HaHa...Ha?

Investigating the Affective Communication properties of Body Movement during Laughter.

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This project report is submitted as an examination paper. No responsibility can be held by London University for the accuracy or completeness of the material therein.
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Abstract

Laughter is a complex, multi-modal phenomenon and important non-verbal affective communicative signal between humans. It is posited that such significance will persist on incorporating laughter into human-machine interaction and that future technologies capable of recognising and responding appropriately to the affective cues of non-verbal communications modalities such as laughter will provide enjoyable, powerful interaction styles. Increasing affective computing research effort focuses on how non-verbal cues such as body movement can be used in machine recognition of affect, but laughter body movement has not yet been examined. This study provides a quantitative investigation into how body movement influences perception and categorisation of laughter, for future use in machine interpretation of laughter through body movement. Using motion capture, 474 samples of naturalistic, non-acted body movements were collected from 9 participants responding to stimuli eliciting hilarious, social, awkward and fake laughter. Movement samples when laughter was not present were also recorded. These samples were processed into gender- and culture-neutral avatar animations without audio. A randomised subset of 126 animations was administered as stimuli in a forced-choice perceptual categorisation experiment with 32 naïve participants, obtaining ground truth categories for each stimulus as depicting one of either hilarious, social, awkward or fake laughter, or non-laughter. This data was analysed to determine how quantitative measures of 14 unique body movements differed depending on the ground truth category assigned. Results indicate that several upper body movements, including bending of the spine and range of hand motion do influence perception of laughter and in categorising whether hilarious or social. This study provides an initial, quantitative deliverable of body movement measures for researchers incorporating laughter body movement detection into future affective human-avatar interaction.
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CHAPTER 1. INTRODUCTION

1.1 Motivation

Laughter plays a key role in the human experience and mutual human interactions. As with other non-verbal behaviours, laughter supports a number of communicative functions, such as providing information about how a person is feeling, otherwise referred to as their ‘affective state’. The ILHAIRE EUFP7 project, under which this work sits, is a European effort to develop scientific knowledge about human laughter. Ultimately, its aim is to apply these findings to building avatars and sociable conversational machines, capable of recognising, creating and exploiting the communication signals inherent in naturalistic laughter, to interact with humans in a fully believable fashion. The goal of this project, within the wider ILHAIRE context, is to aid development of such affective technology by identifying specific features of body movement that contribute to the human perception of different types of laughter, outputting quantitative measures of these movements.

Beyond what many people likely consider its key role as a physical response to humorous, joyful situations, there exists a diverse range of communicative functions of laughter within human-human interaction, including rapport building, resolution of conversational dialogue and turn taking. Subtle differences have also been noted in its use by men and by women, with women tending to laugh more than men, for example. In short, laughter provides a rich communicative tool for human interaction.

* ‘ILHAIRE’ stands for ‘Incorporating Laughter into Human Avatar Interactions: Research and Experiments’ and is part of the European Union Seventh Framework Programme (EUFP7).
How then, might research into laughter positively contribute to the field of human-computer interaction? The key role of laughter as a communicative modality seems to suggest the answer may be ‘quite substantially’.

Affective computing is concerned in large part with machines being able to interpret and express human verbal and non-verbal emotional signals to some degree, adapting responses intelligently to human affective signals, of which laughter is one, and mediating affect as appropriate to the user goal (Bullington, 2005; Picard & Klein, 2002). Norman suggested that when positive affect is not catered for in design, tasks may become more difficult and less pleasurable (Norman, 2004). The implication is that as a richly communicative non-verbal signal of human affect, machines capable of responding appropriately to laughter to enhance positive affect, may make tasks more enjoyable and improve the user experience.

Of concern to HCI researchers, many tasks now involve no interaction with another human and are resolved completely via technology, such as in e-commerce or e-learning. Relating this to ‘human computing’ (Pantic, Pentland, Nijholt, & Huang, 2006), people may find conversational agents and avatars capable of expressing and recognising subtle nuances in laughter to be more acceptable and effective in cooperatively assisting people in achieving their goals. Given the acknowledged importance of laughter for successful communication between humans, it is apparent that technology capable of interpreting and responding to laughter is a necessary step to true human-avatar interaction.
In investigating the challenges of processing complex human behavioural signals needed for technology capable of interacting in such a naturalistic, believable manner with humans, researchers have focused much attention on computational studies of non-verbal affective signals expressed via the face, which has included smiling and laughter (Niewiadomski, Urbain, Pelachaud, & Dutoit, 2010; Petridis & Pantic, 2008a, 2008c). Other modalities studied have included audio patterns in the voice, respiration and EMG (Bailenson et al., 2008; Niewiadomski et al., 2010; Szameitat et al., 2009).

However, a growing area of research involves investigating the movement of the body as another modality of affective expression. This is the modality of interest to this study. A literature review will highlight the apparent gap in the empirical study of the perception of naturalistic, non-acted laughter and the affective content it may convey through movement of the body. This gap provides the justification for carrying out this study.

1.2 Research questions

The aim of this study is captured in two research questions. The goal is to establish, in the absence of context provided by other modalities such as facial expression or voice:

1. What body movements reflect the expression of laughter?

2. Which are the features of those movements that people use to detect and categorise laughter?
These questions imply the hypothesis of this study to be that humans use particular body movements, to some degree, to detect laughter and distinguish between types of laughter. Multimodal examination of laughter and body movement is outside the scope of this work, as the first step is to establish a set of body movements alone that contribute to laughter perception. Multimodal investigation can be developed in future, once these findings are established.

The research process undertaken to address these questions included using video and a motion capture system to record the body movement of naïve participants whilst laughing in response to stimuli designed to elicit different types of laughter. This data was used to generate simple animations (without audio content) of a faceless, gender-neutral and culture-neutral avatars (Figure 1), with each animation clip depicting body movement during a single bout of a certain type of laughter, as determined by the researcher. A subset of these clips formed stimuli in a forced choice perceptual experiment in which a separate group of participants were each asked to categorise each of the entire subset of clips into one of five types of laughter, including hilarious, social, awkward, fake and non-laughter. After feature extraction of body movements depicted in the categorised perceptual stimuli, statistical analysis was used to test whether features of body movement used in the perception of laughter and discrimination of laughter types.
Figure 1. Sequence of stills from one of the animated perceptual stimulus used in this study, depicting motion-captured, naturalistic body movement during a bout of laughter.

1.3 Contribution

This work contributes to the field of human avatar interaction research by:

1. Identifying quantitative measures for a key subset of body movements that significantly affect human perception of naturalistic laughter, to feed into research on multimodal machine detection and synthesis of laughter.

2. Identifying quantitative measures for body movements that contribute to discrimination between types of laughter.

3. Providing a modest corpus of non-acted body movement during bouts of different types of laughter, for further study and interrogation.

4. Providing proof of concept of a customised motion capture system for specialised data collection.
1.4 Structure

The next chapter comprises a literature review, which investigates several topic areas that inform the research questions: justifying focusing on the body as the modality for study and investigative methods used. This includes discussion of psychological and physiological studies of laughter and its communicative properties, human perception and HCI contributions including investigation into machine detection and recognition of affect. Subsequently, a summary of the overall design of the research process used in this study is presented, in turn followed by an account of the customisation of existing motion capture technology to better meet the requirements of investigating the research questions. Chapters six, seven and eight provide overviews of the administration of the experiment conducted to investigate human perception of laughter through body movement. The report closes with a discussion of the findings from the perceptual study, situating them in the context of both the research questions and wider literature, and a conclusion, with a note on future direction for work incorporating laughter and body movement into human avatar interaction.
2.1. Laughter

Although a conspicuous feature of human life, pre-dating speech as an expressive social signal, estimated to be over 7 million years old and present in all cultures, researchers have noted that laughter has been the subject of fewer empirical studies (and, as perhaps as a consequence, is much less well understood) than might be imagined (Adelswärd, 1989; Reuderink, 2007; Ruch & Ekman, 2001; Szameitat et al., 2009). Along with physiologists, the fields of psychology and linguistics have driven much research that has been undertaken particularly, where laughter has been shown to play an important function across a range of scenarios in human interaction.

2.1.1 Physiology and descriptions of laughter

Ruch and Ekman (2001) note that the term ‘laughter’ is not used consistently or precisely by the research community, so it is important to clarify the terminology used in this thesis. A prototypical laughter episode is seen as comprising a ‘bout’, which includes the onset and offset of highly variable respiratory, facial and skeletomuscular activity, accompanied by a variable vocal signal. Within this bout occur laughter ‘pulses’, the individual vocalisations, which, when occurring more than once in a bout, comprise a laughter ‘cycle’. Additional terminology exists, but the terms above will be sufficient to describe laughter throughout the remainder of this thesis. One caveat is that the term ‘type’ can be used in physiological laughter studies to differentiate between ‘spontaneous’ and ‘voluntary’ laughter (Ruch & Ekman, 2001), whereas in this study the term refers to emotional category of laughter.
Laughter causes distinctive body movements. During bouts of intense laughter, significant postural changes are observed, along with a general lowering of muscle tension, which may cause the person laughing to hold onto something or even sit down (Ruch, 1993). These muscular changes are accompanied by rapid changes in lung pressure causing highly dynamic, involuntary, connected body movement throughout the abdominal region, spine and neck and shoulders and can cause distinctive secondary movements such as throwing back the head, which facilitates expulsion of air from the throat (DiLorenzo, Zordan, & Sanders, 2008; Ruch, 1993). Vibrations throughout a range of body locations (such as in the larynx and the fingers) are also present and generally measured around 5Hz or 5 pulses per second (Luschei, Ramig, Baker and Smith 1997, Clynes 1980, both as cited in Ruch & Ekman, 2001). Finally, shoulder movement vertically has been shown to be positively correlated with laughter (ILHAIRE Consortium, 2012).

2.1.2 Psychology of laughter

Within psychology, it has been demonstrated that laughter supports key functions of paralinguistic communication within human-human interaction (HHI) and it has observed that it has notable presence in nearly all databases on human interaction available (Urbain, 2012). As demonstrated for speech before it (Kienast & Sendlmeier, 2000), the acoustic qualities of laughter can express affective states (Niewiadomski, Urbain, Pelachaud, & Dutoit, 2010; Petridis & Pantic, 2008a, 2008b; Schröder, 2003; Szameitat et al., 2009). It has been shown to create rapport, consensus and trust (Nijholt, 2002), and provides a mechanism for handling face threats socially and resolving tensions often present in conversation between what is said and intended and what may
be heard and interpreted (Adelswärd, 1989; Murata, 2009). It can provide further conversational scaffolding through ‘back-channelling’ (Hammer, Reichl, & Raake, 2004), thus supporting turn taking (Bevacqua, Pammi, Hyniewska, Schroder, & Pelachaud, 2010; Pantic et al., 2006). This has been described as laughter facilitating ‘smooth communication’ (Iida, Okamoto, & Takanashi, 2009).

When focusing explicitly on laughter as a communicative phenomenon in the context of gender, the functions of laughter within and between gender groups can be even more subtle and complex. Women have been shown to laugh more than men (Adelswärd, 1989). Further, laughter seems to serve slightly different social functions for men and women, particularly on a strategic level when it occurs in same-sex versus mixed-sex groups. Men tend to elicit laughter by deploying more self-directed and less teasing humour in mixed-sex groups than do women, who in turn also tend to laugh more than their male counterparts in situations such as job interviews with interviewers of the same sex. (Adelswärd, 1989; Lampert & Ervin-Tripp, 2006).

Although implied by its communicative properties, it is worth noting that laughter does fall into many distinct categories, communicating different types of affect (Darwin, 1872; Ruch, 1993; Ruch & Ekman, 2001; Tani, 2009). Different acoustic features exist within laughter (Bachorowski, Smoski, & Owren, 2001), which contribute to the listener’s perception of affective content in the laugh, including for example joy, taunting, and differences in valence, either negative or positive (Devillers & Vidrascu, 2007; Szameitat et al., 2009). Furthermore, an extensive variation of laughter types is observable in corpora on human interaction, whether their original aim was laughter study or otherwise (Urbain, 2012). Laughter has been classified to include types such as

2.2 Human Avatar Interaction and Laughter

Avatars and embodied conversational agents capable of assisting humans in via complex naturalistic language processing conversational styles are the focus of increasing attention for application in customer service, e-learning and clinical contexts (Borzo, 2004; Cassell, Bickmore, Campbell, & Vilhjálmsson, 2000; Gaggioli, Mantovani, Castelnuovo, Wiederhold & Riva, 2003; Konstantinidis, Luneski, Frantzidis, Costas, & Bamidis, 2009; Qiu & Benbasat, 2005; Vilhjálmsson & Cassell, 1998). One can infer that to achieve truly satisfactory naturalistic human-avatar interaction (HAI) on a similar level to human-human interaction, significant effort should be made to understand the communicative contributions made by various modalities of laughter, so that they might be correctly interpreted or synthesised by machine agents. Niewiadomski argued in 2007 that emotionally effective agents were more likely to build successful relationships with humans, but acknowledges that its highly multimodal nature makes laughter exceptionally challenging to incorporate into human-avatar interactions (Bevacqua et al., 2010; Niewiadomski & Pelachaud, 2007; Niewiadomski et al., 2010).

Added to this, moving outside solely a focus on laughter to wider HAI, Gratch notes the collaboration needed across a diverse range of research fields to make naturalistic HAI a reality, including facial animation, perception, natural speech processing and non-verbal communication (Gratch et al., 2002; Pantic et al., 2006)). With such complexity in terms of the research problems themselves and the research
areas to be addressed, it is unsurprising, as noted by Pantic, and later Gunes et al., that true machine understanding of human behaviour is still in its infancy (Gunes, Schuller, Pantic, & Cowie, 2011; Pantic et al., 2006). This implies research methodologies taking small, incremental steps toward understanding in each area, particularly one so little studied as laughter, would be beneficial.

2.3 Study of non-verbal communication modalities

2.3.1 Affect and audio, visual and other non-verbal signals

Both the psychology and affective human-computer interaction literature demonstrate the considerable study applied thus far into understanding non-verbal communication modalities. Widely perceived as the being chief amongst the human non-verbal communication channels, the face has been subject to the bulk of the study effort (Pantic et al., 2006). This holds true in terms of understanding both the expression and perception of non-verbal signals delivered via the face and their applications in human-human and human-computer interaction (Afzal & Robinson, 2009; Ashraf et al., 2009; Bailenson et al., 2008; Castellano et al., 2009; Ekman, 1993; Juslin & Laukka, 2003; Krinidis & Pitas, 2010; Melder et al., 2007; Niewiadomski & Pelachaud, 2007; Niewiadomski, Bevacqua, Mancini, & Pelachaud, 2009; Pantic & Bartlett, 2007; Reuderink, 2007; Russell, 1994; Sebe, Bakker, Lew, Cohen, & Huang, 2004; Urbain, Bevacqua, & Dutoit, 2010). Other non-verbal modalities that have received attention as reliable indicators of affect include physiological signals such as heart rate and electrodermal response, and respiration (Bailenson et al., 2008; Niewiadomski et al., 2010).

A number of these studies have focused specifically on laughter, including its ability to express affective state such as joy and taunting through its acoustic qualities.
Szameitat et al., 2009); how intense laughter is perceived to be through audio visual features (Niewiadomski et al., 2010); examinations into machine recognition of laughter through the audio-visual modalities (Petridis & Pantic, 2008a, 2008b, 2008c; Reuderink, 2007; S. Scherer, Schwenker, & Campbell, 2009) or machine synthesis of naturalistic laughter (Niewiadomski et al., 2010; Urbain et al., 2010).

2.3.2 Affect and the body

Comparatively, the human body as a modality for affective expression and perception has been, until relatively recently, subject to far fewer studies. However, it seems it may be a fruitful avenue of investigation, given that research indicates that i) body posture may be more affectively expressive than the face in some cases (Wallbott, 1998, Ekman & Friesen, 1969; Ekman & Friesen, 1974); ii) that people trust body expressions more than the face when the two do not match (Meeren, van Heijnsbergen, & de Gelder, 2005; van Heijnsbergen, Meeren, Grèzes, & de Gelder, 2007) and iii) that body expression also impacts recognition of emotions in other modalities such as the voice (Van den Stock, Righart, & de Gelder, 2007). The impression of historically scant but now growing research having taken place in this area is enhanced by the fact that the first bimodal face and body gesture database was not created until 2006 (Gunes & Piccardi, 2006). Since then, the need has been noted for body expression to be further incorporated into affective communication study (Dael, Mortillaro, & Scherer, 2012).

Kleinsmith and Bianchi-Berthouze highlight that a contributing factor into body movement being less studied originally was high cost of equipment involved (often requiring motion capture technology) but that since cost has been steadily decreasing, such studies are becoming more common (Kleinsmith & Bianchi-Berthouze, 2012).
Particularly in the last decade, a sample of whole body affective communication studies have included examinations of emotion expression through dance movement and music (Camurri, Lagerlöf, & Volpe, 2003; Camurri, Mazzarino, Ricchetti, Timmers, & Volpe, 2004; Camurri, Volpe, De Poli, & Leman, 2005), affective states through body gesture dynamics and generalised motions (Castellano, Villalba, & Camurri, 2007), static postural data (Coulson, 2004; Kleinsmith, Bianchi-Berthouze, & Steed, 2011), affect recognition when the face is not easily viewable (Karg et al., 2009), emotion from gestures (Kapur, Kapur, Virji-babul, Tzanetakis, & Driessen, 2005), emotional gaits (Ma, Paterson, & Pollick, 2006; Roether et al., 2009) and the perception of affect cross-culturally through body posture (Kleinsmith, De Silva, & Bianchi-Berthouze, 2006). All of these studies have included findings identifying body movement as a significant communication channel in the expression and detection of affect, but none have explicitly focused on laughter.

A data gathering exercise examining laughter, body movement and other modalities has been undertaken by the ILHAIRE group, separate to this study, with the aim of creating a laughter database (ILHAIRE Consortium, 2012), though full results are not available at the time of writing.

2.4 The present study

There appears to be a gap in the affective computing literature on the body’s contribution to perception of laughter. Like laughter itself, the body is a strong modality for indicating affective state. It stands to reason therefore that investigation into body movement’s influence on the perception of laughter could provide interesting findings for the fields of human-avatar interaction and machine recognition of affect. As an
initial study, it is sensible to first focus solely on the modality of body movement. Multi-modal analysis, such as combining facial signals with movement in laughter should be a follow up study. This provides the inspiration for both research questions in this study:

1. What body movements reflect the expression of laughter?

2. Which are the features of those movements that people use to detect and categorise laughter?

2.5 Methodologies for examining affect and the body

In studies of the body and affective expression, a recurring pattern is found throughout the methodological approaches. This involves, firstly, the data collection of movement samples, secondly some variation of coding of those samples and finally, in many cases, the presentation of all or a subset of the collected movements portrayals as stimuli often in either some sort of categorisation tasks involving human participants, or machines (Camurri et al., 2003; Camurri et al., 2004; Castellano et al., 2007; Coulson, 2004; Karg et al., 2009; Meeren et al., 2005; Roether et al., 2009; Wallbott, 1998).

2.5.1 Data collection of affective samples

With regard to the first step, data collection, Urbain (2012) identifies three approaches available to researchers. The first involves ‘natural expression’, where data is collected from the real world, with participants often not aware that they are being recorded until after data collection. Such an approach is acknowledged as being difficult
technically and can be problematic for recording quality (Afzal & Robinson, 2009; Urbain, 2012).

The second approach open to researchers is ‘induced response’, where naïve participants are presented with different stimuli (such as video) designed to elicit different types of naturalistic, non-acted response. Examples include studies recording music-induced naturalistic postures or collecting examples of affective postures from naïve participants as they played video games (Kleinsmith et al., 2011; Thrasher, Zwaag, Bianchi-Berthouze, & Westerink, 2011).

Finally, and something of a point of contention in the research community, affective samples can be gathered using acted data. As argued by Banziger and Scherer, actor portrayals should not be classified as being ‘unnatural’ (in a binary contrast with those of naïve participants being ‘natural’), but rather should be seen as useful in gathering prototypical representations of affect, but unsuitable for recording expressions of spontaneously occurring emotions (Scherer & Banziger, 2004). As such, acted portrayals have been suggested to be contrived and less valid for use in everyday environments for machine recognition of naturalistic affect (Kleinsmith & Bianchi-Berthouze, 2012; Thrasher et al., 2011). That said, actor-gathered data informs a significant portion of non-verbal affective communication research in this area (Camurri et al., 2003; Castellano et al., 2007; Dael et al., 2012; Kapur et al., 2005; Karg et al., 2009; Ma et al., 2006; Roether et al., 2009).
2.5.2 Coding and categorising affective samples – Ground Truth

Throughout the literature, video analysis is used as part of the data collection stage, after which either expert, trained observers code the affective signals in the video (for example, Ashraf et al., 2009; Bailenson et al., 2008) or naïve observers supply categorisations, either once, separately (from larger participant samples) or repeatedly (Camurri et al., 2003; Kleinsmith et al., 2011; Roether et al., 2009; Wallbott, 1998). Russell (1994) also notes that such a coding approach is more successful as a forced-choice design, with observers requested to make a categorisation based on a limited number of affective labels. Further, although identified as being a very labour intensive technique (Afzal & Robinson, 2009; Wallbott, 1998), such coding creates what can be considered robust ‘ground truth’ categories for the segmented affective signals under study. This is often used to test the agreement of machine learning algorithms with human observers (Kapur et al., 2005; Kleinsmith et al., 2011; Roether et al., 2009).

Particularly noteworthy is the work of Coulson (2004) who presented 527 perceptual stimuli of body postures in a forced choice design categorisation task involving six emotional labels. Each session lasted up to 50 minutes, but a repeated measures t-test to verify the experiment validity indicated that participants’ categorisations did not deteriorate in quality due to fatigue, therefore it seems that such perceptual experiments can provide quite a number of trials over a period of at least 30 minutes without the quality of the categorisation suffering.

2.6 Motion Capture in affective data gathering

Motion capture is frequently used as a data collection tool in the study of affective body movement (Kapur et al., 2005; Karg et al., 2009; Kleinsmith et al., 2011;
Ma et al., 2006; Niewiadomski et al., 2010; Roether et al., 2009). Dael (2012) points out that whilst video is a less expensive approach, and does not require the controlled environment and equipment needed for motion capture, video is more useful for capturing gross body movement descriptions, whereas motion capture technology provides objective measurements of body movement.

In practical application of motion capture to collect laughter data, McKeown (2012) notes increased success when participants were invited as pairs of friends, thus negating the potentially socially-uncomfortable and ‘unnatural’ scenario of wearing a motion capture suit and laughing spontaneously with a team of researchers unknown to the participant.

Further, motion capture data is relatively easy to segment (Ma et al., 2006), and allows for the creation of simplistic, gender-neutral, culturally-neutral avatars, which can be used in categorisation tests with human observers to quantitatively explore the contributions of specific features of movement to communication of affect (Roether et al., 2009). Such representations are effective both as static and animated stimuli and might neutralise some of the effects of culture and gender on laughter perception and production found by Kleinsmith et al (2006)(Kleinsmith et al., 2011, 2006; Roether et al., 2009). They also allow a ‘bare bones’ approach control to the researcher in reducing to its elemental values the movement feature under investigation. Humans can correctly discern human motion, even when presented with the sparest of stimuli, such as point light animations (disconnected white dots moving in black space, where the shape of a human walking is discerned readily) (Blake & Shiffrar, 2007).
2.7 Summary

This chapter has explored the literature on the physical and psychological properties of laughter and identified it as an important non-verbal human communication cue. The importance of incorporating such cues into human-avatar interaction has been noted, while observing that machine recognition of affect is in its infancy. After outlining that the body is an important affective communication channel, it is surmised that a significant gap in the literature exists regarding fundamental, quantitative understanding of the influence of body movement on laughter perception. The second half of the chapter examines methodologies used in the study of non-verbal affective communication and identifies a framework of features common to many, including the use of motion capture technology to collect examples of body movement and the perceptual categorisation studies run thereafter to identify which features contribute to which communication of affect. The next chapter outlines how the existing body of work in the area of affective study and laughter science contributed to the overall design of this study.
CHAPTER 3. RESEARCH DESIGN AND APPROACH

3.1 Purpose

Investigating the research questions to identify body movements that contribute to the perception of and categorisation of laughter required a research approach consisting of several structured phases. The specific implementations of each phase will be reported in more detail in the subsequent chapters. The functions of this section are to:

i) Summarise the key outputs of each phase of the research project, providing an outline of the ‘shape’ of the research.

ii) Relate decisions taken on elements of the research design back to the appropriate literature.

3.2 Establishing study aims and scope

Key to determining how to undertake design of the study, was to clarify the intended output. Two key outputs were identified:

i) A list of human body movement features for examination.

ii) A subset of these movement features that significantly influence perception of human laughter (if identified).

The potential number of body movement features to analyse was considerable. A description of every single movement present within the body during bouts of laughter would be neither informative, nor useful in addressing the research questions. To focus scope, a specific initial subset of body movement features was identified for
examination, informed by the literature, such as shoulder movement during laughter (DiLorenzo et al., 2008; ILHAIRE Consortium, 2012; Ruch & Ekman, 2001). The full list of features analysed is available below, in section 3.8 Results compilation (Table 1).

Further, the effect of these features on laughter perception was restricted to individual analysis. Cluster analysis of body movement feature pairs was deemed outside the scope of this first, fundamental study into body movement and laughter perception.

3.3 Research project stages

The timeline of the project plan provides an overview of the sequence of work phases undertaken and is illustrated in Figure 2 below.

![Timeline for research activities undertaken in this study.](image)

Figure 2. Timeline for research activities undertaken in this study.
3.4 Motion capture suit customisation

Identified as a useful technique from the literature, motion capture of naturalistic movement was chosen to build the body movement stimuli for a perceptual experiment. The literature on the highly dynamic body movement present during laughter suggested that shoulder movement would be a pertinent area of study and the detection of shoulder activity should be an aim of the data collection exercise. It was also hypothesised that detection of spinal activity (predominantly bending) during laughter would also be of interest (DiLorenzo et al., 2008; Ruch & Ekman, 2001).

An Animazoo IGS190 motion capture system (MOCAP) was tested in several different configurations, to identify the most suitable for detecting subtle, naturalistic shoulder movement. This phase involved testing the MOCAP system in its default configuration to provide a performance baseline and then making incremental customised adjustments to the positions of the sensors measuring shoulder and spine activity. These adjustments were repeated until the system could detect very subtle shoulder and spinal movement in the wearer and display these on screen via the motion capture avatar. This is discussed in more detail in the Motion Capture System Customisation chapter 4.

3.5 Motion capture data gathering

3.5.1 Methodological design decisions

The design of the laughter body movement data collection phase was established, also considering data post processing for development of perceptual stimuli. As identified in the literature, different types of laughter and body movement have both been shown to convey different emotional content, however they had not
previously been examined together. Methodological approaches of previous research to informed the direction of this study.

It was decided to run naïve non-actor participants in pairs for the data-gathering phase. As highlighted, the literature suggests the use of induced affect, non-acted data was more appropriate to this study of spontaneous laughter (Scherer & Banziger, 2004). Secondly, participants’ recruitment in pairs was informed by the work of McKeown (2012) who noted that participants were more amenable to laughter with a friend than with strangers on the research team.

It was hoped that pair-recruitment might have other benefits. These included logistical advantages, such as making the data collection sessions more interesting to run for both participants, and, therefore, hopefully more straightforward for the researchers. Secondly, having a friend would lessen any feelings of self-consciousness the primary participant might experience whilst wearing the MOCAP suit. Thirdly, when considering affective coding of video of the data gathering sessions was to take place afterward, it was postulated that having a second participant on video would help strengthen the researcher categorisations of the laughter gathered, by providing another point of reference when appraising, for example, whether the primary MOCAP participant was laughing in a hilarious way at an external stimulus, or engaging in social laughter with the secondary participant. Participants were recruited predominantly from the MSc class group of the researcher, with the justification that natural laughter might be more easily induced. It was decided to restrict data gathering sessions to 70-80 minutes to avoid participant fatigue.
Four different types of laughter for elicitation from the naïve non-actor participants were chosen. These included hilarious, social (or back-channelling), awkward and fake. Laughter types needed to be relatively straightforward to elicit both in terms of task and within the time available. The focus on a small subset of laughter types for collection was made to allow collection of enough samples in each category and ensure an adequate supply for use in the perceptual experiment. This was also dictated by the need to keep the number of categories used in the perceptual experiment to within manageable levels so as not to overload either set of participants (the first in producing different types of laughter, the second in categorising stimuli into different types of laughter), or to make the data analysis unwieldy later. This was in line with Coulson’s work involving six affective categories (Coulson, 2004). The laughter types chosen represent some of the more frequently occurring, according to the ILHAIRE laughter database (McKeown et al., 2012). Definitions of these laughter types for the context of this study, informed by the ILHAIRE database are as follows:

1. **Hilarious**: a response to an external stimulus found to be humorous that causes the participant to respond by laughing in an unrestrained way.

2. **Social**: polite laughter, as part of a conversation or as a way of back-channelling information.

3. **Awkward**: a laughter expressing some slightly negative emotion, being either a laugh expressing hilarity mixed with discomfort caused by the stimulus being viewed or an embarrassed sort of laughter as a result of being self-conscious.

4. **Fake**: a non-spontaneous, forced or planned laugh.
Laughter was elicited with participants in standing and seated positions. This decision was taken to lessen participant fatigue, and owing to literature sources such as (Ruch, 1993; Ruch & Ekman, 2001) identifying significant changes in muscle tension that occur during laughter, to examine whether these would cause differences in movement similar categories of laughter in each condition.

3.5.2 Summary of motion capture data gathering activity

Nine data collection sessions took place, after a pilot, involving teams of two participants per session. Sound and video of each session was recorded to aid post processing. One participant from each pair was asked to wear the MOCAP system and different types of stimuli were administered to both participants together in the hope of eliciting different types of laughter, and recording the associated body movement in both standing and seated positions. This is discussed fully in the Motion Capture Data Collection chapter 5.

3.6 Motion capture post processing and stimuli build

Motion capture data was analysed alongside the video data by the researcher to identify all laughter bouts of the primary participant wearing the MOCAP system. Coding was performed solely by the researcher as the repeated, multi-observer coding processes often used as highlighted in the literature review was too time intensive in this instance. Naturally, this process is subjective and so the researcher codes were taken as a guide only and did not form the ground truth for later analysis. For each session, the laughter onset and offset and the type of laughter was identified (from one of hilarious, social, awkward or fake).
To address the first research question and identify body movement that distinguishes laughter from non-laughter, samples were also created within which the MOCAP participant was not laughing. These episodes comprised the final category for the perceptual experiment: body motion that does not depict a laugh.

This mark up allowed the creation of video-only animations of faceless, gender-neutral, culture-neutral avatars. Each animation depicted one instance of laughter or non-laughter and were suitable for use as stimuli in a perceptual experiment. The steps involved in this post data collection processing are fully explained in chapter 6.

### 3.7 Perceptual experiment

#### 3.7.1 Methodological design decisions

The core of this research involved exploring perceptions of body movement during laughter. To achieve this, a perceptual experiment running naïve participants was created.

To prevent order effects, stimuli were randomised. Uploading the stimuli to YouTube and then randomising the list of the unique URL associated with each in Excel proved an efficient way of countering order effects in the experiment and facilitated data analysis.

The final selection of stimuli was influenced by three factors. The first was that there should be an even split as far as possible between stimuli showing the avatar in a seated or standing position. The second was that the spread of laughter stimuli administered should be similar to the frequency of the occurrence of each type of laughter as defined by the ILHAIRE laughter database (McKeown et al., 2012). Thirdly,
in an effort to keep the participants engaged in what could reasonably be considered a boring task if administered incorrectly, it was decided that the categorisation session should take participants no more than 30 minutes, with a short break at the halfway point, per Coulson (2004). With these considerations in mind, the final list of stimuli included 126 clips of body movement depicted via avatars. See Figure 3 for stills from one of the animated perceptual stimuli used in this study.

**Figure 3.** Sequence of stills from one of the perceptual study stimuli.

### 3.7.2 Summary of perceptual experiment activity

As endorsed by the literature, a forced choice design perceptual experiment was deemed most suitable to examine the research questions. Thirty-two naïve participants were asked to categorise each the body movement in each animated stimulus from the same set of 126 into one of five categories: hilarious laughter, social laughter, awkward laughter, fake laughter and movement not depicting laughter. None of these participants had taken part in the original motion capture laughter gathering. Participants were also asked a series of post-task completion questions in a semi-structured format to explore
what features of body movement they used to help categorise each stimulus. Chapter 7, Perceptual experiment method, provides full details of this phase.

3.8 Results compilation and analysis

Finally, participants’ categorisation of the stimuli from the perceptual study was analysed and, where agreement between the participants on the categorisations was suitably high, these were taken as the ground truth for that stimulus, per the approach of previous studies outlined in the literature review. Within the project scope, informed by the laughter physiology literature and a theory approach, a list of body movement features for analysis was defined.

Each feature was analysed individually to identify its unique contribution to laughter perception as a first step in understanding what the modality of body movement might offer to machine recognition of laughter. Cluster analysis (out of potentially huge numbers of feature pair combinations available) was considered out of scope and did not form part of this study. Three inputs played a role in defining the list of body movement features to analyse.

Firstly, and most substantially, body movement previously cited in the literature as having some proven or suspected presence during laughter, particularly related to shoulder movement as previously mentioned in relation to the work of DiLorenzo et al (2008). Frequency of body vibration in the five-hertz range was also chosen for exploration. This was deemed of interest per work previously undertaken which identifies internal body vibration of various organs and systems at five hertz being present during laughter episodes (DiLorenzo et al., 2008; Ruch & Ekman, 2001). This
was also the case for curling of the spine, which was considered would pick up the considerable bending motions present during intense laughter.

Secondly, the post-task completion interview responses were interrogated to identify features that the participants reported as being important in the identification and discrimination of laughter types from the stimuli trials. This was done relatively informally to pull out key themes from this data. The raw file of the participants’ responses on this topic is available in the appendix. Suggested features for analysis from this exercise included:

i) Movement and ‘rocking’ of the shoulders up and down.
ii) Movement of the head forward and backward.
iii) Turning the face (away from the perceived stimulus).
iv) Taking large steps backwards.
v) Hugging and holding the abdomen.
vi) Spreading hands and moving hands toward the mouth.

Finally, the researcher visually inspected the stimuli as categorised with the participants’ ground truth, and noted any additional features that seemed common to how they had been classified. Many of the observations had already been identified in the participant interviews, but others included stamping of the foot and clapping of the thighs.

Once refined, this list of body movement features could be broadly divided into two general types. The first included detection of specific, discrete features of body movement (such as the minimum distance of the hand from the face during laughter.
bouts). The second set was concerned more with extraction of generalised features of movement within the stimuli, such as the correlation of shoulder distances from the hip over time during laughter bouts, taking inspiration from the literature (Castellano et al., 2007). It was expected that the features analysis of the first category was more likely to yield clear demarcations between laughter types, whereas the latter would be less distinct, but still provide valuable data. Full analysis of these features is available in Results, chapter 8.

3.9 Summary

This chapter has outlined the stages involved in quantitatively addressing the research questions on body movement and laughter. It has justified the reasoning behind both the overall design and scope of research and, within that, experimental design decisions taken based on previous studies. The following chapters outline the execution of the research in more detail.
### Table 1.

*Body movement features analysed for influence on laughter perception in this study.*

<table>
<thead>
<tr>
<th>General area</th>
<th>Specific Feature</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand and arm activity</td>
<td>Min. distance between hands.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Max. distance between hands.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Range of distance between hands.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand from head.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand from hip.</td>
<td></td>
</tr>
<tr>
<td>Shoulder activity</td>
<td>Left shoulder power at 5Hz.</td>
<td>Measure of presence of 5Hz vibrations in left shoulder.</td>
</tr>
<tr>
<td></td>
<td>Right shoulder power at 5Hz.</td>
<td>Measure of presence of 5Hz vibrations in right shoulder.</td>
</tr>
<tr>
<td></td>
<td>Range of shoulder line rotation in azimuth.</td>
<td>Measuring rotation of the upper body during laughter bouts.</td>
</tr>
<tr>
<td></td>
<td>Correlation of shoulder distances from hip.</td>
<td>Correlation between left and right shoulder vertical positions.</td>
</tr>
<tr>
<td>Spine activity</td>
<td>Compound spine power at 5Hz.</td>
<td>Spine vibrations in the lower and upper back at 5Hz.</td>
</tr>
<tr>
<td></td>
<td>Range of upper back activity.</td>
<td>Measure of curl of the upper back forwards and backwards.</td>
</tr>
<tr>
<td></td>
<td>Range of lower back activity.</td>
<td>Measure of curl of the lower back forwards and backwards.</td>
</tr>
<tr>
<td></td>
<td>Range of neck activity.</td>
<td>Measure of curl of the lower back forwards and backwards.</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity.</td>
<td>Measure of curl over lower back, upper back and neck forwards and backwards.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Max. minus min. angle observed.)</td>
</tr>
</tbody>
</table>
CHAPTER 4. MOTION CAPTURE SUIT CUSTOMISATION

4.1 Motivation for suit modification

This chapter provides detail on the development and evaluation of the prototype customisations on an Animazoo IGS190 motion capture system (MOCAP).

The default configuration of the MOCAP system involves wearing a series of small, lightweight gyroscopes that are attached over the participant’s clothing using Velcro straps. There are 17 gyroscopes used, with each fitting to a different part of the participant’s body, computing the angles and offsets in 3D space between the gyroscopes for each of their limbs, head, and torso, and so on in relation to each other. Figure 4 illustrates how the sensors correspond each segment of the wearer’s body and a representative default avatar of the wearer is shown in Figure 5.

![Diagram showing motion capture sensor table and default avatar](image)

Figure 4. Motion capture sensor table showing the sensors used (rear view). Red highlighted sensors depict customised use for this study.
Figure 5. Avatar as depicted by the motion capture system during recording trials.

Per the literature, the shoulders were identified as an area of examination in this study. The standard configuration of the MOCAP system (see Figure 6) involves fabric strapping (effectively, like belts or braces) supporting the positioning of several of the sensors. This configuration restricted the movement of some of the sensors in relation to the hip particularly the shoulder sensors, which in standard configuration are attached on the back, near the shoulder blades.

Figure 6. Default configuration of the motion capture system with braces-like straps over the chest.
In initial informal testing of the system in standard configuration to check its suitability for use in this study (having a partial focus on shoulder movement), practice movements of real and exaggerated, fake laughter were recorded of the researcher. Visual inspection of the MOCAP avatar showed the standard suit configuration was not effective in capturing any but the most grossly exaggerated shoulder movements. For more subtle movements, when the researcher could be seen in person to be moving his shoulders, this was not reflected well visually (if at all) by the avatar. Therefore, before the system could be deployed in this study, it was decided to make some adjustments from the standard configuration to better display subtle shoulder movement.

4.2 Prototype development and evaluation

An incremental development and testing phase took place. Due to timing and scope limitations, the evaluation approach was informal and was confined to finding a solution agreed to be fit for purpose. The principal researcher and a volunteer from the ILHAIRE research team wore various configurations of the MOCAP system and visually inspected the movement of the avatar until one was found that was deemed suitable: in this case, that visually apparent, but subtle shoulder movement created in person should also be visible on the avatar, and that it would neither negatively impact the wellbeing of participants, nor adversely collect data collection of naturalistic body movement.

The first iteration involved removing the shoulder gyroscopes from their standard position on the shoulder blades, attached to Velcro straps (worn like a pair of braces). These were then manually held in place by the researcher on the shoulders of the volunteer and, in exploratory, systematic, fashion, moved about in different rotations.
at different points on the volunteer’s shoulders to get a rough, directional idea of what position was most effective at capturing subtle shoulder movement for this study (Figure 7).

Figure 7.  L-R: Examples of several positions where the shoulder sensors were tested. Far right image identifies the final configuration chosen for the shoulder sensors. (Original illustration copyright K. Sean Sullivan.)

Gyroscope positions tested included the top of the shoulder line, in front of and behind the shoulder (at the top of the pectoral muscle and trapezius respectively). In these positions, it was moved incrementally closer to the neck. It was also positioned outside the clavicle on the upper arm. At each repositioning of the gyroscope, the volunteer was asked to raise and lower his shoulders and the avatar representation was
visually inspected. As the MOCAP system gyroscopes measure angle and rotation, it was found to be most effective for the purpose of this study when positioned away from the neck along the top of the shoulder line, as if being worn as an epaulette.

Once established as a viable position, several design variations were tested that would attach the shoulder sensors to the tops of the wearer’s shoulders and remain there during natural movements for a period of up to two hours (the upper time limit forecast for the data gathering sessions). The second major iteration involved using bandages to attach the sensors in place, but in evaluating the performance of this option under movement (such as exaggerated arm movement or clapping of hands, both of which were postulated as being potentially present during the data gathering sessions), it proved unstable, with the sensors prone to major slippage and movement. This was discarded on the grounds of posing too great a risk to corrupting the data collected in the laughter elicitation trials.

4.3 Final configuration

Ultimately, an elegant solution involved attaching a strip of Velcro to the shoulders and spine of a close-fitting lycra sports top. The Velcro was glued to the sports top as an epaulette. Further, another continuous Velcro strip was positioned running down the spine of the top. As before, this approach was evaluated informally using a range of motion of the shoulders and visually inspecting the resulting avatar, as well as ensuring it was reasonably comfortable to wear with the remainder of the MOCAP equipment, did not unduly restrict naturalistic movement and was not harmful to participants’ wellbeing. It met all of these requirements.
Worn over the participant’s own clothes, this proved a simple, but effective way of attaching the shoulder sensors firmly in place, but allowing a good range of unrestricted movement to the participant whilst also picking up subtle, slight variations in shoulder movement as desired to explore the study research questions. Likewise, the strip along the spine allowed for connection of an additional spine sensor so that bending of the back was more readily apparent in the data. The lycra nature of the top meant that the sensors were always positioned close to the body.

To ensure a range of body sizes could be accommodated during data collection, a selection of men’s and women’s sports tops were modified in this way, and participants could wear the one that best fitted them during the laughter collection phase (Figure 8).

Figure 8. Customised version of the motion capture suit being fitted (L), and laid out for testing (R). Note Velcro additions to the spine and shoulders of the sports top.
CHAPTER 5. MOTION CAPTURE DATA COLLECTION

5.1 Aim

A data collection exercise was performed with naïve participants. This consisted of eliciting different types of laughter from the participants, whilst wearing the customised motion capture suit, thereby recording body movement as it took place in each laughter bout. This recorded movement was to form the basis of the visual perceptual stimuli used later in the project to investigate the properties of body movement that contribute to human perception and categorisation of laughter.

5.2 Participants

Eighteen participants were recruited in pairs, with movement data collected from one member of each pair (as only one participant per pair wore the MOCAP system). The MOCAP wearing participants comprised three males and six females (mean age 25.7 years old, standard deviation 2.54). Participants were recruited from among the researcher’s MSc class group and the UCL Psychology Pool. Each was paid £5.00 for their time. Participants were drawn from a mix of cultures, including Western European, East Asian, North American and South Asian.

5.3 Materials and equipment

5.3.1 Apparatus

Body movement was recorded using an IGS190 motion capture system, with suit modifications as described previously. Audio and video was recorded on a 12.5mp DSLR camera. A clapperboard was used to help synchronise the different recording media streams in post processing. Two standard flatscreen computer displays were
connected on dual display from one desktop computer. A large wall-mounted audio-visual display system was also used to present stimuli via the researchers laptop. Additionally, video and respiration data was recorded using EyesWeb software and respirators via a MS Lifecam HD3000 webcam. (Note that whilst respiration data was gathered from the participant wearing the MOCAP system, this was collected opportunistically for separate analysis later by the ILHAIRE research team, and respiration data does not form any part of this study.)

5.3.2 Laughter elicitation materials

Laughter elicitation materials included lists of tongue-twisters, several videos available on YouTube (shown in the original and not edited by the researcher), predominantly of humorous internet memes, a list of songs with the word ‘love’ in the title, and an adapted version of a ‘Pictionary’ style game. See Table 2 for an overview of the tasks, the order in which they were administered, the position of the primary MOCAP participant during the task and the type of laugh it was hoped it would elicit. These were the laughter categories selected to form the basis of the perceptual study and include hilarious, social, awkward and fake.
Table 2.  

Laughter elicitation materials used during data gathering trials.

<table>
<thead>
<tr>
<th>Trial Section</th>
<th>Task</th>
<th>Approx. duration (mins)</th>
<th>Target laughter elicitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing</td>
<td>Tongue twisters.</td>
<td>5</td>
<td>Hilarious, some awkward.</td>
</tr>
<tr>
<td></td>
<td>(mini-break, discuss previous task.)</td>
<td>3</td>
<td>Social.</td>
</tr>
<tr>
<td></td>
<td>Watch YouTube video – Laughing man meme.</td>
<td>8</td>
<td>Hilarious, social.</td>
</tr>
<tr>
<td></td>
<td>(mini-break, discuss previous task.)</td>
<td>2</td>
<td>Social.</td>
</tr>
<tr>
<td></td>
<td>Watch YouTube video – The Nazis lose Fenton meme.</td>
<td>5</td>
<td>Hilarious.</td>
</tr>
<tr>
<td></td>
<td>(mini-break, discuss previous task.)</td>
<td>2</td>
<td>Social.</td>
</tr>
<tr>
<td></td>
<td>Puerile song titles (Optional word replacement task).</td>
<td>5</td>
<td>Hilarious, social.</td>
</tr>
<tr>
<td>Break</td>
<td>Participants rest, chat with researchers.</td>
<td>10</td>
<td>Social.</td>
</tr>
<tr>
<td>Sitting</td>
<td>Paint Pictionary extravaganza.</td>
<td>10</td>
<td>Social, hilarious.</td>
</tr>
<tr>
<td></td>
<td>(mini-break, discuss previous task.)</td>
<td>2</td>
<td>Social.</td>
</tr>
<tr>
<td></td>
<td>Frijj – comic videos shown to one participant, the second watches the expression of the first.</td>
<td>5</td>
<td>Hilarious, awkward.</td>
</tr>
<tr>
<td></td>
<td>(mini-break, discuss previous task.)</td>
<td>2</td>
<td>Social.</td>
</tr>
<tr>
<td></td>
<td>Watch YouTube video – Evil laughing baby pratfall meme.</td>
<td>2</td>
<td>Awkward, hilarious.</td>
</tr>
<tr>
<td></td>
<td>(mini-break, discuss previous task.)</td>
<td>2</td>
<td>Social.</td>
</tr>
<tr>
<td>Throughout</td>
<td>Perform fake laughter as requested</td>
<td>3</td>
<td>Fake.</td>
</tr>
</tbody>
</table>
5.3.3 Equipment configuration and room layout

Data gathering took place in large, quiet classrooms with flexible furniture that was moved to the sides of the room, affording participants plenty of space to move about. The equipment layout of the room was slightly different for the standing and seated tasks and Figures 10 and 11 below demonstrate the layout differences.

5.4 Procedure

On arrival, the study was explained to participants verbally. An information sheet was provided, with written details of the data collection study to read beforehand and to take away. The researcher demonstrated how the MOCAP system was worn and any participant questions about the study were addressed. Participants signed consent forms and the researcher recorded their age. Example forms are available in the appendix. This administrative process and setting up the MOCAP system on the primary participant took between 20 and 25 minutes at the beginning of each session.

Each session lasted an additional 50 to 60 minutes, with the first half comprising of tasks performed whilst standing and the second half seated tasks. Participants were given short breaks of a minute or two between all tasks and a slightly longer break between the standing and seated portions. During all these sessions, audio and video was recorded from several angles, with video capturing both participants at once, with clear views of their faces and entire bodies. Both video and MOCAP were recorded at 60 frames per second. To prevent data loss, the MOCAP recording was stopped and restarted throughout the sessions.
5.5 The ‘Travolta’ – Synchronising motion capture with AV

As the MOCAP system recorded only motion, without sound or video, it was necessary for post processing to include some way of synchronising the timestamps of the audio and video feeds with that of the MOCAP. This was achieved by having the MOCAP participant perform an exaggerated, distinctive movement that would be readily identified during post-processing. The movement chosen to represent this involved participants taking a large step forward with one hand on their hip and the other held in the air above their heads, similar to the pose famous from the film Saturday Night Fever (McCormick & Badham, 1977), (Figure 9). It frequently induced bouts of laughter in participants.

Figure 9. The ‘Travolta’ pose, made famous by the film Saturday Night Fever, and used here to synchronise the video and motion capture recording streams.

5.6 Standing tasks

Whilst standing, participants’ movements and the direction they faced were not strictly restricted other than remaining in view of the video cameras. As such, for the
standing tasks, there was the potential for many of the participants to face several different directions as the tasks progressed and they moved around during laughter episodes (as taking several steps backwards during intense bouts of laughter was not uncommon). It was felt that to restrict participant movement beyond the camera recording considerations would have added an unacceptable level of artificiality to proceedings and adversely affected the odds of gathering a sufficient number of laughs. Figure 10 demonstrates how the equipment was arranged during the standing tasks.

![Figure 10](image.png)

**Figure 10.** Overview of room and equipment layout for the standing portion of data collection.
Task one consisted of participants reading each other tongue twisters one at a time in alternating turns, with the instruction to try to get through as many as possible in five minutes. Two versions of the tongue twisters were used: one used for six of the sessions in English and, for those sessions with East Asian participants, a separate list of Mandarin Chinese language tongue twisters was used. It was felt that this would be more successful than using English tongue twisters for this population. Participants were advised not to worry about getting the tongue twisters correct, but just to move through them as fast as possible. This task was designed to elicit laughs to be classified as hilarious.

The second task involved participants standing side by side whilst watching meme videos on YouTube. Again, both of these were included to elicit hilarious laughter.

In two cases, where participants were native English speakers and good friends of the researcher, the third task involved reading a list of song titles, all including the word ‘love’. Participants were asked to replace the word ‘love’, with ‘knob’. This resulted in puerile phrases but again was successful in eliciting hilarious laughs.

During short breaks between these tasks, participants were allowed to discuss what they had just completed and were engaged in general small-talk, under the pretence of needing time to set up for the next task. However, recording continued and at this point, several back-channelling laughs were observed whilst the participants engaged in conversation with the researchers and between themselves. These laughs were generally classified as social laughs.
5.7 Seated tasks

The equipment arrangement was adjusted for the seated segment of the laughter elicitation sessions. This is summarised in Figure 11.

![Diagram of room and equipment layout for the standing portion of data collection]

Figure 11. Overview of room and equipment layout for the standing portion of data collection.

The next set of tasks involved the participants sitting down facing each other, with a computer monitor in front of each. Both monitors were connected to one desktop
and the display was mirrored on each screen so that both participants could see the same picture on both displays.

In the first of the seated tasks, participants had to pick a clue from many, out of a cup, written on a small piece of paper. They were not allowed to disclose what was on the paper to the second participant, but rather had to draw clues for their partner using Microsoft Paint, which the other participant could see on their monitor. This task and environment were designed with the goal of eliciting hilarious and social laughs in the main. It was observed that many participant pairs had prolonged (15 to 20 seconds plus) bouts of laughter throughout this exercise and much of the communication between participants as they guessed what the other was drawing took place predominantly with laughter and some gestures, but not very many words. An example of this is when the drawing participant would answer a guess from their partner with a laugh, the tone of which was meant to convey whether the guess was correct or not. This type of laughter fits into the ‘social’ category.

In a number of cases, participants were alternately shown hilarious videos (often of animals behaving in amusing ways) one at a time, with the other participant asked to look at the face of the participant viewing the amusing stimulus. The second participant could not see the stimulus, but as the viewing of the stimulus was passed back and forth, it was hoped that this would stimulate more hilarious laughter.

Finally, participants were asked to view a video on YouTube. This video depicted sequences of home video style footage from all over the world, generally showing people suffering pratfalls or some personal embarrassment or injury. Generally
speaking, the tone of the video is designed to cause amusement and hilarity but also some level of discomfort as the viewer is aware that many of the people at which they are laughing could probably have suffered painful injuries as a result of these falls and mishaps. However, the video is cut to show a baby laughing in between each segment. This results in many viewers laughing, but often some sense of restraint, as if the participants experienced a pang of guilt when viewing another’s misfortune and laughing inappropriately. This type of laugh was classified as being an awkward laugh.

5.8 Fake laughter

Throughout both standing and sitting trials, participants were periodically requested to produce a fake laugh. Participants were asked to imagine what they thought a grand, overblown, ‘theatrical’ laugh might be, and to produce that. Further, they were also asked to imagine a social situation with an imbalanced power element, such as with one of their university lecturers or their boss, where the more powerful person had said something that they themselves thought was funny, but that the participant did not. Participants were asked to imagine they had to laugh at what had been said out of politeness and to show respect and to ensure the listener cannot detect the laugh is disingenuous.

Once the seated tasks were completed, participants were thanked for their time, paid for their time, debriefed, assisted in removing the MOCAP system, and given the opportunity to ask further questions about the study.
5.8 Summary

This section has described the research methodology used to collect examples of body movement during bouts of predominantly naturalistic laughter of different types. Eleven sessions were completed, with data collection being successful for nine of these. Successful data sessions yielded just over seven hours of both video and motion capture data. How this data was processed to build the visual perceptual experiment stimuli is discussed in the next chapter.
CHAPTER 6.  POST PROCESSING MOTION CAPTURE DATA

6.1 Video analysis and mark up

In total seven hours of video data from the nine data collection exercises was analysed twice, counting only the laughs of the primary MOCAP suit wearing participant (for conversion to laughter movement stimuli for the perceptual experiment). The first high level analysis involved counting all the laughs evident in the videos, without making an attempt to categorise them. This was performed manually and yielded a count of 753 bouts of laughter over nine sessions. An example of the mark-up sheet is available in the appendix.

A second, more thorough analysis included noting every instance of a laugh, real or fake, and the video timestamp when the laughter onset and offset, along with a categorisation of what type of laugh the researcher believed it to be, of the list of hilarious, social, awkward, or fake. Onset is defined here as the moment when the laughter visibly begins (often accompanied by a raising of the shoulders), with offset defined as the moment that the body returned to a state of rest, when the laughter cycle finished and pulses of laughter were no longer visibly or audibly apparent to the researcher. If a laughter bout was observed in the video but the researcher was not confident it was one of the types of laughs mentioned, it was not included in the database. Timestamps segmenting non-laughter episodes were also noted.

On completion, 549 segments of video were marked up. Of these, 508 comprised bouts of laughter and 41 segments comprised non-laughter. Table 3 summarises how the video segments were categorised by the researcher.
Table 3.

Segmentation of video of data collection trials by researcher coded laughter type.

<table>
<thead>
<tr>
<th>Total segments</th>
<th>Total segment time (mm:ss)</th>
<th>Hilarious</th>
<th>Social</th>
<th>Awkward</th>
<th>Fake</th>
<th>Non-laughter</th>
</tr>
</thead>
<tbody>
<tr>
<td>[M, SD]</td>
<td></td>
<td>296</td>
<td>130</td>
<td>54</td>
<td>28</td>
<td>41</td>
</tr>
<tr>
<td>549</td>
<td>41:02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>[4s, 2s]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.2 Parsing and segmentation of the MOCAP data

The motion capture files were then processed using MATLAB. As the .BVH file format used by the motion capture system does not contain timestamp data, the point in each file where the participant completed the ‘Travolta’ pose was used as a point of reference to synchronise the video timestamp with the motion capture data.

The motion capture data was processed in MATLAB to output 549 separate .AVI file format animated clips, each corresponding to a segment identified in the mark up of the original laughter gathering session videos. These clips depicted a very simple animated stick-person avatar whose motion was based on the body movement of each participant during a particular segment of video. The avatar was gender neutral and its body proportions were held constant in all clips: its proportions were equal in the animations whether it was generated from the movement of a six foot male participant or a five foot female participant. Animations did not include audio. See Figure 12 for a still image from one of these animations.
Viewing angle was standardised as much as possible, so that all stimuli were viewed from slightly above (an elevation of 5 degrees) and the body was seen from slightly the right hand side of directly front on. However, it was not possible to standardise this completely for all stimuli because i) the viewing angle could only be set once in a sequence of clips from the same motion capture file and remained static thereafter and ii) because the participants’ movements in the standing segment during data collection had not been strictly controlled due to concerns about inhibiting their laughter, several participants changed direction several times during the recording. In some longer animations, this rotation became very apparent.

### 6.3 Refinement of the stimuli list

Each of the 549 animations was inspected visually alongside the video data to evaluate its suitability for possible inclusion as a stimulus in the final perceptual experiment. Animations were discarded wherever any data problems with the MOCAP recording had occurred or if the posture of the avatar (including incidences where
participants crossed their legs while seated) was judged potentially very unnatural looking and distracting. Finally, where frames were dropped in the original MOCAP recordings, the animations were built in MATLAB with linear interpolation to prevent jerkiness of animation. If this figure was above 20 contiguous frames (one third of a second, recording at 60fps), these clips were also deemed unsuitable. On completion of this editorial process, 474 .AVI animation files were deemed suitable for possible inclusion as stimuli in the perceptual experiment on body motion during laughter, discussed in the next chapter.
CHAPTER 7. PERCEPTUAL EXPERIMENT METHOD

7.1 Motivation

The wider goal of this research is to provide actionable data to researchers working to incorporate laughter into human-avatar interaction. The aim of this study is to establish, in the absence of context provided by other modalities such as facial expression or voice:

1. What body movements reflect the expression of laughter?

2. Which are the features of those movements do people use to detect and categorise laughter?

This chapter outlines the methodology used in a perceptual experiment to investigate these questions.

7.2 Review of selection criteria for final laughter movement stimuli

Discussed in chapter 3, with justification from the literature review, it is useful to quickly review how the final list of stimuli was established. These three factors included:

i) That there be an equal a split as possible between clips depicting body movement in seated and standing positions.

ii) That the spread of laughter stimuli as categorised by the researcher should be of a similar frequency to that described in the ILHAIRE laughter database (McKeown et al., 2012)
iii) That participant fatigue be mitigated by ensuring the task could be completed within 30 minutes, including a break in the middle.

Of the list of 474 animations of body movement during laughter deemed suitable for use as stimuli in the experiment, 126 were selected, with particular attention given to ii) above. As noted at the end of the previous chapter, stimuli where more than 16 contiguous frames had been dropped in the original recording had been discarded. The maximum number of contiguous dropped frames in the final stimuli list was 16 (mean 5.99, standard deviation 3.76). Table 4 is a count of how the researcher-rated laughter clips were spread across the five categories.

Table 4.

*Final breakdown of stimuli trials for perceptual experiment.*

<table>
<thead>
<tr>
<th>Total trials</th>
<th>Hilarious</th>
<th>Social</th>
<th>Awkward</th>
<th>Fake</th>
<th>Non-laughter</th>
</tr>
</thead>
<tbody>
<tr>
<td>126</td>
<td>34</td>
<td>43</td>
<td>16</td>
<td>19</td>
<td>14</td>
</tr>
</tbody>
</table>

7.3 Pilot

An informal pilot session with a friend of the researcher tested the logistics of the experimental procedure and allowed time to make changes to the implementation if needed, before running the full experiment. Data from this pilot study was discarded. Further, definitions of each perceptual category (‘hilarious’, ‘social’, ‘awkward’, ‘fake’, ‘not laughter’) were informally tested on five people to gather feedback on their comprehensibility and clarity and, again, make changes where needed. To clarify, none
of the people used for pilot testing were included in the final set of participants, discussed below.

7.4 Participants

Thirty-two participants, English native language speakers with normal or corrected-to-normal vision, were recruited from the UCL Psychology Pool. As stipulated in the recruitment notice, none of the participants to join this perceptual study had taken part in the original laughter gathering sessions. Seventeen of the participants were male and 15 female, ages 20 to 72 years old ($M$ 33, $SD$ 14, mode 28). Participants were paid for their time.

7.5 Materials and apparatus

The perceptual experiment was administered on a desktop computer running Microsoft Excel 2010, with Internet Explorer v8.0.6.

One hundred and twenty six perceptual stimuli in the form of short video animations were uploaded to a private channel on YouTube set up by the researcher (so access to the stimuli was restricted to those provided with the URL). Stimuli ranged in length from one second to 10 seconds ($M$ 4s, $SD$ 2s). An example still of one of the stimuli and how it appeared to participants is available in Figure 13. Printed definitions and examples of each laughter or non-laughter categorisation were provided. Sample URLs for the stimuli used include:

http://www.youtube.com/watch?v=-ZoYD4zaaeM
http://www.youtube.com/watch?v=q7BV65P CvPw
http://www.youtube.com/watch?v=Cfw0YTIRJbU
7.6 Design

Using a within-subjects forced-choice design, each participant categorised each of 126 animations of body movement, according to one of five possible categories, including hilarious, social, awkward, or fake laughter, or non-laughter. Stimuli were randomised for each participant.

7.7 Procedure

The perceptual experiment was conducted in quiet cubicle rooms. Participants were welcomed at the beginning of each session and the study explained verbally. They were provided an information sheet with further detail. Any questions participants initially had were addressed and a demonstration of how one of the animated clips would appear and how to move between the Excel sheet and the browser to view the
animations was provided. It was clarified that the stick figure animation in each clip had no face and that there was no audio in any of the clips. Participants were asked to make their categorisation solely on what they perceived based on the stick figure avatar’s movements. At this point, participants signed a consent form and their ages were recorded.

The researcher made clear that each clip they were about to view was one of hilarious, social, awkward, fake or non-laughter. To help ensure participants were clear on the meanings of each of these categories, the researcher provided printed definitions of each of these types of laughter with examples for use during the trial. Again, participants were given the opportunity to ask clarifying questions to ensure they understood before progressing. The text used in the laughter category definitions used with participants is available in Table 5 and the appendix.

Participants were informed that the animations would depict a figure in both standing and seated positions. However, in an effort to prevent participants’ focus being shifted onto anything other than the movement they were asked to categorise, no information was provided on the context of the animation. Participants were requested not to view a clip more than once, and encouraged to go with their ‘gut’ instinct. It was hoped that this would prevent the participants trying to create a context for what they were seeing and overthinking the context of the clip. However, it should be noted that this was not controlled for as the study ran two participants at once in different cubicles so it was not possible to monitor every single clip being viewed.
Table 5.


defined for participants.

<table>
<thead>
<tr>
<th>Laughter type</th>
<th>Definition</th>
<th>Example(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hilarious</td>
<td>The person is laughing in an unrestrained way as a response to something he or she finds really very funny and amusing.</td>
<td>Someone is watching their favourite comedian on TV and is laughing as a response to their jokes.</td>
</tr>
<tr>
<td>Social</td>
<td>This may be polite laughter as part of a conversation. It can show an acknowledgement of what another person has said is correct or show courtesy and good manners to the speaker.</td>
<td>Someone is having a conversation with a friend and is laughing as a way of acknowledging what their friend is saying and showing that they are enjoying their friend’s story/anecdote.</td>
</tr>
<tr>
<td>Awkward</td>
<td>This type of laugh expresses some sort of slightly negative emotion. It can be either: a laugh expressing hilarity and also some discomfort caused by what the person is laughing at, or an embarrassed sort of laughter as a result of being self-conscious.</td>
<td>Example 1: someone may have fallen over on the street in front of strangers and laughs as a way of diffusing the embarrassment he or she feels for having fallen. Example 2: a person may be watching a video that shows someone else getting hurt by accident but which has some sort of amusing or ridiculous aspect that they find funny. They laugh in response to this but simultaneously feel a twinge of guilt, as they know the situation they are laughing at may have been quite painful or distressing for the person in the video and laughing at that might be inappropriate.</td>
</tr>
<tr>
<td>Fake</td>
<td>A forced or planned laugh.</td>
<td>Someone laughs because they feel they have to, but not because they naturally want to.</td>
</tr>
<tr>
<td>Not a laugh</td>
<td>The person is not laughing! They may be speaking or coughing or simply listening to someone else speaking.</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Participants could refer to the category definitions and examples as they completed the task, in case they were unsure about any of the classifications. The Excel sheet used by each participant had a column of URLs, one per row. Participants clicked on each URL to load each YouTube clip in the browser and watch the short stimuli of
an avatar moving. They were asked to access the stimuli trials in order, from the top and working down the sheet. At the halfway point, participants had a break of two minutes to rest.

To minimise the risk of participants inadvertently recording a category for a trial more than once, conditional formatting was used in the answer sheets to turn the cells pink as participants categorised each stimulus. An example excerpt of one participant’s Excel answer sheet is available in Figure 14.

![Excel sheet](image)

**Figure 14.** An example of the Excel sheet used to administer the perceptual experiment.

On completion of the categorisation, participants were asked short follow up questions, recorded by the researcher and available in the appendix. These included:

i) Whether the participant felt the categories the researcher had asked them to use were sufficient for what they perceived in the stimuli?
ii) Were there categories that they felt very confident in making their categorisation decision and if so, what were some of the movement features that helped them reach that decision?

iii) Conversely, they were also asked if they found some categories more difficult to identify than others.

Finally, participants were debriefed and allowed to ask any other questions they had about the study and its purpose and make additional comments. Participants were then thanked for their time and paid.
CHAPTER 8. RESULTS

8.1 Introduction and approach

Analysis of the participants’ categorisation data was guided by a theoretical approach. Ground truth categories were identified, based on categorisation agreement among participants as per previous studies (Kleinsmith et al., 2011). Data was examined in exploratory fashion, including how the categorisation of the stimuli differed between male and female participants MATLAB was used to extract quantitative values of various features of body movement present in the perceptual stimuli (such as range of movement between the hands), and these features were subjected to one-way ANOVAs to determine if any features had a significant effect on how the laughter movement was categorised.

8.2 Initial analysis

The total number of categorisations made overall was counted: 4032 categorisations were made in total by 32 participants over 126 stimuli. The maximum count applied to each trial in a particular category was taken as being the ground truth categorisation for that stimulus. Where the highest category agreement count among the participants for a particular stimulus was ten or less (or was tied between two categories), that stimulus was discounted from further. Table 6 illustrates how the counts in each category were refined through these steps.
### Table 6.

*Final categorisation of stimuli trials in perceptual experiment.*

<table>
<thead>
<tr>
<th>Analysis Stage</th>
<th>Hilarious</th>
<th>Social</th>
<th>Awkward</th>
<th>Fake</th>
<th>Non-laughter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Perceptual trials raw scores</td>
<td>721</td>
<td>1058</td>
<td>678</td>
<td>567</td>
<td>1008</td>
</tr>
<tr>
<td>2. Ground truth established</td>
<td>22</td>
<td>41</td>
<td>6</td>
<td>4</td>
<td>44</td>
</tr>
<tr>
<td>3. Final ground truth (agreement &gt; 11 participants, not tied for categorisation)</td>
<td>21</td>
<td>32</td>
<td>4</td>
<td>1</td>
<td>41</td>
</tr>
</tbody>
</table>

This finalised categorisation count was examined from two other perspectives. The first to examine how the perceptual stimuli were categorised by participants against the categories assigned to each stimulus by the researcher, who had the benefit of video and audio context to help make the categorisation. The second was inspired by the literature on gender difference in laughter to explore whether the male and female participants categorised the stimuli differently. This is outlined in two figures. Figure 15 shows a confusion matrix of how all 32 participants categorised the stimuli overall, against the original researcher categorisation. Figure 16 is a confusion matrix of how the male and female participants categorised the stimuli.

<table>
<thead>
<tr>
<th>Participants</th>
<th>Total</th>
<th>Hilarious</th>
<th>Social</th>
<th>Awkward</th>
<th>Fake</th>
<th>None</th>
<th>Tied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Researcher</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hilarious</td>
<td>34</td>
<td>9</td>
<td>12</td>
<td>4</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Social</td>
<td>43</td>
<td>7</td>
<td>13</td>
<td>1</td>
<td>2</td>
<td>18</td>
<td>2</td>
</tr>
<tr>
<td>Awkward</td>
<td>16</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Fake</td>
<td>19</td>
<td>5</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>None</td>
<td>14</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>

**Figure 15.** Confusion matrix of participant categorisation of the stimuli against those of the researcher.
Female Participants

<table>
<thead>
<tr>
<th>Total</th>
<th>Hilarious</th>
<th>Social</th>
<th>Awkward</th>
<th>Fake</th>
<th>None</th>
<th>Tied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male Participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hilarious</td>
<td>25</td>
<td>17</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Social</td>
<td>35</td>
<td>0</td>
<td>17</td>
<td>5</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Awkward</td>
<td>7</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Fake</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>None</td>
<td>39</td>
<td>0</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>23</td>
</tr>
</tbody>
</table>

Figure 16. Confusion matrix of categorisation (dis)agreement between male and female participants.

Data was not analysed for statistical significances in (dis)agreement between the male and female participants in this study, but these descriptions of the data are reported as part of the exploratory analysis that was undertaken inspired by literature review, and for possible exploration in future work on this area.

Small sample sizes the awkward and fake categories (awkward = 4, fake = 1) meant both were removed from further statistical analysis as this was unlikely to lead to meaningful findings. Table 7 shows the final counts of the categorised stimuli that went forward for inferential statistical analysis, and also identifies how many stimuli in each category contained examples of laughter movement in a standing position and how many in a seated position.

8.3 Final features to analyse

The list of potential movement features was mapped to the capabilities of the analysis of the MOCAP data (which records angles between joints and offsets of gyroscope sensors in XYZ space). The final list of features is illustrated in Table 8 including how each was measured. Figure 15 serves as a reminder of how sensors on the MOCAP suit mapped to the movement features analysed.
Table 7.

*Final count of categorised stimuli included in inferential analysis. Note the removal of ‘awkward’ and ‘fake’ stimuli from the analysis.*

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Hilarious</th>
<th>Social</th>
<th>Awkward</th>
<th>Fake</th>
<th>Non-laughter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total stimuli count</td>
<td>91</td>
<td>21</td>
<td>32</td>
<td>0</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>‘Seated’ stimuli</td>
<td>39</td>
<td>15</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>‘Standing’ stimuli</td>
<td>52</td>
<td>6</td>
<td>23</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
</tbody>
</table>

Figure 17. Review of motion capture system sensor arrangements (rear view).
Table 8.

*Body movement features analysed for influence on laughter perception in this study.*

<table>
<thead>
<tr>
<th>Body movement feature</th>
<th>Examining</th>
<th>Output (per trial)</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. distance between hands.</td>
<td>Hand and arm movement.</td>
<td>Min. relative distance between hand sensors.</td>
<td>3D Euclidean distance.</td>
</tr>
<tr>
<td>Max. distance between hands.</td>
<td>Hand and arm movement.</td>
<td>Max. relative distance between hand sensors.</td>
<td>3D Euclidean distance.</td>
</tr>
<tr>
<td>Range of distance between hands.</td>
<td>Hand and arm movement.</td>
<td>Max. minus min. relative distance observed between hands.</td>
<td>3D Euclidean distance.</td>
</tr>
<tr>
<td>Min. distance of hand from head.</td>
<td>Hand being raised to mouth.</td>
<td>Min. relative distance between hand and head sensors.</td>
<td>3D Euclidean distance.</td>
</tr>
<tr>
<td>Min. distance of hand from hip.</td>
<td>Hands being clutched to abdomen.</td>
<td>Min. relative distance between hand and hip sensors.</td>
<td>3D Euclidean distance.</td>
</tr>
<tr>
<td>Left shoulder power at 5Hz.</td>
<td>Amount of shoulder vibration at 5Hz.</td>
<td>Power spectral density.</td>
<td>Power of vibrations at 5Hz.</td>
</tr>
<tr>
<td>Right shoulder power at 5Hz.</td>
<td>Amount of shoulder vibration at 5Hz.</td>
<td>Power spectral density.</td>
<td>Power of vibrations at 5Hz.</td>
</tr>
<tr>
<td>Range of shoulder line rotation in azimuth.</td>
<td>Measuring horizontal rotation of the upper body during laughter bouts.</td>
<td>Max. minus min. angle observed.</td>
<td>2D angles in degrees.</td>
</tr>
<tr>
<td>Correlation of shoulder distances from hip.</td>
<td>Informed by literature findings of positive correlation in this measure indicating laughter presence.</td>
<td>Correlation of shoulder movement in the Y axis.</td>
<td>Pearson correlation.</td>
</tr>
<tr>
<td>Compound spine power at 5Hz.</td>
<td>Amount of shoulder vibration at 5Hz.</td>
<td>Power spectral density.</td>
<td>Power of spinal vibrations at 5Hz.</td>
</tr>
<tr>
<td>Range of upper back activity.</td>
<td>How much the upper spine bends forward and back during laughter.</td>
<td>Max. minus min. angle observed.</td>
<td>2D angles in degrees.</td>
</tr>
<tr>
<td>Range of lower back activity.</td>
<td>How much the lower spine bends forward and back during laughter.</td>
<td>Max. minus min. angle observed.</td>
<td>2D angles in degrees.</td>
</tr>
<tr>
<td>Range of neck activity.</td>
<td>How much the neck bends forward and back during laughter.</td>
<td>Max. minus min. angle observed.</td>
<td>2D angles in degrees.</td>
</tr>
<tr>
<td>Range of compound spine activity.</td>
<td>Measure of curl over lower back, upper back and neck forwards and backwards</td>
<td>Max. minus min. angle observed.</td>
<td>2D angles in degrees.</td>
</tr>
</tbody>
</table>
8.4 MATLAB analysis

The original motion capture files for each of the remaining categorised stimuli were reprocessed in MATLAB, returning numerical values, each corresponding to one of the 14 body movement features being examined. Thus, each categorised stimulus had 14 associated values. These values were each a measure of some body movement present in the stimulus, calculated to output one of the following, depending on the feature concerned (see column ‘Measure’ in Table 8):

1. 3D Euclidean distances: Each MOCAP gyroscope records its offset in XYZ space and its relative rotation from the hip sensor, taken as the root measure for all other sensors. This allows relative Euclidean distance between two points to be inferred using the formula:

   \[ d = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2} \]

2. 2D Angles: These are calculated as the angle formed at the apex where three MOCAP sensors meet, based on their relative positions in 3D space. For example, angle at the neck sensor is a measure of the angle formed between where an imaginary line from the head sensor position to the neck sensor position, meets the line drawn from the upper spine sensor position to the neck sensor position. The position of the neck sensor forms the apex and the angle is here.

3. Correlation: defined via the Pearson correlation coefficient between the vertical position of the left shoulder and the vertical position of the right shoulder. These positions are sampled from the Y offsets of both shoulder sensors. Sixty samples
are taken of each shoulder Y position per second of animation. For \( n \) samples per animation, where \( X \) is the measure of left shoulder vertical position and \( Y \) the measure of right shoulder position, written as \( x_i \) and \( y_i \), where \( i = 1, 2, \ldots, n \), then the correlation coefficient between vertical position of the left shoulder sensor and the right shoulder sensor, \( r \), can be written as:

\[
T_{xy} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{(n - 1)s_x s_y} = \frac{\sum_{i=1}^{n} (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^{n} (y_i - \bar{y})^2}}
\]

4. Power at 5Hz: Using MATLAB to estimate the power spectral density of vibrations of the sensors caused by laughter via the Welch method. (Hayes, 1996). This is a Fourier transform technique to identify the constituent elemental frequencies present in a sinusoidal wave. Welch’s method splits the data into overlapping segments, creates modified periodograms of these segments and averages the resulting periodograms to produce the power spectral density estimate. In short, this was performed to isolate body vibrations measured by the MOCAP sensors in the frequency of 5Hz, a value that has been observed per the literature review during physiological studies of laughter at much deeper level within the body, such as internal muscle vibration, or pressure in the fingers.
8.5 Analysis of body movement features by category

8.5.1 Inferential analysis – procedural rationale and summary

Aims of the inferential analyses were twofold: i) to test the non-directional hypothesis of this study that some body movements have an effect on whether laughter is perceived, and ii) to identify a subset of body movements that had a statistically significant effect in the categorisation of laughter type.

Values for body movement features were subjected to analysis using one-way analyses of variance (ANOVA) to examine whether any of the features contributed to different categorisation of the laughter stimuli. Planned comparisons and post-hoc tests (Bonferroni, or, where variance was not equal, Tamhane’s T2), were also used to examine features that contributed to categorising the stimulus as hilarious laughter, social laughter or non laughter, separately, between the seated and standing position conditions.

Further analysis examined planned contrasts for body movement features within each laughter categorisation: e.g. whether range of hand movement was more significant in hilarious laughter whilst standing, or hilarious laughter whilst seated. Given the number of features analysed, in the interests of space, summary tables are provided for each analysis, with a written note on movement features that demonstrated a significant effect on categorisation.
8.5.2 Movement features contributing to overall categorisation

For both the seated laughter position and the standing laughter position, a one-way ANOVA was conducted to evaluate the relationship between each body movement feature and the categorisation of each stimulus as hilarious, social or non-laughter, using an alpha level of 0.05. A summary of the results of this ANOVA for seated laughter is provided in Table 9, immediately after which are presented the planned contrast and post hoc test results for the seated condition and figures to visually present the post hoc corrected relationships between the means. The summary ANOVA table for standing laughter, is listed later, in Table 12.

8.5.2.1 Seated Laughter

Examining the $F$ values in Table 9, all with degrees of freedom of (2, 36) and an alpha of 0.05, the ANOVA reveals significant differences in laughter categorisation across six body movements while seated, including range of distance between hands ($F = 7.05$), range of shoulder line rotation in the azimuth, ($F = 10.03$) and several measures of curving of the spine. No other body movement features showed a significant effect on categorisation.

Two-tailed planned contrasts were used to test how these movement features affected categorisation and whether the mean values for each feature were significantly different between i) hilarious and social laughter categories combined versus non-laughter and ii) whether there were significant differences in mean movement values between hilarious and social laughs. Table 10 summarises the results of both planned contrast tests.
Table 9.

ANOVA for laughter movement in SITTING position. *p < 0.05

<table>
<thead>
<tr>
<th>Primary Body area</th>
<th>Movement Feature</th>
<th>(df)</th>
<th>F ratio (Mean sq errors between, within)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand Activity</td>
<td>Min. distance between hands</td>
<td>2, 36</td>
<td>0.02 (4.16, 216.78)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Max. distance between hands</td>
<td>2, 36</td>
<td>1.79 (407.37, 227.07)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of distance between hands</td>
<td>2, 36</td>
<td>*7.05 (471.63, 66.91)</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand from head</td>
<td>2, 36</td>
<td>1.28 (401.62, 313.57)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand to hip</td>
<td>2, 36</td>
<td>1.59 (478.37, 33.66)</td>
<td>n.s</td>
</tr>
<tr>
<td>Shoulder Activity</td>
<td>Left shoulder power at 5Hz</td>
<td>2, 36</td>
<td>(125.75, 79.08) 1.22</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Right shoulder power at 5Hz</td>
<td>2, 36</td>
<td>(0.01, 0.08) 1.04</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of shoulder line rotation in azimuth</td>
<td>2, 36</td>
<td>(0.08, 0.08) *10.03</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Correlation of shoulder distances from hip</td>
<td>2, 36</td>
<td>(0.18, 0.02) 1.21</td>
<td>n.s</td>
</tr>
<tr>
<td>Spine and Neck Activity</td>
<td>Compound spine power at 5Hz</td>
<td>2, 36</td>
<td>(0.529, 0.439) 1.08</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of upper back activity</td>
<td>2, 36</td>
<td>(0.84, 0.78) *12.07</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of lower back activity</td>
<td>2, 36</td>
<td>(744.12, 61.93) *11.42</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of neck activity</td>
<td>2, 36</td>
<td>(487.62, 42.69) *14.21</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity</td>
<td>2, 36</td>
<td>(478.37, 33.66) *18.20</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

(3114.63, 171.18)
Table 10.

Planned comparisons for laughter in SITTING position. Summary of significant results. 
All tests below are two-tailed. *p < 0.05

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Movement Feature</th>
<th>t</th>
<th>(df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Range of distance between hands</td>
<td>*4.06</td>
<td>29.97</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of shoulder line rotation in azimuth</td>
<td>*5.02</td>
<td>22.90</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of upper back activity</td>
<td>*5.42</td>
<td>19.99</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of lower back activity</td>
<td>*5.03</td>
<td>20.64</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of neck activity</td>
<td>*5.43</td>
<td>27.66</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity</td>
<td>*6.11</td>
<td>24.48</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2</td>
<td>Range of upper back activity</td>
<td>*2.60</td>
<td>19.03</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>Range of lower back activity</td>
<td>*2.80</td>
<td>17.45</td>
<td>0.012</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity</td>
<td>*3.44</td>
<td>19.76</td>
<td>0.003</td>
</tr>
</tbody>
</table>

The upper section of Table 10 summarises the significant results of the first planned contrast test in the seated condition (laughter versus non-laughter). The means of all features listed in contrast 1 were higher in animations categorised as showing laughter than those thought not to contain laughter.

The lower section of Table 10 lists results for the contrast between hilarious social categories. Here the means of features indicating spinal activity were significantly higher for hilarious than for the social category. No other significant differences were found in these contrasts.

Post-hoc comparisons using Tamhane’s T2 identified several statistically significant pair wise comparisons, summarised in Table 11. In the case of every
movement feature listed, the mean value of the hilarious category was significantly higher than in the non-laughter category. For two spinal activity movement features it was also significantly higher than that of social: range of lower back activity ($M_{\text{Hilarious}} = 12.80, 95\% \ CI [7.20, 18.41]$ and $M_{\text{Social}} = 5.08, 95\% \ CI [2.82, 7.23]$) and range of compound spine activity ($M_{\text{Hilarious}} = 33.49, 95\% \ CI [22.54, 44.44]$ and $M_{\text{Social}} = 13.86, 95\% \ CI [7.94, 19.77]$). The results for the features range of activity at the upper and lower back and the range of compound spine activity all indicate that the mean values for these features are also significantly higher in the social category than in that of non-laughter. Other than those listed in Table 11, no other significant pair wise combinations were observed for categories in the sitting condition.

In Figures 18-23, these significant relationships between movement features and how the stimuli were categorised is presented visually.
Table 11.
Post-hoc tests of laughter categorisations in SITTING position, using Tamhane T2. Summary shows significant relationships between mean values of pair categories. ‘H’ = hilarious laughter, ‘Soc’ = social laughter, ‘No Laugh’ = non-laughter. *p <0.05

<table>
<thead>
<tr>
<th>Movement Feature</th>
<th>Category</th>
<th>M</th>
<th>Category</th>
<th>M</th>
<th>Key takeaway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of distance between hands</td>
<td>H</td>
<td>15.84</td>
<td>No Laugh</td>
<td>4.91</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[10.22, 21.45]</td>
<td></td>
<td>[2.25, 7.57]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soc</td>
<td>6.47</td>
<td>No Laugh</td>
<td>1.48</td>
<td>*Soc &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[3.15, 9.78]</td>
<td></td>
<td>[0.89, 2.07]</td>
<td></td>
</tr>
<tr>
<td>Range of shoulder line rotation in azimuth</td>
<td>H</td>
<td>0.24</td>
<td>No Laugh</td>
<td>0.021</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0.13, 0.35]</td>
<td></td>
<td>[0.01, 0.03]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soc</td>
<td>0.02</td>
<td>No Laugh</td>
<td>0.89</td>
<td>*Soc &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[0.01, 0.03]</td>
<td></td>
<td>[0.89, 2.07]</td>
<td></td>
</tr>
<tr>
<td>Range of upper back activity</td>
<td>H</td>
<td>15.44</td>
<td>No Laugh</td>
<td>1.48</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[8.71, 22.16]</td>
<td></td>
<td>[0.89, 2.07]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soc</td>
<td>6.47</td>
<td>No Laugh</td>
<td>1.48</td>
<td>*Soc &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[3.15, 9.78]</td>
<td></td>
<td>[0.89, 2.07]</td>
<td></td>
</tr>
<tr>
<td>Range of lower back activity</td>
<td>H</td>
<td>12.80</td>
<td>No Laugh</td>
<td>1.59</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[7.20, 18.41]</td>
<td></td>
<td>[0.68, 2.50]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soc</td>
<td>5.02</td>
<td>No Laugh</td>
<td>1.59</td>
<td>*Soc &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[2.82, 7.22]</td>
<td></td>
<td>[0.68, 2.50]</td>
<td></td>
</tr>
<tr>
<td>Range of neck activity</td>
<td>H</td>
<td>14.60</td>
<td>No Laugh</td>
<td>3.31</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[10.38, 18.83]</td>
<td></td>
<td>[1.88, 4.73]</td>
<td></td>
</tr>
<tr>
<td>Range of compound spine activity</td>
<td>H</td>
<td>33.48</td>
<td>No Laugh</td>
<td>5.15</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[22.53, 44.43]</td>
<td></td>
<td>[2.98, 7.32]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soc</td>
<td>13.85</td>
<td>No Laugh</td>
<td>5.15</td>
<td>*Soc &gt; No Laugh</td>
</tr>
<tr>
<td></td>
<td></td>
<td>[7.94, 19.77]</td>
<td></td>
<td>[2.98, 7.32]</td>
<td></td>
</tr>
</tbody>
</table>
Figure 18. In the sitting position, perceptual stimuli categorised as laughter had a significantly higher mean value for range of distance in hand movement than non-laughter.

Figure 19. The significantly different means in range of hand distance between hilarious and non-laughter categories, while seated.
Figure 20. In the sitting position, stimuli categorised as hilarious demonstrated significantly greater range of rotation of the shoulders in the azimuth (where the upper body of the avatar turns substantially) than non-laughter.

Figure 21. The significantly different means in range of shoulder rotation in the azimuth between hilarious and non-laughter categories, while seated.
Figure 22. In the sitting position, significant differences in whether a stimulus was categorised as hilarious, social or non-laughter were demonstrated when examining the compound spinal activity. Generally, hilarious or social categorised stimuli demonstrated increased bending of the spine. Further, there is also significant difference between means for hilarious and social.

Figure 23. The significantly different means in range of compound spinal activity across stimuli categorised as hilarious, social or not laughter.
### 8.5.2.2 Standing Laughter

Table 12.

ANOVA for laughter movement in the STANDING position. *p <0.05

<table>
<thead>
<tr>
<th>Primary Body area</th>
<th>Movement Feature</th>
<th>(df)</th>
<th>F ratio (Mean sq errors between, within)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hand Activity</td>
<td>Min. distance between hands</td>
<td>2, 49</td>
<td>0.59  (125.75, 79.08)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Max. distance between hands</td>
<td>2, 49</td>
<td>2.03 (645.51, 318.25)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of distance between hands</td>
<td>2, 49</td>
<td>*5.06 (935.05, 184.85)</td>
<td>0.010</td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand to head</td>
<td>2, 49</td>
<td>*3.96 (1504.66, 380.05)</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>Min. distance of Hand to hip</td>
<td>2, 49</td>
<td>0.09 (5.90, 66.48)</td>
<td>n.s</td>
</tr>
<tr>
<td>Shoulder Activity</td>
<td>Left shoulder power at 5Hz</td>
<td>2, 49</td>
<td>1.77  (0.01, 0.01)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Right shoulder power at 5Hz</td>
<td>2, 49</td>
<td>1.89  (0.02, 0.01)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of shoulder line rotation in azimuth</td>
<td>2, 49</td>
<td>2.20 (0.30, 0.14)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Correlation of shoulder distances from hip</td>
<td>2, 49</td>
<td>3.15 (0.77, 0.25)</td>
<td>n.s</td>
</tr>
<tr>
<td>Spine and Neck Activity</td>
<td>Compound spine power at 5Hz</td>
<td>2, 49</td>
<td>1.46  (1.89, 1.30)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of upper back activity</td>
<td>2, 49</td>
<td>*9.27 (89.29, 9.63)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of lower back activity</td>
<td>2, 49</td>
<td>*12.42 (93.83, 7.56)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of neck activity</td>
<td>2, 49</td>
<td>2.73  (31.42, 11.50)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity</td>
<td>2, 49</td>
<td>*10.78 (543.02, 50.37)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
The results of the one-way ANOVA on movement features in the standing position, again with an alpha of 0.05, are shown in Table 12. They demonstrate significant differences in standing laughter categorisation across five movement features including range of distance between the hands, the minimum distance of the hand from the head, and three measures of spinal activity. No other body movement features demonstrated a significant effect on standing laughter categorisation.

As with the seated laughter category data, planned contrasts were used to test how movements affected categorisation. Again, the first examined significant effects between the hilarious and social laughter categories taken together against non-laughter and the second whether there were significant differences in mean movement values between hilarious and social laughs in the standing condition. Table 13 summarises the significant results of both planned contrast tests for the standing condition.

**Table 13.**

*Planned comparisons for laughter in STANDING position. Summary of significant results.*  
*Contrast 1: Hilarious and Social vs Non-Laughter. Contrast 2: Hilarious vs Social. All tests below are two-tailed. *p < 0.05*

<table>
<thead>
<tr>
<th>Contrast</th>
<th>Movement Feature</th>
<th>t</th>
<th>(df)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Range of distance between hands</td>
<td>*3.12</td>
<td>49</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand from head</td>
<td>*-2.81</td>
<td>49</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Range of upper back activity</td>
<td>*4.30</td>
<td>49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of lower back activity</td>
<td>*4.98</td>
<td>49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity</td>
<td>*4.64</td>
<td>49</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2</td>
<td>Range of lower back activity</td>
<td>*2.11</td>
<td>49</td>
<td>0.040</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity</td>
<td>*2.06</td>
<td>49</td>
<td>0.045</td>
</tr>
</tbody>
</table>
The upper portion of Table 13 summarises the significant results of the first planned contrast test in the standing condition (laughter versus non-laughter), and demonstrates that higher levels of spinal activity were present in laughter categorised clips than in non-laughter, as was a higher range of hand movement. The mean minimum distance of the hand from the head was significantly lower in laughter than in non-laughter categories. The lower part of Table 13 summarises results for the second planned contrast (hilarious versus social) and presents a higher level of spinal activity in hilarious than in social categories for standing.

Post-hoc comparisons using Bonferroni identified several statistically significant pair wise comparisons, summarised in Table 14, and including range of distance between the hands, minimum distance of the hand from the head during the stimulus and measures of spinal activity. The means of the hilarious category for each features were consistently higher than those of the non-laughter category. In two spinal measures, the means were greater in social than in non-laughter. Other than those listed in Table 14, no other significant pair wise combinations were observed for categories in the standing condition. Figures 24-27 visually represent the relationships between the Bonferroni-corrected means of a subset of these features.
Table 14.

Post-hoc tests for laughter in STANDING position, Bonferroni corrected. Summary shows significant relationships between mean values of pair categories. ‘H’ = hilarious laughter, ‘Soc’ = social laughter, ‘No Laugh’ = non-laughter. *p <0.05

<table>
<thead>
<tr>
<th>Movement Feature</th>
<th>Category</th>
<th>M</th>
<th>95% CI</th>
<th>Category</th>
<th>M</th>
<th>95% CI</th>
<th>Key takeaway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of distance between hands</td>
<td>H</td>
<td>29.59</td>
<td>[4.05, 55.13]</td>
<td>No Laugh</td>
<td>10.38</td>
<td>[5.93, 14.84]</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td>Min. distance of hand to head</td>
<td>H</td>
<td>34.15</td>
<td>[8.08, 60.23]</td>
<td>No Laugh</td>
<td>56.79</td>
<td>[48.27, 65.32]</td>
<td>*H &gt; No Laugh</td>
</tr>
<tr>
<td>Range of lower back activity</td>
<td>H</td>
<td>8.96</td>
<td>[5.69, 12.22]</td>
<td>No Laugh</td>
<td>3.38</td>
<td>[2.43, 4.34]</td>
<td>*H &gt; No Laugh</td>
</tr>
</tbody>
</table>
Figure 24. Examining the range of compound spinal activity in the standing position illustrates that significantly higher means are present in categorisations marked laughter over non-laughter and hilarious laughter over social laughter.

Figure 25. The significantly different means in compound spinal activity between hilarious, social and non-laughter categories, while standing.
Figure 26. When standing, significant differences were observed in categorisation of stimuli based on minimum distances between the hand and the head in each clip. Clips where the hand came closer to the head were marked as hilarious rather than non-laughter to an above-chance level.

Figure 27. The significantly different means in minimum distances from the hand to the head between hilarious and non-laughter categories, while standing.
8.5.3 Within-category comparisons

A final one-way ANOVA was performed only examining significant contrasts within laughter types, or rather, examining the relationship between the mean of a movement feature and how it influenced categorisation of hilarious laughter in the standing position as opposed to the sitting position. This is summarised in Table 15.

Bonferroni-corrected post hoc tests were completed, demonstrating the only significant relationship is between the means for range of rotation of the shoulders in the azimuth between standing and seated hilarious laughter, with the mean being significantly higher in standing hilarious laughter than in sitting, summarised in Table 16, and visualised below, in figure 28.

Figure 28. The mean of range of rotation in the azimuth was shown to be significantly higher in standing hilarious laughter than in sitting hilarious laughter.
### Table 15.

ANOVA examining just laughter movement (trials marked hilarious or social); non-laughter trials are not included in this data. *p <0.05

<table>
<thead>
<tr>
<th>Primary Body area</th>
<th>Movement Feature</th>
<th>(df)</th>
<th>F ratio (Mean sq errors between, within)</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hand Activity</td>
<td>Min. distance between hands</td>
<td>3, 49</td>
<td>0.77 (126.09, 162.92)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Max. distance between hands</td>
<td>3, 49</td>
<td>1.37 (375.68, 275.91)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of distance between hands</td>
<td>3, 49</td>
<td>2.04 (367.27, 179.70)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand from head</td>
<td>3, 49</td>
<td>0.73 (251.00, 343.52)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Min. distance of hand from hip</td>
<td>3, 49</td>
<td>1.50 (133.15, 88.72)</td>
<td>n.s</td>
</tr>
<tr>
<td>Shoulder Activity</td>
<td>Left shoulder power at 5Hz</td>
<td>3, 49</td>
<td>2.21 (0.07, 0.03)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Right shoulder power at 5Hz</td>
<td>3, 49</td>
<td>2.25 (0.07, 0.03)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of shoulder line rotation in azimuth</td>
<td>3, 49</td>
<td>*6.44 (0.52, 0.08)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Correlation of shoulder distances from hip</td>
<td>3, 49</td>
<td>*3.60 (0.99, 1.12)</td>
<td>0.020</td>
</tr>
<tr>
<td>Spine and Neck Activity</td>
<td>Compound spine power at 5Hz</td>
<td>3, 49</td>
<td>1.33 (0.81, 0.61)</td>
<td>n.s</td>
</tr>
<tr>
<td></td>
<td>Range of upper back activity</td>
<td>3, 49</td>
<td>*5.06 (258.73, 51.06)</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>Range of lower back activity</td>
<td>3, 49</td>
<td>*4.59 (165.11, 35.95)</td>
<td>0.007</td>
</tr>
<tr>
<td></td>
<td>Range of neck activity</td>
<td>3, 49</td>
<td>*9.48 (257.63, 27.16)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Range of compound spine activity</td>
<td>3, 49</td>
<td>*8.13 (1274.25, 156.73)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Table 16.

Post-hoc tests of trials, Bonferroni corrected. Summary shows significant relationships between mean values of pair categories. ‘H Stand’ = hilarious standing laughter, ‘H Sit’ = hilarious sitting laughter. *p <0.05

<table>
<thead>
<tr>
<th>Movement Feature</th>
<th>Category</th>
<th>M</th>
<th>95% CI</th>
<th>Category</th>
<th>M</th>
<th>95% CI</th>
<th>Key takeaway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range of shoulder line rotation</td>
<td>H Stand</td>
<td>0.69</td>
<td>[0.18, 1.20]</td>
<td>H Sit</td>
<td>0.24</td>
<td>[0.13, 0.35]</td>
<td>*H Stand &gt; H Sit</td>
</tr>
<tr>
<td>in azimuth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8.6 Summary

This section has described the analysis of the results of the perceptual experiment to test whether body movement does significantly affect the perception of laughter in the absence facial or audio cues and identify a subset of movement features that significantly impact on how laughter is categorised. Data gathered in the perceptual experiment was analysed using one-way ANOVAs and an alpha of 0.05. Results were found indicating a significant relationship between several means of body movement features and how stimuli were categorised to an above chance level. The implications of these results are discussed in the next chapter.
CHAPTER 9. DISCUSSION

9.1 Hypothesis

The aim of this research was to identify a set of body movement features that is significantly indicative of the presence of laughter to observers, and helps distinguish different types of laughter. The goal was also to provide initial tangible output of the specific quantitative properties of these features to researchers incorporating laughter into human-avatar research. The hypothesis was that movement from different types of laughter would be perceived differently to above chance level by observers.

9.3 Results

9.3.1 Initial observations

Within the raw participant categorisation data, the 17 male and 15 female participants did demonstrate similar categorisation for many stimuli in hilarious, social and non-laughter. They seemed less ready to draw clear conclusions about fake and awkward laughter, meaning that to the participants of this study, more context and other modalities such as audio might have helped make a firm decision on whether these types of laughter were present in the stimuli. These agreement levels between the genders could form the basis for future studies, to determine whether statistically significant differences exist between the genders on categorising laughter from body movement or whether each gender tends to use different features to make a categorisation decision. It did not form a core part of this study.
9.3.1 Research Question 1. What body movements reflect the expression of laughter?

The analysis indicates that several body movement features identified via the literature as being present to varying degrees during bouts of laughter had a significant impact on whether movement presented in the perceptual stimuli was categorised as depicting laughter. In both the standing and seated positions, presence of significant spinal activity seems to provide an indication of laughter, with the activity and curl at the neck also significantly important for the seated position. It appears the more the spine and neck curl, the more likely laughter is to be perceived. Perhaps the neck activity seems less perceptually important in the standing position because spinal activity is more obvious, with greater degrees of freedom, whilst standing than whilst sitting, and therefore the spine is given more attention in standing scenarios.

The range of distance between the hands also seems important for both standing and sitting positions. This reflects the physiological studies which discuss movement in the arms during bouts of intense laughter (Ruch, 1993). Further, predominantly inspired by the participant post-categorisation task interviews, the minimum distance between the hand and the head was also significant in categorising laughter as hilarious in the standing position. This reflects the gesture of many Western European cultures at least, of lifting a hand to the mouth or the face during intense laughter, but is here shown to be computationally significant in perceiving laughter from a movement. It would be interesting for future work to examine how this is perceived differently in different cultures.
These findings resolve the first research question by providing a first subset of movement features used by humans to determine the presence of laughter. They provide initial confirmation that the hypothesis outlined in the introductory chapter is correct. See Figures 29-31 for a sample of stimuli depicting varying levels of spine activity, each categorised differently by participants.

Figure 29. Stills from two stimuli, each depicting movement categorised as hilarious. Note the strong curvature of the spine.

Figure 30. Stills from two animations, each depicting movement categorised as social. Minimal spinal curvature is present.

Figure 31. Stills from one animation depicting movement categorised as non-laughter. Movement in this animation is almost not discernible and the avatar appears very still throughout.
9.3.2 Research question 2: Which are the features of those movements that people use to detect and categorise laughter?

There are two research outputs in answer to this research question. The first involves the features used to detect laughter from body movement, which are effectively those identified above. The second examines categorisation of laughter types, once laughter has been detected through movement. Results here indicate, although perhaps less resoundingly than for the first research question, that body movement features do contribute to laughter being categorised differently. In the seated position, significantly higher mean values for lower back activity were associated with stimuli categorised as hilarious over those marked social.

Within laughter categories, mean values for range of shoulder movement in the azimuth, as indicated in the final subsection of the results chapter, was significantly higher for hilarious standing laughs than hilarious seated. This was the only significant result of the analysis of movement features within laughter categories. Further, it seems sensible as it is a measure of how much a person turns their upper body to the left and right. There is more flexibility to do this whilst standing, therefore a greater range of motion in this field is to be expected.

Categorisations between and within laughter types should be explored further with a greater sample size of different laughter categories in future. Likewise, the body features chosen for analysis in this study may significantly contribute to the categorisation of movement as being hilarious laughter, but other movement features, not examined here, might be more effective in identifying demarcations between laughter categorisations. That is for future consideration.
9.3.3 Case of the shoulders

Outside of the range of rotation mentioned above, perhaps surprisingly, there were no significant findings in relation to shoulder movement as part of the analysis. This could be that, in spite of customisation work to the MOCAP system, the shoulders were not the main focus of attention for participants during the trials, or are perhaps a secondary feature of movement used to detect laughter. It is also entirely possible that 5Hz frequencies of vibration measured throughout the low level hierarchy of the body, such as vibrations in finger pressure, remain bounded there, and do not manifest themselves visibly in higher, more complex bodily structures, such as the shoulders.

9.4 Implications, contributions and applications of this study

This work makes a specific contribution to the field of affective research by identifying quantitative measures for a key subset of body movements that are significant in human perception and categorisation of naturalistic laughter, which can feed into research on multimodal machine detection and production of laughter. The work also provides a modest corpus of non-acted body movement during bouts of different types of laughter, for further study, and delivers proof of concept of a customised Animazoo IGS190 motion capture system for more sensitive data collection of shoulder movements.

Positioning this work in the context of the wider literature, the results support those of previous researchers who have identified the body as a significant channel for affective communication of different types, worthy of further exploration (Camurri et al., 2003; Castellano et al., 2007; Dael et al., 2012; Kleinsmith & Bianchi-Berthouze, 2012; Roether et al., 2009), and add to the volume of research illustrating the suitability
of motion capture and forced choice experimental design for this class of study. Further, in focusing on body movement, which has historically been a slightly less studied modality for affective expression than the face, this work complements those studies that have focused on other modes of affective expression in laughter, such as acoustic signals (Niewiadomski et al., 2010; Szameitat et al., 2009). Finally, in line with both the stated need for research in several diverse fields to pool knowledge and findings in furthering development of affect-capable avatars (Gratch et al., 2002; Pantic et al., 2006), and in order to make small but steady incremental steps forward in a field in its relatively early days, this work provides a very modest contribution toward quantitative, computational measurement in one modality of a deeply complex multi-modal human affective behaviour, laughter.

This study contributions have applications in the design of machine recognition of affective and non-verbal cues through laughter body movement which are very early milestones on the road to naturalistic human-avatar interaction in the future, across a wide range of contexts from customer service and education, to clinical scenarios, such as the treatment of emotion disorders and phobias (Borzo, 2004; Cassell et al., 2000; Gaggioli et al., 2003; Qiu & Benbasat, 2005; Vilhjálmsson & Cassell, 1998)

9.5 Limitations

9.5.1 Motion capture

As noted in the literature review, the motion capture system provides advantages in the objectivity of its data, but it is slightly problematic nonetheless. The fact that the suit can take upwards of five minutes for two researchers to set up correctly on one participant adds to the inherent strangeness of the experience of wearing the motion
capture suit reported by participants. It suggests that analysis of ‘naturalistic’ body movement samples gathered in this way is still far from ideal. However, it is one of the proven methods favoured in the community and is state-of-the-art at present, until such time as technology allows for suitably high-fidelity body motion recording without the need for cumbersome sensors.

It proved difficult to recruit large numbers of participants for the data-gathering stage, most likely because sessions needed up to two hours of participants’ time, so the sample size is somewhat low. Further, eliciting laughter generally from participants was not overly challenging and laughter was observed consistently throughout all sessions bar one. The use of varied material in the elicitation phase was useful, but some additional material, designed to elicit laughter as a secondary activity, had to be discarded as, even with the more sedentary tasks, the experiment proved physically quite tiring for the participants and researchers as it involved tasks performed at quite a fast pace, and laughing for such prolonged periods is somewhat exhausting. It would be useful to run more sessions of shorter duration with a subset of tasks. This would allow for easier collection of non-hilarious laughter types and increase sample sizes to allow for future statistical testing.

9.5.2 Coding and post-processing of data

Coding samples with one researcher would be a limitation if the researcher’s categorisations were taken as the ground truth categories for the stimuli, as these are inherently subjective. This is illustrated by the contrasts shown in the confusion matrix of participants’ categorisations against those of the researcher. However, wider scope to allow for trained observers to first categorise the stimuli, perhaps in repeated steps as in
Kleinsmith et al. (2011), would provide additional analysis for the influence of context and other modalities such as audio and facial expression on the categorisations.

Animation and processing of the motion capture trials is relatively straightforward in theory, but in practicality, quite laborious and tedious. Interpolation of missing frame data, a necessary part of this post-processing, and other recording problems such as movement from the motion capture not corresponding to that on video also reduces the validity of segments and they need to be discarded for use as trials in perceptual tests. To achieve a solid sample size of perceptual trials after this editorial and discarding process, researchers need to elicit substantially more (in this case, almost 70% more) instances of the movement under study in the data collection phase.

9.5.3 Perceptual experiment and analysis

In the perceptual experiment, the laughter definitions may have needed more rigorous testing. In the raw scores applied by participants, it seems those laughs identified as hilarious were those that had very large ranges of movement in the hands and spine, indicating that the participants may have been expecting quite dramatic movements before willingness to categorise a laugh as hilarious. It was noted that a number of trials that the researcher categorised as hilarious were marked social by participants.
CHAPTER 10. CONCLUSION

10.1 Future work

This thesis has taken a literature-inspired research approach and conducted quantitative research into how body movement in laughter is perceived and which are the features of this movement that contribute to the perception of different types of laughter. It has positioned a quantitative study of body movement during laughter in the context of the development of future avatars and technology, capable of true multi-modal expression and detection of affect.

The immediate next step of this project will be to make these quantitative measures of body movement and laughter perception available to the ILHAIRE research team to build into their wider research remit of incorporating laughter into human-avatar interaction. Future research should include cluster analysis of body movement feature combination pairs, such as range of hand movement and spinal activity together, to identify how combinations influence perception of laughter.

Other potentially interesting ways to explore these findings include examination of gender issues in perception of laughter movement, which was not the core focus of this study. Do male and female participants perceive different movements differently? Which movements are more influential than others on how women and men categorise laughter movement? This could extend to studies not just of laughter perception, but also laughter production, with analysis of the differences in body movements produced by male and female participants in response to various laughter or affect inducing
stimuli. Cultural aspects on both the production and perception of movements might also be examined.

Beyond this, a further set of body movements for analysis could be identified to slowly build an increasingly complex, layered multi-modal corpus, along the lines of knowledge development from across a range of research fields called for by Gratch (2002) in an effort to create avatars demonstrating truly believable human behavioural patterns. As suggested by Kleinsmith and Berthouze (2012), crowdsourcing affective labelling of these recordings in the corpus may also prove valuable as a less expensive, less subjective way of coding these samples still key to these studies into multimodal machine analysis of affect.

In closing, laughter is a fundamental phenomenon forming an integral part of the human experience. It provides highly complex, nuanced, multimodal communication in human interactions, without even uttering a word. If the admittedly daunting challenge of incorporating laughter into the human-machine interface is overcome, it will likely play a key role in that interaction also. Whilst automated detection of affect is still in the early days of development, the work of today’s researchers enables small, but necessary steps toward the future. Affect-capable avatars and machine agents might enrich our future relationship with technology, providing interaction styles that are more satisfying, enjoyable, naturalistic and, perhaps, even hilarious.
References


Appendix 1:

Motion capture data gathering information sheet

Information Sheet

<table>
<thead>
<tr>
<th>Title of Project:</th>
<th>ILHAIRE – Incorporating Laughter Into Human-Avatar Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study has been approved by the UCL Research Ethics Committee as Project ID Number:</td>
<td></td>
</tr>
<tr>
<td>Staff: 1112/002</td>
<td></td>
</tr>
</tbody>
</table>

Name, Address and Contact Details of Investigators:
Dr Harry Griffin
Email: harry.griffin@ucl.ac.uk
Telephone: 020 7679 4491

Ciaran (Kio) McLoughlin
Email: ciaran.mcloughlin.11@ucl.ac.uk
Telephone: 07760 140 926

Post: UCL Interaction Centre
MPE8 8th Floor University College
London
Gower Street
London
WC1E 6BT

We would like to invite you to participate in this research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, please read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

The "ILHAIRE" project is part of the EU 7th Framework Programme on ICT – Information and Communication Technologies. ILHAIRE aims to explore and develop original scientific theories on laughter and lay the foundations of truly multimodal, multicultural laughter-enabled man-machine interaction. ILHAIRE will ultimately develop motion analysis algorithms for automated analysis of movement cues for different types of laughter and dialogue models that will allow embodied conversational agents to respond to user laughter by producing laughter themselves.

We are interested in how people laugh and the role of laughter in interaction between people. In order to investigate these questions further we need to use video to record various aspects of behaviour during interaction and laughter, including vocalisations, facial expressions and body movements. In order to record your body movements and respiration we may also fit sensors to various parts of your body. These are totally non-invasive and have been used in many experiments before in our lab and elsewhere without ill effect.

We will then ask you to either: (i) produce/act laughter alone in a small group, (ii) view images and/or videos and/or text, and (iii) observe another member of the group while we show them images and/or videos and/or text. None of the images, videos or text that you will be shown will be upsetting. In all cases, we will record your response on video and, where used, the motion-capture system and respiration sensor systems.

It is up to you to decide whether or not to take part. If you choose not to participate, you won't incur any penalties or lose any benefits to which you might have been entitled. However, if you do decide to take part, you will be given this Information Sheet to keep and asked to sign a consent form. Even after agreeing to take part, you can still withdraw at any time and without giving a reason.

All data will be collected and stored in accordance with the Data Protection Act 1998.
Appendix 2:

Motion capture data gathering consent form

<table>
<thead>
<tr>
<th>Title of Project:</th>
<th>ILHAIRED - Incorporating Laughter into Human-Avatar Interactions</th>
</tr>
</thead>
</table>
This study has been approved by the UCL Research Ethics Committee as Project ID Number: Staff 1112/002 |

Participant's Statement

I \[Signature\] agree that:

- I have read the information sheet and/or the project has been explained to me orally;
- I have had the opportunity to ask questions and discuss the study; and
- I have received satisfactory answers to all my questions or have been advised of an individual to contact for answers to pertinent questions about the research and my rights as a participant and whom to contact in the event of a research-related injury.

- I understand that my participation will be taped/video recorded, and I understand, and consent to, these recording being used for analysis within UCL.
- I understand, and consent to, these recording being used for analysis by other members of the ILHAIRE consortium. Delete as appropriate: Yes/No
- I understand, and consent to, the video or images of me, with no other identifying information, being used for demonstration at scientific conferences or meetings not restricted to the ILHAIRE consortium. Delete as appropriate: Yes/No
- I understand that, where the motion capture system is being used, I must not take part if I have any pre-existing medical conditions that would cause me discomfort or pain as a result of wearing the motion-capture system.
- I agree to be contacted in the future by UCL researchers who would like to invite me to participate in follow-up studies. Delete as appropriate: Yes/No
- I understand that if I am being paid for my assistance in this research, some of my personal details will be passed to UCL Finance for administration purposes.
- I understand that I am free to withdraw from the study without penalty if I so wish, and I consent to the processing of my personal information for the purposes of this study only and that it will not be used for any other purpose. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

Signed: Date:

Printed: Number:

Investigator's Statement

I \[Signature\] confirm that I have carefully explained the purpose of the study to the participant and outlined any reasonably foreseeable risks or benefits (where applicable).

Signed: Date:
Appendix 3:

Data gathering experimental script (including pilot tasks)

Admin Material for each Data Gathering Session

Print:
Study information form x2
Study consent form x2
MOCAP Procedure document (for reference)
Visitor list per day to leave with security team
Laughter tick-chart for end-of-day / post data gathering analysis

Computer:
Desktop/KioMScDataGathering/ParticipantX_Date/filesneeded
Includes:
MOCAP recordings
Respirator recordings
DSLR recordings
Webcam recordings
Audio recordings
‘Cube’ photo for baseline

Session Logistics

Laughter types to elicit:
Hilarious / Social / Awkward / Fake / Schadenfreude / Speech

2 phases:
Standing
Sitting

Total: 1.5 hours
20 minutes to set up and explain study
Each phase 30 minutes duration – 20 minutes activity, 10 minutes ‘break’ total
Real 5 / 10 minute break between phases
Check information is saved correctly
10 minutes warm-down and debrief
Session Script
Pre-Arrival
Pre-Arrival of Participants
Check Admin material is complete in print and on computer (see above)
Play (carnival) music on laptop (via projector if possible)
Play stand-up showreel on Youtube or other Youtube videos
Carnival: http://www.youtube.com/watch?v=gHwHiymSojk
Carnival 2: http://www.youtube.com/watch?v=iqpekFXDa6w
Music: John: http://www.youtube.com/watch?v=TLPxTKR7A70
Music: TomTom Club: http://www.youtube.com/watch?v=uNQBTyNpPpc
Music: Under Your Spell Drive: http://www.youtube.com/watch?v=xTkgYmAXMB0
Music: Ce Jeu: http://www.youtube.com/watch?v=GxFa9HLdhIY
Music: Terminally Chill: http://www.youtube.com/watch?v=ss5gBDa3OTA
Music: Alt-J Dissolve Me: http://www.youtube.com/watch?v=T_VSixF6DaY
Music: The Knife Kino Live: http://www.youtube.com/watch?v=a-SfiSoGc0

Arrival and Set-Up
Welcome Participants
Provide study information and background
Explain study purpose
Walkthrough study information document
Clarifying questions
Demonstrate equipment to be worn
Explain consent form, data protection and withdrawal issues
Verify consent verbally
Sign consent forms
Make sure they’re comfortable
Offer water
Explain ‘game’ and ‘prizes’ to Ps as suiting up. Working together in a team to gain points against other P-groups. Get points for tasks.
Get P1 to put on MOCAP Vest top
Attach respirator sensors to P1
Set up MOCAP suit fully on P1
Sit them down
Michael take one side of suit, Kio takes other side and suits up participant - See ‘MOCAP Procedure’ for reference
Stand up to connect wires
Check sending data correctly to computer and recording
Check respirator data - Michael
Standing:
Measure cm inhaled fully
Measure cm exhaled fully
Seated:
Measure cm inhaled fully
Measure cm exhaled fully
Make note of these in the Ps file on Respirator

Technical Checks 1
Take photo of P1 in MOCAP suit for baseline measures
Save to Session folder
Set alarm for 20 minutes to remind about SD card in camera pausing
Synchronise in view of all cameras
with clapper to sync audio and respirator streams (do this near DSLR)
Do a very particular movement on MOCAP to sync WC1 and MOCAP
Check picture and sound being recorded on:
DSLR
MOCAP
WC1
Respirator 1
Phase 1: Standing Tasks
Begin Standing Tasks
**Standing Task 1**: Wii games (5 mins)
(Break)
Save MOCAP
Record again
Renorth
Reset DSLR and begin recording again
**Standing Task 2**: Reading Tongue Twisters as fast as possible to each other (5 mins)
Save MOCAP
Record again
Renorth
Reset DSLR and begin recording again
(Break)
Save MOCAP
Record again
Renorth
Reset DSLR and begin recording again
(Break)
Fake laugh standing
Save MOCAP
Record again
Renorth
Reset DSLR and begin recording again
**Standing Task 4**: YouTube (5 mins)
Hick contagious laugh
[http://www.youtube.com/watch?v=mIfhOF-w1XI](http://www.youtube.com/watch?v=mIfhOF-w1XI)
Fenton - Hitler
[http://www.youtube.com/watch?v=moLK15PzZLc](http://www.youtube.com/watch?v=moLK15PzZLc)
P&R Sugar
[http://www.youtube.com/watch?v=gxmfx0-nj4U](http://www.youtube.com/watch?v=gxmfx0-nj4U)
David Brent Dancing
[http://www.youtube.com/watch?v=qurTK_0re3Y](http://www.youtube.com/watch?v=qurTK_0re3Y)
Royce You Know Nothing
[http://www.youtube.com/watch?v=pGldM85dXYs&list=UUIJTOz3YyQwgr7OeLGrGkKg&index=4&feature=plcp](http://www.youtube.com/watch?v=pGldM85dXYs&list=UUIJTOz3YyQwgr7OeLGrGkKg&index=4&feature=plcp)
Laughing Baby
[http://www.youtube.com/watch?v=RP4abiHdQpc](http://www.youtube.com/watch?v=RP4abiHdQpc)

**Standing Task 5**: Mystery box (2 mins)
**Standing Task 6**: Song titles replacement (5 mins)
**YouTube**: Cursing Extravaganza Curb  
http://www.youtube.com/watch?v=r5avCWvL7lw

Have them think of offensive words  
Song titles read-through as fast as they can  
Break & Data quality check

**BREAK**

Stop recording  
Save data  
Let Ps relax  
Double check sample of data  
Continue to play YT reel  
Maru Cat  
http://www.youtube.com/watch?v=8uDuls5TyNE

Set up for seating tasks  
Ps must be facing each other with monitors between them  
Fit Respirator 2 on P2  
Connect both monitors to white desktop

**Technical Checks 2**

Set alarm for 20 minutes to remind about SD card in camera pausing  
Begin recording for seating tasks – Check picture and sound on:  
DSLR  
MOCAP  
WC1  
Respirator 1  
Respirator 2  
Camcorder  
Synchronise in view of all cameras  
with clapper to sync audio and respirator streams (do this near DSLR)  
Do a very particular movement on MOCAP to sync WC1 and MOCAP  
Clapper in view of WC2 to sync audio
Phase 2: Seated Tasks

**Seated Task 1:** Frijj game (on Kio’s Machine) (5 mins)
Each P gets 2/3 goes depending on laughter levels
http://www.frijjtheincredible.co.uk/youlolyoulose/game
(Break)
Recalibrate MOCAP
Sync again?

**Seated Task 2:** Paint Pictionary (5 mins)
P1 pulls a card from the deck
Has to try draw it but with their monitors switched on
P2 has to guess what it is
Time limit – 1 minute
Play music from Countdown (Kio’s Machine)
http://www.youtube.com/watch?v=e32kaa9TzeE
Second round: Monitor switched off for drawer
Each P gets 3 goes?
(Break)
Fake laugh seated
Recalibrate MOCAP
Sync again?

**Seated Task 3:** Frustration HTML games (2/3 mins) Grey Desktop
Airport Security Game:
http://digg.com/newsbar/topnews/Airport_Security_Flash_Game_Hilarious
Frustration Game: Grey http://www.arcadecabin.com/play/the_frustration_game.html
Urinal Quiz: http://www.arcadecabin.com/play/the_urinal_game.html
Fart Game: http://www.y100games.com/funny-games-y100-fart-game/a/31646

**Seated Task 4:** Tongue Twisters again (1 min)

**Seated Task 5:** YouTube Wind-down
Schadenfreude laughter reel YT (2 mins)
http://www.youtube.com/watch?v=gLHrk7-1aSo
Laughing Baby videos
http://www.youtube.com/watch?v=ZWHpcKXt-qQ&feature=related (3 mins)
Wrap-up and wind-down – final checks
Complete
Stop recording
Save all recordings and paperwork
Debrief Ps while removing equipment
Final scores?
Any final questions
Thank Ps for their time
Appendix 4:

Manual video markup sheet
Appendix 5:
Perceptual body movement categorisation information sheet

Information Sheet

<table>
<thead>
<tr>
<th>Title of Project:</th>
<th>ILHAIRE – incorporating Laughter into Human-Avatar Interactions Phase: Categorising Laughter types through body movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>This study has been approved by the UCL Research Ethics Committee as Project ID Number:</td>
<td>Staff 1112/002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name, Address and Contact Details of Investigators:</th>
<th>Dr Harry Griffin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Email: <a href="mailto:harry.griffin@ucl.ac.uk">harry.griffin@ucl.ac.uk</a></td>
<td></td>
</tr>
<tr>
<td>Telephone: 020 7679 4491</td>
<td></td>
</tr>
<tr>
<td>Ciaran (Kio) McLaughlin</td>
<td></td>
</tr>
<tr>
<td>Email: <a href="mailto:ciaran.mclaughlin.11@ucl.ac.uk">ciaran.mclaughlin.11@ucl.ac.uk</a></td>
<td></td>
</tr>
<tr>
<td>Telephone: 07760 140 028</td>
<td></td>
</tr>
<tr>
<td>Post: UCL Interaction Centre</td>
<td></td>
</tr>
<tr>
<td>MPSG 8th Floor, University College London</td>
<td></td>
</tr>
<tr>
<td>Gower Street</td>
<td></td>
</tr>
<tr>
<td>London WC1E 6BT</td>
<td></td>
</tr>
</tbody>
</table>

We would like to invite you to participate in this perceptual research project. You should only participate if you want to; choosing not to take part will not disadvantage you in any way. Before you decide whether you want to take part, please read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or you would like more information.

The "ILHAIRE" project is part of the EU 7th Framework Programme on ICT – Information and Communication Technologies. ILHAIRE aims to explore and develop original scientific theories on laughter and lay the foundations of truly multimodal, multicultural laughter-enabled man-machine interaction. ILHAIRE will ultimately develop motion analysis algorithms for automated analysis of movement cues for different types of laughter and dialogue models that will allow embodied conversational agents to respond to user laughter by producing laughter themselves.

We are interested in how people laugh, the role of laughter in interaction between people and how people perceive laughter through the body movement of others. In order to investigate these questions further we have gathered video data of real people laughing, speaking and interacting and used this to create short, simple, anonymised animations which depict their body movements as they laugh, speak etc. We need your help to view a sample of these animations and to categorise them as part of a short task.

We will ask you to view a series of images and/or videos and/or text and assign a label to each based on what type of laugh or interaction you think the images best represent. None of the images, videos or text that you will be shown will be upsetting. In all cases, we will record your response on paper and on computer. This should take about 30 minutes and will include a short break in the middle.

It is up to you to decide whether or not to take part. If you choose not to participate, you won’t incur any penalties or lose any benefits to which you might have been entitled. However, if you do decide to take part, you will be given this information sheet to keep and asked to sign a consent form. Even after agreeing to take part, you can still withdraw at any time and without giving a reason.

All data will be collected and stored in accordance with the Data Protection Act 1998.
Appendix 6:
Perceptual body movement categorisation consent form

<table>
<thead>
<tr>
<th>Title of Project:</th>
<th>ILHAIRE – Incorporating Laughter into Human-Avatar Interactions Phase: Categorising Laughter types through body movement</th>
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</tbody>
</table>

### Participant’s Statement

I 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Appendix 7:

Perceptual categorisation definition sheet for participants

The types of laughter we are examining as part of this study are:

**Hilarious**
Definition: the person is laughing in an unrestrained way as a response to something he or she finds really very funny and amusing.

Example: someone is watching their favourite comedian on TV and is laughing as a response to their jokes.

**Social**
Definition: This may be polite laughter as part of a conversation. It can show an acknowledgement of what another person has said is correct or show courtesy and good manners to the speaker.

Example: someone is having a conversation with a friend and is laughing as a way of acknowledging what their friend is saying and showing that they are enjoying their friend’s story/anecdote.

**Awkward**
Definition: This type of laugh expresses some sort of slightly negative emotion. It can be either a laugh expressing hilarity and also some discomfort caused by what the person is laughing at, or an embarrassed sort of laughter as a result of being self-conscious

Example 1: someone may have fallen over on the street in front of strangers and laughs as a way of diffusing the embarrassment he or she feels for having fallen.

Example 2: a person may be watching a video that shows someone else getting hurt by accident but which has some sort of amusing or ridiculous aspect that they find funny. They laugh in response to this but simultaneously feel a twinge of guilt, as they know the situation they are laughing at may have been quite painful or distressing for the person in the video and laughing at that might be inappropriate.

**Fake**
Definition: A forced or planned laugh.

Example: someone laughs because they feel they have to, but not because they naturally want to.

**Not a laugh**
Definition: The person is not laughing! They may be speaking or coughing or simply listening to someone else speaking.
Appendix 8:

Post categorisation task interview responses

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>M</td>
<td>Speech / Should have been labeled Conversation</td>
</tr>
<tr>
<td>B</td>
<td>F</td>
<td>Angry</td>
</tr>
<tr>
<td>C</td>
<td>M</td>
<td>All seemed OK. Standing, felt he was not a laugh. Sitting down hilarious was much easier to spot. Abdomen movement was more noticeable than laughing and laughing. The first movement - if they were around, they would be. He perceived this to be awkward - seems like some legit movement - often difficult to distinguish. The act of laughing, when they are doing, hand movements seem a little more noticeable. If the head was going forward and they were collapsing, he considered this a facial, headless laugh. Hand movements made things much more obvious - more of a facial. A physical comedy act.</td>
</tr>
<tr>
<td>D</td>
<td>M</td>
<td>Difficult to see based on this person - only the bit, big movements were very obvious. Difficult to distinguish an obvious laugh and awkward and awkward and awkward</td>
</tr>
<tr>
<td>E</td>
<td>M</td>
<td>Not a laugh - thought they were dancing and walking. Social and awkward were hard to distinguish. If the hand or face was up and stayed up and didn’t move, they were difficult to distinguish. Awkward and awkward were difficult to distinguish.陡峭 was a bit of a challenge</td>
</tr>
<tr>
<td>F</td>
<td>F</td>
<td>Interesting but difficult without the facial expression. Some omissions were made regarding the social and awkward. Shaking hands were not always present. Shaking hands were difficult to distinguish sometimes. Sometimes were quite different - the face was more obvious. Lack of facial expression on the movement and the posture, seemed to be following a pattern more than anything. Social was a little bit, but not as exaggerated</td>
</tr>
<tr>
<td>G</td>
<td>M</td>
<td>A lot looked like petites conversations. A lot looked like they were being supplied for people - one or two were like they were ushers. Shaking was hilarious, but that was about it.</td>
</tr>
<tr>
<td>H</td>
<td>M</td>
<td>Looking at the movement, there were more visible movements and it was obvious. Awkward was more obvious. The face was the laughing. It was being recognised - small movements like a trigger. Covering the mouth.</td>
</tr>
<tr>
<td>I</td>
<td>F</td>
<td>No social and fake seeing the difference was a bit confusing. Flappy hand was the big movement to identify. Social was easy to identify. Social was quite obvious</td>
</tr>
<tr>
<td>J</td>
<td>F</td>
<td>Not a lot. There was a lot of movement. A lot of movement was noticed. A lot of movement was missed</td>
</tr>
<tr>
<td>K</td>
<td>F</td>
<td>There were movements - not very much. Some was missed. Some was quite obvious. A lot of movement was noticed. A lot of movement was missed</td>
</tr>
<tr>
<td>L</td>
<td>M</td>
<td>Generally after the first few it was easier. Took a while to get used to not having fake to rely on. He thought the categories were fine. This was the first time he was aware of the issue for the first time. Awkward was by far easiest to identify. Hardy any movement was missed. One small movement means social. Awkward was defined as awkward movement - nervous or embarrassed body movements, could be map movements crosswise then this.</td>
</tr>
<tr>
<td>M</td>
<td>M</td>
<td>Maybe something in between hilarious and social laughing was missing. Interesting in her mind would involve much bigger movements. Bending forwards and backwards was a big giveaway for hilarious. If there were back and forth movements, this would be social - this could be maybe tasks. Shoulder movement - if this wasn’t present, this was a fake laugh. Also for feminine hand flaps to indicate giggles</td>
</tr>
<tr>
<td>N</td>
<td>F</td>
<td>Difficult without people’s face. Awkward was easier - something that was happening. Awkward and awkward movements were very noticeable.</td>
</tr>
<tr>
<td>O</td>
<td>M</td>
<td>Difficult - no other type of category needed. Awkward was very easy to identify. Social and fake looked similar - open to interpretation on which. Social and fake looked similar - open to interpretation on which. Social and fake looked similar - open to interpretation on which.</td>
</tr>
<tr>
<td>P</td>
<td>F</td>
<td>Some were very unusual. They were unusual as the laughing categories. Less funny and less embarrassing - less pronounced. Less tendency to involve more the movement of the head in the scream. Also and fake didn’t want.</td>
</tr>
<tr>
<td>Q</td>
<td>M</td>
<td>Little awkward generally - some movements meant hilarious - head movement he associated with laughter. Difficult to gauge without the face. All categories were marked as being enough. Spotted head was easy to spot. Sometimes persisting but would be losing focus for a bit back and hands face less being avoided.</td>
</tr>
<tr>
<td>R</td>
<td>M</td>
<td>Some were very slow to spot. Some of them saw the facial expression. Some were difficult to see. Some were quite obvious. Quite obvious. Some were difficult to see. Some were quite obvious. Quite obvious.</td>
</tr>
</tbody>
</table>
| S           | F      | Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were difficult to see. Some were dif