established the body posture of sadness is distinctly characterised by a forwards head bend. Moreover, Camurri et al. (2003) analysed the recognition of emotion from body movements in the context of dance. They observed that the limbs expand from the body when a happy dance is performed. Though there are established works in the expression of emotions through body movement, there is still a lack of research in the area. This aligns with the research gap of IVA and dance which is further described in section 2.4. The following section introduces dance and its potential benefits in IVAs.

2.3 Dance

Dance can be viewed from numerous different perspectives of human behaviour including physical behaviour and communicative behaviour (Hanna, 1987). The physical behaviour of dance refers to the process of the human body releasing energy through muscular responses to stimuli that are received by the brain such as music or sound. This stimulus is translated in the human body as energy that contracts and expands, as muscles that flex and stretch, and as

gestures and movement that travels throughout the body and space. The communicative behaviour of dance refers to body language that enables a person to speak without spoken words but rather movement of words. This critical behaviour is the foundation of most motivation and actions of dance.

2.3.1 Dance Movement Therapy (DMT)

Dance has been studied for centuries for the purpose of expression, understanding emotions and therapy (Molinaro et al., 1986), namely Dance Movement Therapy (DMT) (Ritter and Low, 1996). According to Molinaro et al. (1986), dance was traditionally connected to healing and was used to influence fertility, birth, sickness and death. Today, DMT is an emerging profession and is defined as the "psychotherapeutic use of movement as a process which furthers the emotional, cognitive, social and physical integration of the individual" (Adta.org, 2014). DMT has been attributed to improve human emotional expression through non-verbal communication, self-awareness and body-awareness, integration within social contexts and overall sense of wellbeing (Ritter and Low, 1996, Aktas and Ogce, 2005). Some of the areas that DMT has been applied include breast cancer (Sandel et al., 2005), schizophrenia (Xia and Grant, 2009), eating disorders (Krantz, 1999) and depression (Haboush et al., 2006). According to Xia and Grant (2009), dance therapy can be applied to humans of all ages, genders and cultures. They have identified that the benefits of dance therapy is that it can treat people with medical, social, developmental, physical and psychological impairments. This can be beneficial if humans were able to interact with a virtual dance therapist. Understanding the ability of IVAs to express and influence emotion through dance would be one step towards developing such a therapist.

2.4 IVA and Dance

Research in IVAs and dance is slowly growing as technology develops, new technology emerges and its benefits are realized. Dance has been mainly studied as the subject for the development of realism and believability of IVA behaviour and animation (Loke et al., 2009, Rehm et al., 2008, Reidsma et al., 2006b, Reidsma et al., 2006a). Dance has been analysed for emotion recognition (Camurri et al., 2003, Clay et al., 2009) and modelled for behaviour expressivity (Pelachaud, 2009) of IVAs. There is a growing interest in virtual trainers for improving human physical fitness and providing therapeutic exercises (Ruttkay et al., 2006). This has been applied to the context of dance instructors and has been investigated with

ballroom dance. However, there is still little or no research in the area of the influence of dancing IVAs on human emotions.

2.4.1 IVA as Dance Instructors/Teachers

Various studies have aimed at developing IVAs as dance instructors to replace the traditional approach to teaching dance. Huang et al. (2012) stated that IVAs are suitable candidates for learning physical tasks like sports, gymnastics or dance that require long periods of repetition of practice from the learner. Huang et al. (2012) justified that having an IVA as a virtual instructor means that it can be available anytime with fewer constraints in setting up in a location. Huang et al. (2012) contended that the advantage of virtual instructors in comparison to human instructors is that virtual instructors have limitless energy and patience on all learners. Also, the implication of a virtual instructor means that the learner will "never feel embarrassed to practice when they are still unskilful" (Huang et al., 2012, p.489). Based on these justifications of research of a virtual instructor, Huang et al. (2012) presented a methodology for modelling a virtual ballroom dance instructor. The behaviour of the instructor was designed based on the results of the human-human tutoring experiment. The prototype of the system was yet to be built, hence the believability of the model and the effectiveness of improving ballroom dance learner's skill was not yet evaluated.

Hachimura et al. (2004) developed a dance training system that integrated motion capture and virtual reality technology. The learning environment of the system was displayed on a wall which included the virtual instructor overlapped with the virtual character which represented the body of the user. In the system, the user is able to perform and observe the dancing motions of the virtual instructor and their virtual character in real time.

Chan et al. (2011) extended this study and implemented a prototype of an unassisted dance training system that used the same technology. The contribution of their work was the added feedback of user performance. The users learned dancing sequences demonstrated by a virtual instructor displayed on screen. The user's motions were captured and analysed for their correctness and accuracy of imitation, and feedback was given to them. For example, the students' movements are visualised next to the virtual instructor on the screen and when an incorrect move is executed, the section of the body part is highlighted in red. The results of the study showed that the system can assist and motivate the users to learn and improve their skills.

2.5 Chapter Summary and Conclusion

Previous research has commonly identified that emotions can communicate information and impact human behaviour (Keltner and Haidt, 1999, Van Dyke Parunak et al., 2006, de Melo et al., 2009). The importance of emotions in IVAs is that they can enhance the believability and realism of IVAs. However, there are fewer studies that analyse the expression of emotions through body movements. Most of the previous research has focused on facial expressions. This aligns with the research gap of IVAs and dance. There is still need for research in the study of the influence of dancing IVAs on human emotions. The research approach used in this study is explained in Chapter 3:.

Chapter 3: Methods

The goal of this project is to investigate the influence of a dancing IVA on human emotions. We have chosen a positivist research approach that uses the literature to posit and predict an outcome. In chapter 1 we stated the research question:

Can a dancing IVA influence human emotions?

To answer this high-level research question, we have refined it as follows.

RQ1: *Can watching a dancing IVA depicting different emotions influence human emotions?*

Drawing on the IVA, emotion and dance literature, we have proposed the following set of hypotheses in order to answer our research question, beginning with the null hypothesis that there will be no influence.

- H_0 The humans' emotions are not influenced by the IVAs emotion
- H_2 Watching a happy dancing IVA will make the human happier
- H_3 Watching a sad dancing IVA with make the human sadder
- H_4 Watching an angry IVA will change the humans' level of anger

Hypotheses H_2 and H_3 suggest that the agent's emotion will be contagious and produce an increase in the same emotion in the human. These two hypotheses are supported by work which shows that watching an emotive dance can evoke the emotion in the viewer (Reidsma et al. (2006a)). However, H_4 suggests that an angry dance may either increase the feeling of anger in the human watching the dance, or may dissipate some of their current anger by providing a means of releasing that anger. This last hypothesis is based on the historical origins of angry styles of dance, such as Breakdancing in Hip-Hop, which originated in the streets as a way for gangs to deal with their anger against other gangs (Bennett, 1999, Stapleton, 1998)

We also seek to determine if it is necessary for the human to recognise the emotion being depicted in order to be influenced emotionally. Thus, we ask the following additional research question and propose the following hypothesis.

RQ2*: Can humans recognize the emotions portrayed in the IVAs dance movements?*

- H_1: Humans can recognize the emotion portrayed by the dancing IVA

To achieve our goal, we conducted an experiment involving participants watching a dancing IVA that displays three different emotions (anger, sadness and happiness). An experiment allows us to manipulate selected variables to determine their effect on the variable/s of interest while controlling other effects in order to test our hypotheses. Use of an experiment is in line with many other studies on IVAs and expression of emotions (e.g. (Atkinson et al., 2004, Gunes and Pantic, 2010, Camurri et al., 2003).

Our experimental design is outlined in Section 3.1, including a subsection (3.3.1) describing the design of the IVA's emotions portrayed via dance. Participants, Procedure, Materials, and Instruments and Measures are presented in sections 3.2, 3.3, 3.4 and 3.5, respectively.

3.1 Experimental Design

The experiment was based on a 'repeated measures' design with one within subjects factor (dancing character) and one between-subjects factor (display order). The dancing character factor displayed three different emotions. There were six different display orders as shown in Table 1. Each participant watched the three dancing characters in only one display order of emotions. Each display of dancing character took 1 minute and 50 seconds. The display order of emotions was randomly allocated to participants by the survey software (Qualtrics). In order to design and implement a dancing character that depicted happy, angry or sad, it was necessary to draw on the literature which describes how these emotions are portrayed in dance. Our dancing emotion design rationale is presented next.

Table 1: Between-within subject design

Display Order of Emotions	**Dancing Character**		
	First	Second	Third
ASH	Angry	Sad	Happy
SHA	Sad	Happy	Angry
HAS	Happy	Angry	Sad
AHS	Angry	Happy	Sad
SAH	Sad	Angry	Happy
HSA	Happy	Sad	Angry

3.1.1 Dance and Emotions

The dances of the three dancing characters representing three different emotions were created by only one dancer to act as an experimental control. The research evidence shows that actors or dancers differ to a large degree in the way they interpret and encode emotions (Scherer, 1986, Wallbott, 1998). The three different emotions of the dancing character encoded were selected from Ekman's six basic emotions of happy, sad, anger, disgust, fear and surprise (Ekman, 1992). The study focused on encoding the expression of anger, happiness and sadness through dance movements. The emotions selected were based on the consistent findings of most studies that anger, happiness and sadness are most accurately recognized through postures and facial expressions (Coulson, 2004).

The design of the angry, sad and happy dancing character follows a similar approach to a study by Camurri et al. (2003) classifying the dance movements with respect to emotions (Anger, Sadness and Happiness) and Laban's dimensions (Time, Weight, Space and Flow). The difference in the approach in this study is the additional classification of the dance movements with respect to specific body parts focusing on the arms, head and legs.

In this study, the emotions of the dancing characters are designed based on Laban dimensions and movement characteristics. The Laban dimensions include Time (duration), Weight (tension, transfer and activity), Space (contraction and expansion) and Flow (frequency, tempo changes/pauses, rhythm). These cues were associated with different combinations of movement characteristics which include movement quality, arms, head and legs which represent each emotion of anger, sadness and happiness. These cues were constructed based on research findings of non-verbal expressions of anger, sadness and happiness (Wallbott and Scherer, 1986, Montepare et al., 1987, De Meijer, 1989, Frijda, 1989, Wallbott, 1998, Montepare et al., 1999, Pollick et al., 2001, ADA et al., 2003, Camurri et al., 2003, Atkinson et al., 2004, Coulson, 2004, Gunes and Piccardi, 2007, Xu et al., 2013). The detailed design of the dancing character and emotions is shown in Table 2. Appendix A: Character Dance and Emotion Design contains the behaviours that were included in the dancing character implemented in our study. Of significance (see results section), for technical reasons and time constraints it was not possible to model the clenched fists for the angry dancing character.

Table 2: Dancing Character and Emotions Design

Emotion	Dimension	Characteristics			
		Movement Quality	Arm	Head	Legs
Anger	Time	Short duration of time (Camurri et al., 2003) Fast (Xu et al., 2013, Montepare et al., 1987, Pollick et al., 2001)	Faster than Sadness and Happiness (ADA et al., 2003)		
	Weight	High tension that builds up then 'explodes' (Camurri et al., 2003) Forward or backwards weight transfer (Coulson, 2004) High movement activity and dynamics (Wallbott, 1998) Hard (Montepare et al., 1987)	Higher force than Sadness and Happiness (ADA et al., 2003) High activation (Pollick et al., 2001)		Stamping of feet (Atkinson et al., 2004) Heavy footed (Montepare et al., 1987)
	Space	Expansive movements reaching out from the body centre or chest (Gunes and Piccardi, 2007, Atkinson et al., 2004, Darwin, 1998) Action-filled (Montepare et al., 1999)	Short or similar distance as Sadness (ADA et al., 2003) High arm swings raised forwards and upwards (Montepare et al., 1987, Coulson, 2004) Raised fists (symbolic of Anger) (Coulson, 2004, Darwin, 1998)	Head erect (Darwin, 1998) Bowed with jutted chin (Coulson, 2004)	
	Flow	Frequent tempo changes with shorts stops between changes (Camurri et al., 2003)	Short hold time (Xu et al., 2013) Jerky (Pollick et al., 2001)		

Sadness	Time	Slow movement (De Meijer, 1989, Wallbott and Scherer, 1986) Long duration of time (Camurri et al., 2003)	Lower speed than Anger and Happiness (ADA et al., 2003) Slow speed (Xu et al., 2013)		
	Weight	Soft (Montepare et al., 1987) Passive, less active and less energetic (Frijda, 1989, De Meijer, 1989, Wallbott and Scherer, 1986, Darwin, 1998, Xu et al., 2013) Backward weight transfer (Coulson, 2004)	Lower force than Anger and Happiness (ADA et al., 2003) Low activation (Pollick et al., 2001)		Less heavy footed than Anger but not Happiness (Montepare et al., 1987)
	Space	Contracted chest and lack of movement (Atkinson et al., 2004, Darwin, 1998, Frijda, 1989, Montepare et al., 1987) Collapsed body posture (Wallbott, 1998)	Shorter distance than Anger and Happiness (ADA et al., 2003) Small waving amplitude, small movements (Xu et al., 2013) Low arm swings (Montepare et al., 1987)	Dropped head (Atkinson et al., 2004) Lowered head (Xu et al., 2013) Forwards head bend (Coulson, 2004)	Short stride length (Montepare et al., 1987)
	Flow	Smooth with few tempo changes (Camurri et al., 2003, Montepare et al., 1987)			

Happiness	Time	Fast (Montepare et al., 1987)	Lower speed than Anger (ADA et al., 2003) Fast waving speed (Pollick et al., 2001, Xu et al., 2013)		Faster paced walk than Anger or Sadness (Montepare et al., 1987)
	Weight	High and Low tension (Camurri et al., 2003) Loose and relatively soft (Montepare et al., 1987) High force (Camurri et al., 2003) High movement activity and dynamics (Wallbott, 1998) Weight transfer is not predictive (Coulson, 2004)	Lower force than Anger (ADA et al., 2003) High activation (Pollick et al., 2001)	Backwards head bend with raised chin (Wallbott, 1998)	Least heavy footed than Anger and Sadness (Montepare et al., 1987)
	Space	Expansive movements reaching out from the body centre (Camurri et al., 2003, Gunes and Piccardi, 2007, Wallbott, 1998) Action-filled (Montepare et al., 1987)	Longer distance than Anger and Sadness (ADA et al., 2003) Raised arms (Atkinson et al., 2004) Large amplitude (Xu et al., 2013) High arm swings raised above shoulder level forwards and upwards (Coulson, 2004, Montepare et al., 1987) Hands kept high and are made into fists (Gunes and Piccardi, 2007)	head backwards (Coulson, 2004)	Jumping up and down (Atkinson et al., 2004) Stretched from the body (Cammuri et al., 2003) longer stride length than sad, but shorter than anger (Montepare et al., 1987)
	Flow	Frequent tempo changes with long stops between changes (Camurri et al., 2003)	Short hold-time (Xu et al., 2013) Jerky (Pollick et al., 2001)		

3.2 Participants

We sought to recruit at least 30 participants, which using a *latin square* design would allow us to have 10 participants experience each of the characters (angry, happy, sad) first, second and third when combining these orders across the six orders given in Table 1. We sought to recruit participants that were dancers and non-dancers so that our results can be generalized to a population that is not just dancers or non-dancers. The targeted general age of participants was 18 years and over, both male and female. The study did not collect the participants experience and knowledge of avatars and virtual environments and it is possible that it may have influenced the participants' responses such as their liking of the character.

The participants were predominantly students recruited from Macquarie University. There were advertisements posted around the Macquarie University, North Ryde campus and online on computing and dance unit pages on Macquarie University's online learning system, iLearn. The study was announced in dance classes with posters handed out to students and invitation emails were distributed to computing students. The study was also advertised on the Facebook pages of Macquarie Dance Academy and Crossover Dance Studios. All advertisements contained a link to the survey including the information and consent form in Appendix C: Poster Advertisement. No payment or reward was offered for participation.

3.3 Procedure

The participants were directed to the information and consent form when the survey link was accessed as shown in the complete survey in Appendix B: Qualtrics Survey. It notified the participants the study's short title 'Therapeutic Dancing Character', the purpose "exploring whether a dancing character is useful for dance therapy" and the time duration expected to be around 15 to 20 minutes. The study was voluntary and the participants were given the option to provide their email address if they wished to receive a copy of the results.

The participants who completed the information and consent form proceeded to the demographics section where they were asked about their gender, age, reason of invitation to participate in the study, first language, and views of dancing. Next, in the pre-questionnaire, the participants were asked to select what best describes how they are feeling among Ekman's six basic emotions of sad, happy, angry, fear, disgust and surprise on 5-point Likert scales from 1 to 5 for each emotion (e.g. Not Sad – Sad). The participants were also asked about the overall strength of their emotions on a 5-point Likert scale from 1 to 5 (i.e. Weak to Strong). At the end of the pre-questionnaire the participant was asked an open-ended question on what

other emotions they were feeling to identify a free response of emotions that were not provided as options in the previous questions.

In the next section of the survey, the participants were instructed that the following three subsections would present three different dancing characters each followed by a post-questionnaire on their experience watching the dancing character. The participants were not primed that they would be asked to identify the emotion being expressed by the dancing character. This was excluded from the instructions to avoid influencing the participants' emotion or make them feel that the study is expecting a change in their emotion. This was where the repeated measures design mentioned in section 3.1 was applied to allow measuring order effects. The purpose of this design was to see whether priming is needed and beneficial, and to see if there is an order effect. After viewing the instructions, the participants were randomly allocated to one of the six display orders of emotions of a dancing character (see Table 1). The first subsection displays the first dancing character to the participant where the participant was asked to watch the video in full screen and notified that there is no sound to avoid confusion. The participant was then instructed to complete questions on emotion recognition and emotion intensity of the dancing character. The participant was also asked about their emotions with same questions as the pre-questionnaire. The procedure of the first subsection is repeated for the following subsections watching dancing character 2 and completing post-questionnaire on experience, and watching dancing character 3 and completing post-questionnaire on experience. At the end of the experiment, the participants were asked to complete a post-questionnaire on their liking of the character, agreement on statements on the usefulness of the dancing character, the need for music and an open-ended question on other comments. The complete procedure of the study is summarised in Table 3.

Table 3: Survey procedure

Section	**Estimated Time Duration (minutes)**
Read Information and consent form	2
Complete Demographics	2
Complete Pre-questionnaire	2
Watch Dancing Character 1 and complete post-questionnaire	4
Watch Dancing Character 2 and complete post-questionnaire	4
Watch Dancing Character 3 and complete post-questionnaire	4
Post-experiment questionnaire (Overall experience)	2
Total	20

3.4 Materials

The study required the use of a number of tools including:

- Kinect Sensor for Windows v1.0 (Microsoft, 2015) to capture the skeleton data of the dance
- Brekel Pro Body is an application interface for converting skeleton data of the dance into Biovision Hierarchy (BVH) animation file format to be further processed in Motion Builder 2015. It enables calibration of the Kinect Sensor to the dance space and live streaming of the dancer.
- Motion Builder 2015 (Autodesk, 2015) was used to map the skeleton to a character and to smooth the dance animations.
- MediaCoder (MediaCoder, 2015) was used to render the flash videos.
- Qualtrics (Qualtrics, 2014) was used to host the online survey (see section 3.5)
- Bit.ly (Bitly, 2015) was used to shorten the Qualtrics survey link into bit.ly/dancingstudy. The Qualtrics link was shortened because it was too long and complex for it to be easy to remember by potential participants. Bit.ly also provided stats on when the link of the survey was clicked on and where it was accessed from (i.e. Facebook, iLearn)

The creation of the dancing character is described in the next subsection.

3.4.1 Dancing Character

The appearance of the dancing character was created in minimal context with no face, no clothing, no music, no gender, no background, no theme and no dialog. The appearance of the dancing character is represented by the figure and movements of a full human body displayed in a contrasting plain background with grid floors to establish sense of gravity and grounding of the dancing character (see Figure 1). This was done to purely experiment the interpretation of the movements of the dancing character without inferences or influences from the appearance of the dancing characters and its environment (Marsella et al., 2006). For example, it has been found that in congruence of facial and bodily expressions, emotion recognition was mainly judged from facial expressions (Clavel et al., 2009). This suggests that the appearance of the dancing character can influence the participants' emotion recognition of the dancing character. Thus, it was decided that the dancing character with no other defined qualities (e.g. face, clothing, music, gender, background, theme, dialog), will

ensure that the participants will engage the participants to focus on the movements of the whole body of the dancing character irrespective of other qualities of its appearance.

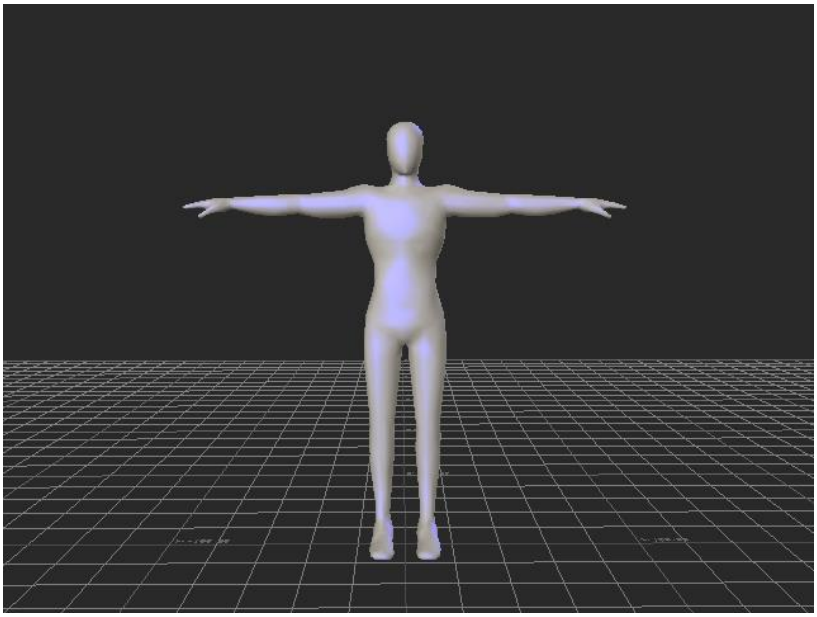


Figure 1: Dancing Character Appearance (in T-Pose position)

The three dancing characters consisted of three 1 min and 50 seconds video clips of three different dancing characters including an angry dancing character, a sad dancing character and a happy dancing character expressing three different emotions through movement. The recording and modelling of each dance followed a layered approach similar to the study of Camurri et al. (2003). The layered model used in this study is sketched in Figure 2 below, where each layer inputs and outputs are displayed and what process was employed.

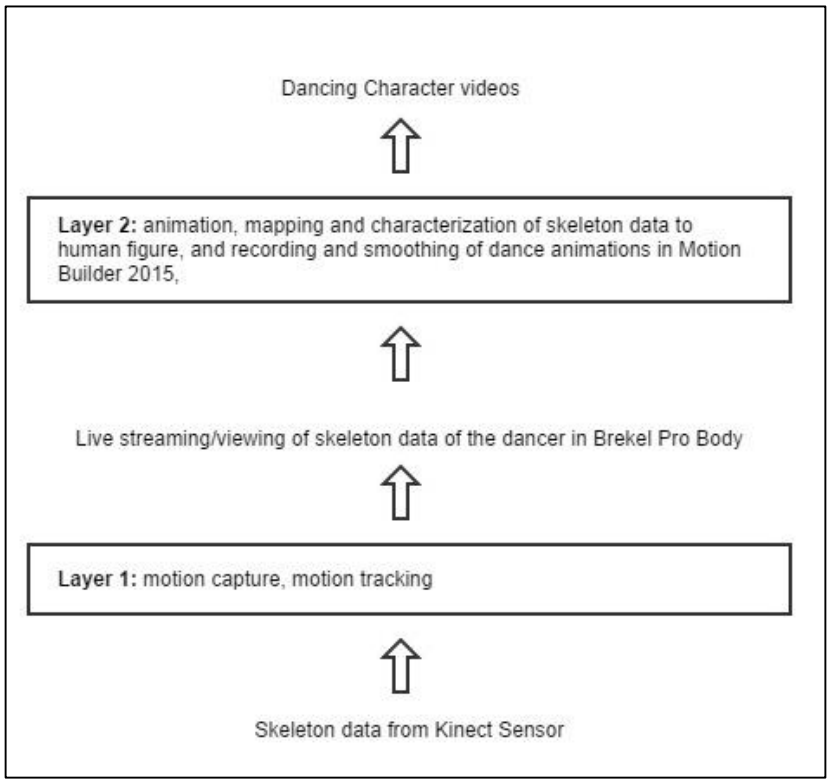


Figure 2: Layered approach of recording and modelling dancing characters

Layer 1 is responsible for the motion capture and motion tracking of the dancer. The motion is captured by the Kinect Sensor standing fixed in the same frontal view of the dance space. The Kinect Sensor captures the skeleton data of the dancer and is viewed and streamed in Brekel Pro Body. Although, the use of the Kinect Sensor and Brekel Pro Body eliminated the requirement of motion suits, the limitation of the use of these tools was that it did not capture hand clasps or movements of the fingers of the hand. Layer 2 is responsible for animation, mapping and characterization of the skeleton data to a human figure in Motion Builder. The recording and smoothing of each dance animations is completed here.

3.5 Instrument and Measures

The survey consists of five sections including the information and consent form, demographics, pre-questionnaire, post-questionnaires on each experience of watching three different dancing characters and a post-experiment questionnaire on the overall experience. The complete survey can be seen in Appendix B. Qualtrics was used to create the survey and capture the data. Qualtrics allowed all questions regarding emotions and the order in which the dancing IVA were presented to be randomised.

As can be seen in Appendix B, the surveys contained a mixture of Likert scale questions, forced-choice questions and free response. The use of a Likert scale is common for

identifying, measuring and ranking the recognition, perception and effect of virtual agent's expression of emotions. Forced choice questions were used for identifying what single emotion is presented, perceived and/or experienced. Due to the importance of this data, we discuss measurement of emotion recognition in section 3.5.1 below. We used free-response questions, such as to elicit other emotions (Section 2, Q8 and Section 3 Q10) or reasons for (dis)liking the character (Section 4 Q1), were used when the range of responses were unknown and/or large or when we did not want to influence their choices, e.g. why is music (not) essential (Section 4 Q5).

3.5.1 Measuring Emotion Recognition

The recognition of emotion was collected by a six-alternative forced-choice methodology as it was found to be the most commonly used methodology for measuring emotion recognition in studies of verbal and non-verbal expression (Atkinson et al., 2004, Coulson, 2004, Camurri et al., 2003, Fabri et al., 2004). This method consists of choosing one emotion amongst the six emotion labels of anger, happiness, sadness, fear and disgust which are randomized in order. The percentage of participants distributed to emotion labels chosen was used as the recognition score.

The recognition of emotion collected from forced choice method was also translated into binary variables (Not Recognized = 0, Recognized = 1) for the angry, sad and happy dancing character. The rating of emotion intensity was also collected using a 5-point Likert scale from 1 (meaning the character weakly expresses the emotion) to 5 (meaning the character strongly expresses the emotion).

The methods used to analyse this data are presented in the results chapter.

3.6 Chapter Summary and Conclusion

The experiment was based on a 'repeated measures' design with one within subjects factor (dancing character) and one between-subjects factor (display order). Each participant watched the three dancing characters in only one display order of emotions which was randomly allocated. Each display of dancing character took 1 minute and 50 seconds.

The recording and modelling of each dancing character followed a layered approach similar to the study of Camurri et al. (2003). Layer 1 captured the motion of the dancer recorded as skeleton data using a Kinect Sensor. The Kinect Sensor was calibrated to the dance space and the motion capture was processed in Brekel Pro Body. Layer 2 mapped and characterized the

skeleton data to a human figure in Motion Builder. Motion Builder was also used finalize the recording and smoothing of the dance animations. The dance animations were embedded in the survey as flash video files.

The creation of the survey and collection of the data was made in Qualtrics. Qualtrics was used to randomize the order of questions on emotions and the display of the dancing characters. The survey also contained a range of Likert scale questions, forced choice questions and free response to measure emotion recognition.

Chapter 4: Results and Discussion

In the following sections, we describe the pilot study (4.1), the participants demographics (4.2), results of the experiment including statistical analysis of research questions of emotion recognition and emotion influence, analyse the post-experiment questionnaire results, qualitative analysis and survey structure. The discussion of results and answers to the research questions are included within the relevant sections.

4.1 Pilot

There were 14 participants who volunteered for the pilot study. The participants were post-graduate students recruited from the Department of Computing at Macquarie University and completed the study as part of a class exercise. Five participants withdrew from the study before watching any of the dancing characters and one participant withdrew after watching two dancing characters. In the end, there were 8 participants that completed the pilot study including 7 males (87.5%) and 1 female (12.5%).

The major issue that prohibited the participants from continuing with the study was that the videos of the dancing characters required a QuickTime player. Most of the participants' machines did not have a QuickTime player already installed on their web browsers. Therefore, some had to download before continuing the survey whilst others didn't complete the survey. This was changed in the final study by rendering the videos as flash video files as most updated web browsers already have a flash player installed. The file size of the flash videos was also compressed to reduce time of video buffering. To enhance immersion, full screen was enabled for all dancing character videos.

From the pilot study, it was detected that calibrations were needed to eliminate the bias introduced by the way questions were formulated. This was achieved through order randomization of questions (see Appendix B: Qualtrics Survey). For instance, in the pre-questionnaire section of the survey, the order of the 5-point Likert scale questions on how they are feeling amongst the emotions of sad, happy, angry, fear, disgust and surprise are randomized so that emotions are not biased in order of display.

From the pilot study it was also identified that the survey was too long so some questions were removed and changed. The questions regarding the background of dancing experience were removed as it was evaluated that it was not necessary for answering the research questions of the study. The questions regarding emotion recognition was originally based on

the PAD (Pleasure Arousal Dominance) model (Lance and Marsella, 2008). The PAD model was used as a framework for designing questions to measure the participants' emotion recognition of the dancing character and the participants' emotional state. The PAD model questions were changed to forced choice questions as it was found to be the most common method for measuring emotion recognition as stated in section 3.5.1. Overall, the duration estimation of the pilot study was initially around 30 minutes and was reduced to 15-20 minutes for the final study.

4.2 Participants

In total, 73 participants volunteered for the study. Two people withdrew from the study after completing 'Section 1: Demographics' of the survey. Thirteen people withdrew from the study after completing 'Section 2: Pre-Questionnaire'. Fifty-eight people proceeded to 'Section 3: Dancing Character and Post Questionnaire (Experience)', but one person withdrew after watching one dancing character and two people withdrew after watching two dancing characters. In the end, there were 55 participants who completed the survey. The participants' demographics are shown in Table 4 below.

Table 4: Demographics

		Count	Percentage %
Gender	Male	28	50.9%
	Female	27	49.1%
Age	18 to 24	40	72.7%
	25 to 34	10	18.2%
	35 to 49	4	7.3%
	50 or older	1	1.8%
Reason of Invitation of	Macquarie University Student	34	61.8%
Participation	Other	21	38.2%
First Language	English	36	65.5%
	Other	19	34.5%
Do you like dancing?	Yes	45	81.8%
	No	10	18.2%
Are you a dancer?	Yes	23	41.8%
	No	32	58.2%
Do you watch dancing?	Yes	42	76.4%
	No	13	23.6%
Where do you watch dancing?	Live Performances	6	14.3%
	YouTube	23	54.8%
	Television	4	9.5%
	Other	9	21.4%

Participants included 28 males (50.9%) and 27 females (49.1%). Since the participants were generally students, the mean age was 24.7 years (range 18-51). English was the first language for 61.8% of participants. Other first languages were predominantly Asian languages. Nearly all of the participants like dancing or are dance enthusiasts (81.8%) and the remaining are non-dance enthusiasts (18.2%). There are 23 dancers (41.8%) and 32 non-dancers (58.2%). Nearly all of the participants or specifically dance enthusiasts also watch dancing (76.4%). Those that watch dancing explained that they watch dancing for learning, interest, inspiration, expression and entertainment. For example some participants answered they watch dancing "to learn and to understand how they listen and feel music.", "as a source of inspiration, motivation and because it is entertaining and creates a platform for emotions, and stories", and to "broaden cultural viewpoints".

4.3 Can humans recognize IVA emotion?

The 55 participants who completed the survey were automatically and randomly allocated into one of the six orders by Qualtrics. Analysis of the 3 dancing characters/stimuli x 55 participants (i.e. 165 instances), shows that there were 49 (29.7%) wrong recognition answers (i.e. emotion portrayed by the dancing character was not recognized). In total, the recognition score for 116 correctly recognized answers was 70.3% which is significantly greater than chance level. The chance level is 16.7% (i.e. 100/6 = 16.7%) which is the probability that the participant will choose one of the six emotions as their answer.

The complete set of ratings is shown in Table 5. Individually, recognition rates were dependent on the emotion expressed by the dancing character. Target emotions were recognized at levels greater than chance in 90.9% of happy dancing character, 72.7% of sad dancing character and 47.3% of angry dancing character (See Figure 3). The angry dancing character was the least recognized perhaps because it did not display an emblematic element of anger, namely clenched fists (Coulson, 2004, Atkinson et al., 2004, Darwin, 1998). This was identified as a limitation of the representation of the dancing character presented in the study. Two participants who watched the angry dancing character last commented "the character's movement in the last video was quite weak, so it was hard to determine its emotion" and "the last one was a little unclear making me feel a little confused with emotions." The absence of clenched fist may have been crucial to the strength and clarity of the dancing character portraying anger.

Table 5: Total Recognition Results

Stimulus	Not Recognized		Recognized	
	Count	Percentage %	Count	Percentage %
Angry Dancing Character	29	52.7%	26	47.3%
Sad Dancing Character	15	27.3%	40	72.7%
Happy Dancing Character	5	9.1%	50	90.9%
Total	49	29.7%	116	70.3%

Table 6: Individual Recognition Results[1]

Stimulus	Recognition Response					
	Happy	Sad	Angry	Surprise	Disgust	Fear
Angry Dancing Character	12 (21.8%)	4 (7.3%)	26 (47.3%)	7 (12.7%)	3 (5.5%)	3 (5.5%)
Sad Dancing Character	0 (0%)	40 (72.7%)	1 (1.8%)	1 (1.8%)	0 (0%)	13 (23.6%)
Happy Dancing Character	50 (90.9%)	1 (1.8%)	0 (0%)	2 (3.6%)	0 (0%)	2 (3.6%)

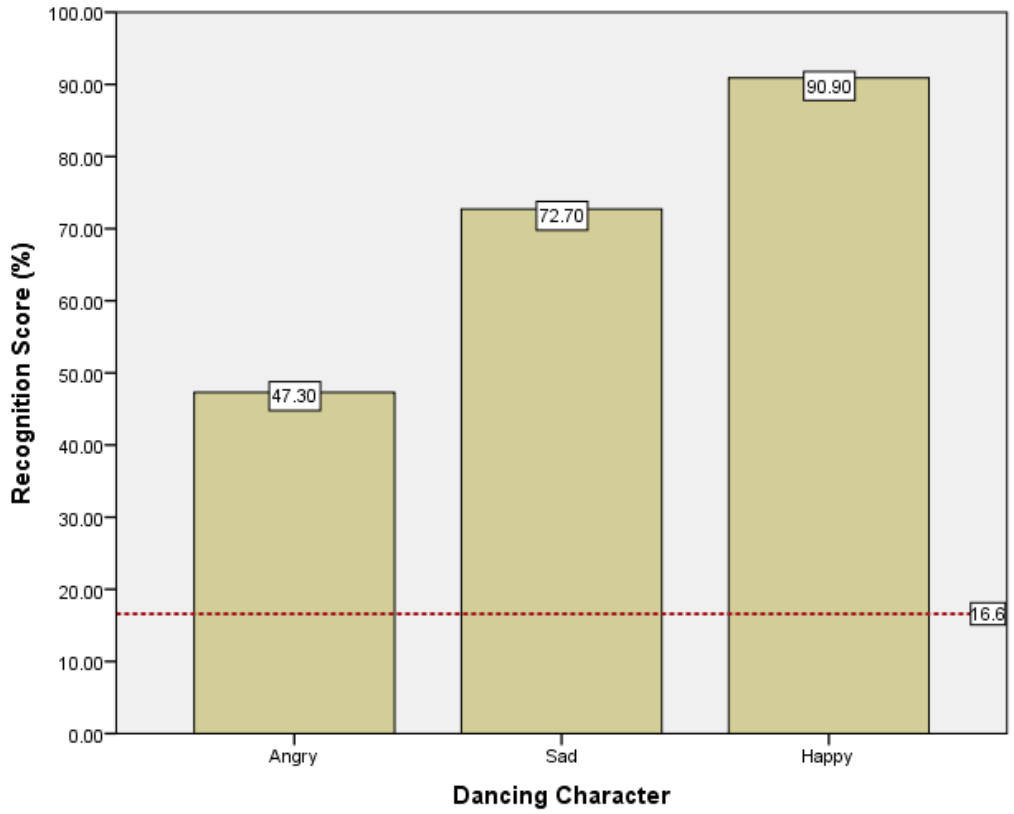


Figure 3: Total recognition scores for each dancing character.[2]

Researchers have found that the non-verbal communication of anger has similar characteristics to the non-verbal communication of happiness. They have similarities in all of

[1] Percentages are shown in parenthesis
[2] The dotted horizontal line represents the chance level (16.6%)

Laban's dimensions of time (fast), weight (high tension), space (expanded) and flow (jerky) and is differentiated by phase relations by the anatomy of the body (Atkinson et al., 2004). This is evident in

Table 6, where the recognition of happiness was close to the recognition of anger (i.e. second most recognized) for the angry dancing character, whilst the other emotions of sad, surprise, disgust and fear were very low in recognition.

4.3.1 Display order

The display order of emotions portrayed by the dancing characters also revealed significant difference. Table 7 shows the comparison between the recognized angry, sad and happy dancing characters, and the six combinations of display order of emotions. It reveals that the lowest emotion recognition mean is when the emotion being portrayed by the dancing character comes first. For example, for the recognition of happy dancing character, the lowest emotion recognition mean is 0.75 (order: Happiness, Anger, Sadness) and 0.82 (Happiness, Sadness, Anger) when the happy dancing character is displayed first (see Figure 6). The lowest recognition mean is also evident when the angry dancing character is displayed first (mean = 0.3, order: Anger, Sadness, Happiness, see Figure 4) and when the sad dancing character is displayed first (mean = 0.56, order: Sadness, Anger, Happiness, see Figure 5). This also indicates that the emotion of anger, sadness and happiness being portrayed by the dancing character is clearer when it is not displayed first. This may be because of the limitation of the experimental design where the participants' awareness of identifying the emotion portrayed by the first dancing character increases after identifying the first dancing character The participant is first asked to label the emotion after the first dancing character is watched. Therefore, when the participant watches the following dancing characters, the participant is aware to look for the emotion being portrayed. For example, when the happy dancing character was displayed after the first or second dancing character, nearly all of the participant recognized the happy dancing character with high recognition means of 0.9 (order: Anger, Sadness, Happiness) and 1 (order: Sadness, Happiness, Anger; Anger, Happiness, Sadness; Sadness, Anger, Happiness). Another factor that might be a reason why the emotion is clearer when it is not displayed first is that the participant can compare the second or third dancing character to the previous dancing character. For example, the highest emotion recognition mean for the angry dancing character was 0.82 (order: Happiness, Anger, Sadness) which is significantly greater than other display order of emotions.

Table 7: Descriptive statistics of Recognized Dancing Character x Display Order of Emotions

Recognized Dancing IVA	Display Order of Emotions	N	Mean	Std. Deviation	95% Confidence Interval for Mean	
					Lower Bound	Upper Bound
Angry Dancing Character	Anger, Sadness, Happiness	10	.30	.483	-.05	.65
	Sadness, Happiness, Anger	12	.50	.522	.17	.83
	Happiness, Anger, Sadness	11	.82	.405	.55	1.09
	Anger, Happiness, Sadness	5	.40	.548	-.28	1.08
	Sadness, Anger, Happiness	9	.33	.500	-.05	.72
	Happiness, Sadness, Anger	8	.38	.518	-.06	.81
	Total	55	.47	.504	.34	.61
Sad Dancing Character	Anger, Sadness, Happiness	10	.80	.422	.50	1.10
	Sadness, Happiness, Anger	12	.75	.452	.46	1.04
	Happiness, Anger, Sadness	11	.73	.467	.41	1.04
	Anger, Happiness, Sadness	5	.80	.447	.24	1.36
	Sadness, Anger, Happiness	9	.56	.527	.15	.96
	Happiness, Sadness, Anger	8	.75	.463	.36	1.14
	Total	55	.73	.449	.61	.85
Happy Dancing Character	Anger, Sadness, Happiness	10	.90	.316	.67	1.13
	Sadness, Happiness, Anger	12	1.00	.000	1.00	1.00
	Happiness, Anger, Sadness	11	.82	.405	.55	1.09
	Anger, Happiness, Sadness	5	1.00	.000	1.00	1.00
	Sadness, Anger, Happiness	9	1.00	.000	1.00	1.00
	Happiness, Sadness, Anger	8	.75	.463	.36	1.14
	Total	55	.91	.290	.83	.99

Although it was identified in section 4.1 that the angry dancing character was the least recognized and least clear, the result indicates that the angry dancing character is clearer when it is displayed after the first dancing character. Another reason could be is that because the angry dancing character is displayed after the happy dancing character, the participant can distinguish it from each other as the majority have already identified the happy dancing character.

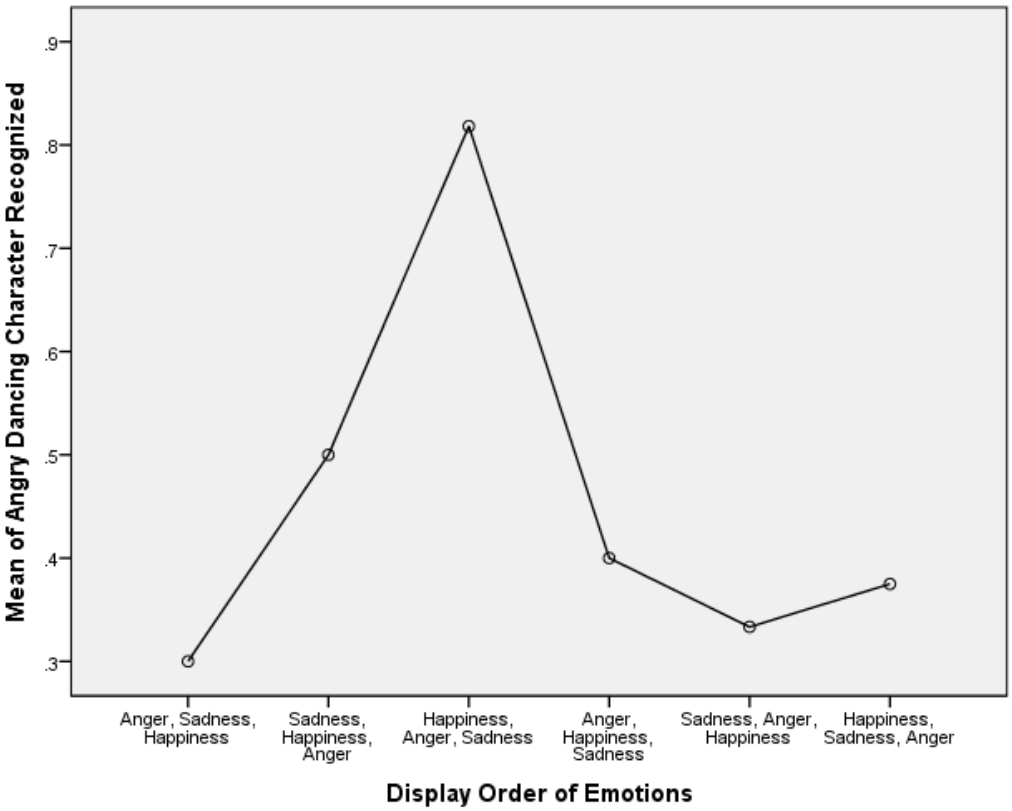


Figure 4: Means Plots of Angry Dancing Character Recognized x Display Order of Emotions

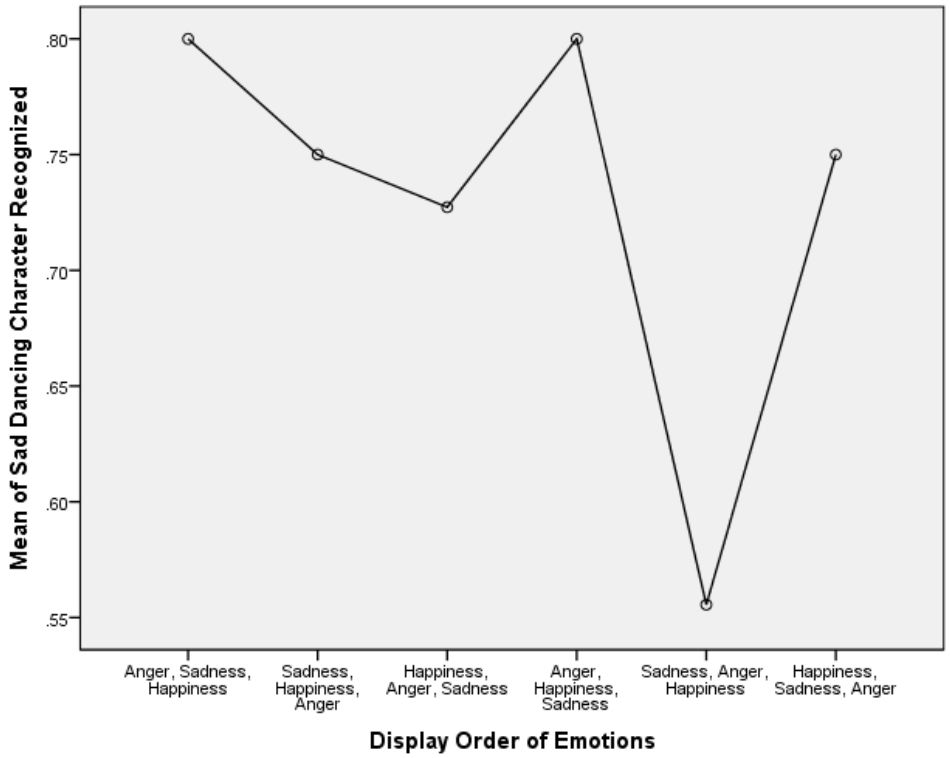


Figure 5: Means Plots of Sad Dancing Character Recognized x Display Order of Emotions

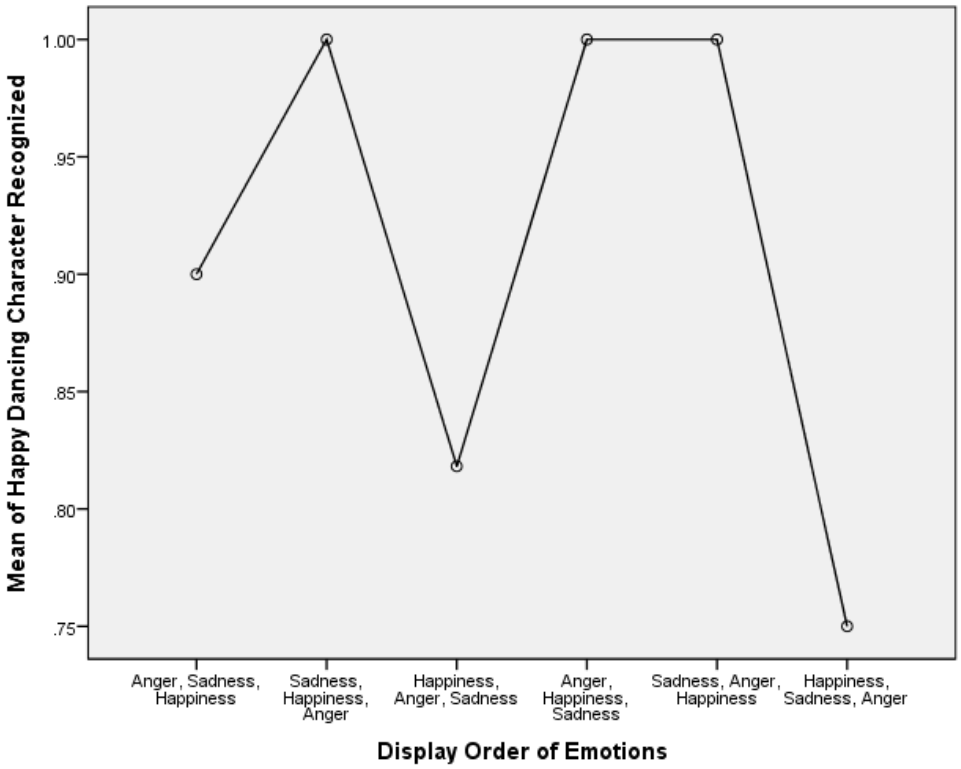


Figure 6: Means Plots of Happy Dancing Character Recognized x Display Order of Emotions

4.3.2 Other factors

To ensure no other factors influenced the results, we ran a number of comparisons to see if any cohorts existed within our participant population in case they may have responded differently to the dancing character. We compared their attitude to dancing, their liking of the character and gender by correct recognition of the dancing character's emotion (see Table 8). We also compared their attitude to dancing and liking the character by gender (see Table 9).

Table 8: Descriptive statistics of participants' Attitude to dancing, Liking the character and Gender x Correct recognition of the dancing character's emotion

		Angry Dancing Character				**Sad Dancing Character**				**Happy Dancing Character**			
		Not Recognized		Recognized		Not Recognized		Recognized		Not Recognized		Recognized	
		n	%	n	%	n	%	N	%	n	%	n	%
Did you like character?	Yes	15	55.6%	12	44.4%	8	29.6%	19	70.4%	3	11.1%	24	88.9%
	No	14	50.0%	14	50.0%	7	25.0%	21	75.0%	2	7.1%	26	92.9%
Do you like dancing?	Yes	23	51.1%	22	48.9%	12	26.7%	33	73.3%	4	8.9%	41	91.1%
	No	6	60.0%	4	40.0%	3	30.0%	7	70.0%	1	10.0%	9	90.0%
Gender	Male	17	60.7%	11	39.3%	8	28.6%	20	71.4%	2	7.1%	26	92.9%
	Female	12	44.4%	15	55.6%	7	25.9%	20	74.1%	3	11.1%	24	88.9%

Table 9: Descriptive statistics of participants' Attitude to dancing and Liking the character x Gender

		Gender			
		Male		Female	
		Count	Percentage %	Count	Percentage %
Did you like the character?	Yes	13	48.1%	14	51.9%
	No	15	53.6%	13	46.4%
Do you like dancing?	Yes	20	44.4%	25	55.6%
	No	8	80.0%	2	20.0%

Chi-squared tests were used in the study to see if there are significant differences between two groups when their responses are categorical (e.g. male/female, like/dislike dancing). Chi-squared tests were used to compare recognition of the character's emotion for each of the three dancing characters with each of the categorical variables (gender, attitude to dancing, liking of the character) and found no significant differences.

The percentage of participants that recognized the angry dancing character did not differ by gender, $\chi^2(1, N = 55) = 1.460$, $p = 0.285$. The percentage of participants that recognized the happy dancing character did not differ by gender, $\chi^2(1, N = 55) = 0.262$, $p = 0.669$. The percentage of participants that recognized the sad dancing character did not differ by gender, $\chi^2(1, N = 55) = 0.049$, $p = 1.000$. Thus, there were no significant differences between recognition of the three dancing character's emotion by gender.

The percentage of participants that liked dancing did not differ by gender, $\chi^2(1, N = 55) = 4.139$, $p = 0.078$. The percentage of participants that liked the dancing character did not differ by gender, $\chi^2(1, N = 55) = 0.162$, $p = 0.790$. Thus, there were no significant differences between the participants' liking of the character and attitude to dancing by gender.

The percentage of participants that recognized the angry dancing character did not differ by attitude to dancing, $\chi^2(1, N = 55) = 0.259$, $p = 0.733$. The percentage of participants recognized the sad dancing character did not differ by attitude to dancing, $\chi^2(1, N = 55) = 0.046$, $p = 1.000$. The percentage of participants that recognized the happy dancing character did not differ by attitude to dancing, $\chi^2(1, N = 55) = 0.012$, $p = 1.000$. Thus, there were no significant differences between the participants' recognition of the three dancing character's emotions by attitude to dancing.

The percentage of participants that recognized the angry dancing character did not differ by liking the character, $\chi^2(1, N = 55) = 0.170$, $p = 0.789$. The percentage of participants

recognized the sad dancing character did not differ by liking the character, $\chi^2(1, N = 55) = 0.149$, $p = 0.768$. The percentage of participants that recognized the happy dancing character did not differ by liking the character, $\chi^2(1, N = 55) = 0.262$, $p = 0.669$. Thus, there were no significant differences between the participants' recognition of the three dancing character's emotions by liking the character

4.4 Can IVA emotion influence human emotion?

Sections 4.4.1, 4.4.2 and 4.4.3 report the influence of IVAs emotions to human emotions depending on what dancing character they watched. This was analysed using a repeated measures ANOVA (multivariate test) to investigate the changes in mean scores of participants' emotion of anger, sadness and happiness over four time points (i.e. different sections of the survey). Section 4.4.4 reports the relationship between recognition, like dancing, like character influences on anger, sadness and happiness. This was analysed using regression analysis to understand whether the participants' anger, sadness and happiness can be predicted based on their recognition of the dancing character, liking of dancing and liking of the dancing character.

4.4.1 Anger Influence

The influence of anger on human emotions is investigated for all four factors measuring the participants' feeling of angry (angriness at pre-questionnaire, after angry dancing character, after sad dancing character and after happy dancing character). Descriptive statistics are shown in Table 10: Descriptive Statistics of Participants' Anger. A repeated measures ANOVA (multivariate test) revealed a significant difference in the means for the four factors (p=0.002). To determine which factor/s were significant we used post-hoc tests and compared each mean with each other by using Bonferroni correction for multiple comparisons with an adjusted significance level of 5%. The results, shown in Table 11, identify a significant difference in the means between level 1 and 2, angriness at pre-questionnaire and angriness after watching the angry dancing character (p=0.024). There was no significant difference in feeling of anger after watching the sad dancing character (p=0.350) or after watching the happy dancing character (p=0.057), though the p-value is approaching significance, possibly because the angry and sad dance were less differentiated from each other.

Table 10: Descriptive Statistics of Participants' Anger

Level	Factor	Mean	Std. Deviation	N
1	Angriness at Pre-Questionnaire	1.15	.356	55
2	Angriness after Angry Dancing Character	1.42	.809	55
3	Angriness after Sad Dancing Character	1.22	.534	55
4	Angriness after Happy Dancing Character	1.04	.189	55

Table 11: Tests of Within-Subjects Contrasts of Participants' Anger

Source	Factor Contrast	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Factor	Level 2 vs. Level 1	4.091	1	4.091	5.400	.024	.091
	Level 3 vs. Level 1	.291	1	.291	.887	.350	.016
	Level 4 vs. Level 1	.655	1	.655	3.782	.057	.065
Error(Factor)	Level 2 vs. Level 1	40.909	54	.758			
	Level 3 vs. Level 1	17.709	54	.328			
	Level 4 vs. Level 1	9.345	54	.173			

Therefore, we can conclude that the participants' anger is significantly dependent on which dancing character they watched (i.e. which emotion the dancing character displayed). Specifically, we conclude that watching an angry dancing character can influence the humans' feeling of anger.

4.4.2 Sadness Influence

The influence of sadness on human emotions is also investigated for all four factors measuring the participants' feeling of sad (sadness at pre-questionnaire, after angry dancing character, after sad dancing character and after happy dancing character). Descriptive statistics are shown in Table 12. A repeated measures ANOVA (multivariate test) revealed a significant difference in the means for the four factors (p=0.000). To determine which factor/s were significant we used post-hoc tests and compared each mean with each other by using Bonferroni correction for multiple comparisons with an adjusted significance level of 5%. The results, shown in Table 13, identify a significant difference in the means between level 1 and 3, sadness at pre-questionnaire and sadness after watching the sad dancing character (p=0.001). There was no significant difference in feeling sad after watching the angry dancing character (p=0.262) but there was significant difference in feeling sad after watching the happy dancing character (p=0.003). Therefore, we can conclude that the participants' sadness

is significantly dependent on which dancing character they watched. Specifically we can conclude that watching a sad or happy dancing character can influence the humans' feeling of sad.

Table 12: Descriptive Statistics of Participants' Sadness

Level	Factor	Mean	Std. Deviation	N
1	Sadness at Pre-Questionnaire	1.47	.766	55
2	Sadness after Angry Dancing Character	1.33	.695	55
3	Sadness after Sad Dancing Character	2.04	1.053	55
4	Sadness after Happy Dancing Character	1.16	.462	55

Table 13: Tests of Within-Subjects Contrasts of Participants' Sadness

Source	Factor Contrast	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Factor	Level 2 vs. Level 1	1.164	1	1.164	1.287	.262	.023
	Level 3 vs. Level 1	17.473	1	17.473	12.493	.001	.188
	Level 4 vs. Level 1	5.255	1	5.255	9.539	.003	.150
Error(factor1)	Level 2 vs. Level 1	48.836	54	.904			
	Level 3 vs. Level 1	75.527	54	1.399			
	Level 4 vs. Level 1	29.745	54	.551			

4.4.3 Happiness Influence

The influence of happiness on human emotions is investigated for all four factors measuring the participants' feeling of happy (happiness at pre-questionnaire, after angry dancing character, after sad dancing character and after happy dancing character). Descriptive statistics are shown in Table 14. Similar to sadness, the repeated measures ANOVA (multivariate test) revealed a significant difference in the means for the four factors (p=0.000). To determine which factor/s were significant we used post-hoc tests and compared each mean with each other by using Bonferroni correction for multiple comparisons with an adjusted significance level of 5%. The results, shown in Table 15 identify a significant difference in the means between level 1 and 2, happiness at pre-questionnaire and happiness after watching the angry dancing character (p=0.000). There was also a significant difference in the means between level 1 and 3, happiness at pre-questionnaire and happiness after watching the sad dancing character (p=0.000). There was no significant difference in feeling happy after watching the happy dancing character (p=0.175). This may be because they feel happier than the happy dancing character and only a happier dancing character can make them

happier. Therefore, we can conclude that the participants' happiness is significantly dependent on which dancing character they watched. Specifically we can conclude that watching a sad or angry dancing character can influence the humans' feeling of happy.

Table 14: Descriptive Statistics of Participants' Happiness

Level	Factor	Mean	Std. Deviation	N
1	Happiness at Pre-Questionnaire	3.29	1.048	55
2	Happiness after Angry Dancing Character	2.47	1.103	55
3	Happiness after Sad Dancing Character	2.07	.940	55
4	Happiness after Happy Dancing Character	3.09	.986	55

Table 15: Tests of Within-Subjects Contrasts of Participants' Happiness

Source	Factor	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Factor	Level 2 vs. Level 1	36.818	1	36.818	24.796	.000	.315
	Level 3 vs. Level 1	81.618	1	81.618	55.521	.000	.507
	Level 4 vs. Level 1	2.200	1	2.200	1.892	.175	.034
Error(Factor)	Level 2 vs. Level 1	80.182	54	1.485			
	Level 3 vs. Level 1	79.382	54	1.470			
	Level 4 vs. Level 1	62.800	54	1.163			

4.4.4 The relationship between recognition, like dancing, like character influences on anger, sadness and happiness

Regression analysis was used to investigate the possible relationships between recognition, liking of dancing and liking of dancing character on human emotions after watching the three dancing characters (angriness after angry dancing character, sadness after sad dancing character and happiness after happy dancing character).

The first regression analysis, shown in Table 16, investigated humans emotions recorded as a scalar variable (Likert scale 1-5, Not Emotional to Very Emotional). Angriness after watching the angry dancing character or sadness after watching the sad dancing character were not affected by recognition, liking dancing or liking the dancing character. This means that the influence of the angry or sad dancing character on the humans' emotions is irrespective of their recognition or like for dancing or the character.

Table 16: Multiple regression of recognition, like dancing and like dancing character on human emotions after watching the three dancing characters

Model	Unstandardized Coefficients		Standardized Coefficients	R	Adjusted R^2	F	Sig.
	B	Std. Error	Beta				
Angriness after Angry Dancing Character							
Recognition	0.301	0.217	0.187	0.187	0.017	1.929	0.171
Like dancing	0.344	0.282	0.166	0.166	0.009	1.495	0.227
Like dancing character	-0.052	0.220	-0.032	0.032	-0.018	0.055	0.816
Sadness after Sad Dancing Character							
Recognition	0.233	0.320	0.100	0.100	-0.009	0.531	0.470
Like dancing	-0.411	0.367	-0.152	0.152	0.005	1.252	0.268
Like dancing character	-0.438	0.280	-0.210	0.210	0.026	2.438	0.124
Happiness after Happy Dancing Character							
Recognition	0.980	0.447	0.288	0.288	0.066	4.802	0.033**
Like dancing	-0.478	0.342	-0.189	0.189	0.017	1.953	0.168
Like dancing character	-0.112	0.268	-0.058	0.058	-0.015	0.176	0.677

***Significance level p<0.05*

The influence of the happy dancing character on the humans' emotions was also irrespective of the participants liking for dancing or the character. However, the results showed that 6.6% of the variance in feeling happy after watching the happy dancing character could be accounted for by recognition. To assess the overall statistical significance of the relation, the results showed that happiness after watching the happy dancing character was significant $R^2 = 0.066$, $F(1, 53) = 4.80$, $p<0.05$.

4.4.5 Intensity of Emotion

The intensity of human emotions is investigated for all four within-subject factors measuring the overall intensity of participants' emotion (emotion intensity at pre-questionnaire, after angry dancing character, after sad dancing character and after happy dancing character) and all six between-subject factors containing the display order of dancing characters (angry dancing character, sad dancing character and happy dancing character). Descriptive statistics are shown in Table 17.

Table 17: Descriptive Statistics of Participants' Emotion Intensity

Display Order of Dancing Character	Emotion Intensity at different sections of survey	Mean	Std. Deviation	N
ASH	Pre-questionnaire	3.00	.471	10
	After Angry dancing character	2.40	.843	10
	After Sad dancing character	2.50	.707	10
	After Happy dancing character	2.70	.823	10
SHA	Pre-questionnaire	2.58	.900	12
	After Sad dancing character	3.25	1.055	12
	After Happy dancing character	2.58	.900	12
	After Angry dancing character	3.08	1.084	12
HAS	Pre-questionnaire	2.73	.905	11
	After Happy dancing character	2.45	.934	11
	After Angry dancing character	2.45	.820	11
	After Sad dancing character	2.27	.905	11
AHS	Pre-questionnaire	2.60	.548	5
	After Angry dancing character	2.40	.548	5
	After Happy dancing character	3.00	.707	5
	After Sad dancing character	2.40	1.140	5
SAH	Pre-questionnaire	2.56	1.014	9
	After Sad dancing character	2.56	1.130	9
	After Angry dancing character	2.56	.882	9
	After Happy dancing character	3.11	1.167	9
HSA	Pre-questionnaire	2.75	.707	8
	After Happy dancing character	3.00	.000	8
	After Sad dancing character	2.88	1.126	8
	After Angry dancing character	2.88	1.126	8

A repeated measures ANOVA (multivariate test) revealed no significant difference in the means for the four within-subject factors (p=0.052). There was also no significance in the means for the six between-subject factors (p=0.237). Therefore we can conclude that the participants' emotional intensity is not influenced by what section of the survey the participant has answered their feelings and what display order the participants' watched the three dancing characters.

4.5 Post-experiment questionnaire

After completing the experiment, participants were asked to complete a post-questionnaire to comment on the dancing character and any other aspect of the experiment using categorical questions (yes/no), 5-point Likert scale statements on participants' agreement on the usefulness of the dancing character (Strongly Disagree – Strongly Agree), and open-ended questions.

The results in Table 18 showed that 50 participants (90.9%) answered that music is essential for the dancing character to be useful and 5 participants (9.1%) answered music is not essential for the dancing character to be useful (see Table 19). These results were obtained from the frequencies of the categorical questions and open-ended questions which collected qualitative data to why participants' liked\disliked the dancing character and why participants' think music is\is not essential for the dancing character to be useful (discussed in section 4.6.3).

The results in Table 20 list the frequencies and means of participants' agreement on the usefulness of the dancing character. The two lowest means were on participants' agreement on learning to dance using a character like the dancing character (m=2.40) and on participants' agreement on the usefulness of the dancing character as a dance partner (m=2.38). This means that the participants' disagreed as they wouldn't like to learn from the dancing character and they didn't see the usefulness of the dancing character as a partner. The other three statements of participants' agreement was on the usefulness of the dancing character for learning to dance (m=3.11), for enjoyment (m=2.89) and for dance therapy (2.93). There means were around 3 which means the participants' neither agreed nor disagreed with the statements.

Table 18: Frequencies of Participants' Liking of the Dancing Character

Did you like the character?	**Frequency**	**Percentage (%)**
Yes	27	49.1%
No	28	50.9%
Total	55	100.0%

Table 19: Frequencies of Participants' answer to the Essence of Music

Would music be essential for this dancing character to be useful?	Frequency	Percentage (%)
Yes	50	90.9%
No	5	9.1%
Total	55	100.0%

Table 20: Frequencies and Means of Participants' Agreement on Usefulness of the Dancing Character

To what extent do you agree with the following statements	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree	Total
	Count	Count	Count	Count	Count	Mean
I would like to learn to dance using a character like this	14	18	13	7	3	2.40
This character would be useful for learning to dance	9	8	10	24	4	3.11
This character would be useful for enjoyment	11	9	14	17	4	2.89
This character would be useful for therapy	7	8	24	14	2	2.93
This character would be useful as a dance partner	11	22	13	8	1	2.38

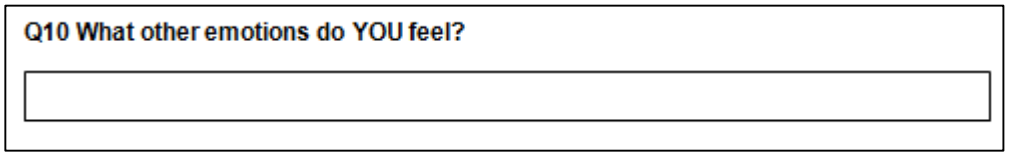
4.6 Qualitative Analysis

Participants were asked a number of open-ended questions requiring a textual response. While this was not essential for answering the research question, a brief analysis facilitated by the use of frequency tables and word clouds to provide a visual representation of the frequency of terms could be further analysed to determine themes. To improve the quality of the word cloud, some pre-processing of the data was undertaken, including removal of stop words, stemming and case-folding.

4.6.1 Analysis of other emotions

At the end of the pre-questionnaire and each post-questionnaire after watching each dancing character, Question 10 allowed the participants to write free text answers to what other emotions they were feeling (Figure 7).

Figure 7: Other emotions question asked at the end of pre-questionnaire and post-questionnaires after watching each dancing character.



At the end of the pre-questionnaire, the most frequent word used to describe another emotion felt by the participant was 7.46% tired and the second most frequent words was 4.48% anxious, 4.48% bored, 4.48% content, 4.48% happy and 4.48% love (Table 21). At the end of watching the angry dancing character, the most frequent word to describe another emotion the participants' felt was 11.11% confused and the second most frequent word was 6.67% bored (Table 22). At the end of watching the sad dancing character, the most frequent words to describe another emotion the participants' felt was 4% bored, 4% confused, 4% creeped, 4% little, 4% relaxed and 4% slight (Table 23). At the end of watching the happy dancing character, the most frequent words to describe another emotion the participants' felt was 5.56% confused and 5.56% little (Table 24). In each post-questionnaire after watching a dancing character, an average of 6.89% of participants felt confused. Among the three dancing characters, 11.11% of participants were most confused after watching the angry dancing character. For instance, a participant who watched the angry dancing character last responded at the post-experiment questionnaire of what she disliked:

"the last one was a little unclear making me feel a little confused with emotions"

Participant 37, Female dancer, Age 22

Table 21: Frequencies of other emotions at pre-questionnaire

	Frequency	Percentage (%)
Tired	5	7.46%
bored, content, happy, love	3	4.48%
calm, confused, excited, exhausted, feeling, indifferent, inspired, relaxed, stressed, worried	2	2.99%
alert, anticipation, bit, determined, driven, fortunate, hehe, joviality, little, lunch, mellow, moment, motivated, optimistic, overwhelmed, peaceful, questions, quite, rational, responsive, satisfied, sense, serene, sick, slightly, time, well	1	1.49%

Table 22: Frequencies of other emotions after angry dancing character

	Frequency	Percentage (%)
Confused	5	11.11%
Bored	3	6.67%
excited, little, neutral	2	4.44%
buck, character, characterised, content, curiosity, dancing, dude, embarrassed, emotion, energetic, feel, irritation, krump, laughter, lol, moody, movements, passionate, patience, proud, pumped, really, relaxed, slight, slightly, stressed, sure, surprised, wondering, worried	1	2.22%

Table 23: Frequencies of other emotions after sad dancing character

	Frequency	Percentage (%)
bored, confused, creeped, little, relaxed, slight	2	4.00%
annoyed, anxious, calm, character, content, course, dancer, dancing, dejected, downcast, embarassed, empathy, excited, fed, feel, feeling, gloomy, inquisitive, interest, intrigued, introspective, irritation, lol, may, moody, normal, particular, perhaps, person, real, sad, satisfied, still, stressed, timid, tired, way, worried	1	2.00%

Table 24: Frequencies of other emotions after happy dancing character

	Frequency	Percentage (%)
confused, little	3	5.56%
bit, bored, interested, joy, neutral, upbeat	2	3.70%
became, confident, content, continuing, count, dance, dancing, delighted, entertained, enthusiastic, excited, feeling, freedom, frustrated, groovy, impatient, last, laughter, laziness, long, love, monotonous, move, need, nothing, one, peaceful, pleased, repetitive, sad, still, stressed, tired, undisturbed, weirdness, wonder	1	1.85%

4.6.2 Analysis of liking of the dancing character

At the post-experiment questionnaire, participants were asked to whether they liked the dancing character or not and comment on what they liked/disliked about the dancing character (Figure 8).

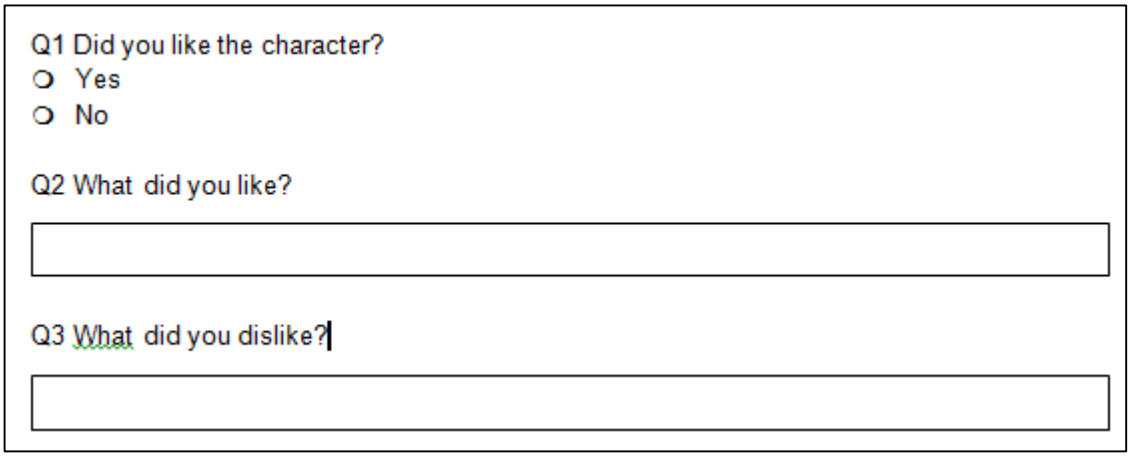


Figure 8: Liking of dancing character asked at beginning of post-experiment questionnaire

The 50 most frequent words was collected from what participants liked about the character (Figure 8, Question 3) and what participants disliked about the character (Figure 8, Question 4). This was used to create a word cloud for both participants' responses of liking of the dancing character (Figure 11) and disliking of the dancing character (Figure 12). The size of the words depicts the frequency of term usage (i.e. larger sized words represent most frequent words). From Figure 11, it can be identified that the participants liked the dance, movements, expression and emotions of the character. The key aspect of what the participants liked about the dancing character was the different emotion expressed by the movements of the angry, sad and happy dancing character. Figure 9 displays some responses from the questionnaire on what participants liked about the dancing character.

"how the dance moves of the character represented their emotions" Female dancer, Age 20

"Conveyed feelings through expressive body language" Male non-dancer, Age 47

"Being able to distinguish emotions through movement. Male dancer, Age 25

"the different dance moves to show different emotions" Female dancer, Age 24

"I thought the movements provided a good representation of the types of emotions that can be conveyed through movement, a point that is emphasised when there is no facial expression to take cue from. It is a pure physical emotional response that is drawn fom me." Male non-dancer, Age 20

"Creative virtual dancer with no music, facial expression, gender or clothes etc to define the character besides movement" Female dancer, Age 22

Figure 9: Participants responses of what they like about the dancing character

It is interesting to note that the participants went further in recognizing the emotions of the dancing character. They identified that emotions was expressed through body language and through movement different emotions can be distinguished. The character was recognized to

be defined without music, facial expression, gender or clothes but purely movement. In spite of that, the majority 90.9% of the participants highlighted the need for music. This is further analysed in the next section.

From Figure 12, it can be identified that the participants disliked the dance, movements, music and the disruptions caused by animation glitches. Based on the responses below on what participants disliked about the dancing character, they found that the looks and animation glitches of the character were creepy. They identified that the dancing character did not use the whole body as it stayed on the same spot with repetitive movement, no facial expressions and only one category of emotions. This was because the design of the dancing character and expression of emotions was constricted with the arms, head and legs conveying anger, sadness and happiness. The participants sought more from the human body represented by the dancing character physically and emotionally. Since there was no music accompanied by the dancing character, participants may have disliked the dancing character as well because there was no music (discussed in section 4.6.3). Though it was still acknowledged that created focus on the movements of the dancing character.

"*the character colour, style, figure and the glitching in his movement (very creepy)"* Female non-dancer, Age 18

"Although it was quite realistic, it was hindered and couldn't be as expressive with the whole body as a real dancer. It lacked the ability to communicate." Female Dancer, Age 21

"too static in the context that he danced on the same spot all the time would be good if it moved more" Male non-dancer, Age 21

"The movements were repetitive, and conveyed one straight category of emotion rather than tell a story. i would have rather been taken on a slight emotional ride." Male non-dancer, Age 21

"No other external emotion besides the movement (ie facials)" Female Dancer, Age 21

"Lack of music. Music could've pushed the emotions further out. But then again that would take away the opportunity to interpret movements" Male non-dancer, Age 23

Figure 10: Participants responses of what they disliked about the dancing character

Figure 11: Fifty (50) most frequent words describing what participants liked about the character

Figure 12: Fifty (50) most frequent words describing what participants disliked about the character

4.6.3 Analysis of need for music

At the post-experiment questionnaire after watching all the dancing character, Question 5 allowed the participants to write free text answers to whether music was essential for the dancing character to be useful (Figure 13). It was found in section 4.5 that the majority 90.9% of the participants highlighted the need for music and 9.1% disagreed.

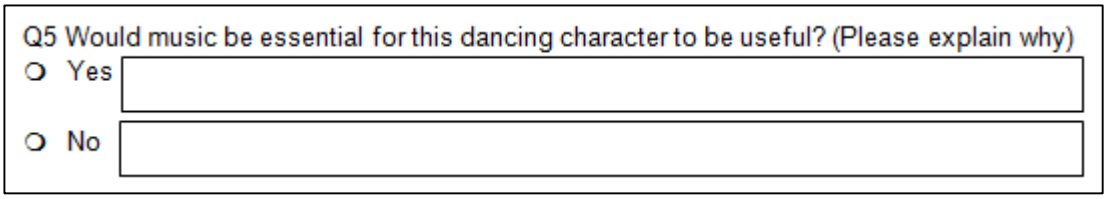


Figure 13: Essence of music question at end of post-experiment questionnaire

The participants highlighted that there is a strong relationship between music and dance (see Figure 14). They stated that music clarifies and enhances the expression of emotions. In spite of that, the participants were able to recognize the emotions and be influenced by the dancing characters portrayed emotions through movement without music. Based on the participants' comments, music should accompany any dance therapy. Although, the results showed that it was not necessary to affect emotion, if people are unwilling or do not like to do the treatment because they want to have music, then the therapy is not likely to be used.

On the other hand, the 9.1% participants that answered music is not essential for the dancing character to be useful explained that the absence of music enabled them to focus on the movement (see Figure 15). The participants' emotions were influenced by watching happy dancing character alone without music. It was also expressed that dancing can exist without music which was the opposite of what most participants' said. Perhaps, dance can be understood without music by people who have studied dance, but for the general population music is essential for understanding dance. The results indicate that further investigation is needed concerning the importance of music in dance therapy.

"I found it irritating that there was no music. I'm not sure why. I guess the association between dancing and music is so strong." Female non-dancer, Age 44

"music adds rhythm and it will allow people to recognise why the character was dancing differently in each video. The genre of music determines the way a certain individual will dance" Female non-dancer, Age 21

"the type of music can also emphasise the emotional portrayal" Female Dancer, Age 23

"if being used as a teacher of dance then yes, because i feel that dance is your body feeling the music and playing out what the music invokes in you" Male Dancer, Age 19

"On a learning perspective, music can get a learner to be on their feet and follow the beat while watching the character. On a therapeutic sense, music would be the input to that can affect a listener's emotions, the dance is the release of said emotion" Male non-dancer, Age 23

Figure 14: Selected comments why music is essential for the dancing IVA to be useful

*"It would be nice to have music, however not essential because dancing can exist without music."*Female Dancer, Age 20

"without music one concentrates more on the movement" Male non-dancer, Age 34

*"No, enjoyment - happiness and a sense of freedom can be emotionally felt by watching the happy character = it inspires the audience to dance and permits a happy feeling."*Male Dancer, Age 22

Figure 15: Selected comments why music is not essential for the dancing IVA to be useful

4.7 Survey structure

Following completion of the study and analysis of results, some limitations observed with the survey in terms of structuring to retrieve more accurate answers and make the process of answering the questions clearer (refer to Appendix B: Qualtrics Survey).

In Section 1, Question 2 the participants were required to input their age in years. The drawback of this is that age is calculated in different ways depending on the culture. Therefore, the question should be changed to ask the date of birth to precisely collect all ages of participants from the same variable. In Section 1, Question 8, the option of 'all of the above' was not included so some participants had to choose other and wrote 'all of the above.' This can be changed in the future by enabling participants to check boxes (check all that apply) instead of a radio button selection.

In Section 3, Question 1, the "neutral" option was not included in the forced choice question of identifying what emotion is portrayed is by the dancing character. This will be implemented in the future as a baseline for emotion recognition to improve comparability across other studies (Juslin and Scherer, 2005).In Section 4, Question 1 asks the participants whether they like the character or not. In the previous sections, the character is mentioned as the "dancing character", this should be changed to "dancing character" to ensure consistency. Also, "in general" should be added at the beginning of the question so that it is clear to the participants that the question is not about the last dancing character they watched but the dancing character in general.

4.8 Chapter Summary and Conclusion

The results of the study show that humans can recognize the emotion portrayed by the dancing IVA and watching the dancing IVA depicting different emotions can influence human emotions. The participants' feelings of anger, sadness and happiness were influenced

based on what dancing character they watched irrespective of their recognition of the dancing character's portrayed emotion or like for dancing or the character. However, significant results showed that the participants feeling of happiness could be accounted for their recognition of the dancing character's portrayed emotion. This may be because the happy dancing character was the most recognized (90.9%). Perhaps improving the animation and clarity of the emotions of the sad and specifically angry dancing character may reveal significance in relationship between recognition and influence. Overall, our results have gained parity with other studies in emotion recognition (Coulson, 2004, Camurri et al., 2003) and have laid a foundation to continue exploring the relationships between dance, IVA and emotions.

Chapter 5: Conclusion

In this chapter, we revisit the research questions outlined in Chapter 1: and summarise the findings and outcomes to these question. We also describe the future work and limitations of the study and offer final remarks.

5.1 Summary and Outcomes

In order to determine whether an IVA can evoke or influence human emotion, an online experiment was created. The online experiment was created to investigate the responses of humans watching a dancing IVA depicting three different emotions and answer the research questions "*Can humans recognize the emotions portrayed in the IVAs dance movements?*" and "*Can watching a dancing IVA depicting different emotions influence human emotions?*"

The results of the study have shown that humans can recognize the emotion portrayed by the dancing IVA, which supports our first hypothesis (H_1). The participants were able to recognize and distinguish between the angry, sad and happy dancing character. The happy dancing character was the most recognized (90.9%), the sad dancing character was the second most recognized (72.7%) and the angry dancing character was the least recognized (47.3%). It was hypothesized that the movements of the angry dancing character were not as clear because the IVA did not display clenched fists which was found by previous studies to be symbolic of anger (Atkinson et al., 2004, Coulson, 2004, Darwin, 1998).

The display order of emotions portrayed by the dancing characters also revealed significant differences for human recognition of emotion. It was observed that the participants least recognized the dancing character's emotion when it was displayed first. This may be because the participants may not be aware of what to identify and how to respond after watching the dancing character. In contrast, when a subsequent dancing character is encountered, the participants can recognize the emotion more clearly as they have become aware of what to look for and can compare the second and third dancing character to the previous dancing character.

There were no significant differences found for participants' recognition of the dancing character's emotion by gender, attitude to dancing and liking of the dancing character. The results of the multiple comparisons tested that none of the other factors measured influenced the results and no cohorts that existed within our participant population that recognized or responded to the dancing character's emotion differently.

The results of the study have shown that watching a dancing IVA depicting different emotions can influence human emotions. The participants' anger, sadness and happiness were significantly dependent on which dancing character's emotion they watched. The angry dancing character changed the humans' level of anger and the sad dancing character made the humans feel sadder, which supports our second (H_2) and third hypotheses (H_3), respectively. Watching a happy dancing character did not make the human significantly happier. Thus, our fourth hypothesis (H_4) is not supported. However, it was found that watching a happy dancing character can influence the humans' feelings of sadness and watching an angry dancing character can influence the humans' feelings of happiness. Therefore, since we are able to accept H_2 and H_3, and found that happy dancing character could influence the humans' emotions and that the humans' happiness could be influenced (though not by the happy dancing character), we are able to reject the null hypothesis (H_0) stating that *humans are not influenced by the dancing character*.

The results of the study have also shown that the influence of the angry or sad dancing character on the humans' emotions is irrespective of their recognition or like of dancing or the character. This was also true for the participants like of dancing or the character for the happy dancing character. This is an important finding, as it indicates that the IVA could possibly be used for therapy and deliver benefits even if the patient was not able to recognise the emotion. However, results showed that the influence of the happy dancing character on humans' feeling of happy could be accounted for by recognition of that emotion.

The participants'' emotional intensity was not significantly different for any of the dancing characters or for any of the sections of the study or display orders.

5.2 Future Work and Limitations

The results would be strengthened if more participants had been recruited. Nevertheless, a population size of 55, with a good spread across dancers and non-dancers and genders and the use of a within subjects design, did provide sufficient data to allow statistical analysis to be performed. Repeating the study, after addressing some of the limitations described below, with more participants representing a wider age range, different cultures and other factors may be beneficial. Also, further analysis of the data could be conducted. In particular, the qualitative data could be analysed in a more structured way using thematic analysis or content analysis. While the qualitative data was not critical to answering the hypotheses we were testing, the quotes suggest some possible interesting themes.

Limitations of our study presented below include aspects of the experiment design, dancing character and survey structure.

5.2.1 Experimental Design

The experiment was based on a repeated measures design with one within-subjects factor (dancing character) and one between-subjects factor (display order). The dancing character factor displayed three different emotions and there were six different display orders. The latin square could have been used for the analysis to combine the six display orders into three display orders. This could increase the balance of participant distribution to each display order condition and increase the concentration of results.

The experiment was analysed for only three emotions from Ekman's six basic emotions which were anger, sadness and happiness. Of these, sadness and happiness were clearly distinguished by the majority of participants, while anger was recognised to a lesser degree. It was known that movements of happiness and anger have similarities in all of Laban's dimensions of time (fast), weight (high tension), space (expanded) and flow (jerky) and is differentiated by phase relations by the anatomy of the body (Atkinson et al., 2004). Also, since only anger, sadness and happiness were investigated, the future work will be to examine and design other emotions including surprise, disgust and fear for a dancing character to understand how other emotions portrayed through dance influence human emotions. This may be important to investigate the effects of different emotions on DMT.

The animation of the dancing character was displayed with no music. Most participants responded that music is essential for the dancing character to be useful. Though, the participants were able to recognize and be influenced by the dancing characters emotions portrayed through movement without music, the participants stated that music clarifies and enhances the expression of emotion. It was commented that music was essential for the dancing character to be useful for teaching and dance therapy. Thus, to further explore the benefits of dance therapy, it is essential that dance is accompanied with music. This future work would require investigating the influence of the dancing character with and without music.

5.2.2 Dancing Character

The modelling of the movements of the dancing character was a major factor in the portrayal and recognition of emotions. The dancing character's movements were limited to the head, arms and legs. The participants also observed that there were some animation glitches of the

dancing character's movements which were found creepy. The participants can identify and recognize the dancing character's emotions more clearly and can engage with the dancing character more if its animations were smoother with no glitches. This future work would require more research on what characteristic body movements indicate specific emotional states and greater expertise in animation in Motion Builder.

Previous research found that clenched fists are an emblematic element of anger which, as noted in 3.1.1, was not modelled in the angry dancing character (Atkinson et al., 2004, Coulson, 2004, Darwin, 1998). It is assumed that modelling clenched fists of the angry dancing character will make the expression and recognition of anger clearer.

5.3 Final Remarks

Dance has been the universal language of the world. It has unified humans of different ages, genders and cultures through expressive movements of one body. For an IVA to be able to dance, it will unify human communication and understanding of IVAs. Dance can enhance the believability of IVAs and humans can realize the benefits of an IVA as a companion, dance teacher or dance therapist. However, dance and its benefits have been inadequately studied in IVAs. Most studies that relate to the expression of dance have mainly focused on facial expressions and fewer studies have analysed the bodily expressions. Moreover, most work in facial expressions and bodily expressions have concentrated on emotion recognition and perception. While some have considered movement, there have not been any studies analysing the influence of dance on human emotions. Thus, our study presents a different way of developing IVAs. It opens up better understanding of the role of human emotions through expressive movements and creates a pathway to achieving the benefits of dance therapy. A significant finding in our research was that the IVA's ability to influence emotion was not dependent on recognition of the emotion. This means that humans or patients with physical or medical impairments can get the benefit of dance therapy just by watching. The research in this thesis on IVA and dance builds a foundation for developing IVAs with beneficial ways to influence human emotions.

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Appendix A: Character Dance and Emotion Design (implemented version)

Emotion	Dimension	Characteristics			
		Movement Quality	Arm	Head	Legs
Anger	**Time**	Fast	Faster		
	Weight	High Tension High Force High Activity Forward or Backward Weight Transfer	Higher Force High Activity		Heavier Footed
	Space	Expanded	Short Distance High Arm Swings	Bowed	
	Flow	Jerky Many Tempo Changes Short Stops between Changes	Jerky		
Sadness	**Time**	Slow	Slow		
	Weight	Low Tension Low Force Low Activity Backward Weight Transfer	Low Force Low Activity		Heavy Footed
	Space	Contracted	Short Distance Low Arm Swings	Dropped	
	Flow	Smooth Few Tempo Changes	Smooth		
Happiness	**Time**	Fast	Fast		
	Weight	High and Low tension High Force High Activity Weight Transfer not predictive	High Force High Activity		Light Footed
	Space	Expanded	Long Distance High Arm Swings	Raised	
	Flow	Jerky Many Tempo Changes Longer Stops between Changes	Jerky		

Appendix B: Qualtrics Survey

Therapeutic Dancing Character Survey

You are invited to participate in a study on 'Therapeutic Dancing Character'. The purpose of the study is to explore whether a dancing character is useful for dance therapy.

The study is being conducted by, Mr. Jon Cedric Roxas, Department of Computing, 61 (0)2 9850 9567, jon.roxas@students.mq.edu.au to meet the requirements of Master of Research under the supervision of Professor Deborah Richards, 61 (0)2 9850 9567, deborah.richards@mq.edu.au, of the Department of Computing, Faculty of Science.

If you decide to participate, during the study you will be asked to fill a demographic questionnaire, pre-questionnaire regarding your current state of emotional feeling and post-questionnaires regarding your experiences after watching three short videos of a dancing character. The duration of the study is expected to be around 15-20 minutes.

We cannot offer any financial reward for participation. However you will gain knowledge about Intelligent Virtual Agents.

Your name and personal details will not be requested. All data will be stored securely, and only the researchers will have access to the data. Any information gathered in the course of the study are confidential, except as required by law.

Participation in this study is entirely voluntary. If you are a student of any of the researchers, your participation or non-participation in this study will have no effect on any aspect of the units you are studying.

If you give your consent, quotes from your work may be used in publications. Your identity will not be disclosed under any circumstances.

The ethical aspects of this study have been approved by the Macquarie University Human Research Ethics Committee. If you have any complaints or reservations about any ethical aspect of your participation in this research, you may contact the Committee through the Director, Research Ethics (telephone (02) 9850 7854; email ethics@mq.edu.au). Any complaint you make will be treated in confidence and investigated, and you will be informed of the outcome.

If you agree to participate in the study and are over 18, please click the checkbox below.

❑ I am over 18 and agree to participate in the study

If you would like to receive a copy of the results, please enter your email address below:

Section 1: Demographic Information

Q1 I am:

- ❍ Male
- ❍ Female

Q2 My Age (in years) is:

Q3 Which of the following describes why you received an invitation to participate in this study (Choose all options that apply):

- ❑ I am a dance student at Macquarie University
- ❑ I am a computing student at Macquarie University
- ❑ Other

Q4 My first language is:

- ❍ English
- ❍ Other (Please enter first language)

Q5 Do you like dancing?

- ❍ Yes
- ❍ No

Q6 Are you a dancer?

- ❍ Yes
- ❍ No

Q7 Do you watch dancing?

- ❍ Yes
- ❍ No

If No is selected, then survey skips to section 2. This note is not displayed on the actual survey

Q8 Where do you watch dancing?

- ❍ Live Performances
- ❍ Youtube
- ❍ Television
- ❍ Other

Q9 Why do you watch dancing?

Section 2: Pre-Questionnaire

For each of the following questions, please select what best describes how you are feeling now:

The following questions are randomized. This note is not displayed on the actual survey.

Q7 How strong overall are the emotions you are feeling?

Q8 What other emotions do you feel?

Section 3: Dancing Character and Post-Questionnaire (Experience)

This section consists of three subsections that present three different dancing characters each followed by a post-questionnaire of your experience watching the dancing character.

The following dancing characters 1-3 are randomized. This note is not displayed on the actual survey.

Dancing Character 1

Please watch the video below in full screen:

Note: There is no sound in this video

Q1 What emotion can you recognize from this DANCING CHARACTER?

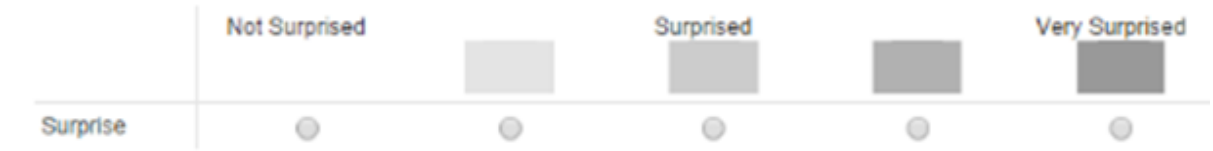
The forced choice question here is randomized. This applies for dancing characters 1-3. This note is not displayed on the actual survey.

- ❍ Happy
- ❍ Sad
- ❍ Angry
- ❍ Surprise
- ❍ Disgust Fear

Q2 How strong does this DANCING CHARCATER express the emotion you selected from the previous question?

For each of the following questions, please select what best describes how YOU are feeling now:

The order of likert scale questions on emotions is randomized. This applies for dancing characters 1-3. This note is not displayed on the actual survey.



Q9 How strong overall are the emotions YOU are feeling?

Q10 What other emotions do YOU feel?

Dancing Character 2

Please watch the video below in full screen:

Note: There is no sound in this video

Q1 What emotion can you recognize from this DANCING CHARACTER?

The forced choice question here is randomized. This applies for dancing characters 1-3. This note is not displayed on the actual survey.

- ❍ Happy
- ❍ Sad
- ❍ Angry
- ❍ Surprise
- ❍ Disgust Fear

Q2 How strong does this DANCING CHARCATER express the emotion you selected from the previous question?

For each of the following questions, please select what best describes how YOU are feeling now:

The order of likert scale questions on emotions is randomized. This applies for dancing characters 1-3. This note is not displayed on the actual survey.

Q9 How strong overall are the emotions YOU are feeling?

Q10 What other emotions do YOU feel?

Dancing Character 3

Please watch the video below in full screen:

Note: There is no sound in this video

Q1 What emotion can you recognize from this DANCING CHARACTER?

The forced choice question here is randomized. This applies for dancing characters 1-3. This note is not displayed on the actual survey.

- ❍ Happy
- ❍ Sad
- ❍ Angry
- ❍ Surprise
- ❍ Disgust Fear

Q2 How strong does this DANCING CHARCATER express the emotion you selected from the previous question?

For each of the following questions, please select what best describes how YOU are feeling now:

The order of likert scale questions on emotions is randomized. This applies for dancing characters 1-3. This note is not displayed on the actual survey.

Q9 How strong overall are the emotions YOU are feeling?

Q10 What other emotions do YOU feel?

Section 4: Post-Questionnaire (Overall Experience)

Q1 Did you like the character?

❍ Yes
❍ No

Q2 What did you like?

Q3 What did you dislike?

Q4 To what extent do you agree with the following statements:

	Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
I would like to learn to dance using a character like this	❍	❍	❍	❍	❍
This character would be useful for learning to dance	❍	❍	❍	❍	❍
This character would be useful for enjoyment	❍	❍	❍	❍	❍
This character would be useful for therapy	❍	❍	❍	❍	❍
This character would be useful as a dance partner	❍	❍	❍	❍	❍

Q5 Would music be essential for this dancing character to be useful? (Please explain why)

❍ Yes

❍ No

Q6 Any other comments?

Appendix C: Poster Advertisement

MACQUARIE UNIVERSITY

Want to watch a dancing character?

You are invited to participate in a study on

'Therapeutic Dancing Character'

The **purpose** of the study is to explore whether a dancing character is useful for dance therapy.

The **online survey** would take around 15-20 minutes to complete.

The study is being conducted by Mr. Jon Cedric Roxas to meet the requirements for the degree of MRes under the supervision of Prof. Deborah Richards. The study has been approved by the Macquarie University Human Research Ethics Committee.

Further information and a consent form together with access to the survey can be found at: **bit.ly/dancingstudy**

For any queries, please contact Jon Cedric Roxas at:
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