Fourteen- to 18-Month-Olds Infer Intentions From Intonation: Evidence From Imitation and Looking Time Measures

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Summary of Thesis

This thesis's aim was to examine the effect of vocal intonation on mental state understanding. This thesis has found that vocal intonation provides important cues for communicating the intentions of others' to infants. The results indicate that infants rely on intonation when making attributions about other people's goal-directed behaviour. These results were first found using an imitation paradigm and extended and confirmed with a looking time paradigm. The first two experimental chapters of this thesis have shown that the tone of voice is a salient cue to mental states. Infants did not only distinguish between intentional and accidental words such as "Whoops" and "There" but they also made the distinction between intentional and accidental mental states from the intonation alone. A looking time measure has also shown promising results for the same distinction between intentional and accidental mental states. The looking time study has confirmed and extended the findings that we saw through imitation. Infants seemed able to distinguish between an intentional and an accidental intonation and looked longer during scenes where the accidental intonation was paired with the end-result. These findings are the first to report results on the intonation of accidental and intentional mental states. The results of this thesis contribute to the literature concerning intention understanding and they extend our knowledge about intonation and the significant role it plays in infancy.

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CHAPTER 1: GENERAL INTRODUCTION

This introduction aims to familiarise the reader with some of the concepts that are central to this thesis, such as intonation and intention. The first part of the introduction will look at intonation and its importance in the lives of babies and infants. I will review how intonation affects behaviour in infants and talk about the acoustical cues that influence this reliance on different kinds of intonation. In this second part of the introduction I will also introduce the concept of intention which plays an important role in organising behaviour and which allows us to interpret behaviour as a result of understanding intentions. I will consider in detail studies that have examined intention understanding and will finally talk about the aim of this thesis which is to address intention understanding through intonation in toddlers.

Intonation

1.1 Definition of Intonation

Intonation is an important aspect of communication. The tone of voice is used to express emotion and is particularly useful in conveying meaning. Intonation is often referred to as prosody and paralanguage. The tone of voice in an utterance carries the extralexical meaning, which is the meaning that we would not necessarily get from the lexical aspects of the utterance, such as the words. An example of this is in utterances that are meant to convey sarcasm or irony. Often in those situations, the person is trying to convey the contrast in their message with a sarcastic or an ironic tone of voice (Capelli, Nakagawa & Madden, 1990). In addition, intonation conveys meaning about discourse, for example, inviting the listener to make a contribution to the conversation, and about attitudes such as being condescending (Cruttenden, 1997). Intonation includes *pitch* (fundamental frequency), *duration*, and *loudness* (intensity).

According to Gussenhoven (2004), pitch is the "auditory sensation of tonal height" (p.1). Pitch results from the vibration of the vocal cords within the larynx, and is often used interchangeably with fundamental frequency. However, fundamental frequency (F_0) refers to the number of repetitions of the regular waveform within one second (Cruttenden, 1997), whereas pitch is what we can hear and which allows us to make distinctions between tones that have high and low pitch (Cruttenden, 1997). Duration refers to the length of a vowel or word or sentence both in terms of its production and in terms of the length that it is perceived to have when it is heard. Finally, intensity is concerned with the "breath force" which is used by the speaker (Cruttenden, 1997, p.2). Other definitions of intonation include the description of "the musical part of speech" (Balog & Snow, 2007 p. 118).

1.2 Intonation contours as signals for infants

Fernald (1992) reported that the intonation contours of maternal speech change according to the message the parent is trying to convey to the infant. Fernald's research revealed that these contours and the messages they convey are similar in different cultures. For example when communicating approval, mothers whose language was English, German, French or Italian tended to have high mean pitch, wider pitch range and the intonation contour in these utterances tended to be rise-fall (bell-shaped). On the contrary, prohibitions were characterised as having lower mean pitch and a narrow pitch range. Vocalisations that conveyed comfort on the other hand had a more smooth and legato quality. In addition to these qualities, when trying to engage attention from an infant, mothers used rising pitch contours (Fernald, 1992). Furthermore, more recent research appears to support that it is through associations between affective contexts and prosodic contours that infants

come to make sense of sound-meaning correspondences that lead to the communication of intention and emotion (Snow & Balog, 2002). Gradually, towards the end of the first year, the tone of voice serves as a marker of words as it highlights and helps the infant identify linguistic units in the speech stream (Fernald, 1992).

Stern, Spieker and MacKain (1982) considered intonation contours as meaningful units of information for 6 month old infants. In their study they looked at different intonation contours to examine the possibility of them acting as signals that communicated maternal intentions, motives, states and feelings. This study is particularly interesting because the researchers were interested in the communicative function of these contours and thus they looked at the interrelationship between pitch contour, sentence type and the context in which these utterances from mother to child were uttered in. Five contour patterns were identified such as sinusoidal, bell, bell right, rise and fall, however, the two that were more consistently seen in the six mothers were the rising and the sinusoidal. The rising contour was uttered in situations where the infant looked away from the mother with neutral affect, which is suggested to have as a goal to get the infant's attention. The sinusoidal contour was expressed more in situations where the infant was smiling and looking at the mother, that may act to maintain the positive affect shared between mother and child.

Similarly, Sullivan and Horowitz (1983) tested the effect that intonation has on the attention of two month old infants. In this study they used both natural and computer synthesised intonations that had a rising or falling contour. By using an infant controlled preferential listening paradigm they found that infants attended more to intonation expressed with a rising contour than to contours with a falling contour in the natural stimuli. Interestingly, the opposite effect was found for the stimuli presented with the computer synthesised intonation. In these stimuli, infants attended

more to the falling contour. One possible suggestion for these findings is that infants might not have noticed the change in contour but might have taken into account the voice quality of the computer synthesised speech. Although the researchers were not able to offer an explanation for this finding, they concluded that the naturalistic rising intonation contour of the female voice is effective in not only eliciting but also maintaining the attention of infants.

1.3 Intonation production in infants and young children

The results of research on intonation expression in adults seem to be consistent through studies. However, when it comes to intonation production in infants, the results are not so harmonious. Balog and Snow (2007) review literature on the development of intonation in infancy and early childhood and they point out the different and often contrasting nature of the results of these studies. For example, they report that some studies have found that intonation is developed by the time infants have produced their first words whereas other studies show that intonation develops in a more unstable fashion. Snow and Balog (2002) suggest that infants produce some core features of intonation before they produce two word utterances but not before they produce their first words. Although detection and understanding studies demonstrate that infants are more attentive to rising contours, when it comes to production, the pattern is different as infants tend to be able to produce the falling intonation contour earlier that the rising intonation contour. This might not be so surprising, as studies with young children have shown that even 4-year-olds have difficulty producing rising contours. A study by Patel and Grigos (2006) has found that 4-year-olds tend to elongate the final syllable of sentences when they are trying to produce questions (rising contours), rather than using higher pitch and intensity as 7-

and 11-year-olds did in this study. These researchers concluded that even at age 7 children are still developing their mastery of intensity in producing rising intonations but by 11 years, children are using mainly changes in pitch to indicate this type of contour and not so much changes in intensity and duration, which is more inline with the acoustic cues used by adults.

Similar findings about the production of rising intonation by 5-year-olds have been shown by Wells, Peppe and Goulandris (2004). However, in their study they propose that when it comes to communicative intent in speech, even 5-year-olds are able to phrase a sentence in a way that it conveys information about their intended meaning. However, this study has found that infants are still immature in their intonation production abilities in producing such meaning with intonational emphasis to aspects of sentences that give out the intended meaning (Wells et al, 2004). This study also makes an emphasis on individual difference in intonation production as they propose that even at ten years when children are reaching adult levels of prosodic development, there is still variability within the 10-year-olds development.

These findings show that intonation is a difficult part of speech to master vocally. Although production of intonation seems a complex task for young infants and children, it is on the contrary a lot easier for them to process and attribute meaning to intonation even in infancy. In the next section I will review some of the findings that show that infants can differentiate through vocal intonation.

1.4 Intonation in infant-directed speech

1.4.1 Studies on young infants' sensitivity to infant-directed speech

Infants are sensitive to vocal characteristics from the womb. Even before birth infants are able to perceive the tone of voice in human speech and shortly after birth

they are capable of discriminating between their mother's voice and a stranger's voice (Hepper, Scott, & Shahidullah, 1993). Well documented research finds that infants are not just interested in any kind of voice, in particular they prefer the high pitched infant-directed speech, in contrast to adult-directed speech (Fernald, 1985, 1991; Hepper et al, 1993). In particular studies have found that the difference between infant-directed and adult-directed speech lays in the variation in pitch rather than other aspects of intonation such as duration and amplitude (Fernald & Kuhl, 1987). Recent research has also suggested that what infants find more attractive in infant-directed speech is the expression of emotion which is more exaggerated in infant directed speech as compared to typical adult-directed speech (Trainor, Austin & Desjardins, 2000). Trainor et al. (2000) have suggested that the emotion in infant directed speech might be vital for communication.

Fernald and Simon (1984) have suggested four hypotheses concerning how infant-directed speech influences communication in infancy. The first hypothesis relates to why infants have a preference for infant-directed speech. They suggest that it may be as a result of the intonation patterns being perceptually more salient and therefore more interesting as auditory stimuli. A second hypothesis refers to the communication of maternal affect to infants. Infant-directed speech is expressed with high pitch and expanded pitch range, two acoustic characteristics that are associated with positive affect and happiness, therefore infant-directed speech could be communicating affective cues to infants. Thirdly, Fernald and Simon suggest that infant-directed speech might function as a way for infants to identify their mother. In support of this hypothesis, Mehler, Bertoncini, Barrière and Jassik-Gerschenfeld (1978) found that infants in their first month recognised their mother when she spoke with exaggerated intonation but did not recognise her when she spoke in a monotone

way. The fourth hypothesis relates to the effect of intonation on the speech perception skills of infants, and I will explore this further in the section below.

1.4.2 Intonation in linguistic development

As we have seen above, the tone of voice and in particular infant-directed speech is influential not only for being an attractive stimulus that infants like to listen to, but as we will see below, it also functions in helping infants attain the perceptual basis of the language they will later learn to speak. The tone of voice plays an important role in the perceptual and parsing abilities of young infants as it aids in their attempts to parse spoken language, an important first step on the path to making sense of spoken language. This is supported by recent research which shows that infant-directed speech facilitates word segmentation skills (Thiessen, Hill & Saffran, 2005). These researchers point out that although infants are able to segment adult-directed speech, they are better in segmentation with infant-directed speech which suggests that this type of speech might provide faster and more efficient learning for infants. A second interesting function of infant-directed speech which could facilitate aspects of speech is the capacity of infant-directed speech to maintain infant attention. Attention plays an integral part in learning because it provides infants with the necessary concentration for them to perceive and process information. Thirdly, infants' word recognition abilities appear to be related to the emotion contained in speech (Singh, Morgan & White, 2004). It has been found that positive affect, as expressed in the voice, has a greater impact on the recognition abilities of infants at around 7.5 months than neutral affect. Infants in this study were habituated to words expressed in happy or neutral affect. These words were later presented in passages that were spoken in neutral or happy affect. Young infants of 7.5 months were able to

recognise the words they had been familiarised with when these words were presented in passages expressed with the same affect as the familiar word. Slightly older infants, 10.5-month-olds were even better at recognising both happy and neutral words when these were presented in a neutral passage and happy and neutral words when these were presented in a happy passage. Together these results demonstrate that intonation serves a central function to the linguistic abilities of young infants.

1.4.3 Effects of intonation on infant behaviour – social referencing studies

In addition to being a signal for aspects of language, intonation also plays a role in regulating infant behaviour. One of the paradigms used to study this regulating effect is the social referencing paradigm. In social referencing situations, studies are formulated in a way in which infants have to seek out signals from others on how to proceed in a strange situation. This procedure has been utilised to examine how infants use emotional cues, especially from their caregivers in order to regulate and guide their own behaviour. In these studies infants are presented with strange toys and they are given either facial, vocal, or bimodal cues from their parents that either encourage or discourage toy exploration. Researchers then look at the amount of toy exploration infants choose to carry out with each cue (Hornik, Risenhoover & Gunnar, 1987; Mumme et al., 1996). For example, Moses, Baldwin, Rosicky & Tidball (2001), examined the behaviour of 12- and 18-month-olds in a novel toy situation with the positive emotion of excitement and the negative emotion of disgust. Infants in this study engaged more with the toy if the experimenter regarded it with positive intonation than when she referred to it with a negative tone of voice. In addition, they found that infants looked longer at the face in the disgust expression and they propose that it might be the result of the children taking longer to assess

whether something that was there in front of them was also something that they should not make contact with (Moses et al., 2001).

Similar studies using nonverbal cues have been conducted using the visual cliff method. In the visual cliff paradigm, infants receive cues that encourage them to cross or not cross what appears to be a drop or a cliff (Sorce, Emde, Campos, Klinnert, 1985; Vaish & Striano, 2004). While most studies that have used the social referencing paradigm had focused on facial cues, three studies, two using the "strange toy" paradigm (Moses et al. 2001; Mumme et al., 1996) and one using the "visual cliff" paradigm (Vaish & Striano, 2004) have been able to exploit the contribution of visual and vocal cues on regulating the behaviour of 12- and 18-month-olds. There is evidence that suggests that during the first year of life infants are more responsive to the tone of voice than facial expressions, as the mother's voice in social referencing situations is more effective at controlling infant behaviour than her face (Mumme, Fernald & Herrera, 1996; Vaish & Striano, 2004). One reason for this greater sensitivity to the voice might be attributable to infants' inability to understand words. Consequently the tone of voice which is a dynamic stimulus may become their primary channel for communication. These studies have found that voice cues on their own generated less "strange toy" exploration and more crossing over the cliff, unlike the facial cues which were not as effective in regulating infant behaviour.

1.5 Developmental changes

1.5.1 Developmental changes of reliance on intonation in infants and young children.

This section focuses on some studies that have shown developmental changes in the reliance on intonation. It has been argued that intonation has a U-shaped

function in infancy and that reliance on intonation changes in relation to language acquisition (Friend, 2001). It is therefore important to review these findings because the age range of the participating infants in this thesis incorporates the stage at which infants are acquiring their first words.

One study that has examined the relation of intonation with word learning was conducted by Margaret Friend (2001). This study examined the significance of affective messages on the regulation of behaviour in infants. This study's design utilised both congruent (facial and vocal paralanguage was consistent with the lexical content) and incongruent (facial and vocal paralanguage was inconsistent with the lexical content) messages for prohibiting and encouraging 15-month-old infants to play with four novel toys. The study found that on the average, infant behaviour was regulated by facial and vocal paralanguage, as infants approached and played longer with the toys when the paralanguage was approving than when it was disapproving. However, comparisons between language level (as measured on the vocabulary inventory CDI) and reliance on lexical or paralinguistic cues revealed that behaviour was better regulated by the lexical cues for infants who had a higher receptive vocabulary and comprehended more stimulus words. This result is consistent with preliminary support by Lawrence and Fernald (1993; as cited in Friend, 2001) who studied behaviour regulation in 9- to 18-month-olds. They found that the behaviour of 9-month-olds was better regulated by the paralinguistic cues than by the lexical cues, whereas the behaviour of the 18-month-olds was regulated by the lexical content of the stimuli.

Across the span of childhood, similar changes in reliance have been observed. Two studies that examined changes in dependence on intonation and lexical cues were performed with children between 4 and 10 years (Friend, 2000; Friend & Bryant,

2000) and adults (Morton & Trehub, 2001). The paradigm used in these studies presents participants with conflicting lexical utterances such as "I got an ice cream for being good" being expressed in a negative tone of voice. These studies found that 4-year-olds relied on the lexical cues when making judgements on how the speaker was feeling whereas 10-year-olds and adults based their judgements of how the speaker was feeling from the tone of voice. These researchers concluded that young children have an understanding of the role of vocal emotion in communication because when they were presented without the lexical cues (e.g., low-pass filtered speech or foreign language) even the 4-year-olds were able to offer correct answers as to what the intonation expressed. The difficulty tends to be in the conflicting cues, something that suggests that young children might have a bias or selective attention towards lexical cues, or an inflexibility which does not allow them to take both lexical and intonation cues into account when making judgements about people's emotions (Friend, 2000; Morton & Trehub, 2001).

One other conclusion from these studies is that children might have not acquired knowledge about the importance of coordination of intonation and lexical cues in communicating information about the underlying meaning such as for ironic and sarcastic messages (Friend & Bryant, 2000; Pexman, Glenwright, Hala, Kowbel & Jungen, 2006). Another possibility is that children might have difficulty integrating the vocal and the verbal information, and therefore, they find it hard to judge the emotion in the intonation when the emotion in the verbal content is conflicting. Although one would expect a linear progression in children's focus from one cue to another over developmental time, this does not seem to be the case. Instead, the development of the focus on intonation and lexical content seems to be characterised by a U-shaped function. Friend's (2000; 2001) studies show clearly that infants begin

to pay attention to the tone of voice during their first year and then in the second year they tend to focus their attention to words, while later at 10 years, they again seem to focus more on the intonation than on the conflicting message of the lexical content. According to Friend (2004) in the first year, attending to nonverbal cues allows infants to form the basis for communication. Later in their second year their attention shifts to language which is a more mature function and which demands more from the infants in order to be acquired. In addition, later on at age 10 we can see a shift again towards intonation which could suggest that as children have acquired language they might shift again to more subtle aspects of communication such as those conveyed through the tone of voice.

1.6 Intonation and mental states

1.6.1 Intonation expresses emotions; does it also express mental states?

As we have seen in the previous sections, intonation is often linked with the expression of emotions and moods. However, intonation can go beyond just indicating the emotions of other people. It can also be used in the expression of attitudes and mental states. For example, Cruttenden (1997) argued that intonation can be used to show attitudes and often linguistic features of speech such as indications of when it is another person's turn to talk. These ways in which people manipulate their intonation can give us vital indications about their intentions, desires and beliefs. Intentions, desires and beliefs are often described as mental states. They are called mental states because they refer to internal states of one's mind, often thought as unobservable which can be inferred or deduced through actions and behavioural indicators. We propose that the tone of voice can be one behavioural

indicator of these mental states, as it can be a channel for making these mental states into observable entities.

Research with adult participants has been carried out on their ability to recognise emotions and mental states from the tone of voice. According to Scherer (2001), for a concept to be identified as emotion, it needs to fit all five of the following categories. First, there needs to be a subjective feeling, second, there has to be an expression of that emotion, third, there should be a cognitive appraisal and evaluation of that emotion, forth, there should be physiology associated with the emotion and fifth, there should be an action tendency. Although I would agree with Scherer on the first 4 points, I disagree on the last point as sometimes we might feel an emotion but we might not be able or not willing to act on it. Some concepts such as happiness and sadness which belong to the basic emotions category can be more automatic and recognised without a lot of conscious input. However concepts such as the mental states of intentions, desires and beliefs might be more difficult to identify. This might be because mental states are more cognitive in nature and might involve more conscious input from the receiver in order to infer a mental state than a basic emotion. In addition, mental states might also be more difficult to identify if the context is not available to the individual. Mental states on one hand might be related to the family of emotions but they might need more cognitive processing because they are more difficult to discern. However some of the more complex emotions, such as frustration might be more difficult to understand and identify because they might require more cognitive processing such as appraisal of the mental states of the person experiencing that emotion. For example when one is trying to understand why he or she is feeling frustrated they might try to appraise their situation in terms of whether something that they wanted or intended was met or not. Therefore, this supports that

mental states might require more processing than emotions. Golan, Baron-Cohen, and Hill (2006) looked at the identification abilities of a control group of typical adults and a group of adults with high functioning Aspergers syndrome. This study showed these participants both facial expressions and vocal utterances of different emotions (such as 'afraid', 'angry', 'sad' and 'happy') and different mental states (such as 'unsure', 'touched' and 'kind') and gave participants multiple choices for the identification of these emotions and mental states in the two perceptual modalities. The results revealed that the control adults did not have difficulty recognising these emotions and mental states both in the face and the voice. The participants with Aspergers syndrome however experienced difficulties with more complex emotions and more complex mental states compared with more simple emotions and mental states. It is also important to note that these participants were matched for mental age and IQ.

Intonation has also been used to examine mental states in sarcasm and irony. Sarcasm and irony refer to situations where what is said is in contrast to what is being meant. These studies suggest that children and adults may be using the tone of voice as a tool to aid them to understand the intentions of others when they are making sarcastic and ironic remarks (Capelli, Nakagawa & Madden, 1990; Happe, 1995; Bryant & Fox Tree, 2002). In one such study, Capelli et al. (1990) found that sarcastic intonation cues facilitated children's recognition of sarcasm whereas contextual cues had less of an effect. However, other studies have revealed the opposite results (Winner, Windmeuller, Rosenblatt, Bosco, Best & Gardner, 1987).

1.6.2 Infant discrimination and recognition of emotions and simple mental states

The ability to discriminate between emotions is one that arises early in infancy. Walker-Andrews defines discrimination as "the ability to tell the difference between two or more objects and events" (1997, p. 437). Infants as young as five months have been found to discriminate between a sad and happy vocal expression as tested in a habituation paradigm (Walker-Andrews & Grolnick, 1983). Another study that has shown that infants are potentially sensitive to the tone of voice as they recognise it to be a human trait was conducted by Walker-Andrew and Lennon (1991). In this study 5 month olds were habituated to the vocal emotions of sadness, anger and happiness and they were also presented with a facial expression that matched the emotion or a facial expression that did not match the emotion or to a checkerboard. The infants in this study discriminated between the emotions when these were matched with a facial expression but not when these emotions were presented with a checkerboard. This is an interesting study which brought the researchers to the conclusion that the presence of a face directs infants' attention to the affective quality of the face and that in previous studies that used checkerboards the infants could had been discriminating just on the basis of acoustic differences in the stimuli but not on the basis of affective meaning. However, if infants in this study were recognising the affective meaning of the vocal stimuli, it potentially suggests that infants were doing something more than just discriminating between the stimuli. It suggests that infants were recognising something about the meaning behind a happy sounding stimulus. Walker-Andrews (1997) defines recognition as "more than detection and discrimination; it involves the person interpreting how someone else will act based on the "expression" in one's face, voice and gestures" (p. 437).

Other studies have tried to examine how intonation may come to describe the mental states and attitudes of adults to infants. In particular, Fernald draws attention

to the role prosodic patterns in maternal speech come to play in communicating maternal intentions. These communicative intentions from mother to infant have been examined in studies on elicitation of attention, expressing praise and showing approval and prohibition to infants. According to a model proposed by Fernald (1992), in the first year of life maternal intonation in the form of infant-directed speech acts as an attention elicitor for infants, as it modulates arousal and affect and communicates emotional meaning. This infant-directed speech paired with the emotional features of caretaking might communicate to infants that it is advantageous for them to focus on infant-directed speech, and as Fernald (1992) has proposed, infant-directed speech has the function of alerting, soothing and offering enjoyment to the young infant, whilst later it helps to direct attention and moderate emotion. This is later followed by a period in which combined with facial and vocal expressions grant "initial access to the feelings and intentions of others" (p. 403) (Papousek, Bornstein, Nuzzo, Papousek & Symmes, 1990).

1.7 Summary of Section

In this section we looked at intonation and how the acoustic characteristics in the voice can help to give additional meaning to what is being said. We also saw how important intonation can be in the first months of life, before infants acquire language. In these sections it was evident that intonation can influence the behaviour of infants. Intonation can give information about the emotions of others but in addition it can also be indicative of people's mental states such as their attitudes, their desires, intention and beliefs. Intonation therefore plays a very important role in communication and in social cognition more generally.

Intentions

1.8 Definitions

Another primary consideration of this thesis will be one specific mental state, that of intention. According to Malle, Moses and Baldwin (2001) intentionality is linked to actions in the sense that action is directed towards events, and therefore, intentionality allows us to detect structure in the complex world of movement around us. This then allows us to organise social interactions because it helps us explain the behaviour of other people in terms of its underlying mental causes (Malle et al., 2001). Malle et al, (2001) also make an important distinction between intentions and intentionality. They proposed that, intentionality is a quality of actions that are purposeful, whereas intention is an agent's mental state that represents such actions. People's mental states can sometimes arise before the execution of the action and sometimes they take place without the presence of any action. They therefore posit that for this reasons we can sometimes ascribe intentions to other people without having to also make judgements as to their intentionality.

1.9 Routes to Intention Understanding

The age at which infants come to understand and infer mental states such as intentions is often, as some continuous theorists claim, early in development, and is an ability that allows infants to perceive other people as intentional beings, even from the first months after birth (Legerstee, 2005). In contrast, discontinuous theorists believe that the ability to infer intentions arises in the end of the first year when they begin to attribute actions to the achievement of goals. Discontinuous theorists are often criticised that they do not provide the origins and the mechanism by which this intention understanding comes about, as well as the impact social interaction plays in

infants' ability to understand intentions. However, some other researchers provide some explanation on how intention understanding arises in accordance with other developmental abilities (Legerstee, 2005). The following sections cover some of the proposed routes for intention understanding. Some of the researchers propose nativist approaches that span from emotions and intersubjectivity to perception of actions. Others propose a non-nativist approach where infants gain an understanding of intentions through more cognitive mechanisms such as the understanding about goals and as a result of understanding other people's intentions (Tomasello, Carpenter, Call, Behne & Moll, 2005).

1.10 Perception of intersubjectivity

The researchers who posit a continuous developmental trajectory in intention awareness often project an understanding of other people as intentional from an early age sometimes even from birth. Trevarthen (2001) for example suggests that this is seen when infants and their parents engage in protoconversations. Protoconversation refers to the phenomenon seen in the first months of an infant's life where the parent and the child take turns in smiling, cooing and talking/babbling, which appears like a conversation between the parent and the child. Trevarthen suggests that infants are able to engage with others from birth because they are equipped with the ability to perceive emotion and engage in cooperative interactions by reading the emotions, motive states and movements of people, which explains infants' ability to contribute and use turn taking in protoconversations (Trevarthen, 2001).

Other researchers who have proposed innate mechanisms in infancy, such as Maria Legerstee, suggest that infants are born with an affect sharing device (AFS). This device is composed of three components which interact with one another. These

components are the ability of infants to infer their own emotions, their ability to infer the emotions of other people and thirdly the ability to have a sense of emotional attunement. Therefore, when infants are seeing others express different emotions towards them they are able to reflect those emotions back through this AFS mechanism (Legerstee, 2005). This hypothesis is similar to that of Meltzoff and Moore (1977). Meltzoff and Moore (1983) have suggested that the mechanism that allows newborns to imitate the facial gestures of adults, such as their tongue protrusions and mouth openings, is facilitated by the mechanism of active intermodal matching. This mechanism allows infants to perceive others' actions (in this case facial movements) and via their intermodal abilities they are able to perceive those actions and produce them themselves. In addition, the "like me" hypothesis that was proposed by Meltzoff proposes that infants interpret others as intentional being because they see themselves as intentional beings. In a recent paper Meltzoff gives the example of an infant wanting to grasp something and seeing another having a similar desire and reaching to grasp a cup in a similar way. Therefore, for Meltzoff, having an innate mechanism that allows infants to interpret the actions of others in terms of their own experiences is what helps infants to gain an understanding of other people's mental states (Meltzoff, 2007).

1.11 Perception of action

Malle, Moses and Baldwin (2001) proposed that infants might get a headstart in their understanding of intentions through a framework where they witness the intentionality of others through their actions, and specifically self-propelled motion. The literature on action perception proposes two broad accounts for the development of understanding of action. Some researchers suggest that understanding of actions

comes early on in development from the first few months of an infant's life. In some studies, researchers have shown that infants are sensitive to actions that are projected towards objects. For example, Woodward has shown that infants as young as 6 months perceive human hands to be directing their action towards an object that they had grasped in the past and not towards a new object (Woodward, 1998). Also, infants attribute goal directed behaviour to grasping actions but not back of hand actions. In addition, Woodward and her colleagues have found that infants of 7 and 12 months do not recognise the hand to be directed towards objects when properties of the hand are changed, such as wearing a glove. However, when infants were explicitly shown that the glove is worn by a human agent, they were able to attribute intentionality and goal directed behaviour to the hand action (Guajardo & Woodward, 2004). Whereas some researchers such as Woodward support that very young infants are able to attribute goal directedness to human agents and familiar actions such as grasping, others have proposed a "wide scope" approach.

In contrast, Gergely and colleagues put forward the hypothesis that young infants understand actions that are unfamiliar (such as back of hand actions) because they are equipped with an abstract and domain specific action representation system, which they called the teleological stance (Gergely, Nadasdy, Csibra & Biro, 1995). The teleological stance assumes that goal directed actions and agents are rational and change in accordance to the affordances in situations, as well as having change on the end state of the situation. The conclusion about the teleological stance was attained with infants between 9 and 12 months. Gergely and colleagues thus criticised the studies by Woodward because in those studies the attainment of the goal was not followed by a movement in the actual toy but instead the hand or the other unfamiliar grasping movements remained static on the toy and the event would end like that.

Therefore, according to Gergely and colleagues, there was no rationality involved in these events as the toy object was not moved, and thus Woodward found results for the human agent's familiar actions and not the unfamiliar actions. According to Gergely and colleagues, if there was a rational goal attainment and change in the end state, the infants would have attributed goal directedness to both the familiar and unfamiliar actions (Kiraly, Jovanovic, Prinz, Aschersleben & Gergely, 2002). In fact these researchers also suggested that the reason why Woodward found the result of longer looking at the same toy but in the new location was because of the fact that the toy was in a new location and thus there was a change in the location, something that they had not seen during habituation.

Similarly to Gergely and colleagues, other researchers have found that understanding action might be related to goal and intention understanding. Infants are sensitive to the biological motions of others and research has shown this infant ability to perceive discrepancies when the motion is interrupted. In a study by Baldwin, Baird, Saylor and Clark (2001), a woman was shown reaching to pick up a cloth towel that was on the floor. Using a looking time paradigm they examined whether 10- to 11-month-old infants would look longer when a pause was inserted during a scene where the woman was half way between reaching and grasping the towel or whether they would look longer at the scene where the pause was inserted at the end of the completed action of the woman successfully picking up the towel and hanging it from a rail. Their hypothesis was confirmed as infants in this study looked longer at the video which had the pause at the moment when the woman was going to perform her intention, i.e., grasp the towel. These researchers suggested two types of explanations, a low level and a high level explanation as an account of their results. The high level explanation is in terms of an understanding of the actor's intention and

the goal that she has, which they see as arising in a top-down manner. On the other hand, the low-level explanation involves perceptual skills and so in this interrupted intention video they might expect the person to locate the object, initiate contact with it and then release it, an explanation that is regarded as identifying structure in action. These researchers believe both these mechanisms are involved in children's understanding in this study and propose that the low-level perceptual mechanism might be a prerequisite for the higher-level intention inference mechanism (Baird & Baldwin, 2001).

This distinction between being aware of something only in perceptual terms and understanding something in a more inferential manner has received attention by different researchers. One of the problems that the account of perceptual structure faces is that the amount of intentional behaviour that an infant will come across varies in great extent. There are ample studies that have shown that similar actions can indicate the same intention unless they are followed with a verbal or nonverbal indication as to the intention of the person performing that action (Carpenter, Akhtar & Tomasello, 1998). Therefore it seems difficult for such an account to encompass the different intentional actions and behaviours that people elicit.

1.12 Perception of goals

On the other hand researchers who subscribe to a different school of thought propose that intention understanding arises later in development, around the age of 9 months and it develops in conjunction to joint attention processes and the ability to form triadic interactions between the infant, another person and an object. These researchers propose that an understanding of intentions derives from an understanding about goals. An extended amount of research has established that infants and

children interpret behaviour in terms of goals (Carpenter et al., 1998; Carpenter, Call, & Tomasello, 2005; Meltzoff, 1995; Gattis, Bekkering & Wohlschlager, 2002). Gattis et al. (2002) suggest that the studies on infants' understanding of intentions reveal that infants interpret behaviour in terms of goals, the mental, nonobserved inferences that one draws and which guide one's behaviour. A lot of these studies were conducted using the behavioural re-enactment procedure where infants are reproducing the direct understanding of their observation, and as the findings indicate, infants reproduce the outcome that the experimenter is trying to achieve rather than the surface behaviour that might arise out of an accidental or unsuccessful attempt to reach that outcome (Carpenter et al, 1998; Meltzoff, 2002). For example, in the Carpenter et al. (1998) and Meltzoff (1995) studies infants saw an adult perform actions that were indicated as accidental or intentional (either with lexical cues or hand movements) and the infants were able to correctly perform on the task because they relied on observable information such as the direction of movement and the adult's words or nonverbal exclamations in order to pull out meaning about the nonobservable intentions of the adult (Gattis, 2002). In these studies therefore, infants were able to draw inferences based on what the experimenter's goal was and whether it was achieved or not. In the case of the experimenter in the Meltzoff study who was trying but failing to pull apart a dumbell, the infants inferred the unobserved goal which was to separate the dumbell, so when it was their turn on the task, they were able to fulfil the goal of separating the two parts. This classic study has often been criticised for being aided by stimulus enhancement and emulation learning for the affordances of the stimulus (Charman & Huang, 2002). However, other researchers have shown that the intention understanding exhibited in this task is found in 18- and 15-month-olds but not so competently in 12-months-olds, which could question why

these other forms of social learning are not functioning at the younger age group (Bellagamba & Tomasello, 1999; Bellagamba, Camaioni & Colonnesi, 2006).

Another study that examined goal understanding in 12- to 18-month-olds showed that depending on the context infants attribute different goals to similar situations. In particular, Carpenter et al (2005) showed these infants a toy mouse that either hopped (with beebeebee sound effects) or slid (with beeeeee sound effects). There were also two conditions, a house and a no house condition. In the house condition, the infants saw either the hopping or sliding movements of the mouse (with sound effects) going into one of two houses. In the no house condition the houses were absent so the infants only saw the hopping or sliding (with sound effects). The results of this study showed that in the house condition infants interpreted the goal to be "putting the mouse into the house" as they ignored the hopping and sliding and directly put the mouse in the house. However, in the no house condition, infants interpreted the goal to be the "hopping" and "sliding" as infants produced sliding and hopping actions and sometimes even the sound effects associated with that. This study thus shows that infants' learning about goals is flexible and their plans of actions can change according to their interpretations of goals.

Wellman and Phillips (2001) also suggested that what manifests intentionality in behaviour are action directedness and action connectedness. The action directedness feature of behaviour refers to the behavioural movements towards certain objects but not others such as a hand reaching for a cup. Additionally, action connectedness refers to the distinctive connections that go along with intentional behaviours, such as a turn of the head and body towards the cup and a happy facial expression at reaching the cup or a negative expression at not being able to reach the cup. These facial expressions may be supplemented with vocal expressions such as

"Yes!" or "Oh!" Researchers suggest that action directedness arises earlier than action connectedness (Phillips, Wellman, & Spelke, 2002; Wellman & Phillips, 2001; Woodward, 1999). These emotional-cognitive reactions (as Wellman and Phillips (2001) call these facial, verbal and vocal expressions), together with the object directedness (such as the hand reaching for a cup) are what manifest and identify intentions. Some recent studies seem to reinforce this argument. In a study, Behne, Carpenter, Call and Tomasello (2005) had an experimenter hand toys to 9-, 12- and 18-month-olds and they found that infants became more impatient when the experimenter was unwilling to give them a toy, by teasing them (e.g., by smiling in a teasing way). On the contrary, infants who had seen the experimenter trying but being unable to give them the toy, because she accidentally dropped it (e.g., by having a facial expression of surprise and frustration), appeared to be less impatient. This study also examined the responses of 6-month-olds but found that infants at this age were not able to differentiate between unwilling and unable actions. The conclusion drawn from this study is similar to the abovementioned findings, which point out that infants as young as nine months are able to understand the goal-directed actions of an adult, and the facial expressions connected to this.

Another important aspect of goal understanding in infancy arises from the ability to use communicative intentions. For example, in a study 14-, 18- and 24-month-olds saw an adult either pointing or gazing towards a box to indicate that there was a toy hiding inside the box, or pointing and gazing but in an absentminded nature (noncommunicative) towards the box. This study found that in the communicative intention conditions children of all age groups were able to correctly find the hidden toy. In comparison, when the experimenter was pointing or gazing in a noncommunicative way, the children searched equally at both locations (Behne,

Carpenter & Tomasello, 2005). This study shows that in understanding communicative intentions, infants display an understanding of others as intentional being who have intentions and who will communicate those to another being. It also emphasises the significant difference between low level attentional cuing processes such as noncommuncative points and gazes and the influential effect of a similar point of a communicative nature. This knowledge of communicative intentions is therefore very important for infants, as it contributes to their awareness of why people do and enhances their attempts to make sense of the world (Behne et al., 2005).

1.13 Tomasello et al's model of intentionality

One model for intention understanding has been posed by Michael Tomasello. This thesis focuses on this model because it is the most complete model which explains intention understanding and its development and there is ample data to support this developmental model. Tomasello proposes that human infants develop skills of shared intentionality within the first and second year of their lives. They do so by their capacity to understand others as animate, goal directed and intentional agents who have a species specific motivation to share emotions, experience and activities with other people (Tomasello et al, 2005). According to Tomasello and his colleagues, what distinguishes us from nonhuman primates is not our ability to perceive others as having intentions or having attentional states, but rather our motivation to share our intentions with others and thus participate in shared intentionality which is an integral part of our human culture.

Although this model focuses primarily on intention understanding as it arises around the first year, it also attempts to explain the developmental progression from early infancy to early childhood, and in addition it describing how this intention

understanding develops from understanding others as intentional beings to communicating and sharing intentions. The advancement of understanding others as intentional beings begins from an understanding of animate actions such as self-propelling actions and motion, and slowly perceiving actions as being directed towards objects and people in the world. In turn, this understanding becomes more sophisticated as infants begin to understand that people attend to things. Around the age of 9 months infants also become capable of joint attention themselves which allows them to become more socially and cognitively involved with other people and their surroundings. This understanding then grows as infants begin to understand that people have goals associated with aspects of their environment, and that they will work towards the achievement of these goals. When gaining an understanding of goals infants also gain knowledge about intentions or the plan of action towards the goal. Understanding that people are intentional and that they have distinct intentions that they direct towards the accomplishment of their goals gives infants a more complete awareness about why people act in certain ways in different contexts (Tomasello et al, 2005). In learning about culture Tomasello and colleagues proposed that infants may learn from others around them by using different forms of social learning, depending on their inferences about others behaviour, such as they might use imitation to copy salient behaviour that might be beneficial to them in different contexts.

1.14 Understanding intentions measured through imitation

Infants' understanding of the intentions of others has often been demonstrated in studies that use imitation paradigms to assess what infants understand. Imitation is one of the mechanisms of social or observational learning and is important because it

allows infants to acquire skills efficiently unlike other types of learning such as associative learning. Want and Harris (2002) explicate different types of social learning, among them local enhancement, stimulus enhancement, emulation, mimicry and imitation. Local enhancement refers to the interest brought about in a particular location where one has seen another performing an action. Stimulus enhancement refers to the interest that is instigated from the object being used to obtain a certain goal. Emulation learning is concerned with learning about the properties of objects or the causal relations between objects, as in the case for example of a chimpanzee watching how termites are extracted though putting a stick down a termite mound. In watching this the chimpanzee can understand something about the affordances of the stick (being long and lean) and also may understand something about the causal relations involved in the situation, for example that termites get attached to the stick when that enters the mound. By emulation learning then, chimpanzees can choose their own object with similar properties and carry out similar actions (Want & Harris, 2002). Mimicry involves copying actions without necessarily knowing or understanding the goal behind those actions. Imitation on the other hand entails that the person imitating has an understanding of the overall goal and the specific intentions or plan of action for achieving that goal.

Imitation is a very powerful tool in developmental psychology because it is one of the nonverbal procedures that allow us to establish what it is that infants are aware of. Imitation is particularly important in assessing intention understanding as studies have shown that children copy differently depending on their understanding of the task, the goals and mental states that they infer from the demonstrations. For example, through the use of imitation paradigms we have learned that infants interpret the behaviour of people as rational as a study by Gergely, Bekkering and Kiraly

(2002) has shown. In this study an experimenter turned on a push light that was on a table with the use of her forehead. This experimenter sat on a chair in front of the light and then leaned and turned the light on with her forehead. There were two conditions in this study. In one condition the experimenter had her hand free and laid them on the side of the box where the touch light was on, whereas in the other condition her hands were occupied because she had a blanket on her shoulders and she was holding together the two parts of the blanket. Fourteen-month-old infants who had seen the hands free demonstration turned the light on with their forehead. The infants who had seen the hands-occupied demonstration turned the light on with their hands. The researchers concluded that infants in the hands free condition considered the goal of the experimenter as to turn on the light with her forehead since she had her hands free but decided not to use them. On the other hand, the infants who saw the hands-occupied demonstration interpreted the goal as turning on the light, but because the experimenter's hands were not free since she was holding the blanket, and because their hands were free, they used their hands to turn on the light. Therefore, the infants interpreted the goal of the experimenter and used rational imitation to achieve this inferred goal. The results of this study were recently replicated with younger children, 12-month-olds who selectively copied the intentions of an experimenter depending on whether the experimenter was able or not (Schwier, van Maanen, Carpenter & Tomasello, 2006).

Similarly, in the study mentioned by Carpenter et al (2005) the infants imitated differently according to their understanding of the goal. Thus when there was a house present, infants as young as 12 months imitated differently according to the goal they inferred in each condition. In the no house condition they interpreted the goal to be the specific hopping movements and sounds, whereas in the house

condition, they interpreted the goal to be putting the dog into the house and because of this infants did not imitate or copy the hopping movements and sounds. Studies with older children also reveal that understanding goals and intentions and using imitation to match those goals and intentions is something that happens throughout childhood.

Overview of Thesis

1.15 Summary of previous research and open questions

The findings examined thus far testify to the important role that an understanding of intentions has on the developing infant and how the perception of acoustics becomes a more sophisticated source of information that contributes to communication in the lives of young infants. However, despite a lot of research some questions still remain unanswered. For example, we know that infants are sensitive to the tone of voice from birth and that they are able to discriminate between different acoustical characteristics. At the same time we know that infants are very sensitive to various physical properties of the world such as object shape and size, and sounds objects make among other things. What we are still unclear about is whether infants are able to evaluate and infer the behaviours of others, and more specifically intonation, and whether they use this to come to a realisation about other people's intentions. Taking into account the important role the tone of voice plays in the life of the developing infant, it is important to examine first whether infants can use the tone of voice to infer another person's intention and secondly to examine what aspects of the tone of voice it is that infants find salient and which allow them to interpret these intentions.

1.16 Aims of thesis

This thesis will investigate the development of an understanding of intentions as expressed through the tone of voice. In particular it will examine whether infants can understand the mental states of others when they are expressing purposeful acts and accidental acts through intonation. In addition the thesis will examine mimicry and imitation and will look for differences in the instrumental and social functions in which infants use mimicry and imitation. Finally, the thesis will examine the understanding of mental states from intonation in a looking time study and compare the findings to those of an imitation paradigm.

1.17 Experimental paradigms and studies

This thesis will utilize two different experimental paradigms. In order to observe intention understanding we drew on an existing paradigm that successfully investigated infant responses on toys that resulted in a fun outcome. This paradigm is an imitation or behavioural re-enactment paradigm which posits that children will copy actions according to the understanding about their meaning. Carpenter, et al. (1998) used this paradigm and found that 14- to 18-month-olds were able to distinguish between intentional and accidental actions. The second paradigm utilised in this thesis is a looking time paradigm. This method has been used extensively with young infants and has revealed capacities in infants at a younger age than imitation paradigms do.

The second chapter of this thesis will examine 14- to 18-month-olds' understanding of intentions through verbal cues and intonation. The first study will be a replication of the Carpenter et al. (1998) with the verbal cues of "Whoops" and "There" to establish the finding for the use of this paradigm. The second study will

examine an understanding of intentions but through nonverbal, vocal cues by using foreign words and intonation as an indication of intentional and accidental behaviour. The third chapter will look at 14- to 18-month-olds' understanding of intentions from intonation but with an altered version of the Carpenter et al. study. This study will assess intention understanding through pre-recorded demonstrations in an attempt for better control in the presentation of specific vocal cues that have been pre-rated by adults. The fourth chapter will examine more closely what 18-month-old infants find salient when making judgements about the intentions of others and in particular it will look at the role that valence might have on the children's responses. Finally, the fifth experimental chapter will look at intention understanding in 14-month-olds using a looking time paradigm and how this relates to actual performance on an imitation task.

CHAPTER 2: INFERRING INTENTIONS FROM INTONATION: EVIDENCE FROM IMITATION OF LIVE DEMONSTRATIONS

2.1 Introduction

Ever since the term *theory of mind* was coined by Premack and Woodruff in 1978, a wealth of developmental studies has investigated the trajectory of when children begin to attribute mental states to themselves and others around them. Recent advancements in nonverbal methods have established evidence for some aspects of mental state understanding in children as young as nine months (Behne, Carpenter, Call & Tomasello, 2005; Carpenter, Call & Tomasello, 2005).However, we still have little understanding of *how* children begin to attribute mental states, such as intentions, desires and beliefs to other people. The aim of the current set of studies was to investigate the contribution of intonation cues to infants' understanding of mental states.

One well-documented set of cues that infants use to infer mental states is visual information about other people's bodily actions, and the consequences of those actions. Habituation studies have shown that infants as young as 6 months are perceptive to goal directed hand movements (Woodward 1999). A second possibility is that infants can also use facial cues to infer others' intentions (Olineck & Poulin-Dubois, 2005).

The set of studies presented here investigate a second possibility, that infants use acoustic information, in particular the prosodic features of human speech, to infer mental states. Prosody (or intonation) encompasses several acoustic characteristics of speech, such as pitch, intensity, and duration that convey meaning, attitudes, and emotions (Cruttenden, 1997; Ladd, Silverman, Tolkmitt, Bergmann & Scherer, 1985).

Prosody also facilitates word segmentation (Thiessen, Hill & Saffran, 2005). Based on this evidence, and studies demonstrating that infants are responsive to human speech (Fernald, 1985, 1991, 1992), we reasoned that prosody might also underlie inferencing about intentions. Although infants can use facial cues to infer intentions (Olineck & Poulin-Dubois, 2005), studies of social referencing suggest that vocal cues might be more informative to infants than facial cues as they have a greater effect at regulating infant behavior (Mumme, Fernald & Herrera, 1996; Vaish & Striano, 2004).

We utilized a paradigm developed by Carpenter, Akhtar and Tomasello (1998) to investigate toddlers' imitation and intentions. The Carpenter et al study examined whether infants between the ages of 14 to 18 months are able to distinguish between intentional and accidental actions. In their study, an experimenter performed two actions on a toy. The accidental actions were indicated with "Woops!" and the purposeful actions with "There!" Carpenter et al found that infants reproduced more intentional than accidental actions. This paradigm allowed us to compare the contribution of lexical and intonational cues to infants' understanding of others' intentions. We hypothesized that infants will utilize the information conveyed by the intonation cues and would thus produce more actions indicated by the intentional intonation compared to actions indicated by the accidental intonation.

Study 1: Lexical Cues

In order to evaluate the methodology used in the Carpenter et al. (1998) study we carried out a replication of their study. We wanted to focus on the Accidental–Intentional (A-I) and Intentional–Accidental (I-A) conditions so we excluded the Intentional–Intentional condition.

2.2 Method

2.2.1 Participants

Twenty-two infants (10 boys, 12 girls) between the ages of 14 months, 10 days and 18 months, 20 days (M = 16 months, 15 days) participated in the study. Another 6 infants began the procedure but were not included in the final sample because two grew restless and four had English as a second language and we wanted to test the lexical cues study on infants who were native English speakers. Five more children were excluded due to experimenter error, parental interference or toy malfunction. Parents lived in the city of Cardiff, Wales and its suburbs. Seventeen participants were recruited by telephone from a list of participants who had expressed interest in participating in a study. These children were tested in a child-friendly lab at Cardiff University. An additional 5 participants were tested at a children's café. As acknowledgement for participation, infants were given a t-shirt.

2.2.2 Materials

Five novel toys (four for the experimental part and one for the warm-up part) were constructed from wooden boxes and plastic and iron items. As in the Carpenter et al. (1998) study, these toys afforded two actions which were followed by an interesting result, such as a puppet in a window (the end-result). The toys were constructed in such a way so that they only required one experimenter to produce the end-result. The toys and end-results can be seen in the Appendix. The experimenter manipulated the action items that were mounted on the front of the toy with the left hand and discreetly operated the end-result in the back of the toy with the right hand.

2.2.3 Design

The design for this study was similar to Carpenter et al. (1998). Two actions were modeled on each toy. Accidental actions were immediately followed by the word "Whoops!" and intentional actions by the word "There!" both in the appropriate accidental and intentional intonation. There were two conditions in the study, an I-A condition where the first action was indicated as intentional and the second accidental and an A-I condition where the first action was accidental and the second intentional. Each infant participated in each condition twice. The order of intention and accident was counterbalanced across trials. There were 4 orders and in each of the orders any given toy was presented in a different position. In addition, the order in which the actions were presented and the condition in which they were presented were counterbalanced. For example, in the puppet toy, sometimes the rolling action was first and was indicated as intentional or accidental and sometimes the lifting action was first and was indicated as intentional or accidental, depending on the condition. Each infant observed the demonstration of each toy twice and had the chance to produce those actions twice.

2.2.4 Procedure

During the study, infants sat on their mother's lap in front of a table. The toys were kept under that table. There were two cameras in the room. One camera focused on a profile view of the infant from the waist up. The second camera captured both the experimenter and infant. The experimenter sat on the side of the table near the child. Infants first played with the warm-up toy where the experimenter modeled an action on the toy and music followed. There were no verbal cues during this demonstration. Sometimes children were reluctant to touch the toy so the

experimenter encouraged those children by saying "Can you make it work?" If children still did not reproduce the action then the experimenter used manual coaching for these children until they were able to do it alone, or with the help of the experimenter.

During the test phase, the experimenter modeled two actions on each toy. The actions had a short delay between them and were enacted rapidly in order to appear credible. For example, in the Intentional-Accidental condition, with the puppet toy, the experimenter first did the rolling action and said "There" in a purposeful and satisfied tone of voice. Second she did the pushing action and said "Whoops" in a dissatisfied and surprised intonation. The end-result was a puppet that danced in a window for about a half to one second after the second action. Following the demonstration infants were given a turn to produce a response. The same actions were modeled a second time and the infant again had a turn to produce a response. Therefore, children saw 8 demonstrations and had 8 response trials. The end-result was presented approximately half to 1 second after the second action. During the children's responses, the end-result was activated only if the child had reproduced the intentional action, but regardless of whether the infant had also reproduced an accidental action. The end-result followed between 1 to 2 seconds after performing the intentional action. Throughout the testing, although the infants were looking at the hand actions, the experimenter maintained a positive but neutral facial expression.

2.2.5 Scoring

Infants' responses were scored following the session from the video recording. For each of the 8 trials the children were scored for reproducing the Intentional action only, the Accidental action only, both actions in Order, both actions in Incorrect Order, and neither action.

2.3 Results

The first analysis looked at infants' tendencies to reproduce all kinds of actions, not just the correct intentional actions alone. Therefore, this analysis took into account the overall number of accidental actions and intentional actions performed by the children. For the analyses, the two conditions (A-I and I-A) were collapsed together. The actions that children had performed were divided by the number of valid trials that children had responded to.(usually 8) and then converted to percentages. A 2 (actions: intentional vs. accidental) x 2 (age: younger than 16 months, 15 days vs. older children) mixed model repeated measures ANOVA was carried out on the percentages. The analysis found no difference between age groups, $F(1, 20) = 3.09$, $p > .09$, $\eta = .13$. However, there was a significant difference between the two actions. Overall, infants reproduced more intentional ($M = 67.73$, $SD = 17.76$) than accidental actions ($M = 48.37$, $SD = 19.10$), $F(1, 20) = 7.22$, $p < .01$, $\eta = .27$.

The second analysis examined the children's responses more closely. This analysis drew comparisons between the correct intentional only responses and the three wrong responses, i.e., accidental actions only, actions performed in order and actions performed in the incorrect order. The results of the paired samples t-test revealed an overall significant difference between the intentional and accidental actions, $t(21) = 2.75$, $p < .01$. Means and additional analyses can be seen in Table 2.1.

Additional reliability analyses were carried out, where a naïve coder scored 6 videos. This coding was compared to the scores produced by the experimenter. The result of the Cohen kappa test was excellent at .93. Halfway through the study another coder looked at 6 videos with the volume off and rated whether the actions of the experimenter, as well as the facial expressions were intentional or accidental. The results of this analysis showed that the coder was correct 58% of the time. When the

coder responded correctly the infants also responded correctly 57% of the time and when the coder responded incorrectly, the infants responded correctly 40% of the time. A chi-square analysis was carried out to see if there was any association between the actions produced by infants and the actions identified as intentional and accidental by the coder. The result of this analysis was not significant $\chi^2(1) = 1.26, p > .26$ which suggests that infants were focusing on the words when performing the task.

2.4 Discussion

The findings of this study replicate those of Carpenter et al. (1998). Infants in this study reproduced more intentional actions than accidental actions. The findings suggest that infants were able to use lexical and/or intonation cues to infer and discriminate which action were intentional or accidental. In the following study we examined whether infants are able to discriminate intentional from accidental actions based on intonation cues alone.

Study 2: Intonation Cues

In the second study, we wanted to examine whether intonation alone is enough to guide infants as to the intentionality of two similar actions. In this study we used the Greek words "Ochi" and "Nato" with appropriate accidental and intentional intonations to mark the two actions on the toys. In order to eliminate any possibility that lexical characteristics of the Greek words affect intention understanding, half of the infants heard "Ochi" as intentional and "Nato" as accidental, whereas the other half heard "Ochi" as accidental and "Nato" as intentional. Our hypothesis was that

infants would be able to use these intonation cues in order to distinguish an accidental from an intentional action.

2.5 Method

2.5.1 Participants

Forty-one infants (19 boys, 22 girls) between the ages of 14 months, 0 days and 18 months 15, days (M = 16 months, 8 days) participated in the study. Another 4 infants were tested but grew restless so they were excluded from the study. Eight more infants were excluded due to experimenter error, parental interference, or toy malfunction. Participants we recruited as in Study 1 and were tested in a child friendly lab at Cardiff University. Infants received a t-shirt for participation.

2.5.2 Materials and Design

The materials in this study were the same five toys used in the first study. The design was the same as in Study 1.

2.5.3 Procedure and Scoring

The procedure for this second study was the same as Study 1 with the difference that infants heard the lexical items "Ochi" and "Nato" instead of "Whoops" and "There." Twenty-one infants participated in the condition where "Nato" was expressed as intentional and "Ochi" as accidental. Another 20 infants participated in the reverse condition where "Ochi" was intentional and "Nato" was accidental. Infant responses were scored as in Study 1. As in Carpenter et al., the words were uttered in such a way that the intentional intonation sounded like the experimenter meant to do the action and was satisfied (falling intonation pattern), whereas the accidental

intonation expressed dissatisfaction and surprise (rising intonation pattern). Figures of these patterns are shown in Figure 2.1 and Figure 2.2.

Figure 2.1 Typical pitch contour for intentional intonations

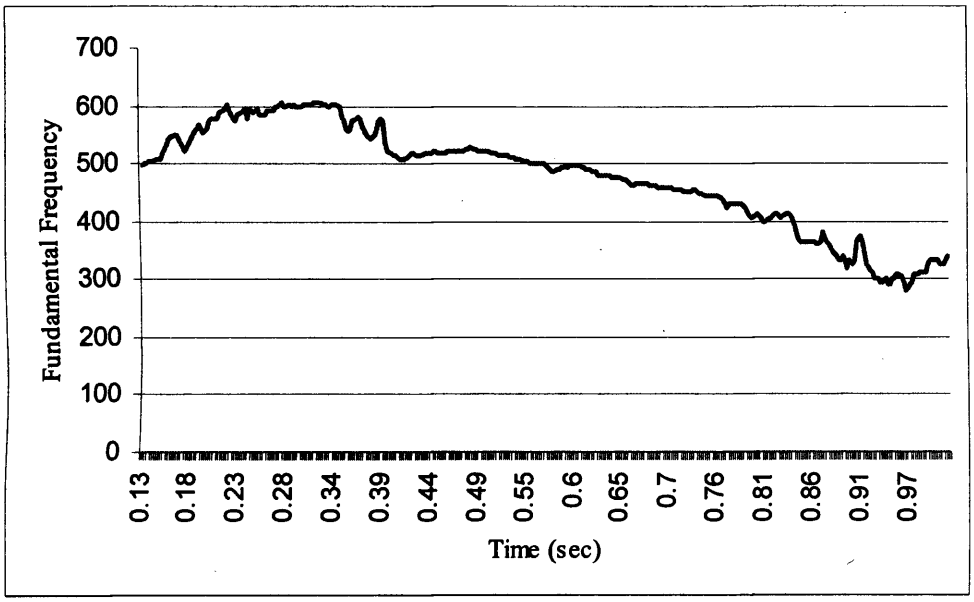
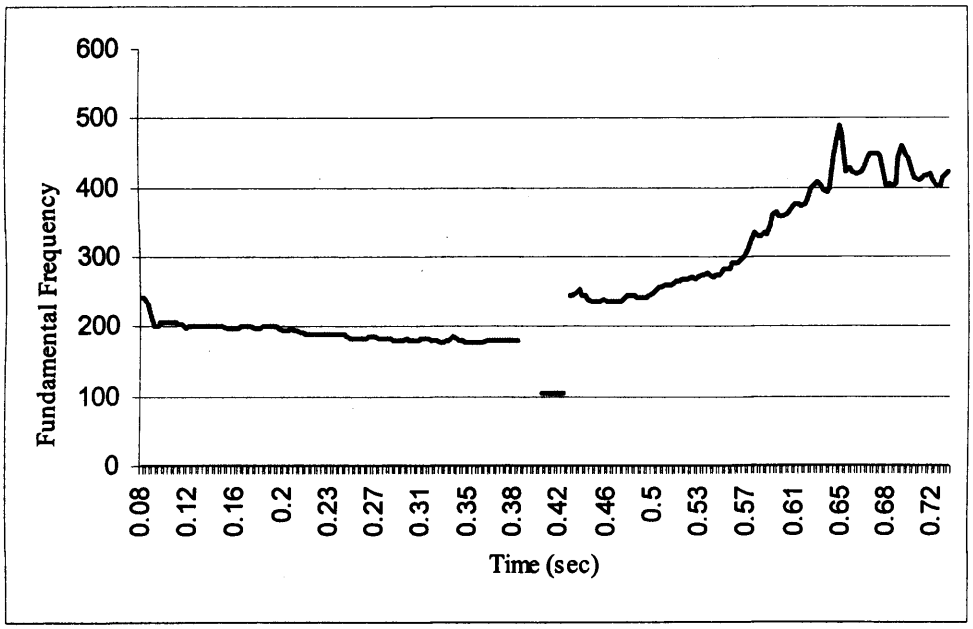


Figure 2.2 Typical pitch contour for accidental intonations



2.6 Results

The analyses used in the second study were similar to those in the first study. The first analysis looked at infants' tendencies to reproduce all kinds of actions, not just the correct intentional actions alone. A 2 (actions: intentional vs. accidental) x 2 (age: younger than 16 months, 8 days vs. older children) x 2 (condition: Nato-Ochi vs. Ochi-Nato) mixed model repeated measures ANOVA was carried out on the percentages. The results revealed no difference between the younger ($M = 61.46$, $SD = 23.85$) and the older children ($M = 61.50$, $SD = 18.60$), $F(1, 37) = .01$, $p > .09$, $\eta = .001$. However, there was a significant difference between the two actions. Overall, infants reproduced more intentional ($M = 75.37$, $SD = 19.41$) than accidental actions ($M = 47.58$, $SD = 23.71$), $F(1, 37) = 19.71$, $p < .001$, $\eta = .35$. The results also revealed a nonsignificant interaction between age and actions, $F(1, 37) = 3.44$, $p > .07$, $\eta = .09$. Finally, there was no effect of condition, $F(1, 37) = .18$, $p > .67$, $\eta = .01$.

The second analysis drew comparisons between the correct intentional only responses and the three wrong responses, and age. A paired samples t-test revealed an overall significant difference between the intentional and accidental actions, $t(40) = 4.69$, $p < .001$. Means and additional comparisons can be seen in Table 1.1. Additional analyses (with Bonferroni corrections) were carried out for the two age groups separately. For the younger group there was no significant difference between the intentional ($M = 46.97$, $SD = 27.07$) and accidental actions ($M = 30.11$, $SD = 20.63$), $t(18) = 1.74$, $p > .10$. However, there was a significant difference between intentional ($M = 57.12$, $SD = 19.82$) and accidental actions ($M = 19.88$, $SD = 17.38$) for older children, $t(21) = 5.48$, $p < .001$.

Another analysis was carried out to control for the possibility of learning throughout the 8 trials. Analyses were conducted on just the first trial children saw.

Wilcoxon tests were carried out and the results were nonsignificant between intentional ($M = .44$, $SD = .50$) and accidental actions ($M = .30$, $SD = .46$), $z = -.96$, $p > .34$ but significant for the comparisons between intentional actions and actions performed in order ($M = .08$, $SD = .27$), $z = -2.98$, $p < .01$ and in incorrect order ($M = .16$, $SD = .37$), $z = -2.13$, $p < .03$. When comparing between the younger and older children separately, the results revealed a significant difference between intentional ($M = .63$, $SD = .50$) and accidental actions ($M = .15$, $SD = .37$) for the older group ($z = -2.32$, $p < .02$), but no significant difference between intentional ($M = .24$, $SD = .44$) and accidental actions ($M = .47$, $SD = .51$) in the younger group ($z = -1.15$, $p > .25$).

Table 2.1

Infant's Overall Percent Reproduction in Studies 1 and 2 and how They Differ From the Correct Intentional Actions. * $p < .05$. ** $p < .001$

Actions	Mean		Standard Deviation	
	Study 1	Study 2	Study 1	Study 2
Intentional	51.63	52.42	19.10	23.71
Accidental	32.27*	24.63**	17.76	19.41
Order	8.71**	11.74**	11.92	14.24
Incorrect order	7.39**	10.38**	11.35	14.56

Additional reliability analyses were carried out, where a naïve coder scored 12 videos, 6 for each condition. This coding was compared to the scores produced by the experimenter. The result of the Cohen kappa test was excellent at .92. Halfway

through the study another coder looked at 12 videos with the volume off and rated whether the actions of the experimenter, as well as the facial expressions were intentional or accidental. The results of this analysis showed that the coder was correct 48% of the time. When the coder responded correctly the infants also responded correctly 54% of the time and when the coder responded incorrectly, the infants responded correctly 47% of the time. A chi-square analysis was carried out to see if there was any association between the actions produced by infants and the actions identified as intentional and accidental by the coder. The result of this analysis was not significant $\chi^2(1) = .67, p > .41$.

An additional analysis was utilised to look at possible differences in performance between the first and second study. This was a 2 (actions: intentional vs. accidental) x 2(study: lexical study vs. intonation study) mixed model repeated measures ANOVA. The results of the analysis were nonsignificant. There were no significant differences between the lexical and intonation studies, $F(1, 61) = 1.78$, p >.19, $\eta = .03$. There was also no interaction $F(1, 61) = .78$, p >.39, $\eta = .01$. This analysis suggests that infants take intentionality into account despite it being expressed in words or intonation.

2.6.1 Intonation Analyses

Intonation analyses were carried out on a sample of utterances from the two conditions. Four utterances were taken from each of the first 29 participant sessions. Two intentional utterances and 2 accidental utterances were randomly taken from each of the 29 sessions for analysis. The analyses compared the mean pitch (Hz), the pitch range, the duration and the amplitude (db) of accidental and intentional utterances. Pairwise comparisons found significant differences between intentional

and accidental intonations. For the mean F_0, the intentional intonations were higher than the accidental intonations (t (57) = 17.66, $p < .001$) and so was the amplitude (t (57) = 20.86, $p < .001$) and the duration (t (57) = 11.25, $p < .001$) for the intentional intonations. The pitch range however was greater for the accidental intonations (t (57) = -4.21, $p < .001$).

2.7 Discussion

Infants in this study were able to use the vocal cues of the Greek words, enabling them to reproduce more intentional actions than accidental actions. The results suggest that intonation is a valid cue to intention by 16 months.

2.9 General Discussion

The aim of these studies was to explore the validity of intonation as a cue to understanding other's intentions for infants between the ages of 14 to 18 months. In these two studies, infants saw demonstrations where an experimenter performed two actions on toys and marked those actions as intentional or accidental. In the first study, the actions were marked by "There!" expressed with intentional intonation, or "Woops!" expressed with accidental intonation. In the second study actions were marked with Greek words, produced with intentional or accidental intonation. The results of these two studies together indicate that infants are able to infer intentions from intonation alone.

From an early age, infants seem to be sensitive to the tone of voice in communication (Fernald, 1985; 1991; 1992). These current studies have shown that this sensitivity can turn into a more sophisticated ability at around 16 months, the ability to gather information about what others intend and do not intend in their

interactions with inanimate objects. The results of the second study demonstrate that infants are able to understand which of two perceptually similar actions, was intentional based on intonation cues alone.

This study's significance lays in the fact that intonation on its own, dissociated from facial or lexical cues can still provide infants with the necessary information about another person's mental state. The results of the second study therefore contribute to the already expanding literature on the importance of intonation in the life of young children.

The capability to infer intentions paired with the sensitivity to intonation information allows toddlers to gain new insights into the mental states of others, and thus the ability to interpret behavior. This is not surprising when one considers that human infants are raised within stimulating environments where linguistic and prosodic attempts to communication begin at a stage in development where infants are still unable to make sense of them. One interesting finding is that infants around 16 months of age begin to change their focus from relying on prosody to relying on their newly acquired vocabulary (Friend, 2001). It has been suggested that this deviation from prosodic to linguistic reliance is brought about by intonation itself as studies have shown that the tone of voice is important in highlighting crucial words that could potentially signify intentions to infants (Fernald & Mazzie, 1991; Grassmann & Tomasello, 2007).

Although the results of the current studies show that infants are sensitive to intentionality in the tone of voice, further studies are needed to examine whether infants infer mental states from different types of vocal cues. An interesting contrast would be to examine whether infants can infer and discriminate intentional and

accidental actions when these are expressed with similar valence, or whether infants rely on a contrast between positive and negative valence to infer intentions.

The question of what specific cues infants use to discriminate mental states relates to a larger question about the universality of the information available from intonation. For example, Fernald (1993) has found that the intonational signature of different communicative messages such as prohibition and approvals seems to be similar in different languages (English, German, and Italian) but not so similar in Japanese. More recently, another study looked at such communicative messages and their identification by a population of an indigenous culture (Bryant & Barrett, 2007). Similar results about vocal emotion discrimination were found in 9 different countries by Scherer, Banse and Wallbott (2001).

Understanding intentions is regarded an early gateway towards mental state understanding more generally (Tomasello & Rakoczy, 2003). The current results show that infants can infer intentions from intonation, thus demonstrating the importance of intonation in understanding mental states.

CHAPTER 3: INFERRING INTENTIONS FROM INTONATION: EVIDENCE FROM PRE-RECORDED DEMONSTRATIONS

3.1 Introduction

In our previous studies (Chapter 2) we examined the ability of infants from 14 to 18 months in a task that elicited their understanding of intentions. These two studies were conducted using a live demonstration from the experimenter and a subsequent response from the infants. Although the results of these studies were in accordance with the hypotheses, we wanted to replicate these results by adding greater control and consistency in aspects of the study, such as the intonations used and any additional cues that might have been unconsciously given during the demonstration period, such as facial cues and the timing between the actions. Another goal of this study was to develop a methodology that could be used for measuring intention understanding in a looking time study such as the one described in Chapter 5. In order to accomplish these aims we video-recorded the demonstrations. This allowed us to gain more consistency, and in addition to create further experiments with these recordings, such as those described in Chapter 4 and 5. This gave us more control over what the infants saw and heard, and allowed us to also examine whether infants can exhibit a similar understanding of intentions in a video-recorded session.

Video-recorded paradigms have been proposed to be more difficult for infants because they posit more difficulties when representing the information presented in the video compared to live demonstrations. Studies that have examined infant behaviour in paradigms that have presented information to infants through video in comparison to information presented through live demonstration suggest that infants

display a "video deficit effect" (Anderson & Pempek, 2005). Studies such as the ones by Hayne and colleagues have found that infants and young children imitate more actions following a 24 hour delay when these actions had been demonstrated live rather than through video (Barr & Hayne, 1999; Hayne, Herbert & Simcock, 2003). Other researchers have found similar findings in children's dual representation abilities as young children (two and a half years) have been found to have difficulties retrieving a toy that was hidden in a room when the hiding procedure was presented through video. However, when they had seen the hiding process from a window facing directly into the room, these children were able to retrieve the object (Troseth & DeLoache, 1998; Schmitt & Anderson, 2002). In addition to this, Pierroutsakos and Troseth (2003) found that when 9-, 14- and 19-month-olds were presented with an array of objects on TV, the younger ones tended to attempt to manipulate the objects by patting and hitting them whereas the 19-month-olds used more directive behaviour, such as pointing to the objects.

Although the abovementioned results propose that infants and young children have difficulty representing information from video, some other research has shown that younger infants are able to encode the information from video, and in particular they seem to be able to use this information in imitation paradigms instead of object search paradigms (Deocampo & Hudson, 2003; Meltzoff, 1988). Deocampo and Hudson (2003) have suggested that imitation tasks are different from object search tasks in that they do not require dual representation competence as "it is not necessary to realize there is a specific referent to the video representation that is occurring in current reality to imitate or to be reminded by the representation" (p. 232). In this study they used a similar setup to Troseth and DeLoache (1998) but instead of a retrieval task they utilised a goal-imitation task where children had to imitate finding

a toy but they also had a goal why they had to find the particular toy. The results of the study indicate that 24-month olds were better at the imitation task when this included a goal, but they still performed badly when the toy retrieval task incorporated a goal. Following these results, we proposed that the intention understanding task in our study might be imitated similarly as in the live demonstrations.

In recording the demonstrations in this study we purposefully did not include the face of the demonstrator because we wanted to see whether infants could still do the study when the face and the gaze cues were not available to them. Gaze research indicates that infants are able to follow gaze from a young age but it is not until they enter their second year that they become able to interpret gaze as a communicative cue. At around the age of 12 months eye gaze gives infants indications of a person's desire, such as whether a person looking at a toy will reach towards that toy instead of another toy that the person did not gaze towards (Woodward, 2003). Researchers using this paradigm conclude that towards the end of their first year, infants have expectations about action goals indicated by an actor's gaze direction and reaching and grasping movements. This understanding of intentionality begins to develop further when infants enter their second year, as infants become able to understand that gazing alone (no grasping), along with emotional expressions,can be the result of a person's desire for an object (Barna & Legerstee, 2005; Phillips et al., 2002; Repacholi, 1998) or an intention to acquire an object (Sodian & Thoermer, 2004; Woodward, 2003).

Despite not providing any facial or gaze cues in this study, we believe that children would still be able to perform on the basis of the intonation alone as we found in our previous study. Also, research has shown that infants are sensitive to

hand actions and they are able to discriminate between specific purposeful and nonpurposeful actions (Woodward, 1999). Consequently, because we wanted to control for the intentionality of hand movements, we recorded the actions on the toys in a way that they appeared neutral, in order that they did not give any cues as to whether they were intentional or accidental.

The results of the previous intonation study also showed that the younger infants in the group had more difficulty making the distinction between the intentional and accidental intonation. One possibility for this might be the pace at which the actions were presented. The rationale was to present these actions rather rapidly in order for them to appear credible. However, in this pre-recorded study we wanted to intentionally slow the pace down in order to give the younger children more time in which to process the intonations and the actions that lead to the goal.

Following the results of the previous intonation study, we wanted to control for any cues that might have been unconsciously given during the demonstration period, such as facial cues and the timing between the actions. We also wanted to have greater control and consistency for the intonations during the utterances. Therefore, we video recorded the demonstrations in order to eliminate confounds relating to alternative cues. This gave us more control over what the infants saw and heard, and allowed us to also examine whether infants can exhibit a similar understanding of intentions in a video recorded session, as we saw in live demonstration sessions. The ages that were tested in this study were 14-month-olds and 17-month-olds.

Study 1: Seventeen-Month-Olds

3.2 Method.

3.2.1 Pilot Study

A pilot study was run in order to obtain the audio stimuli that were to be used in the main study. Twenty adult participants heard 40 utterances. Twenty of the utterances were of the word *Nato*, half of which were expressed with different types of intentional intonation and half were expressed with different types of accidental intonation. The other twenty utterances were of the word *Ochi* half of which were expressed with different types of intentional intonation and half with accidental intonation. The participants were asked to rate whether the intonation sounded intentional or accidental. They were further instructed to think of an intentional intonation as in the case when the person did an action purposefully and achieved it, and for the accidental intentional as in the case when the person did an action which they did not mean to do. The results of the pilot study determined the intentional intonation for a *Nato* utterance (85% of participants rated it as intentional) and the accidental intonation for *Ochi* utterance (100% of participants rated it as accidental). These two chosen intonations were used throughout the study.

3.2.2 Participants

Twenty infants between the ages of 16 months, 4 days and 18 months, 14 days (mean age 17 months,18 days) took part in this study. The participants were recruited by telephone from a list of parents who had expressed interest in participating in a study. Parents lived in the city of Cardiff, Wales and its suburbs. As acknowledgement for participation, parents were given a t-shirt for their child.

3.2.3 Materials

The materials consisted of video recordings of five experimental toys and one warm up toy. The toys were the same as in study one, with the exception of the fifth toy which consisted of a blue pipe handle and a red handle. The end result was in the form of a soft chicken toy. The actions on the toys were video recorded and the end result was produced by another person who was hidden behind the toy. The video recording consisted of the experimenter's arm and hand which performed the two actions with around a 4 second difference between actions. The audio stimuli chosen from the pilot for "Ochi" and "Nato" followed the moment the hand completed each action and was not touching the item. Therefore, in the case of the blue pipe handle, the hand moved to the handle, grabbed it and performed a pulling action. Then, the hand released the handle and paused next to the handle in which moment the intonation followed. After the intonation was heard, the hand moved to the red handle, grabbed it and performed another pulling action, released it and paused next to it, at which point the intonation was heard. The end result followed a second after the hand disappeared from the scene after the second action.

3.2.4 Design

The design of this experiment was identical to the one in the previous studies. Two actions, an accidental action and an intentional action, were modelled on each toy. Accidental actions were immediately followed by the word "Ochi" and intentional actions were followed by the word "Nato" both in the appropriate intonation. In the current study, each infant participated in these 2 conditions twice (two A-I toys and two I-A toys) which were counterbalanced as to the order the toy was presented. The actions related with each toy were also counterbalanced, so that

the action of pulling a handle came first for half of the children while it came second for the other half of the sample. The indication of the accidental and intentional action (i.e. Nato or Ochi) was also counterbalanced so that half of the infants who had the handle being pulled first heard it being expressed accidentally while the other half heard it being expressed intentionally. Therefore, four video clips were created for each toy. This was done in order to have complete counterbalancing for the order of actions and intonations. Therefore, for two video clips, the order of the actions was the same but the intonations were reversed. For the other two video clips, the order of the actions was reversed and so were the intonations. The videoclips were presented in alternating order so that if children saw the first toy presented in the A-I condition, then they saw the third toy in the A-I condition and the second and fourth toy in the I-A condition. The same alternating pattern was followed when the first toy was presented in the I-A condition.

3.2.5 Procedure

Infants in this study first took part in a pilot study in another room prior to taking part in this study. The infants had a break for around 20 minutes where they played with toys in another room. During the study, infants sat on their parents' knee and watched the video clips on a 17 inch computer screen which was placed on the left hand side of a table. The toys were kept under that table and were taken out in turn after both response periods had ended for the previous toy. During the warm-up toy, there were no intonation cues, just one action and the end result. Children who did not produce the end result were shown how to produce it. For the experimental session, although 5 experimental toys were constructed, four were presented for each child in this study, as one of them had already been used in the pilot study the children

had initially taken part in. There were two cameras focusing on the infant, the experimenter and the toys. The experimenter sat on the side of the table near the child. After the children had watched the video, they were presented with the toy they had just seen and just like in the first study they were asked to make it work. The toy was brought up from under the table and the children were given the toy for a response. After their response, the toy was taken down from the table and placed on the floor and was brought up on the table after the second demonstration with the same toy was completed. The procedure followed by the experimenter during the reproduction phase was similar to the previous studies. During the infant's response the end result was activated only if the infant had reproduced the intentional action, but regardless of whether the infant had also reproduced an accidental action. When children were producing the actions, the end result followed about 2 seconds after an intentional reproduction because we wanted to allow the children to produce the accidental actions if they wanted to. Also, if the children were producing the accidental action and were focusing on it for about 5-7 seconds without reaching to produce the intentional action, or when they produced it and looked up for the end result, then the toy was taken away or was placed on the floor in order for the video to be presented again.

3.2.6 Scoring

The scoring was again identical to the first study. Infants' responses were scored following the session from the video recording. For each trial the infants were scored for reproducing the First Action Only, the Second Action Only, Both Actions in Order, Both Actions in Incorrect Order, and Neither action.

3.2.7 Reliability

A second coder naïve to the purpose of the study watched the infant actions without sound and scored them according to whether the child produced one action or two actions. The results of the reliability showed that there was disagreement on only one trial for one child. A coefficient kappa score was calculated on the relationship between the experimenter's ratings and the second coder's ratings. The results showed a strong relationship k = .94.

3.2.8 Learning

In order to eliminate the possibility that infants in this study were learning how to do the task from exposure in subsequent trials, we plotted the data of each trial on a graph. Two graphs were produced, one that included all toys and another for which the Rudolf toy was excluded (Figure 3.1 and 3.2).

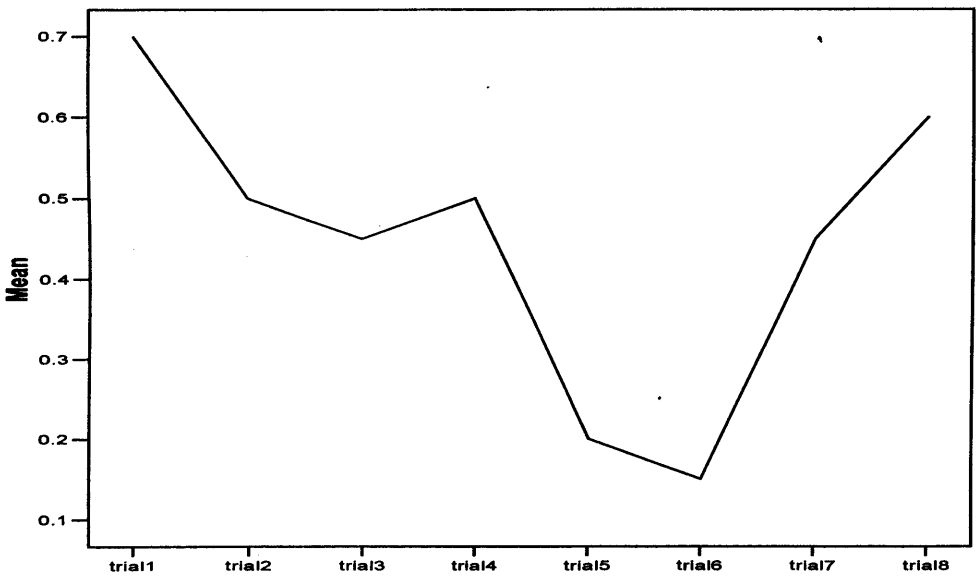


Figure 3.1 *Mean of correct actions produced in the trials for all toys*

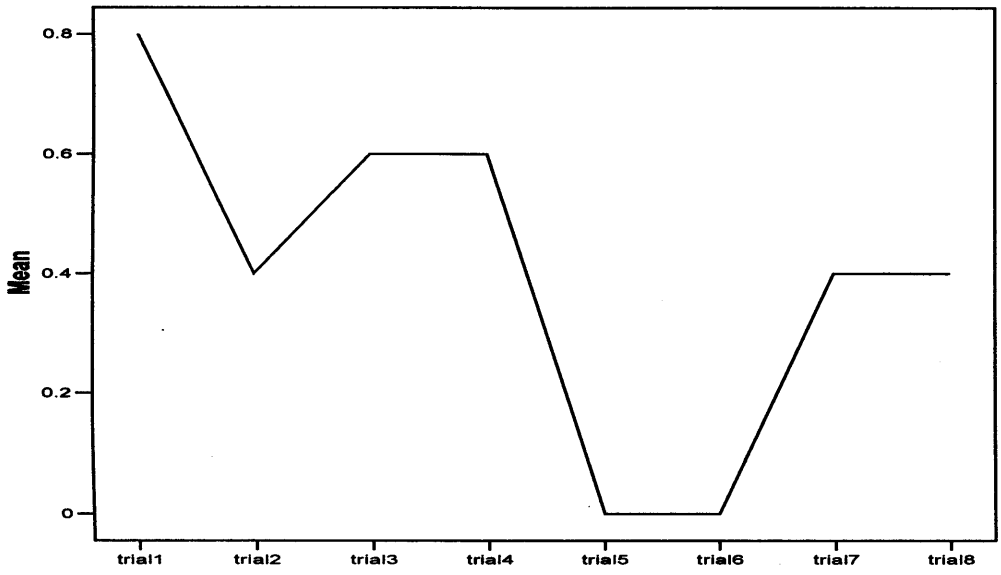


Figure 3.2 *Mean of correct actions produced in the trials for all toys except Rudolf*

3.4 Results

The first descriptive statistics analysis was carried out on all the data combined, regardless of the condition they were in. In addition, these percentages also included actions that were enacted in order and incorrect order. This analysis showed that the total percentage of intentional actions (M = 79.11; SD = 13.65) was greater than the percentage of accidental actions (M = 52.68; SD = 24.39). A Wilcoxon test was carried out on these percentages and revealed that infants were producing significantly more intentional actions than they were producing accidental actions z = -3.19, $p < .001$. When taking into account the times when children produced a single action for accidental and intentional and two actions for the order and incorrect order categories, the results were as following. The percentage of intentional actions (M = 47.95; SD = 23.24) was greater than the percentage of accidental actions (M = 20.27; SD = 14.32), z = -3.26, $p < .001$ and also greater than actions performed in order (M = 13.21; SD = 14.15), z = -2.74, $p < .01$ and actions performed in the incorrect order (M = 18.31; SD = 19.41), z = -3.37, $p < .001$.

Separate analyses for each condition were also carried out. For the A-I condition, the percentage for the intentional actions (M = 41.25; SD = 33.34) was greater than that of accidental actions (M = 15.40; SD = 22.33), z = -2.73, $p < .01$ and greater than actions performed in order (M = 19.60; SD = 22.86), z = -2.50, $p < .01$ and incorrect order (M = 12.50; SD = 25.00), z = -2.69, $p < .01$. Similar results were observed in the percentages of the I-A condition. However, the Wilcoxon test did not produce significant results in all the categories. The percentage of intentional actions (M = 41.25; SD = 31.70) was not significantly greater than that of accidental actions (M = 26.65; SD = 25.01), z = -1.45, $p < .15$ and that of actions in incorrect order (M = 25.00; SD = 26.24), z = -1.50, $p < .13$. It was though significant in the difference between actions performed in order (M = 7.10; SD = 16.79), z = -2.91, $p < .01$.

When the data were examined more closely, it was observed that a particular toy, Rudolf was problematic. Most infants who had seen and received this toy in the experiment chose to perform only one action on it, the action of pulling and not the action of lifting. We speculated that infants must have not encoded the lifting action from the video for various reasons; one of them being that perhaps it was not as salient on the video as the pulling action. We wanted to examine whether this kind of behaviour by the children had affected the results. Therefore, we carried out analyses on the result in which we excluded this problematic toy. These analyses were carried out by converting the raw data into percentages depending on how many toy demonstrations (excluding the one with Rudolf) children had seen.

The overall results, when collapsing the conditions, showed that infants produced significantly more intentional actions than other categories, in all conditions, except in the IA condition where the difference between intentional only

actions and actions produced in the incorrect order was not significant. The results can be seen on Table 3.1 and 3.2.

Table 3.1. *Mean, Standard Deviation and significance values for A - I condition after Rudolf toy was eliminated from the analyses*

Condition	A – I			
	M	*SD*	*z*	*p*
Intentional	53.75	36.52		
Accidental	14.15	22.46	-2.77	.01
Order	23.35	29.10	-2.03	.04
Incorrect Order	11.25	24.97	-2.51	.01

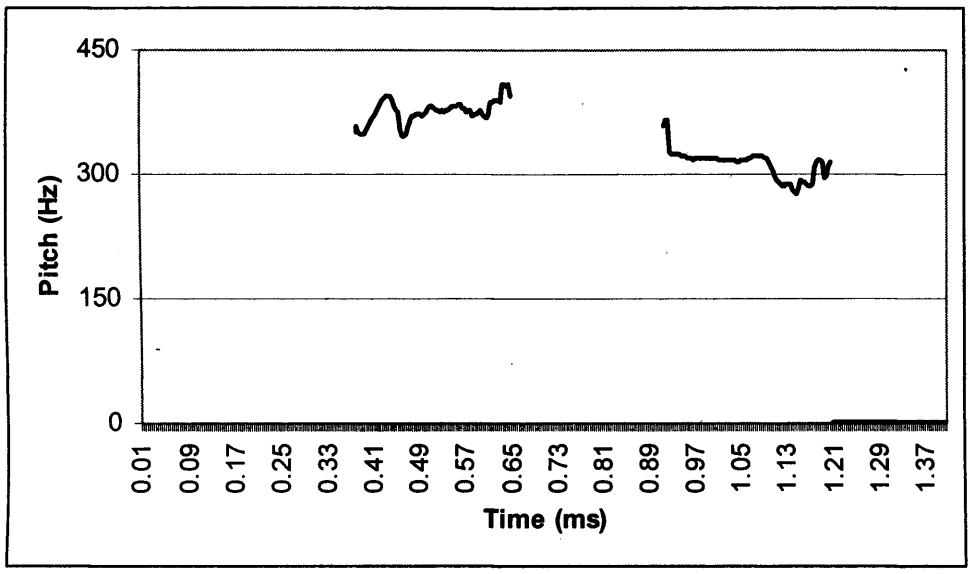
Table 3.2. *Mean, Standard Deviation and significance values for I - A condition after Rudolf toy was eliminated from the analyses*

Condition	I – A			
	M	*SD*	*z*	*p*
Intentional	41.25	36.52		
Accidental	15.00	20.52	-2.38	.02
Order	10.85	21.01	-2.25	.03
Incorrect Order	32.50	33.54	-.78	.43

3.3.1 Vocal Analyses

Vocal analyses using the acoustical analysis software program Praat, were conducted on the two intonations used in the study. The mean F_0 for the purposeful intonation was 374.12 Hz, which was slightly higher than the F_0 of the accidental intonation of 337.08 Hz. The accidental intonation ranged between 393.58 and 281.82 Hz and the intentional between 487.49 and 212.16 Hz. Ideally we would be interested in comparing the pitch ratings for different parts of the two utterances in order to see whether they differed significantly from each other. However, in the accidental intonation there is a 35 millisecond undefined period due to the intonation being pronounced in exaggerated infant-directed speech. Because of this, Praat was not able to define the pitch for that "gap". Katz, Cohen and Moore demonstrated that the pitch contour can give an indication to the pragmatic category of utterances (1996). The purposeful intonation in our study has a contour of rise and then a flat contour which makes it sound as a positive and unequivocal quality. The accidental intonation has a flat contour with a short "gap" which has a quality of sounding unexpected. Graphs of the pitch and intensity contours for the accidental and intentional intonations can be seen on Figure 3.3 and 3.4.

Figure 3.3. *Pitch and Intensity Contours For Accidental Intonation*



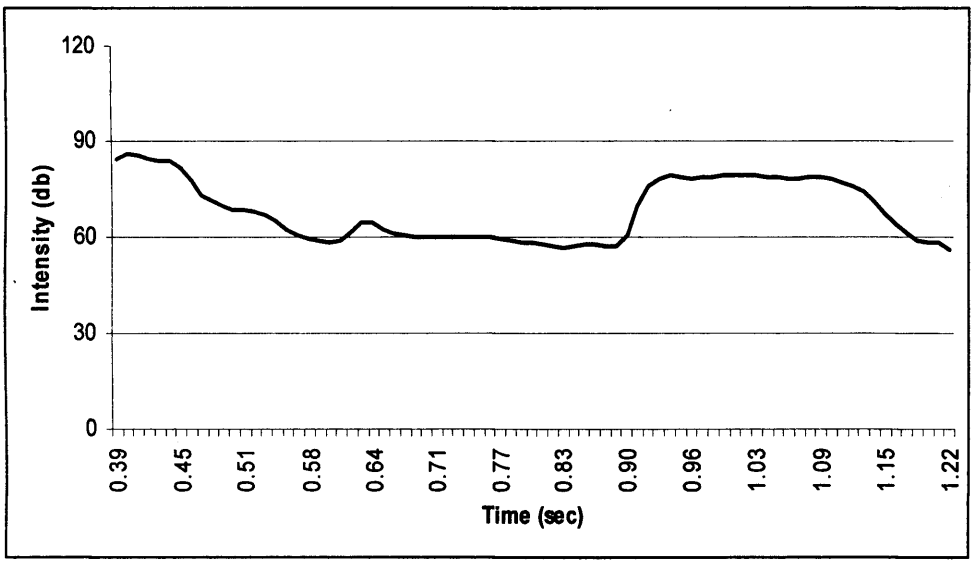
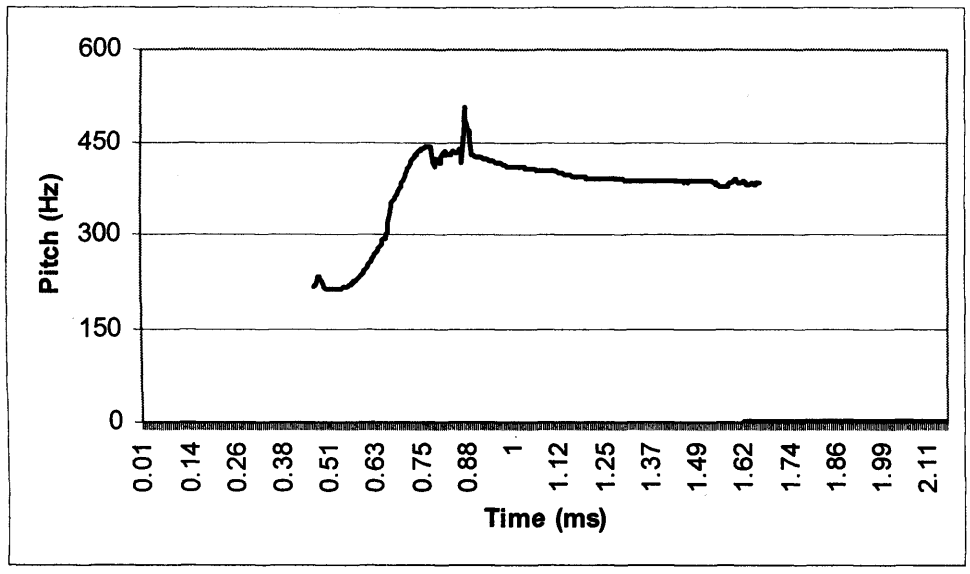
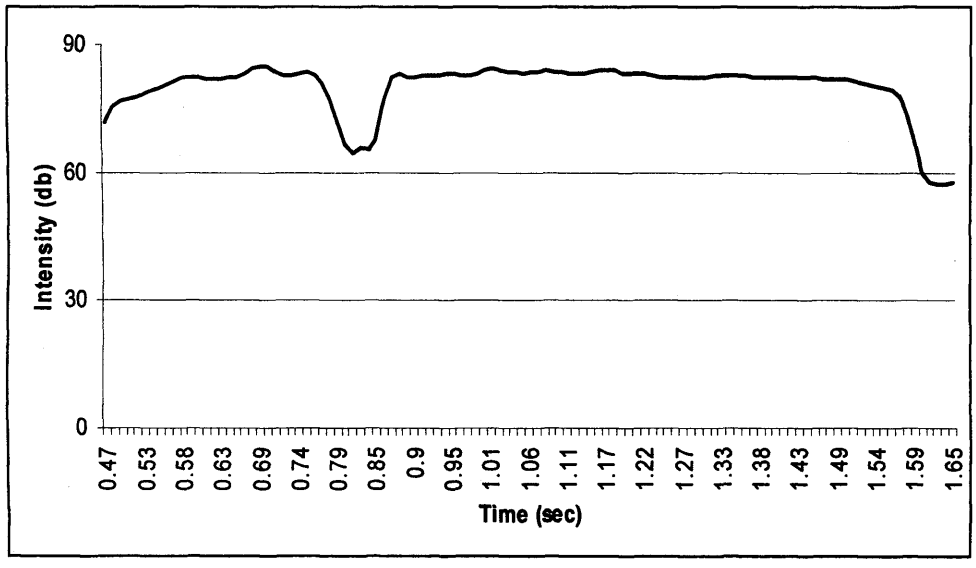


Figure 3.4. *Pitch and Intensity Contours for Intentional Intonation*





3.5 Discussion

The results of this study showed that infants between 16 and 18 months are able to infer the intentions of others through the tone of voice. These findings replicate the findings of our previous study (Chapter 2) where the older children in our sample were able to infer other's intentions. This study's findings are also

important because they show that infants are as able in this prerecorded video demonstration as they are in the live demonstrations of the previous set of studies. Next, we wanted to look at intention understanding though intonation more specifically in 14 month old children. Our previous studies had infants of 14 months in them but in this following study we wanted to examine a group of 14-month-olds more carefully. In order to assess this, we carried out the same experiment as the one reported above with the 16- to 18-month-olds with a group of 14 month old infants.

Study 2: Fourteen-Month-Olds

3.6 Method

3.6.1 Participants

The participants in this study were twenty 14-month-olds. Overall, 29 participants were tested in this study but 3 were excluded due to experimenter error, 4 due to the baby being agitated and not completing the study and 2 due to toy malfunction. The 20 participants in the final sample ranged in age from 13 months, 11 days to 14 months, 24 days. The mean age was 14 months, 5 days.

3.6.2 Design, Materials and Procedure

The toys for this study were similar to the toys for the study with the 17-month-olds. Due to the problem with the Rudolf toy, we started off with the other four toys, Puppet, Chicken, Pirate and Elf. Halfway through the study, because we wanted to use the Puppet toy for another study (the looking time study described in Chapter 6) we ended up changing the Rudolf toy to make the two action parts of it equally salient. We made the two action parts equally salient by placing a handle on

the box which we also painted black to have it match the black circular handle already on the toy. The rest of the toys were the same and the procedure was the same as in the abovementioned study.

3.6.3 Reliability

A second coder naïve to the purpose of the study watched the infant actions without sound and scored them according to whether the child produced one action or two actions. The results of the reliability showed that there was disagreement on only one trial for two children. A coefficient kappa score was calculated on the relationship between the experimenter's ratings and the second coder's ratings. The results showed a strong relationship k = .90.

3.7 Results

The first analysis was carried out on the total number of intentional and accidental actions performed by the infants. This analysis took into account instances where infants had performed both actions in order and both actions in incorrect order. The results of this analysis showed that overall infants produced more intentional actions (M = 71.25; SD = 15.76) than accidental actions (M = 55.63; SD = 23.46), z = -2.00, $p > .046$. The next analysis took into account the overall intentional only actions and compared them with accidental only actions and actions done in order and incorrect order for both the A-I and I-A condition. The results showed no significant differences in the comparison between intentional (M = 41.07; SD = 24.38) and accidental actions (M = 27.94; SD = 15.18), z = -1.69, $p > .09$. However, there were significant results between intentional actions and actions done in order (M = 17.56; SD = 16.89), z = -2.46, $p > .01$ and actions done in the incorrect order (M = 13.39;

SD = 16.42), $z = -2.73$, $p > .01$. Follow up analyses were carried out on the two conditions A-I and I-A separately. These results showed some significant differences in the A-I and I-A condition. These results can be seen on Table 3.3 and 3.4.

Table 3.3. *Mean, Standard Deviation and significance values for A - I condition*

Condition	A – I			
	M	*SD*	*z*	*p*
Intentional	45.42	33.82		
Accidental	24.17	27.56	-1.55	.12
Order	17.50	24.46	-2.39	.01
Incorrect Order	12.92	25.29	-2.41	.02

Table 3.4. *Mean, Standard Deviation and significance values for I - A condition*

Condition	I – A			
	M	*SD*	*z*	*p*
Intentional	37.50	33.93		
Accidental	31.25	25.49	-.38	.71
Order	17.50	23.08	-1.67	.10
Incorrect Order	13.75	18.98	-.1.98	.05

3.8 Discussion

The overall results of the 14-month-olds showed that infants at this age have some understanding about the intentions of others as they copied more intentional actions than accidental actions when all actions were calculated together. However, their results were not as strong as those of the 17-month-olds who performed more intentional only actions than the 14-month-olds. These results suggest that intention understanding as shown by this task develops between 14 and 18 months of age.

3.9 General Discussion

The findings of these two studies are consistent with our findings of the previous study on intention understanding in the tone of voice. The results showed weaker results for the 14-month-olds than the 17-month-olds. One conclusion that we can draw from these results, and from previous findings is that intonation alone is a good source of information for young prelinguistic children as it gives them not only information about emotions, but additional information about mental states such as people's intentions. One can say that the information given out by intonation is vital as it allows young children to gain further insights to the minds of other people without words to guide them to that understanding. This notion is not surprising when we take into account the studies that have shown that infants are sensitive to the tone of voice from moments after birth (DeCasper & Fifer, 1980; Hepper et al., 1993).

In addition, the results of these studies call further attention to the type of intonation that infants find salient. It seems from previous studies that infants from the beginning of their lives are sensitive to emotional prosody. This attention to prosody has been well documented in studies with young infants (Fernald, 1985; 1993; Trainor et al., 2000) and could be a confounding effect that further studies need

to address. However, we believe that other acoustic characteristics such as the shorter duration of the accidental intonation might have given cues as to the abruptness associated with an accidental message and thus to the accidental mental state.

In our two studies we propose that infants are making inferences about mental states. In order to perform well on this task, infants have to make an inference about the experimenter's behaviour, that is, the experimenter's actions (in this case only intonation as the actions are neutral) towards the goal which is to make the toy work. Although we are unable to say with certainty, there is a possibility that infants in this study could be making their responses based on the pitch level of the vocal cues and the pitch contour. In addition, infants could be making their judgements on the basis of valence. The next study examines this possibility of emotional valence guiding infants' behaviour.

The results of this study confirm our previous findings and also show that infants can still succeed on the task despite the fact that the visual and audio stimuli are pre-recorded and not live demonstrations. However, the fact that one of the toys, Rudolf, proved problematic might be related to infants' inability to process all aspects of the video. This predicament might have been a result of saliency. This particular toy had a ring tied to a string which could be pulled and a less distinct box lid that could be lifted. Therefore, it is possible that the video presentation made one action more salient than the other and thus offered different affordances for the infants. Future studies using video demonstrations must make sure that they make stimuli very salient to infants. When such precautions have been taken, this pre-recorded format is a functional and practical arrangement that allows for the control of audio and video stimuli.

The data produced in these studies open up a question that requires further examination. This is a question about what role valence plays in the studies conducted this far. Is it possible that infants are succeeding in these studies as a result of the positive and negative valence that might be incorporated in these stimuli? One possibility is that infants might be successful because they associate the intentional intonation with something that sounds positive and the accidental intonation with something that sounds less positive, or negative. This is an important distinction that needs to be taken into account because in return it might affect infants' judgements about valence and not about mental states. Because this video-recorded paradigm has allowed us to run pilot studies and find representative intonations, a similar study can be carried out using this paradigm that will allow us to tease apart this issue of valence versus mental states. One such study could utilise purposeful and accidental intonations that are similar in pitch, and other vocal characteristics, such as intensity (loudness), duration, as well as the implied positivity or negativity of the sound. The next study should control these acoustical features so that they are kept constant but should discriminate between the mental states so they communicate two different mental states. Only in a highly controlled experiment will we be able to get to the foundation of mental state understanding and the new pre-recorded procedure will allow that.

Previous studies so far have shown that infants are aware of prosody, which plays an important role in the first year of life as it gives infants indications for people's emotions (Trainor et al, 2000). However, as infants gain more experience of people and the world around them, they could be expanding their knowledge of emotional prosody by constructing knowledge about mental states, and how these can be expressed in the tone of voice.

The studies conducted thus far on infants' understanding of intentions from intonation bring us a step closer to answering questions regarding infants' ability to make inferences about people's mental states. The intonations used in the second study have been selected as purposeful and accidental. Although one could state that the results for these studies give us enough reason to believe that infants can make inferences about mental states, this assumption should be further explored in conditions where acoustical characteristics are taken into account. The next study looks at this distinction between valence and mental states.

CHAPTER 4: INFERRING INTENTIONS FROM INTONATION: THE ROLE OF VALENCE

4.1 Introduction

In our previous studies we examined whether infants can infer the mental states of another person through the intonation expressed in her voice. In these studies infants saw an adult in both live and pre-recorded videos produce actions that were followed by accidental and intentional intonations. The results indicate that at around 16 months infants are able to infer the intentions of others from the tone of voice alone. The intonations in the previous studies incorporated various acoustical features such as pitch contours, mean pitch, amplitude and duration of the utterances. One possible confound in these studies is the additional feature of emotional or prosodic valence carried in the intonation when expressing these words. It is therefore possible that the emotional valence associated with the mental state gave infants cues as to intentionality but not necessarily to the mental states of the person expressing the intonation. Therefore, infants in these studies could have discriminated between the two emotions, the positive one associated with the intentional intonation and the less positive one associated with the accidental intonation and based their actions on just the cues given by the valance.

Research has documented infants' ability to discriminate emotions in both the face and voice modalities. More specifically, infants as young as five months are able to discriminate different emotions from the voice such as happiness, sadness and anger when these are presented in conjunction to a facial expression (D'Entremont & Muir, 1999; Walker-Andrews & Grolnick, 1983; Walker-Andrews & Lennon, 1991). Some other studies have found that five month old infants are capable of

discriminating vocal expressions of positive and negative emotions but cannot do the same when they are presented with the equivalent facial expressions (Fernald, 1992). Similarly Moore and colleagues (Moore, Spence & Katz, 1997; Spence & Moore, 2003) found similar results for 6-month-olds, who were able to discriminate emotions of approval and comforting in vocal expressions which differed from 4-month-olds who could only perform the discrimination when they were aided by a facial expression. On the contrary other studies support that infants are able to recognise and distinguish anger, fear and surprise in the facial expressions of female adults (Serrano, Iglesias & Loeches, 1992).

The question of interest in our research, and the one we tried to resolve in this study, is whether infants can discriminate and respond by selecting the appropriate mental state from two similarly positive sounding intonations. A study that investigated infants' ability to discriminate and differentiate between different degrees of positive emotion was conducted by Bornstein and Arterberry (2003). In a series of experiments in this study, infants were habituated to pictures that displayed four degrees of smile. Then they were presented with an expression of an intermediate degree of smile and an expression of fear, both presented by the same person. The five month old infants in this study looked longer at the expression of fear over the new expression of smile which indicates that they recognised the new degree of smile but thought the fear expression differed from the smiling expression they had seen before. This study also demonstrated that infants can not only discriminate among facial expression but they can also categorise facial expressions. This ability to categorise was shown when 5-month-olds were habituated to four degrees of emotion each presented by a different person and then tested on an average smile displayed by a new person and a fearful expression also presented by a new person. The results

showed that despite the fact that the expressions were portrayed by different people, infants appeared to be able to categorise the smiling expression with the ones they had seen during habituation because they still looked longer at the expression of fear. This study's findings support that infants are sensitive to facial expressions of emotion at an early age and they are able not only to recognise and discriminate emotion, but they are also able to categorise it and group it with similar emotions they had previously seen (Bornstein & Arterberry, 2003).

Although studies like the one by Bornstein and Arterberry (2003) have found intriguing results for sophisticated abilities in young infants, this type of abilities have not received as much attention by researchers studying similar abilities in the vocal domain. Furthermore, studies on the ability to infer mental states from the tone of voice are almost nonexistent. With this study, we wanted to examine whether infants at around 18 months of age are able to infer the mental states of another person when the person utters vocal intonation that indicates two different mental states. In our previous studies infants were able to understand and distinguish the two mental states but we wanted to make sure that they were not discriminating on the basis of emotional valence. In these previous studies, it is possible that infants were copying more intentional actions because the intonation following those intentional actions sounded more positive than the accidental intonation that was indicating the accidental actions.

From research on the ability to produce intonation we know that young infants are quite advanced at producing vocal expressions (Balog & Snow, 2007). Research on intonation has found that infants are attracted to positive intonation. Infants also prefer listening to infant directed speech over adult directed speech. A study that compared utterances spoken in positive adult directed and typical infant directed

speech found that infants were more attracted to the adult directed speech which was as a result of the positive affect in the intonation (Singh, Morgan & Best, 2002). Balog and Snow (2007) further suggested that there is a U shaped trend in the production of intonation by infants and young children. They propose that there is more advance production between the ages of 6 and 8 months, which drops between 9 and 14 months and is elevated back to a higher level of production at around 18 to 20 months. These authors further suggest that this falling off in production behaviour might be the result of the developmental changes that infants go through around the ages of 9 months, including the onset of communicative intentions, walking, and the emergence of the first words. Balog and Snow suggest that at 18 months, when infants return to their old levels of intonation production might be the result of stability in their system (Balog & Snow, 2007).

Research that has looked at intonation and in particular the effect of pitch contours on adults' ability to detect various emotions has had inconclusive results as to whether it is the contour or other characteristics of the acoustics of intonation that lead to the discrimination of different emotions. Some researchers, however, have suggested that characteristics such as the pitch range, global F0 level and voice quality might have a greater effect on emotion recognition than the shape of the contour (Ladd, Silverman, Tolkmitt, Bergmann & Scherer, 1985; Scherer, Feldstein, Bond & Rosenthal, 1985; as cited in Banziger & Scherer, 2005). More specifically, Scherer and colleagues have suggested that "vocal aspects covarying with emotional attributions (such as F0 level in this study) might mainly reflect and communicate physiological arousal associated to the emotional reaction, whereas configurations of prosodic features (such as F0 contour shapes) would be used to signal specific

attitudes in association with the linguistic content of the utterance" (Scherer, Ladd & Silverman, 1984; as cited in Banziger & Scherer, 2005, p.256).

One acoustic characteristic of intonation, the pitch contour, has received attention from researchers interested in intonation. Pitch contours have been described in terms of the expression of attitudes. In particular, contours of the type rise-fall (which is the contour that describes this study's intentional intonation) has been described as involving "a sense of finality, completeness, definiteness" (Cruttenden, 1997, p. 92). In addition the low and rising contour has been described as conveying incredulity, as well as an expression that indicates that something might be incorrect (Pierrehumbert & Hirschberg, 1992). At the same time, rising contours have been described as conveying the meaning of "non-finality" (Cruttenden, 1997, p. 92), which in turn might signify incongruity, or that something is questionable.

In our opinion, mental states are providing meaning in the way that pitch contours are providing information about attitudes. We also believe that mental states are related to emotions in the same way that acoustical characteristics of intonation are affecting emotion attributions from the tone of voice. However, we believe mental states to also differ from emotions. We consider the process of mental state understanding to be based on attributions or inferences about unobservable behaviours that can occur in conjunction with observable behaviours. Mental states can therefore be inferences about another person's intentions, desires, and goals among others. Emotions are related to intentions, desires, and goals as they are often the resulting expressions of a successful or unsuccessful plan of action or the result of attaining or failing to meet a goal. Emotions are also observable such as in the expressions in the face and the voice and therefore they might not require the high level processing that a mental state might need. In addition, mental states might differ from emotions, as

mental states are attributions as to what caused that emotion in the first place. Therefore, although valence in emotional expressions might often be enough to help someone understand whether the person is experiencing a positive or negative emotion, some additional step is needed in order to reason why this emotion is linked with this experience. We can therefore conclude that mental state understanding is needed in order to appraise what caused that emotion in the first place and that understanding a mental state is often what helps give meaning to the emotion one is feeling.

In this study, we wanted to see whether infants are able to understand the intentions of another person when the two intonations expressing the different intentions are similar in affective valence but do differ in other acoustical characteristics. In order to achieve this we wanted to include intonations that maintained a similar F0 level and F0 range in order to control for emotional information. At the same time we wanted to manipulate the F0 contour shape in order to manipulate the attitude and mental state conveyed by the speaker. The characteristics that we believe would make an intentional intonation differ from an accidental or nonpurposeful intonation include the pitch contour and to some extent the duration of the utterance.

Study 1: Pilot With Adults

4.2 Method

A pilot study was run in order to obtain the audio stimuli that were to be used in the main study. A female adult produced these utterances and was a native Greek speaker. The adult aimed at producing intonations that had a rise-fall F0 contour for intentional intonations and a rising F0 contour for the accidental intonations. At the

same time the adult tried to produce intonations that ranged from neutral to positive. Fifty utterances were chosen for the pilot study. Five of these 50 utterances were used as practice trials for the first part of the pilot study, which was to rate the utterances as to whether they sounded positive or negative. Another 5 of these utterances were used as practice trials in the second part which was to rate the utterances as to whether they sounded accidental or intentional. Twenty adult participants heard the remaining 40 utterances in each part. Twenty of the utterances were of the word *Nato*, half of which were expressed with different types of intentional intonation and half were expressed with different types of accidental intonation. The other twenty utterances were of the word *Ochi* half of which were expressed with different types of intentional intonation and half with accidental intonation. In the first part of the study the participants were asked to rate whether the intonation sounded positive or negative. After their positive or negative decision they were also asked to rate their decision on a scale from 1 to 5. If they had chosen positive for example, they had to choose how positive it sounded, with 1 being just a little bit positive and 5 being very positive. For the second part they were instructed to rate intonations as to whether they sounded accidental or intentional. They were further instructed to think of an intentional intonation as in the case when the person did an action purposefully and achieved it, and for the accidental intonation as in the case when the person did an action which she did not mean to do. After each decision, participants had to rate the utterance as to how accidental or intentional it sounded on a scale from 1 to 5. The results of the pilot study determined two Nato intonations that sounded equally positive and had the following characteristics. Intentional Nato: Mean Pitch = 336 Hz, Range = 474 to 234 Hz, Intensity = 74 db. Accidental Nato: Mean Pitch = 426 Hz, Range = 842 to 245 Hz, Intensity = 74.55 db. The rating that these intonations

received on the positive valence scale was 2.5 out of 5 (middle). These two chosen intonations were used throughout the study.

Study 2: Study With Infants

4.3 Method

4.3.1 Participants

Nineteen infants took part in this study. The infants' ages ranged from 17 months 12 days and 18 months 17 days. The mean age was 18 months, 2 days. Overall, 22 infants took part in the study but 3 infants were excluded. Two were excluded due to experimenter error and 1 because the infant did not finish the study.

4.3.2 Materials and Design

The materials and design for this study were the same as in the two previous chapters. Four toys were again used for the test phase of this study. Because in chapter 3 we saw that one of the toys, Rudolf was problematic, we decided to exclude it for this study. Instead, we used the other 4 toys, Puppet, Elf, Chicken and Pirate.

4.3.3 Procedure

The procedure for this study was the same as that described in chapter 3. Infants watched videos of an adult's hand performing actions on toys. After each action an intonation that was either intentional or accidental was uttered. Following the second action and the second intonation a fun outcome, the end result, appeared. After each video was completed, the experimenter put the actual toy on the table and asked the child, "Can you make it work?" Infants produced actions and the session

was videotaped in order to score the actions for each toy later. Each child received the training toy and 4 other toys per session.

4.3.4 Scoring

The scoring was the same as in the previous chapters. The infants' responses were scored from the video recordings. The actions were scored as being Intentional, Accidental in Order and Incorrect order as well as Neither action.

4.3.5 Reliability

A second coder naïve to the purpose of the study watched the infant actions without sound and scored them according to whether the child produced one action or two actions. The results of the reliability showed that there was disagreement on only one trial for two children. A coefficient kappa value was calculated on the relationship between the experimenter's scoring and the second coder's scoring. The results showed a strong relationship k = .92.

4.5 Results

The first analysis took into account the overall number of intentional actions and accidental actions by also combining actions that were done in order and incorrect order to the accidental only and intentional only actions. The results of the comparison between overall accidental and intentional actions showed no significant effect. The mean overall intentional actions performed by the children were 72.09 (SD = 14.12) and the mean accidental were 69.26 (SD = 13.99), $z = -.55, p = .59$. The next analysis looked at the comparison between the intentional only actions and accidental only actions and the other categories of actions done in order and incorrect

order. This comparison showed nonsignificant results for the comparison between intentional actions only (M = 29.38; SD = 14.60) and accidental actions only (M = 28.07; SD = 13.53), z = -.16, p = .88. The comparison between intentional actions only and actions done in order was also nonsignificant, (M = 24.78; SD = 12.99), z = -.81, p = .42. However the comparison between the intentional actions only and actions done in the incorrect order was significant (M = 17.11; SD = 10.20), z = -2.51, $p < .01$.

Another analysis looked at the two conditions separately. There were significant results in the comparisons between intentional actions only and actions done in the incorrect order in the Accidental-Intentional condition. The other significant results were between the Intentional only actions and actions performed in order in the Intentional-Accidental condition. The results can be seen in detail on Tables 4.1 and 4.2.

Table 4.1. *Mean, Standard Deviation and significance values for A - I condition*

Condition	**A – I**			
	M	*SD*	*z*	*p*
Intentional	26.31	30.59		
Accidental	28.07	21.91	-.35	.73
Order	36.41	24.88	-.99	.32
Incorrect Order	7.89	11.94	-2.17	.03

Table 4.2. *Mean, Standard Deviation and significance values for I - A condition*

Condition	I – A			
	M	*SD*	*z*	*p*
Intentional	32.45	18.19		
Accidental	28.07	23.44	-.70	.48
Order	13.16	15.29	-3.99	.003
Incorrect Order	26.32	20.28	-.71	.48

4.5.1 Vocal Analyses

Vocal analyses using the acoustical analysis software Praat were conducted on the two intonations used in this study. The mean F_0 for the intentional intonation was 336.15 Hz. The mean F_0 for the accidental intonation was higher with 426.74 Hz. Other characteristics for the accidental intonation included a range of 612.01 Hz and a duration of 1.12 seconds. The intentional intonation had a range of 242.69 Hz and a duration of 0.77 seconds. The amplitude for the intentional intonation was 73.98 db and for the accidental was 74.55 db. The intonation contour for the intentional intonation was a rise-fall contour and the accidental contour was a rising contour. The two contours can be seen in Figure 4.1 and 4.2.

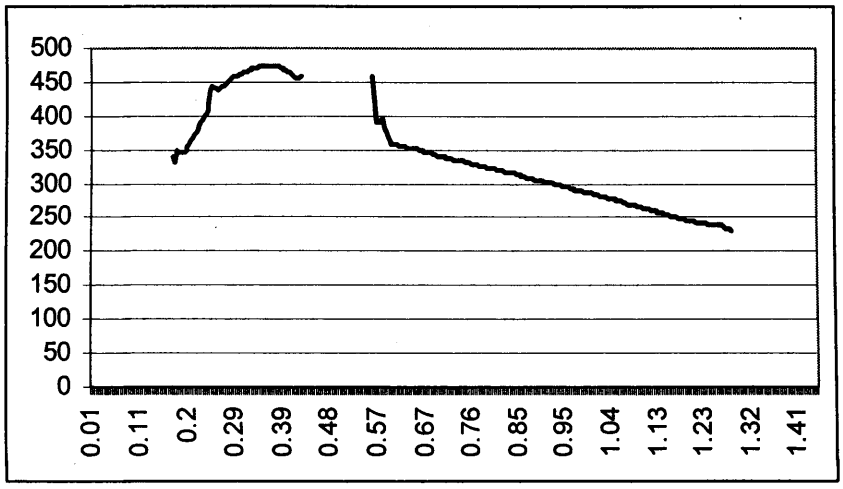


Figure 4.1. *Intentional Intonation Contour*

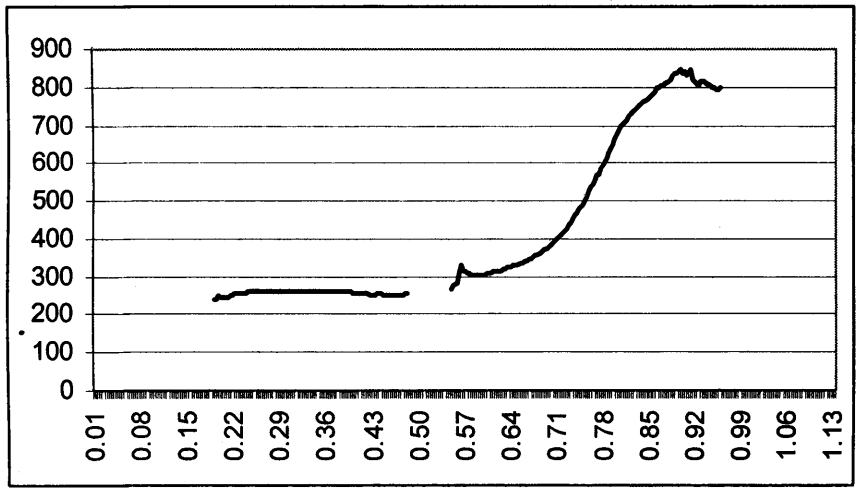


Figure 4.2. *Accidental Intonation Contour*

4.6 Discussion

The results of the current study showed that children have difficulties in this task. The results showed that infants on average produced similar amounts of intentional actions and accidental actions. Therefore, these results showed that the

percentage of correct intentional actions is a lot lower than that observed in our previous studies. The difficulties that infants had with this task can be attributed to different potential factors. One possible factor is that infants cannot distinguish between two intonations that are similarly positive. It is possible that infants cannot hear the difference between the two mental states, that is, they hear them as similar due to the resemblance in valence. However, our hypothesis that the intonation contour should be able to inform infants about another person's mental state makes us sceptical about such a conclusion. In addition, the study as it stands right now has some confounds that are likely to have given rise to the above results. The first confound are the words chosen for this study. During the pilot study, we presented adults with the word Ochi and the word Nato pronounced with both accidental and intentional intonations. Some of these intonations received a very positive rating, some received a rating of around 5 (max positive rating) and some received a rating of less than 5. We decided to choose intonations that were rated as close to a rating of 5, however, the two representative intonations for this rating were of the word Nato. Therefore, we ended up using these 2 intonations which were expressed with the same word. Having these intonations expressed through these two words might be a hindrance for this study as children at this age are word learners. Studies like the Friend study (2001) have shown that around 16 months, when infants begin to build their vocabulary, they tend to focus more on the words of a message rather than the intonation in which the message is expressed in. Therefore, due to the fact that the infants in this study were 18-month-olds it is possible that a lot of the infants in the sample focused more on the words than on the intonation. This is one of the reasons that could explain why we see a lot fewer intentional actions in this study and why we see more accidental actions and actions done in order and incorrect order than in

previous studies. This confound could be resolved by including two different words instead of one.

From the results of this study we are therefore unable to conclude whether the intonation contours have or do not have an effect when it comes to interpreting mental states, such as intentions. Further research is needed to provide answers to the question of mental states through the tone of voice. A possible avenue for research is through adult participants. This question of intonation contours and other acoustical characteristics has not been widely and consistently studied and research is lacking especially for the mental state of intention. Further research could examine the role that valence plays when we are inferring mental states. It is important to carry out work that takes valence into consideration and which tries to shed light to the function and relationship of valence to mental states. For this reason, it might be easier to test hypotheses with adult participants to understand the role of valence and then apply this to work with infants and young children.

CHAPTER 5: INFERRING INTENTIONS FROM INTONATION: EVIDENCE FROM LOOKING TIMES

5.1 Introduction

In this chapter I will consider a new method for assessing intention understanding, the looking time paradigm. Our first aim for using this method is to replicate the findings that we have found with the imitation paradigm in the previous chapters. A second aim for using this paradigm is to assess intention understanding in our 14-month-old sample that was not performing as well as the older infants. Looking time paradigms have demonstrated that they can yield results with younger infants because all that is required from these infants is to look at the stimuli without having to exhibit any other form of behaviour. In the following paragraphs I will discuss research that utilised this paradigm and reveal what types of questions have been answered as a result of using this paradigm.

As the paradigm's name suggests, this methodology depends on infant attention as a measure which is elicited by the infant's looking behaviour following different events. This paradigm has been used to study infants' understanding of perception, cognition and social cognition. In addition to the different areas of research, it has been utilised to examine different mechanisms and processes, such as categorisation and discrimination (Bornstein & Arterberry, 2003). One area that has received a lot of attention from researchers using looking time paradigms is goal attribution. Looking time paradigms have been widely used in the study of this particular area because goals are linked to actions, and actions can be easily executed with hand movements, head turns, and pointing. Because infants have the ability to

observe and process such actions, this reasonably easily set up method has been utilised widely to study these aspects of social cognition.

The looking time paradigm and its variants have been used for decades to study both perceptual and cognitive aspects of behaviour. Some of the modifications of the looking time paradigm include the "habituation paradigm" and the "violation of expectancy paradigm." The habituation paradigm rests on the assumption that infants become used to (and thus habituate) looking at a scene that is repeated. This repeating scene familiarises the infants with the relations of two or more aspects of the scene. Habituation is determined by calculating the criterion at which infants look at the scene for approximately half of the time that was spent looking at the scene the first 3 times it was presented. Following habituation, they are presented with two test events which differ slightly from the initial habituation event. One of the test events is similar with what infants were looking at during habituation, whereas the other scene differs in relation to the initial habituation scene. The dependent variable of interest is the amount of time infants look at one of the test events versus the other.

In order to illustrate how this technique works, I will focus on some studies by one of the biggest exponents of the habituation technique, Amanda Woodward. Woodward and her colleagues have demonstrated on various occasions that infants are sensitive to the hand actions of others and the goals to which these actions are extended to. In one of her studies Woodward was interested in the effect that agency, either animate or inanimate, might play in the attribution of goals. For this study she compared infants' looking time to events where a human arm was reaching and grasping objects versus looking time at scenes where a rod or a claw were grasping these objects. In one such study, 5-, 6- and 9-month-olds were habituated to the arm of a person that reached and grasped one of two toys that were placed next to each

other (Woodward, 1998). Following habituation, during the two test events the position of the toys was changed, so that infants saw either the person reaching and grasping the same toy as before (now in the other toy's position), or reaching and grasping the other toy which was now in the same position as the toy that was grasped during habituation. So the person now either reached towards the same position as during habituation, but grasped a different toy (new goal/old path) or grasped the same toy as habituation but from a different position (old goal/new path). In the inanimate conditions, the same procedure was carried out but this time the arm was replaced by a rod, (or a claw in another condition). The results indicate that in the arm condition, infants looked longer at the object than at the path of movement. This was not seen in the inanimate conditions. More specifically, the 6- and 9-month-olds (and the 5-month-olds to some extent) in the hand condition dishabituated, that is they regained interest to the new goal/old path test events. The infants in the inanimate conditions responded to the test events equally. Woodward concluded that infants in the hand condition selectively encoded the goal of the actor's grasp and the infants in the inanimate condition did not. These findings suggest that infants can differentiate between human agency and inanimate agency and expect that human activity is goal directed. In a follow up study, these results were extended to grasping movements versus back of hand movements. The results again showed that 5- and 9-month-olds interpreted the grasping movements to be directed towards the toy, which they interpreted as the goal of the grasping action, whereas they did not show preference between the two test events in the back of hand condition (Woodward, 1999).

Other studies using this methodology have confirmed these findings. For example, Hofer, Hauf, and Aschersleben (2005) replicated Woodward's (1998) claw condition and obtained similar results. However in a separate condition, when prior

to the study they showed 9-month-olds that it was an actual person who was operating the claw behind the screen, and were also given the chance to play and examine the claw, they found that 9-month-old infants performed similarly to 12-month-olds. They looked longer at the object change than the path change. These researchers concluded that infants were able to distinguish between the two events and attribute goal directedness after they had seen the claw being treated as a tool. Similarly, Guajardo and Woodward (2004) found that showing infants that a glove covered hand belonged to a person altered previous results where 7- and 12-month-olds had seen the gloved hand without an indication that it was worn by a person. They concluded that the interpretation that infants give to an entity and its relation to goal directed action relates to the extent to which that entity is viewed as human or not.

Other studies by Woodward and colleagues have generalised these findings to the relation between gazing and objects at 12 months and the relation between objects and gazing together with grasping movements at 7 and 9 months (Woodward, 2003). These results showed that infants consider gazing towards objects as an intentional and goal-directed action. Similar findings were shown in a study that examined the relation between pointing and objects, as 12-month-olds but not 9-month-olds looked longer towards the goal object rather than the path of motion. This finding suggests that 12-month-olds understand the relation between people's pointing actions and the object they are attending and referring to (Woodward, Sommerville & Guajardo, 2001). Taken together these findings on goal-directed behaviour through habituation reveal that even at 5 months, infants have expectations about goal directedness from human agents.

I am now turning to the other form of looking time paradigm, the violation-of-expectation paradigm. This paradigm presupposes that infants have expectations

about events in the world and relies on the notion that infants are sensitive to the incongruent aspects of these events. Researchers who have used this paradigm consider that infants attend differentially to certain events, depending on the expectations they have about the role of these events, and therefore they look longer at events that violate their expectation. In the violation of expectation paradigm researchers usually familiarise rather than habituate infants before the test events. This is because if infants already have a notion about the event then they do not need additional time to become familiar with it. Studies that use the violation-of-expectation paradigm have mostly focused on young infants' understanding of physical properties in the world. In a review of studies using violation-of-expectation to examine infants' understanding of occlusion, containment and covering, Baillargeon (2004) showed that infants around the age of 2.5 and 3 months are able to detect violations in the relationship between objects and their locations, the property of objects to not allow other objects in them when they are closed, and that objects continue to exist even when they are covered. These findings seem to suggest that infants have some sense of physics early on in development.

In addition to using violation-of-expectation to study physical properties, some researchers have also used it to examine social aspects of behaviour. Phillips et al., (2002) examined the relation between facial expression and intentions. They argued that because an intentional and a non-intentional movement can appear behaviourally identical, it is other features such as movements and expressions which can help us in identifying intentions. They propose that intentional actions (which are described as acts that are directed towards target objects) and additional behavioural characteristics such as gaze, facial expression and vocalisations can give an indication as to whether an intention is positive or negative. Phillips et al. use the term "functional

connections" to describe the connections between movements and facial and vocal expressions. They also suggest that the object-directedness of actions on objects and these functional connections that link actions and expressions can help identify intentions. In one of their studies with 14-month-old infants, they utilised gaze to examine whether infants can attribute intentionality to gaze when no grasping action was involved (Phillips et al, 2002). In this study, there were two toy cats placed on the left and right side of a table. The infants saw the adult only directing gaze to one of the two cats during the familiarisation trials (the experimenter looked at one of two cats but did not grab it during habituation). The experimenter looked at the cat with an expression of interest and joy and said "look at the kitty." These familiarisation trials were infant controlled so if the infant looked away from the trial for more than two seconds, the trial ended. During the test events, the adult looked and emoted towards the other cat (Cat B, i.e. not the one they saw in habituation). Following the test events a curtain fell which then opened again to reveal the adult holding one of the cats. During the incongruent event the experimenter picked up cat A, and during the congruent event she picked up cat B. Infants were shown the consistent event 3 times, and the inconsistent event 3 times. These were shown in alternation. Phillips et al. (2002) found that infants looked longer at the incongruent events than the congruent events.

An interesting aspect of the Phillips et al study is that even though these infants were only familiarized to the gaze and the emotion (visual-emotional regard) of the experimenter without subsequent action during habituation, they were still able to infer that this visual emotional regard would result in the experimenter picking up the cat that they were expressing interest towards. This suggests that the 14-month-olds demonstrate recognition of the connection between visual-emotional regard and

subsequent actions and find it strange when the adult did not proceed to complete their intention to pick up the cat they were emotion towards. In addition, the researchers claim that since the familiarisation phase did not show the subsequent actions (only the visual-emotional regard), then the infants could not have learned this emotion-action connection in this procedure. Thus, the data provide strong support that infants at 14 months expect an adult to pick up something that the adult regards positively (Phillips et al., 2002).

This study by Phillips et al (2002) is one of the first to demonstrate that infants are sensitive to the mental states of others, such as their intentions. More recently, another study has examined a different mental state, the mental state of belief (Onishi & Baillargeon, 2005). This study is particularly important because experimental studies on belief have not been able to find belief understanding arising before the age of 3 years. Many studies have not been successful at showing an understanding of belief in children younger than 3, probably because the methods employed have required verbal responses from children (Wimmer & Perner, 1983). Onishi and Baillargeon (2005) utilised a nonverbal violation-of-expectation task which made it appropriate for younger infants, in this case, 15-month-olds. Infants in this study watched an experimenter hide a toy (a watermelon slice) in one of two locations (a green box and a yellow box). Following this, the infants watched one of four belief induction trials. In one condition, infants saw the experimenter watch as the yellow box that was empty moved closer to the green box that contained the toy, and move back again to the original position. In another condition, the toy moved from the green box to the yellow box (on its own) while the experimenter observed this taking place. The third condition was the same as the second condition, but this time the experimenter was concealed behind a curtain and because of this she could not see the

toy moving from the green box to the yellow one. The fourth and final condition was longer than the other three conditions because the experimenter was present in the first part and watched the toy moving from the green box to the yellow. Following this, the curtain fell and the experimenter was unable to see the toy returning back to the green box. Therefore, the first two conditions were true belief conditions because the experimenter witnessed the movement of the boxes and the toy and the last two conditions were false belief conditions because the experimenter was not aware of the toy's position in the final location. During the experimental trial infants saw the experimenter reaching to find the toy either in the green or yellow box. Infants in this study looked longer at the scene where the experimenter reached to the location where she did not see the toy being hidden. Infants therefore had an expectation that people reach in places where they last see something being hidden. This study is very important and interesting because it has managed to show understanding of false belief in 15-month-olds in a task on which even 3-year-olds have difficulty with.

These looking time studies have been revolutionary in that they are able to show results in infants of very young ages. However, they do not seem to make a connection between being able to show understanding, and then be able to act according to this understanding. It is therefore of interest to look at studies that have examined looking time and subsequent performance on similar experimental tasks. Having two tasks that can be compared can also allow us to see individual differences in how infants can perform on different tasks that require different skills, for example looking and attention in the looking time task and direct production in the experimental task.

However, one study that has looked at this distinction was carried out by Sommerville and Woodward (2005). In this study they examined whether infants can

organise action representations in order to achieve a goal, as in the case of pulling a cloth to retrieve an object. In the habituation for the toy-on-cloth condition infants saw a demonstrator pull one of two different coloured clothes towards her and then grab the toy from that cloth. During testing in the *new goal* event, the demonstrator pulled the cloth that was the same as in the habituation phase, but this time the toy on the cloth was the opposite to the one seen during habituation. In the *new means* event, the demonstrator pulled the cloth that she did not pull during habituation, but this time on it was the same toy as the one that was used in habituation. For the toy-off-cloth condition the two toys were on the table next to the cloths. In the habituation phase the experimenter pulled one cloth (it was just a cloth, the toys were on the side of the cloth, not on it) and then grabbed the toy which was on the side of the cloth. In the *new goal* event the experimenter pulled the same cloth that the infants had seen her pull during habituation but grabbed the new toy. During the test trials infants looked longer at the *new goal* events in the *toy-on-cloth* condition, whereas on the *toy-off-cloth* condition they looked equally at both events. Sommerville and Woodward's (2005) findings suggest that infants understood that pulling the cloth was done to achieve the goal of taking the object from the cloth.

In the second part of the study, Sommerville and Woodward wanted to identify when infants develop the ability to organise action sequences. To assess this they gave infants a production task and they looked at relationships between the two tasks. The action condition consisted of a yellow duck which the infants handled, after which the duck was taken away and put on the cloth. Infants had 30 seconds to retrieve the duck. A number of other toys were used in consequent trials. All toys and cloths differed from the ones used in habituation. The results revealed that infants who performed planful actions in the action production condition also viewed

the actions of the adult in the habituation as directed towards the toy. The opposite was found for infants who did not act planfully in the action production condition. One important conclusion that can be drawn from this study is that infants who are good at attributing intentions to others, as seen through their looking time behaviour, are also good at producing that intention themselves.

This chapter describes a study whose motivation was to see how infants would perform on a looking time task where infants first become habituated to a video of a two-step sequence and end-result, such as those used in the experiment in chapter 3. After the familiarisation phase infants received one test trial that was either congruent or incongruent with what they had seen during habituation. The end result was present in both the congruent and the incongruent trials. The rational for the congruent trial was that infants had seen that action being performed and yielding an intentional intonation. Thus, when they later saw it during the test trial they would expect that the end-result would appear since that is the intentional action. The rationale for the incongruent event was that infants would have matched that action with the accidental intonation so they would not expect the end-result to appear after this accidental action was performed. We decided to make this study a between subjects study, and thus we were interested in examining the differences in looking time between the infants who saw the congruent trial during testing and the infants who had seen the incongruent trial during testing. The hypothesis of the looking time study is that infants who receive the incongruent trial would have a longer looking time than the infants who are presented with the congruent trial.

We also wanted to compare looking time performance to actual intention understanding through an imitation paradigm. We wanted to draw similar associations as the Sommerville and Woodward (2005) study by seeing whether the

infants who looked longer at the incongruent condition would also produce intentional actions on the imitation paradigm. Therefore, after the looking time study was completed, infants were taken to an adjacent room where they saw the actual toy. During this part of the study infants sat on their parents lap and were asked to make the toy work just like in our previous imitation studies. The infants did not receive a demonstration phase in this part of the study because we wanted to see if they would be able to transfer their understanding and expectation from the habituation study. The overall hypothesis of this study was that infants who had looked longer at the incongruent trial would also perform better on the imitation task.

5.2 Method

5.2.1 Participants

Twelve infants took part in the study. The mean age of the group was 14 months, 2 days (range 13 months, 11 days to 14 months, 24 days). Participants were recruited through playgroups, libraries and leisure centres in Cardiff, Wales. The participants in this study first took part in the looking time paradigm, and then took part in an imitation trial.

5.2.2 Materials and Procedure

The materials in the looking time study consisted of 10 trials for the habituation phase, and 1 trial for the testing phase. The toy chosen for this study was Puppet. The two actions on Puppet are a pushing action and a rolling action. The end-result was a dragon finger puppet that appeared in a small window and moved about in that window. The video clips consisted of either the pushing action first (followed by the intentional or accidental intonation) and the rolling action second

(followed by the intentional or accidental intonation), or the actions performed in the opposite order. The end-result appeared 1 second after the hand disappeared from view. The test events consisted of only the pushing or rolling action, this time without the intonation. The end result appeared 3 seconds after the hand disappeared from view.

The presentation program was set up so that the scene would end when infants looked away from it for more than 2 seconds. If infants looked away during the first 1 second of the presentation then the same scene restarted. The experimenter watched the infant in a monitor next to the testing room and pressed a button when the infant was looking at the screen. When the infant stopped watching the scene the experimenter released the button. The computer calculated how long infants looked at the scenes. During the study infants sat on a high chair about 60 centimetres away from the screen. In order to get the infants to sit on the chair and also to make them feel more comfortable in the experimental booth, they were presented with a video of two puppets dancing to a children's song. After the child sat on the high chair and seemed attentive to the screen, the experiment began. During the study, parents sat behind the child and listened to music through headphones. This was done so that parents would not be able to hear the intonations. Parents were instructed to smile if their infant looked back at them and put their arms around the infant to comfort them if they were feeling distressed. If infants were distressed and were reaching for their parent we allowed them to sit on their parent's lap during the remaining study.

The screen used for the presentation of the stimuli was a 19 inch LCD screen. The camera was directly above the middle of the screen and two speakers were placed in the middle, below the screen. These speakers were covered over by black cloth to make them invisible to the child. The testing room was also covered with black cloth

all over, except around the screen and the lens of the camera where the cloth was cut around these surfaces. During the study, infants were firstly presented with a bright line drawing that attracted their attention. Once their attention was directed to the screen the trials began. Before each trial, the line drawing was flashed on the screen in order to get the infants' attention and then infants were presented with the next trial.

5.2.3 Familiarisation Trials and Test Trials

The videos for the habituation phase were edited so that there was a 1 second time period before the actions began. The habituation trials consisted of an adult's arm and hand performing two-step actions which were followed by the end result. The actions were about 3 seconds apart to allow for the intonation to be uttered. When both actions were finished and the hand disappeared from the screen, there was a 1 second pause before the end-result was activated. During the end-result period, the puppet came out of a window and danced about for a few seconds. After that the puppet slowly retreated. Following that there was a 90 second pause where just the toy remained static on the screen.

The test trials were constructed in the same way except that there was only one action and this was not followed by the intonation. Each action was followed by the end-result. The timings were also the same as in the habituation trials, with the only difference being a 3 second delay instead of a 1 second delay between the time when the hand disappeared and the end result appeared.

This study comprised 8 different orders. These 8 orders were made with four videos that showed the 4 possible orders of actions and intonations on the toys. To these 4 videos we also added the test trials and through this complete

counterbalancing we ended up with 8 videos. Half of the infants received the congruent test trial and the other half the incongruent trial.

This was an infant-controlled habituation and trial study so the test trial (and the habituation trials) ended if the child had looked away for longer than 2 seconds or if they had looked for the whole duration of the trial, that is, for 90 seconds. Infants received a maximum of 10 habituation trials and 1 test trial.

5.2.4 Imitation Trial

After infants finished the looking time study, they were taken to the adjacent room to see the actual toy and perform on the imitation task. During this trial the infants sat on their parent's lap and just received the toy without any previous presentation.

5.2.5 Scoring

The video of each infant was scored using the software program Observer. The experimenter coded the infants' looking during the whole trial by indicating when the infants were looking at the screen and when the infants looked elsewhere. The experimenter also coded when specific key aspects of the video took place, such as the toy first appearing on the screen, the appearance of the end-result and when the trial ended. For the habituation trials we analysed looking time from the beginning of the trial up until the child looked away for more than 2-3 seconds. For the analysis of the experimental trials, we were interested in the amount of looking that had occurred from the point when the end-result first appeared and until the end of the trial.

The imitation trial was scored as in the previous chapters, such as intentional action only, accidental action only, actions in order and actions in incorrect order.

5.3 Results

5.3.1 Habituation Phase

On average, infants had 10 habituation trials. All children took all 10 trials except for one child who took 6 trials. There was no difference between the infants in the two conditions in their overall looking time over habituation $F(1, 11) = .001, p > .97$. This shows that infants in the two conditions had a similar looking behaviour before the test trial. These results can be seen on Table 5.1.

Table 5.1. *Infant Mean Looking Time During Habituation and During Test Trials in the Accidental and Intentional Conditions*

$^{*}p < .05$.

Condition	Average habituation trials	Test Trial
Intentional	23.23 (4.71)	7.72 (4.74)
Accidental	23.05 (10.10)	13.56 (4.37)*

5.3.2 *Test Trials*

Infants in the accidental condition looked longer at the incongruent test event than the infants in the intentional condition $F(1, 11) = 4.91, p < .05$. The means can be seen on Table 5.1. The range of looking time for the accidental condition was between 3.32 seconds and 15.52 seconds. The range for the accidental condition was 8.44 seconds and 17.97 seconds.

5.3.3 *Reliability*

A second coder scored the videos for three of the infants in this study. The coder was instructed which codes to use in scoring the video and the output of the scoring was compared with the output of the main experimenter. Reliability was scored within +/- 2 frames. The results were 100% accurate.

5.3.4 *Comparison With Imitation Trial*

Due to having only one trial as the test trial in this study, it might not be completely possible to examine the relation between the infants' looking behaviour and their imitative behaviour on the toy. The reason for this is because children might be prompted to copy the action on the test trial as that action produces the end result in both the accidental and intentional test trial. Due to the small number of children tested, we were also unable to carry out an analysis but the frequencies of the children's responses can be seen on Table 5.2. From these data we can see that infants produced a mix of matching behaviours and nonmatching behaviours. More participants are needed in order to see a relationship between the looking time task and the imitation task. These actions can be seen on Table 5.2.

Table 5.2. *Infant's Imitation Scores That Matched the Test Trial Action in the Accidental and Intentional Conditions*

	Trial Matched	Trial Not Matched	Both Actions	
			Order	Incorrect order
Infants	5	4	3	1

5.4 Discussion

Infants in this study were habituated to scenes of a person performing two actions on a toy and indicating each action as intentional and as accidental. Following the second action a puppet appeared as an end-result. Following the habituation trials, half of the infants in this study received the accidental trial and half of the infants received the intentional trial. The results show that the infants in the accidental condition looked longer than the infants in the intentional condition. This is a notable finding because it is significant even with 12 participants. Although these results are significant we need to conduct this study with more participants in order to also see relations with the imitation measure.

The results of this study are in agreement with the result of other studies on infants' understanding of intentions and goals but it goes one step further to show that

infants can detect and possibly infer something about the mental states of other people. The results of this study suggest that infants were able to form associations between the intonations and the actions during the habituation phase and later showed differential looking time responses according to the condition that they were in. The looking behaviour of infants in the accidental condition suggests that they had organised their understanding in such a way that allowed them to spot the incongruency in the test trial. At the same time, the results also suggest that the infants in the intentional condition also had an expectation about the intentional event which allowed them to see the test trial as congruent and going according to their expectations.

Whether infants were just detecting or in fact making attributions about the mental states is something that this task cannot tell us. However, it is possible that we might be able to tease the two apart by testing younger infants. It is possible that younger infants at 8 months might not be so skilled at attributing mental states. If however they exhibit similar looking times to those of the 14-month olds in this study then we might be able to conclude that detection is probably the primary factor driving these results. If on the other hand they don't show this distinction in looking time, then we could assume that an inference mechanism could explain the results of the 14-month-olds' looking times.

This looking time study demonstrates the distinction between intentional and accidental mental states through the use of an intentional and an accidental tone of voice. This study has confirmed and expanded the results of the previous chapters that found similar findings with imitation measures. However, as it was also pointed in the previous studies, the two tones of voice might carry a positive and a negative valence. As discussed previously, it is possible that the infants in this study were able

to do this based on the incongruency of the negative valence and the positive outcome. Although the imitation paradigm in Chapter 4 was not successful (due to limitations in our stimuli) in confirming our hypothesis that infants are making inferences about mental states, it is possible that we might be able to show evidence for that hypothesis using the looking measure with two positively valenced intonations.

CHAPTER 6: GENERAL DISCUSSION

The aim of this chapter is to draw together the findings of the previous chapters and to discuss their importance and implications. Besides drawing conclusions from the studies addressed in this thesis, this chapter will also reflect upon the weaknesses and limitations of these studies. In turn the chapter will also consider follow up studies that could potentially provide alternative paradigms for these limitations and will attempt to give answers to various questions that might have arisen from the discussion of the results.

6.1 Summary of Main Findings

This thesis has found that vocal intonation provides important cues for communicating the intentions of others to infants. The results indicate that infants rely on intonation when making attributions about other people's goal-directed behaviour. These results were first found using an imitation paradigm and extended and confirmed with a looking time paradigm. This thesis looked at both the distinction between positive and negative valence and positive and positive valence used to communicate mental states. At this point we are unable to confidently conclude about the results from the positive – positive comparison but more studies will be carried out to help us understand this distinction.

6.2 Inferring Intentions From Intonation

The findings of Chapter 2 demonstrate that imitation of intentions can occur after both lexical and intonational information. The first study of Chapter 2 replicated the results of the Carpenter et al (1998) study and thus showed that infants between 14 and 18 months can copy the intentions of other people when these intentions are

manifested in the word "There" and tend to ignore actions indicated with the word "Whoops." Similar results were observed when the words were replaced with Greek words that maintained the intentional and accidental intonation of the intentional and accidental messages. It is important to note that the results were obtained even after the Greek words were counterbalanced with the intonations. This allows us to conclude that infants can attribute intentions even when the words have no lexical meaning to them. Infants are able to attribute intentions on the basis of intonation alone. Another important finding from this study is that children were able to perform the task from the first trial they saw demonstrated. This is a critical finding because it indicates that infants were not learning through the task but instead they had a knowledge of intention already in place and they were exhibiting this knowledge in the task.

6.3 Intention Understanding from Intonation with a Video-Recorded Method

The third chapter assessed a new methodological approach for presenting the imitation paradigm. This was motivated for two reasons. The first reason for using this video methodology was concerned with the application of intonation control. Since the main purpose of the thesis was the investigation of intonation cues, it was important to assess different intonations in pilot studies and to present them consistently to each participant. By presenting infants with these prerecorded video we were able to carry out pilot studies in which adults rated the intonations and thus chose the most representative intonations. Another important reason for using this methodology was to see whether infants would be able to perform similarly to the live task or whether they would be hindered by the fact that it was not live and in addition by the fact that the only visible human characteristic was that of an arm. The results

of this study showed that infants were not hindered by the methodological differences of this study. Previously, studies had found that children are sensitive to differences in the type of demonstration. For example, Meltzoff (1995) found that when infants were presented with a human demonstrator they were able to infer what the demonstrator's goal and intention was when he was failing to pull apart two parts of a dumbell. However, when the demonstrator was a machine, children did not attribute an intention or a goal to this machine. This and many other studies (Baillargeon, 2004; Woodward, 1998) that have found similar results demonstrate that infants are sensitive to human agency and they tend to treat humans and inanimate agents differently. In the case of this study, even thought the modeller was not present there in the room but was presented through the monitor, children were still able to attribute intentions and thus saw this demonstrator as an animate agent.

In addition to this, other research found mixed results regarding infants' abilities to represent information presented through videos instead of live demonstrations and proposed that infants display a "video deficit effect" (Anderson & Pempek, 2005). Our results however seem to demonstrate that there is no such deficit in our sample. The results therefore are in accordance to the proposition posited by Deocampo and Hudson (2005) who have suggested that imitation tasks might not require dual representation competence as other studies that were conducted with video demonstrations, such as object search tasks.

Although our video-demonstration study proved similar to the live studies, there was one complication with one of the toys, Rudolf. This toy proved to be problematic as in the video one of its action components was not as salient as the other one, so children tended to prefer one action over the other. When this was discovered and controlled for in the analysis the results still showed similarities to

those of the live study in Chapter 2. The studies in Chapter 3 also showed differences between the older and younger children, like in the studies of Chapter 2. The 16- to 18-month-olds in this study performed better than the 14-month-olds. The fact that some 14-month-olds in this study performed equally well to the 16- to 18-month-olds indicates that there are individual differences in the acquisition of intention understanding and that it is not an attainment that is seen in a narrow age group.

6.4 Distinguishing Positive Mental States

The fourth chapter reported the results of a study that tried to assess the understanding of mental states from two equally positive intonations. This study offers the first attempt to distinguish between valence and meaning for mental states through the tone of voice. The results of this study showed that 18-month-olds performed fewer intentional actions than in our previous studies and a lot more accidental actions than in our previous studies. There are possible explanations for this study's results. Firstly, it is possible that infants' failure to succeed on this task might be associated to the inability to distinguish between the two mental states. It is possible that by controlling the valence we have taken away the cue that was salient to the infants and made it difficult for them to distinguish the purposeful and nonpurposeful mental states. Secondly, the study has potential confounds. One of these confounds is that the words used for the purposeful and accidental mental states were both the same. During the pilot study we presented adult judges with the words Ochi and Nato expressed in different intentional and accidental intonations. We used these two words for consistency as this was what we had used in our previous studies. However, when it came to the results, the two intonations that were rated as highly accidental and intentional and at the same time rated as equally positive were both of

the word Nato. Due to time constrains we decided to use the two stimuli even if the words were the same. Because of this it is possible that the findings might be confounded as a result of having the same words. As we saw from previous studies, infants at the age of 18 months are acquiring language and therefore, by having two stimuli be the same word might have affected the results negatively (Friend, 2001). Future studies need to be conducted to account for such confounding effects.

6.5 Assessing Intention Understanding Through a Looking Time Measure

The fifth chapter examined infant intention understanding with an alternative methodology to that previously used. Imitation was used in the previous chapters but because we found that the14-month-olds were not performing as well as the older children, and because we know from previous research that they have an understanding of intentions at that age, we decided to assess their understanding with another method, a looking time paradigm. There has been a lot of research done with even very young babies using looking time measures and one of their advantages is that it only requires infants to look, something that even very young infants are capable of. Looking time measures rest on the assumption that infants dishabituate to events that violate their expectation and thus they look longer at those events. This study is among the first to examine looking time using intonation as the critical cue and in addition it is the first to assess infant's understanding in a between-subjects design using only one test event which is novel in both the congruent and the incongruent test trials. Previously studies had used up to 3 pairs of test trials and they assessed this in a within-subjects design.

The results of this study revealed that infants looked longer at scenes that violated their expectation, that is, they looked longer at scenes that depicted the

accidental action being followed by the end-result. This shows that even infants of 13 and 14 months are able to detect the goal of the demonstrator and they look longer when the goal is met with the unintentional action. This is a very important finding and it will be discussed further as these results and this methodology open new areas of exploration for intention understanding and the distinction between purposeful and nonpurposeful, or accidental behaviours more precisely.

The looking time study of this thesis shows that even young infants who have not exhibited this understanding in the imitation task were able to show awareness on the looking time measure. Although the results of the looking time study are still preliminary, they suggest that infants look longer at the incongruent events where the accidental action is paired with the end result. Although it is not possible to say what it is exactly that infants are showing in looking time studies, the results of several looking time studies seem to suggest that infants have expectations about actions and the goal directedness of these actions. It is interesting to see that infants in the accidental condition looked on average longer than the children in the intentional condition therefore this suggests that they perceived the inconsistency and looked longer. This study's findings are similar to studies conducted with looking time paradigms and which have found that infants detect discrepancies and show awareness of goal-directedness (Sodian & Thoermer, 2004; Sommerville & Woodward, 2005). Infants in our study seem to be aware of goal directedness and furthermore they appear to be aware of the tone of voice as a cue for mental states. The significance of our study lies in the cue of intonation. Previously a lot of studies on intention understanding and goal attribution looked at actions as a cue. In our study, the actions made by the demonstrator were visually similar and were discriminated as accidental or intentional through the intonation. Due to the

encouraging results of this initial study we would like to carry on collecting more data in order to get results with stronger significance.

One possible reason why infants might be finding the imitation task harder but still exhibiting understanding through looking time could be as a result of their inability to inhibit some cues over others. It is possible that even though infants spot the incongruency in the looking time task, when they get to produce that understanding they might find the task too complex for their abilities. Further studies that look at inhibition, attention and information processing as possible factors affecting infants' performance are needed to understand this difference between recognition and production.

6.6 Intention Understanding in Infancy

The studies of the second and third chapters demonstrate that the understanding of intention progresses rapidly in the first month of a child's second year. Although our study has shown that 14-month-olds might not produce as strong results as 18-month-olds, they still seem to have a rudimentary understanding of another person's intentions from intonation. The findings from this thesis go together with other similar studies that have used the same methodology such as those of Carpenter et al (1998) and more recently the study by Olineck and Poulin-Dubois (2006). Similar findings on the general area of intention understanding have been proposed by other researchers such as in the studies by Tomasello and colleagues (2005), Meltzoff (1995) and Bellagamba and colleagues (1999; 2006) among others.

This finding that intention understanding develops in the first half of the second year goes against some of the theories in the field. Continuous theorists support that the age at which infants come to understand and infer mental states is

often early in development, and is an ability that allows infants to perceive other people as intentional beings, even from the first months after birth (Legerstee, 2005). Trevarthen (1979) also has proposed that infants are capable of early intersubjectivity where from the first months they are able to share emotion with others. This early intersubjectivity later gives rise to secondary intersubjectivity and this is depicted in episodes where infants are beginning to share with others aspects in their environment. Although this theory might have similarities to other theories in the field, such as Michael Tomasello's theory about joint attention, still attributing intention understanding to very young infants, although a tempting supposition, it still needs to be interpreted with caution. Despite this, it is evident that emotion plays a very important role in the lives of young infants. Further research is needed to draw consistent links between how emotion might be related to forming an understanding of intentions and its progression from early infancy to later infancy.

Understanding other people's mental states is a great achievement of young infants as it shows that around 16 months infants display some aspects of a theory of mind. Some researchers propose that what we see from studies such as the ones reported in this thesis is only elementary in comparison to standard theory of mind such as the Sally-Anne task and the Smarties task which call for an understanding of belief. Understanding others' intentions as was seen in this thesis is only one aspect of understanding the mental states of others but recently more research has been conducted on belief in 15-month-olds and this study has produced some exciting findings that suggest that an understanding of others' mental states might arise before the age of 4 years as it was previously thought (Onish & Bailargeon, 2006).

6.7 Intonation as a Salient Cue to Intentions

The important message from this thesis is that intonation is a salient cue for inferring mental states. All experimental studies in this thesis, except one whose drawbacks we have discussed, have shown that the tone of voice is something that can indicate the purposeful or accidental nature of a message. In addition, this thesis' findings support results from previous research that has found that intonation can guide the behaviour of infants. The studies reported in this thesis are in accordance with the findings of studies carried out by other researchers. Similar findings on the effect of intonation on behaviour have been reported by Fernald (1992) who found that mothers used specific intonation contours to convey messages such as approval, prohibition, and attention, which were also used to elicit specific behaviour from the infants themselves. Similar findings have also been reported by Stern et al (1982) and Sullival and Horowitz (1983). Interestingly, the intonation reported by all these researchers, such as bell shaped or falling contours for approvals and rise for attention are similar to the intonation that we used in our studies to express purposeful and nonpursposeful meaning. Papousek et al (1990) also report rising intonation contours and they also ascribe them the role of eliciting attention. Papousek et al though conclude that the high pitch might be the responsible characteristic for the effect of maintaining infant attention. However, in our positive-negative study we have used a rising contour that has a lower mean pitch than the intentional one. This could therefore suggest that the pitch as a characteristic of intonation might not be enough to communicate meaning. This implies that intonation contours are important signals to infants, however, we do not propose that they are the only characteristic of intonation that contributes to meaning. An interplay of other acoustical characteristics

of intonation, such as pitch range, duration, amplitude and voice quality also play an important role in identifying and inferring meaning from utterances.

In addition to taking intonation characteristics into account, it is important to consider the context in which the intonations are uttered in and also who is uttering these intonations. For example, it is possible that in our studies the context of the novel toys with the end-result could have helped children in interpreting the intentions of the experimenter by discerning that the desire and the goal of the experimenter was to get the end result. Following from this end goal it is possible that children attributed the intention of the experimenter to be what the experimenter is going to do to get to that goal. Because the actions themselves were not informative in these studies infants relied on the two intonations to help them decipher which action was that activated the end result.

Recently, studies that have looked at the intonation patterns of parents reading books with humorous and sweet themes to their children have found that parents use a rising intonation when reading the humorous book (Hoicka & Gattis, 2006). These researchers propose that parents are using the rising contour in order to indicate to their child that something in the text is not quite right and that it requires interpretation. They further suggest that because humour often is the result of incongruity, parents are trying to indicate this incongruity with their tone of voice. By using this rising contour, parents are trying to communicate to their children humorous mental states.

The results of these studies help to carry this view further by suggesting that the tone of voice helps infants to gain understanding into other people's intentions. The results of this study are an extension to the Carpenter et al. (1998) and Olineck and Poulin-Dubois (2005) studies.

6.8 Purposeful vs Nonpurposeful Actions and Mental States

Mental states are the unobservable internal states of people's minds which can be inferred or deduced through actions and behavioural cues. The focus of this thesis was mental states and in particular intentions and how these can be inferred from the tone of voice. One interesting aspect of this thesis is the distinction between purposeful and nonpurposeful mental states. When studying intention understanding it is important to be able to understand when something is done purposefully and equally important to understand that something is done but without that purpose in mind. However, there are still questions that still need answers such as whether being able to understand the intentions of others might necessitate an understanding that others also do things by accident. That is, to be able to have an understanding of others' actions as intentional does one might need to understand that sometimes people do things that go against what they intended. More studies need to be done in order to examine when infants first show an understanding that others sometimes do accidental actions that do not meet their intentions.

What we still are not aware of is when the distinction between accidental and intentional actions arises. Very young infants might be able to detect intention understanding in actions that are clearly intentional and clearly accidental but they might still not be able to identify them as mental states. In our studies infants were shown actions that looked similar perceptually but the mental state carried through the intonation was indicating whether they were intentional or accidental. It is therefore possible that even younger infants than those tested in this thesis, would be able to do well on the task if they are presented with explicitly accidental and intentional actions with the appropriate intonation. Being able to see this distinction earlier will help us understand the progression of action perception and how it links with the

understanding of others' minds. In addition, this progression will also allow us to draw comparisons between actions as mental states and other forms of behaviour such as intonation and facial expressions. Finally, it might also help us understand whether distinguishing between intentional and accidental mental states might first arise as perceptual detection in action and then progress into inference of a mental state.

Future Studies

6.9 Intonational characteristics in communicating intentions

The literature on the role of intonation contours and acoustical characteristics is still not very concise on what might have a more influential role when making decisions about emotions and attitudes. More consistent research needs to be done with adult participants in order to understand the role that certain contours, in combination to other characteristics might have on inferring attitudes and mental states. One other important characteristic of intonation which might be especially significant to indicating intentions is that of the force or intensity of the voice. Often parents report that their children will not respond to them saying "no" to certain occasions but that when the parent expresses the "no" with more forceful intonation then children tend to take the message more seriously. This might be similar to what other studies on nonverbal communication have found. For example, Behne, Carpenter and Tomasello (2005) found that it is the way that someone points and the way that someone gazes that makes a difference on whether a child will find a toy hidden in the location that these gestures are directed towards. Fourteen- and 18-month-olds in this study were not able to find the hidden toy if the experimenter used absent-minded gaze and distracted point, but indeed found the toy if the gaze was ostensive and the point more intentional. Therefore, just as the way in which these

gestures differ, perhaps so does the intonation in communicating intentions. It would therefore be interesting to study intonation characteristics and their interactions with communicative intentions. Intonation is a very dynamic stimulus and there are many aspects of it that still need clarification. To conduct this type of research one has to be familiarised with computer programs that allow speech to be simulated in order to contain certain characteristics of intonation, such as a certain level of pitch, a certain F_0 range, amplitude and duration.

6.10 What voices and agents do infants attribute intentions to?

We know from previous research that infants attribute intentions to human agents. One possible next study that could help us explore this further is to examine whether infants can still attribute this intention to a nonhuman agent. It is possible that if a rod is doing the actions and getting the end result while the same human intonations follow after each action, children might not be able to do well on the task because they might not be able to associate the intonations with the end result and the mental states of the rod. Therefore, children might only be able to do this task in the context of a human person even if they are unable to see the human's face as we saw in the study reported in Chapter 3.

Another interesting comparison would be to use different voices in combination with the human and nonhuman agents. For example in order to assess the effect of intonation we could use a nonhuman agent such as a rod doing the actions but at the same time use a human voice to express the mental states. Similarly, we could use a human agent such as a limb for the actions and a metallic computerised voice that will still communicate intentional and accidental mental states.

6.11 Distinguishing two Positive Mental States

The study described in chapter 4 that compared two positive sounding intonations that portrayed two different mental states found null results. Because of this null result we are not in a position to interpret the findings. However, there are possibilities for why the results have turned out this way and these interpretations allow us to plan for further studies. The first predicament is that the words that were used in the study were both the same. As it was discussed above this could have confused children. The reason for this confusion might be that infants at this age are word learners and this might have an influence as they could be focussing a lot on the actual words and might be disregarding the intonation. The study by Friend (2001) found that infants who had a better vocabulary focused more on the words of a message rather than the intonation. Therefore, a further study could repeat the same rationale but should include two different words rather than the same one. Overall, it seems that this study was too difficult for the 18-month-olds and this suggests that we might need to take a step back, understand the effect of valence better with the help of adult participants and then try another study with infants.

Another follow up study that can prove important in trying to see this distinction between two mental states that are expressed with similar valence had been utilised by Walker-Andrews and her colleagues (1983; 1991). In their studies they habituated infants to a visual stimulus while they presented an audio stimulus simultaneously. After habituation, during the test event, they maintained the same visual stimulus but they changed the audio stimulus and they saw that infants dishabituated if they noticed a change in the audio stimulus. This type of paradigm can be used when we want to test infants on their discrimination abilities for different

intonations. This will give us an idea of whether infants can actually tell the difference between two similarly valenced words that mean a different mental state.

6.12 Using Looking Time Measures to Gain Insight to Accidental Understanding

In using the Carpenter et al (1998) method, we found that 14 month olds were not as proficient as the older infants in interpreting the intentions of others. This finding is similar to the findings of Meltzoff (1995) and Bellagamba and colleagues (2006). It is possible that intonational cues to unintentional or accidental events might arise later than the understanding of intentional events. However, we cannot say this for certain as there is a lack of research in this particular area. Therefore, we propose that systematic studies have to be conducted in order to see when the distinction between accidental and intentional actions first arises. We have talked about how action understanding is very important in early infancy so a study might be conducted using a preferential looking technique. In using the preferential looking technique, infants can be presented with a video of someone's hand doing a clear accidental action with an object and another hand doing a clear intentional action with an object. These videos can be manipulated so the accidental and intentional manipulation of the object happens at the same time and at which time a middle speaker can present an accidental audio message for half of the children and an intentional audio message for the other half of the children. The dependent variable in this case will be how long infants look at the matching video combination. It is expected that they will look longer at the matching video than the nonmatching video-audio combination. This study can utilise intonation as a cue instead of lexical terms because we know from our findings and from previous research that intonation is a salient cue to young infants.

When we will be able to understand when this understanding between intentional and unintentional behaviour arises, we can begin to examine what it is that might give rise to the understanding of this distinction. Methods that utilise looking time can potentially become very useful when working with young infants.

In addition to this, it would also be interesting to see when and how infants begin to understand that people do things they did not intend but at the same time they meet their goal. For example, when do infants begin to understand the concept that sometimes people get "lucky" even when they did not intend to do something but they still achieved their goal. Luck is often expressed with surprise because something that you did not expect or in some cases something that you did not intend gave out a positive result. In those cases, it looks like something nonpurposeful or perhaps negative can result in something positive. Can children understand this distinction as well or do they only understand that something positive can give rise to something positive and that something negative can give rise to something negative? Research suggests that around the age of 9 months, infants might be able to cognitively evaluating discrepant events (Scherer, Zetner & Stern, 2004) Attributing mental states and perhaps the evaluation of purposeful and accidental events could utilise cognitive mechanisms. This understanding of the distinction between purposeful and nonpurposeful actions and mental states is something that could be assessed through looking time methodologies.

6.13 Desires and Intentions

The mental state of desire has received some attention in childhood but not in infancy. Desire is related to outcomes and goals. Malle and Knobe (2001) propose that the content of desires is the outcome as in the sentence "Jane wants to have a

birthday party," whereas intention refers to the goal-directed actions undertaken to achieve an outcome, such as "Jane intends to make a cake." The birthday party and the cake both are goals to these desires and intentions. This example shows us the subtle distinction between desires and intentions. Another interesting proposition from Malle and Knobe is concerned with the type of reasoning required for desires and intentions. They suggest that because desires and intentions differ in content then they also operate differently as a way of reasoning. They propose that desires are often the input of reasoning whereas intentions the output of reasoning. The example they give is that if someone has a desire to help a homeless person (input) then this may lead to them volunteering in a soup kitchen (output). This then leads to making a distinction between having a desire for which one might do nothing about and an intention which is more likely to end up in some form of action (Malle & Knobe, 2001).

Studies in childhood have found that children understand desire earlier than they understand other mental states such as beliefs and one possible reason for this is that desires might be easier to infer than beliefs (Wellman & Woolley, 1990). Due to the subtle but distinct differences between desires and intentions, it would be interesting to study these in infancy.

6.14 Using Neuroimaging Technology to Study Intention Understanding

One other interesting question that arises from this thesis is whether intention understanding through intonation is a valence based task or an intention based task. An interesting prospect is to study this in adults through fMRI methodology. Recently an area that has received a lot of attention is that of mirror neurons. It has been suggested that a special area in monkeys' brains (F5 – ventral premotor cortex)

lights up when they watch conspecifics perform actions, or when they hear an action taking place (Rizolatti, Fadiga, Gallese & Fogassi, 1996). Similarly, in humans researchers have found that the human mirror neuron system (BA 44 – inferior frontal gyrus of Brodmann area) is active when humans are presented with dynamic facial expressions (Sato, Kochiyama, Yoshikawa, Naito & Matsumura, 2004). These findings suggest that this area in the brain involves the understanding of actions and that in addition it might be involved in processing dynamic emotional stimuli. Our pre-recorded demonstrations have actions in them that look very similar and intonations that distinguish these actions from one another as to the intention of the speaker. These demonstrations could be presented to adults in the fMRI scanner and we could see whether the intonation in this context could be processed in a similar way to the studies on facial expressions. In addition, as intonations on their own (without the actions) are dynamic and social stimuli, it would be interesting to see if they would activate the same area on their own.

6.15 Using ERP to Study Positive Mental States

Event-related brain potential is a method that has been used to study brain activation to different stimuli. Studies have also used it to look at brain responses to the emotional prosody of happiness, anger and neutral emotion (Grossmann, Striano & Friederici, 2005). This particular study has found that infants show differential activation between these three emotional prosodies. More specifically, the prosody for anger elicited more negative response in the ERPs than did the other two prosodies which suggests that infants were paying more attentions to the angry prosody. This was also found for happy prosody over neutral prosody and it suggests that emotional stimuli might receive more processing from the brain than neutral stimuli.

This type of methodology would be useful in seeing the effect that two positive intonations that express two different mental states would have on infants' ERPs. It is possible that the mental state of accidental might be allocated more attention due to the fact that it has the rising contour, which we propose might be associated with being more questioning and might require more attention and inference.

6.16 Links With Language Acquisition

We have also seen in the introduction of this thesis that intonation also plays an important role in language acquisition as it helps children with the parsing of sounds and the highlighting of important aspects of language. Because of this important role that intonation plays in developing language, it would be interesting to examine more closely how parents use their tone of voice when talking to their children, how their children respond to that and more specifically look at whether imitation may play a part in these interactions between parent and child. It would be interesting to also see how infants' babbling progresses from simple forms to more complex forms. This might also allow us to draw comparisons between the research described in the introduction regarding production abilities in young infants.

Conclusions

The first two experimental chapters of this thesis have shown that the tone of voice is a salient cue to mental states. Infants did not only distinguish between intentional and accidental words such as Whoops and There but they also made the distinction between intentional and accidental mental states from the intonation alone. The looking time measure has also shown promising results for the same distinction

between intentional and accidental mental states. The looking time study has confirmed and extended the findings that we saw through imitation. Infants seemed able to distinguish between an intentional and an accidental intonation and looked longer during scenes where the accidental intonation was paired with the end-result. These findings are the first to report results on the intonation of accidental and intentional mental states. The results of this thesis contribute to the literature concerning intention understanding and they extend our knowledge about intonation and the significant role it plays in infancy.

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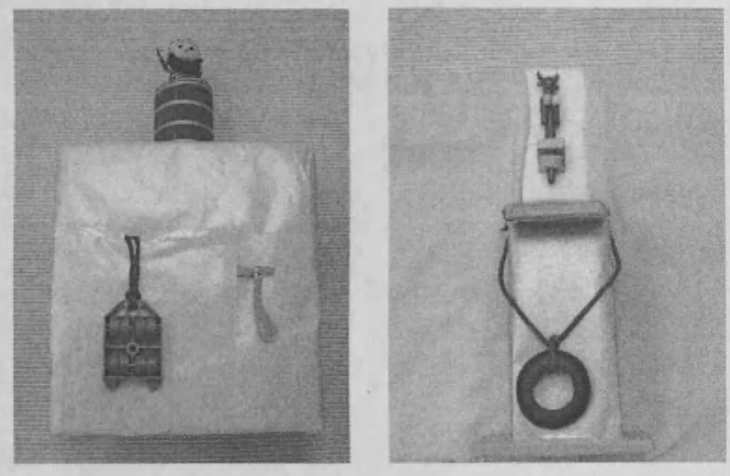
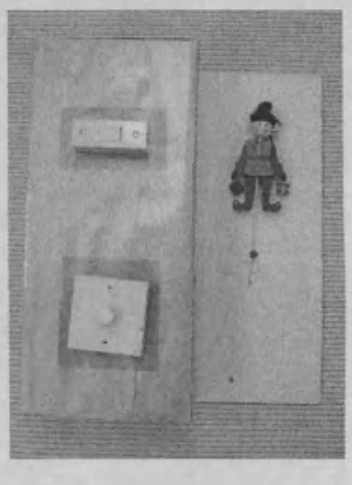
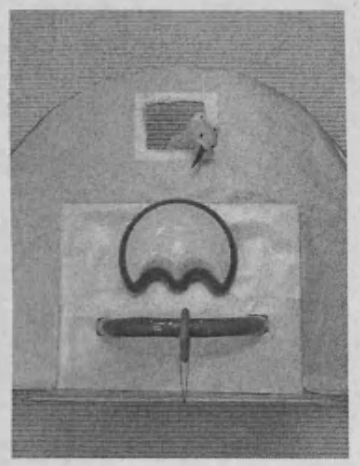
Appendix 1

Figure Caption

Figure 2.1 Photographs of the toys and end results used in the experimental trials of the studies. The actions on the first toy consisted of rolling the wheels and lifting the handle. The end-result was a jack in the box. The second toy consisted of pulling a rubber ring which was attached to string and lifting a blue extended block of wood. The end-result was a reindeer that made punching movements. The third toy consisted of pushing a button and rolling a button. The end-result was a dancing elf. The fourth toy consisted of rolling a ring and pushing a button. The end-result was a green dragon puppet.







Appendix 2

Instructions for the two undergraduate pilot studies.