Emotion Matching and Emotion Regulation in Infancy

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Declaration

This work has not previously been accepted in substance for any degree and is not concurrently submitted in candidate for any degree.

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This thesis is based on the following manuscripts.

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This thesis is dedicated to Harold Fish.

Contents

Chapter One: General Introduction and Literature Review

1.1. Introduction to First Steps

First Steps was a longitudinal project investigating infant motoric, communicative, and imitative development over the first 18 months of life. A total of 37 infants participated in the project, whereby mothers-to-be were recruited through the National Health Service, National Childbirth Trust, and via recruitment materials distributed in GP surgeries, libraries, and leisure centres throughout Cardiff and the Vale of Glamorgan. Participation in the project required that mothers and their infants attend monthly testing sessions that took the form of breakfast meetings; this enabled mothers to engage socially with other mothers participating in the project.

Many forms of data were collected throughout the First Steps project. Experimental data was recorded at each month, where infants participated in at least 2 experimental tasks that investigated some form of infant development. Observational data was collected at each testing session, in the form of a recorded 10 minute interaction between each mother and their infant. Questionnaire data was gathered at set ages throughout the project to assess temperament, and the cognitive and communicative ability of each infant. Finally, mothers were trained and instructed to record daily diary entries of their infant's development on a Palm computer. Diary data entries were downloaded at each month to provide some insight into the developmental changes that emerged between testing sessions. Collection of all of these different forms of data aimed to provide a rich and detailed picture of infant development over the first 18 months of life.

Data collected within the First Steps project provides the basis of this thesis, which specifically investigates the development of emotion matching and emotion regulation over the course of infancy, and attempts to address key theoretical questions that have emerged from reviews of the research conducted to date.

1.2. Introduction to Emotion Matching

Scientific research into emotion began with Darwin's (1890) detailed and photographic accounts of investigations into the meaning and musculature involved with each emotional expression. Since then, researchers such as Ekman (1992; 1999) have significantly contributed to our knowledge and understanding of emotional expressions, by establishing a Facial Action Coding System (FACS) as a taxonomy of emotional expressions. However, in recent years investigation into the ability to match emotional expressions, particularly during infancy, has become more dominant in both emotion and infant development research.

Emotion matching can be defined as the ability to accurately copy the same facial configuration of another individual with, or without, experiencing the associated internal emotional state. The ability to produce, and match, an emotional expression is one of the first forms of communication, albeit non-verbal, that an infant engages in. Indeed, Emde, (1998, p.1236) refers to emotion matching as the "language of infancy". Infant ability to accurately match emotional expressions is a clear indicator of the level of an infant's social and cognitive development. Emotion matching serves several purposes: it helps forge social relationships, particularly with primary caregivers, and it is linked to the development of other cognitive skills, such as, the development of language (Bloom, 1998). However, emotion matching studies to date have produced inconsistent findings and as a result a number of debates have ensued, raising key unanswered questions about emotion matching in infancy.

1.3. What are the theories behind emotion matching?

The precise mechanisms underlying emotion matching early in development remain contentious. Many psychologists claim that emotion matching is a form of facial imitation, but disagree as to whether imitation is an innate ability as proposed by Meltzoff and Moore (1977), or whether it develops slowly over the course of infancy as Piaget (1964) posits. Other theorists believe that any form of matching can be explained in terms of behaviour specific mirror neurons (Di Pellegrino, Fadiga, Fogassi, Gallese & Rizzolatti, 1992). Whilst others suggest that emotion matching is best explained by a mechanism of emotional contagion, wherein infants catch the emotions they observe and consequently display them. These opposing theories are presently considered to help elucidate the current understanding of emotion matching.

Meltzoff and Moore (1997) proposed a nativist account of imitation, claiming that the ability to imitate is present from birth, and offered an Active Intermodal Mapping (AIM) framework. Here, the ability to imitate is based on shared representations across perception and action. When an infant observes an act, equivalence is drawn between their observation of another's motor acts and their own motor acts. This process is achieved through an internal proprioceptive feedback loop and a supramodel representation system where all previous representations are stored, thus enabling infants to match emotional expressions.

Meltzoff and Moore (1997) highlighted that although the AIM framework is active from birth, there are key developmental changes in imitative ability over the course of infancy. Although neonates can imitate mouth openings and tongue protrusion, they cannot imitate everything (Meltzoff & Moore, 1977; 1983). As infants age, they engage in higher level imitation and interpret behaviour beyond simple relations to more complex goal-directed actions. Infants come to understand the end-state of an act and the way in which the act is performed. A reciprocal matching relationship develops, this "bidirectional learning" enables infants and adults to learn from their matching behaviours, and for infants to test to what extent adults will copy them (Meltzoff & Moore, 1997). Beyond this, infants start to exaggerate their matches and become overly aware of their matching behaviour as they gain further understanding of what it is to match. Infants also start to display evidence of deferred imitation, and at around 18-months-old start to perform inferred imitation, where infants copy the intended, rather than the failed attempts, of an action sequence (Meltzoff, 1995).

An opposing theory, presented by Piaget (1962), proposed that imitation develops slowly, and is based on learning through multiple interactions between infants and their social partners. Piaget (1962) outlined a progression characterised by six stages of imitative development. During stage one, from birth, no imitation occurs, but infants prepare for imitation through reflex schemas. During stage two, from 1- to 2-months-old, infants sporadically imitate vocal and head-to-hand gestures. Infants learn to incorporate external or experiential elements into their reflex schemas to form circular reactions, through assimilation (preservation), and accommodation (modification). During stage three, from 4-months-old, infants engage in systematic imitation of familiar vocalisations and visible gestures. Infants become more actively engaged, attempting to prolong vocalisations and gestures through imitation. During stage four, from 8- to 9-months-old, infants progress to imitate non-visible gestures. During stage five, from 1-year-old, infants systematically imitate, engaging in investigation and active exploration. Finally, during stage six, from 18- to 24-months-old, infants form internal representations of imitative behaviours, facilitating deferred imitation. According to Piaget's (1962) theory of imitation, systematic emotion matching would therefore not be expected to be observed until near the end of the first year of life.

A new, and alternative, theory posed by Di Pellegrino et al. (1992), claims that there are specific neurons in the brain that fire during both the action by the individual and the observation of the same behaviour. These mirror neurons are thought to be vicariously implicated in all forms of matching behaviour, from the development of empathy, to the development of language, theory of mind, and intention understanding. Although mirror neuron theory could explain some aspects of social learning behaviour, there are doubts as to the uniqueness and specificity of these mirror cells. Mirror neurons may not be the only cells that hold a distinct mirror property, as this phenomenon has been observed in other cells. Furthermore, mirror neuron responses may simply be noise in typical motor system functioning, and the analysis of cell functioning has largely been based on verifiably weak qualitative descriptions, rather than quantitative analysis of cell properties.

A final explanation of emotion matching, is that of emotional contagion. Hatfield, Cacioppo, and Rapson (1992, p153-154) defined emotional contagion as "the tendency to automatically mimic and synchronize facial expressions, vocalizations, postures, and movements with those of another person and, consequently, to converge emotionally". Hatfield Cacioppo, and Rapson (1994) espouse a theory of emotional contagion arising due to imitation and facial feedback. Hatfield et al. (1994) claimed a combination of imitation, synchrony, and feedback resulted in individuals 'catching' the emotions of others. Much evidence supports Hatfield et al.'s (1994) theory of emotional contagion. For instance, Darwin (1890) proposed a facial feedback hypothesis, where emotions are affected and can either be strengthened, or attenuated, depending on whether they co-occur with the appropriate feedback from facial muscles. Furthermore, Strack, Martin, and Stepper (1983) demonstrated that participants who held a pen in their mouth to facilitate a smile, reported more intense humour responses when viewing cartoons. This result suggests that cognitive mediation is not necessary for facial feedback to occur and that merely activating certain muscles can evoke an emotive response. Although this may provide the best account of emotion matching, evidence is yet to establish whether emotion matching, as a result of emotional contagion, starts with a facial match of the emotion and results in the infant experiencing the internal emotion, or whether the reverse is true and the infant experiences the internal emotion before they display the associated external facial expression.

1.4. What are the underlying processes involved in emotion matching?

The precise processes behind emotion matching in infancy remain uncertain with research only focusing on adolescents and adults. Nonetheless, evidence from such research may provide some insight into the processes involved in emotion matching earlier in life. McIntosh, Reichmann-Decker, Winkielman, and Wilbarger (2006) proposed a dual pathway account of emotion processing in adolescents and adults consisting of a cortical pathway involved in slower conscious and controlled response processes, wherein individuals selectively inhibit their matching, and a subcortical pathway which is rapid, automatic and unconscious. McIntosh et al. (2006) highlighted the distinction between these two pathways by demonstrating that only automatic emotion matching was impaired in Autistic Spectrum Disorder (ASD) participants, with voluntary emotion matching remaining unaffected, compared to a matched control group for whom both automatic and voluntary emotion matching was demonstrated. The possibility of a dual pathway account of emotion processing is supported by a number of other studies (Adolphs, 2006; Leppanen & Nelson, 2006). Although, little is known about which processes are involved in emotion matching in infants, Leppanen and Nelson (2006) have claimed that a cortical voluntary pathway is reliant on experience and develops slowly over the course of infancy, and that the subcortical automatic pathway is predominately innate and utilised from birth.

1.5. Do infants emotion match, and does this ability alter according to valence of expression?

Some researchers claim that emotion matching is an innate ability present at birth. One of the first studies to provide evidence of emotion matching in neonates was conducted by Field, Woodson, Greenberg, and Cohen (1982). Field et al. (1982) presented three facial expressions (happy, sad, and surprise) to neonates using a visual habituation paradigm. Field et al. (1982) noted that neonates discriminated between different facial expressions, perceiving the distinctive features of each expression, but also matched all three of the modelled expressions of happiness, sadness, and surprise. This result is supported by claims of facial imitation of non-emotional facial expressions in early infancy, as demonstrated by Meltzoff and Moore (1977).

Yet, a number of other studies have found no clear evidence of emotion matching and instead claim infants can only rudimentarily discriminate between emotional expressions. Montague and Walker-Andrews (2001) presented live two emotional expressions of happiness and surprise in the format of a game of peek-a-boo, where the model said peek-a-boo in an analogous tone to the displayed emotion at the start of each trial. Results indicated differences in looking times, looking patterns, and affective responsiveness; all of which indicated that infants could only discriminate expressions. However, Montague and Walker-Andrews (2001) found no evidence of matching expressions, rather, infants responded with affective changes when modelled expressions changed. Such affective changes included increased lability, frequency of non-neutral expressions, and frequency of interest or surprise expressions. Other research has also demonstrated that although infants are capable of discriminating expressions at 3-months-old, when tested using a visual habituation paradigm, no evidence of matching was found (Young-Brown, Rosenfeld, & Horowitz, 1977).

Nevertheless other researchers have found evidence of selective matching in early infancy. Haviland and Lelwica (1987) assessed 10-week-old infants by presenting them with three emotional expressions, those of joy, sadness, and anger, modelled by their mothers. Results showed that 10-week-old infants discriminated all three emotional expressions, but only matched two of the expressions, that of joy and anger, but not sadness. This demonstrates a potential effect of valence on emotion matching. Haviland

and Lelwica (1987) noted that infants, whilst not matching, nonetheless produced more mouthing movements during the modelled sad expressions than any other modelled expression. Such mouthing movements have often been described as a self-soothing mechanism. For instance, Aronson and Roseblum (1971) noted 'tonguing', excessive tongue movements, as an early response to distressing expressions. In contrast, Jones (1996) found that infants tended to make mouth movements to express interest in oral exploration, rather than in response to a particular valence of expression.

The effects of valence have also been identified in emotion discrimination tasks. Caron, Caron, and Maclean (1988) found that 4-month-old infants easily discriminated between happy and sad expressions but had more difficulty with angry expressions. It was not until 7-months-old that infants distinguished between happy and angry expressions, and only when visual displays included vocal accompaniment. Yet at 5-months-old, infants discriminated between sad and angry expressions without vocal accompaniment. As anger is an ambiguous expression to interpret, infants may be unsure how to perceive and process anger compared to other less ambiguous expressions, such as a happy expression. There is also ambiguity in how to respond to an angry expression. Thus, infants may fail to match an angry expression because they do not know how to respond; some may respond with anger, whereas others might respond with fear, or even sadness.

1.6. Does emotion matching decline with age?

Few studies have investigated age-related changes in matching, but the studies carried out have identified a decline in matching as age increases. Field, Goldstein, Vega-Lahr, and Porter (1986) noted that facial imitation declined between 2-and 6-months-old. Similarly, Fontaine (1984) established that non-emotional facial matching peaked in infants at 2-months-old and then progressively declined until 6-months-old. Fontaine (1984, p.332) posited that rather than imitative abilities disappearing by 6-months-old, infants instead viewed the experiment as a “spectator event” and did not see the need to match. At 6 months, infants have greater knowledge about people and how they communicate through expressions, enabling them to choose when to observe and when to respond.

The apparent decline in emotion matching could be explained in terms of Uzgiris’ (1981) two functions of imitation. Initially, a reflexive form of emotion matching could be linked with the social function of imitation, allowing the infant to forge strong social bonds in the first few months of life. This would be typified by frequent automatic emotion matches. Indeed, reflexive emotion matching was noted by Dimberg, Thunberg, and Elmehed (2000) who highlighted that when individuals viewed emotional facial expressions they unconsciously matched. Later, a conscious form of emotion matching could emerge, linked to the cognitive function of imitation, enabling the infant to learn new skills, reinforce such skills and cognitively develop further. This would be typified by controlled conscious choices of when, and what, to match based on infants’ established social interaction knowledge base.

Emotion matching decline may be linked to other developmental changes in infancy; one such developmental change is that of attention. During the first 6 months, infant attention systems develop significantly, extending from having the ability to track visual stimuli to actively attending, disengaging, and reorienting attention consciously and preferentially (Colombo, 2001). One problem identified in infants aged 3 to 4 months is that of sticky fixation (Butcher, Kalverboer, & Geuze, 2000; Goldberg, Maurer, & Lewis, 1997). Sticky fixation occurs when an infant is focusing on a stimulus and becomes fixated to the extent that they cannot look away, resulting in upset and frustration. The ability to look away enables individuals to avert their gaze if they feel uncomfortable whilst viewing an expression or an event. However, this ability does not develop until later in infancy. Evidence of more frequent matching early in infancy may reflect the fact that infants cannot disengage and are fixated upon viewing the modelled expressions. Once the ability to gaze avert has been established, infants can utilise gaze aversion to help them redirect their attention away from the stimulus, resulting in fewer matches.

By 6-months-old, infant social development has advanced to the extent that they have a greater understanding of the emotional affordances of certain environments or activities and of contingent behaviours. Most assessments of emotion matching mimic a social interaction, and evidence suggests that within this environment infants expect people to smile at them (Rochat, Striano, & Blatt, 2002). Therefore, infants may be disinclined to match any expression that does not fit with their social expectations. In addition, infants may have formed associated internal emotional responses to each expression. Older infants may be more likely to match positive expressions, compared to negative expression, in order to experience the positive internal association. Furthermore, research demonstrates that infants understand and expect the expression that they produce to be reciprocated and displayed back to them (Rochat et al., 2002). Thus, infants may start to selectively match happy expressions to ensure the experimenter reciprocates and thus avoids producing sad expressions. Therefore, although emotion matching may appear to decline, it may actually only be selectively declining according to valence of expression and infant preferential accordance for positive or happy emotional expressions.

1.7. Are there gender differences in emotion matching?

One traditionally investigated source of individual differences is that of gender. Research into emotion matching in adults has produced evidence of a gender difference in emotion matching. Adult females were found to be both better matchers, particularly of happy expressions, and faster matchers (Dimberg & Lundquist, 1990; Hampson, van Anders, & Mullin, 2006). Such a gender difference may also be present earlier in life, for instance, during infancy. Interestingly, gender differences in emotional expression are not culturally universal, suggesting gender norm socialisation is implicated in individual emotional development capacity. Ahadi, Rothbart, and Ye (1993) found that females in the United States of America scored higher on a measure of emotional expression for sadness than males, whereas, in China the reverse was discovered, and males scored higher on the same measure for sadness than females. Thus, it would appear that if gender differences emerge in emotion matching behaviour, infant ability to recognise and match emotional expressions may be at least partly influenced by environmental socialisation factors. Indeed, a potential environmental contributor to gender differences may be the nature of maternal interactions with their infants. Research has identified that mothers are more emotionally expressive, mentioning feelings more frequently, to their daughters than to their sons (Brody, 1993; Dunn, Bretherton, & Munn, 1987).

1.8. Is emotion matching linked to other forms of matching behaviour?

One key question is whether infants who are able to match emotional expressions are also able to imitate other behaviours. A number of studies have investigated infant ability to imitate non-emotional facial expressions, and to imitate sounds (Chen, Striano, & Rakoczy, 2006; Meltzoff & Moore, 1977). If the same infants are able to perform both emotion matching and imitation, this might indicate a shared underlying theory of imitation to best provide an explanation for matching behaviour in infancy. However, if infants are able to perform only one of these behaviours, this might indicate that differing theories might underlie each behaviour, for instance, an emotional contagion explanation may best explain emotion matching, instead of an imitative theory. In order to establish whether a differing mechanism, other than imitation, is involved in emotion matching, emotion regulatory behaviours will have to be considered.

1.9. Why are there inconsistencies in emotion matching study results?

Inconsistencies in emotion matching research results may arise partly due to methodological differences, for instance, whether presentation and coding of expressions are conducted live or via a recording. Within Field et al.'s (1982) study, coding was completed live, thus it was unlikely that all subtle changes in expressions could accurately be noted. Furthermore, expressions of happy and sad were guessed correctly at only just above chance level (58% and 59% respectively). This research was conducted on neonates averaging 36-hours-old, yet a wealth of research has demonstrated that neonatal visual system is poor, to the extent that they focus primarily on contrast patterns (Siegler, Deloache, & Eisenberg, 2003). Tellingly, a replication of Field et al.'s

(1982) study, involving two, instead of one live coder, failed to find any evidence of emotion matching (Kaitz, Meschulach-Safaty, Auerbach, & Eidelman, 1988).

Variations in emotion matching results owe much to whether expressions are just facially modelled or if they include analogous vocal accompaniment. In Montague and Walker-Andrews' (2001) study, the model provided both facial and vocal emotion cues, making it impossible to distinguish results specific to just facial expression cues. When only visual information is provided for the infant, most research finds that emotion matching does not occur until after 5-months-old (Campos & Stenberg, 1981; Oster, 1981). Montague and Walker-Andrews (2001) presented expressions in the format of a game of peek-a-boo, whereby the vocalisations that accompany the game actually appeared to enhance the responsiveness of infants (Fernald & O'Neill, 1993).

Results from research into emotion matching also differed according to the paradigms used for assessment. Original studies into the development of emotion typically involved either visual habituation, or preferential looking paradigms. Following Field et al.'s (1982) emotion matching study, research shifted to using simple matching paradigms, although more recently, Montague and Walker-Andrews (2001) have adjusted the game of peek-a-boo to assess emotion matching ability in infancy. Their methodological use of the game of peek-a-boo has a number of advantages over preferential looking paradigms and visual habituation procedures. Primarily, peek-a-boo is a game that very young infants are familiar with, and socialised into co-operating and willingly engage in playing, whilst also being highly effective at eliciting attention in infants of all ages.

The mode of display in which expressions are modelled also affects emotion matching performance. Sato and Yoshikawa (2007) looked at emotion matching in students aged 19- to 22-years-old, comparing the use of dynamic and static displays. Dynamic anger and happy expressions were presented using computer morphing and videos, whereas, static images of the expressions were taken from the apex of the expressions in the dynamic presentation. Using FACS, they found matching for only dynamic expressions, with no matching for static presentations of expressions. Latency analyses also found facial responses occurred rapidly, 500 to 900 milliseconds after the onset of dynamic changes in facial expressions when viewed. However, frequency of matching remained low overall; matching only occurred 20% of the time. This research interestingly noted how simple changes in the way stimuli are displayed can affect matching. It would appear that a dynamic presentation is the most realistic, and as a result is more likely to evoke emotional matching.

Another methodological difference found in emotion matching research is in whom models the expressions presented to the infants. Some studies have successfully used the infant's mother as the model (Haviland & Lelwica, 1987). This is riddled with reliability and consistency issues as it is difficult to ensure that each mother exactly models each emotional expression and is not tempted to encourage their infant to match and take their role beyond that of a experimenter model. Thus, to avoid such issues, most studies have fittingly employed a novel experimenter as the model.

1.10. Introduction to Emotion Regulation

Emotion regulation can be defined as the ability to modify and manage an affective response. Emotion regulation, which develops over the course of infancy, enables infants to cope with heightened levels of emotion, albeit positive or negative, and manifests itself in many forms (Kopp, 1989). Infants slowly progress from adult-guided regulation to self-regulation. However, little is known about self-regulation in infancy (Fox & Calkins, 2003; Kopp, 1989). In order for infants to be able to self-regulate, infants must first have developed an established sense of self. Research is yet to clearly identify which emotion regulation strategies infants adopt, or explain the developmental progression of self-regulation, and whether there is any link between emotion regulation and other forms of regulatory behaviour, emotion matching, or causally assumed distinctions between the self and ones environment.

1.11. Emotion regulation: the self versus other?

One of the main philosophical claims about infant development is that a sense of self develops during infancy and this enables infants to distinguish between themselves, others, and their environment. Possessing a sense of self allows infants to interpret what they observe and to relate it to their own mental and physical states. A sense of self, also allows infants to engage in self-regulation instead of relying on external sources to regulate their affective states. Piaget (1962) proposed adualism, whereby infants are born with their physical and psychological selves as being clearly distinct, but are unable to differentiate between sensory stimulation that is dependent on their own actions and that which is independent of their own actions. Furthermore, Piaget (1954) claimed that an infant does not develop a true sense of self, which resembles that of an adult, until around 18-months-old. If adualism is accurate, it would mean that infants could not emotion match, or engage in self-regulation, until late in infancy. In contrast, natural dualism theorists, such as Reid (1983), proposed that infants' psychological and physical selves are distinct, and that from birth infants are capable of clearly differentiating themselves and their actions from those of others and from events and stimuli attributed to their environment. If natural dualism is accurate, it would mean that infants can both emotion match and self-regulate early in infancy.

Research on infant imitation supports a natural dualism view that infants have at least a basic sense of self at a much younger age than adualism proposed. Kugiumutzakis (1985) argued that infants can distinguish between themselves and others from birth, and that infant ability to imitate highlights their capacity to link perception to their own actions. Stern (1988) stressed that part of the development of the self relies on infants imitating the emotional expressions of those around them so that they become synchronised; he termed this 'affect attunement'. Evidence of Stern's (1988) affect attunement can be found in Field, et al.'s (1982) research, highlighting that neonates are capable of matching and distinguishing between the emotional facial expressions of happy, sad, and surprise. Evidence of emotion regulation in infancy may be indicative of a developed sense of self sooner than Piaget's (1954) adualism theory posited.

Further support for a sense of self existing earlier in infancy than adualism theorists claim, comes from research into infant self-consciousness. Reddy (2000) asserts that coyness, a self-conscious emotional reaction involving self-conscious cognitions, is evident in infants from 2- to 3-months-old. Coyness was assessed during interactions by noting the occurrence of coy smiles (smiles with simultaneous gaze and head aversion and curving arm movements). If a sense of self is present early in infancy, thus enabling infants to engage in matching behaviours and demonstrate coyness, it can be extrapolated that infants also have the capacity to engage in at least some basic forms of self-regulation.

1.12. Which emotion self-regulation strategies do infants employ?

Kopp (1989) noted that from birth infants use fortuitous reflexive behaviours, such as sucking, as a mechanism to modify discomforting states. However, this elementary form of regulation is accidental, unplanned, and unmonitored. Kopp (1989) claimed that true emotion regulation does not develop until later in infancy, and its developmental progression is slow, relying on the motoric, cognitive, and social developmental advances of the infant and the complex interactions between these factors. From 3- to 6-months-old, evidence of consistent self-regulation in infancy emerges. Infants were found to utilise gaze aversion (GA) to regulate emotional affect after viewing distressing stimuli, and to modulate excessive stimulation during maternal interactions (Field, 1981; Harman, Rothbart, & Posner, 1997).

GA has been noted as an emotion regulation strategy adopted by adults, but little is known about its usage in infancy (Kendon, 1967). Keltner (1995) found that in adults the prototypical emotional expression of embarrassment ceases with averted gaze. In infants, Field (1981) investigated the relationship between GA and heart rate in 4-month-olds. Heart rate was assessed with electrodes at a baseline, and during each of 3 activity levels of maternal interactions. Mothers were told to either hold a still face (low activity), or interact as they would normally at home (moderate activity), or try and keep their infant's attention (high activity). Field (1981) noted that GA and tonic heart rate were higher whilst infants were engaged in low and high activity maternal interactions, compared to those of moderate activity. These results can be explained in terms of GA functioning to modulate excessive stimulation. Infants become overly stimulated in the high activity interaction condition, during which mothers are frantically trying to keep their infants attention, and during the low activity interaction condition where mothers are modelling a still face.

Another behaviour that infants may adopt to regulate emotion is that of spontaneous blinking (SB), and previous research has identified that SB rate varies according to the kind of stimuli that are presented. An increase in SB rate was noted in response to greater emotional intensity, for instance, during feeding, and when presented with a novel stimuli (Bacher & Smotherman, 2004). A decline in SB rate was noted in response to reading, and daydreaming (Holland & Tarlow, 1975; Karson, Staub, Kleinman, & Wyatt, 1981). Blink rate was also found to differ in individuals with certain illnesses, for example, individuals with Schizophrenia demonstrate increased blink rates whereas individuals with Parkinson's disease demonstrate reduced blink rates (Deuschel & Goddemeier, 1998; Karson, 1983). This demonstrated effect is thought to be linked to associated changes in dopamine levels in individuals with the aforementioned conditions. It has been postulated that SB rates provide an indirect measure of dopamine levels (Karson, 1983). Compared with adults, infants physiologically need to blink only rarely. Infants' eyes have a thicker lipid tear film so fewer blinks are required to replenish the film (Lawrenson, Birhah, & Murphy, 2005). On average infants only blink 2 to 5 times per minute, compared to adults who blink 15 to 20 times per minute (Bacher & Allen, 2008; Doughty & Naase, 2006). Due to the reduced SB rate in infancy, and the effects of stimuli on SB rate, it would be interesting to investigate any changes in SB rate in response to emotion and the presence of affect inducing stimuli in infancy.

1.13. Does emotion regulation depend on valence?

Despite most definitions of emotion regulation including the regulation of both positive and negative expressions, research to date has generally investigated only the use of regulatory behaviours to modify negative expressions or situations. Kopp's (1989) review of emotion regulation focused predominantly on the regulation of distress and negative emotions. Moreover, Buss and Goldsmith (1998) explored infant ability to use distraction and approach as putative regulatory behaviours in response to changes in levels of fearful and angry distress, finding that regulation was most effective in response to angry distress. Furthermore, Buss and Kiel (2004) noted that out of different distress expressions, 24-month-old infants typically displayed the greatest intensity in sadness expressions only when looking at their mothers. This result demonstrates that infants have some control over both their expressions of negative affect and to whom they choose to display their emotions. Although it is useful to identify how, and to what extent, infants can regulate negative affective states, it is also important to note how infants regulate positive affective states, and whether there is a difference in the regulatory behaviours according to valence.

1.14. Is temperament linked to emotion regulation ability?

To date there has been little, if any, research investigating the links between emotion regulation and temperament. However, research by Pilkonis (1977) noted that behaviours typical of the temperament construct of shyness, overlap with those now established as regulatory behaviours, such as averting eye contact with an affective stimulus, or GA. Therefore, it is possible that individual differences in temperament, particularly the construct of shyness, may result in similar individual differences in regulation ability.

1.15. Is emotion regulation linked to other forms of regulatory behaviour?

The function of emotion regulation is to allow individuals to disengage and reorient their attention. The development of attention is thought to play a central role in the ability to regulate affect (Posner & Rothbart, 2000). Ruff and Rothbart (1996) highlighted that there are three general processes of attention: selection, engagement/sustainability, and executive control. Infants demonstrate selection from birth as they display an orienting reflex to attend to highly salient stimuli. This attention system slowly progresses over the first year of life to develop reactive and sustained attention, and then controlled, focused attention. Although very young infants can attend selectively to stimuli, attention disengagement and reorientation is very difficult for infants due to their limited attention systems. One-month-old infants clearly demonstrate difficulties in disengaging from a central stimulus to gaze avert and reorient attention; a problem that was found to still persist, although to a lesser extent, in 3-month-old infants (Atkinson, Hood, Wattambell, & Braddick, 1992). It is not until around 4-months-old that infants are thought to be capable of utilising basic, controlled attention shifts, and this ability continues to develop over the first year of life (Johnson, Posner, & Rothbart, 1991). Colombo (2001) noted the developmental progression of attention, highlighting that any executive form of visual attention, required by GA, is not reached until between 3- to 6-months-old. Such attention research indicates that links may exist between the level of attention control development that an infant displays and their ability to employ GA as an emotion regulation strategy.

Another regulatory behaviour that develops over the course of infancy is that of inhibition. The A-not-B task provides a typical measure of response inhibition in infancy. Results from the A-not-B task demonstrate that infants continue to look at the same location for an object, even when it has been moved to another location, until 8- to 12-months-old (Piaget, 1962). Infants who demonstrate the ability to inhibit a response may be more likely to also demonstrate the ability to regulate emotion, compared to infants who are yet to develop the ability to inhibit. Similar underlying processes may be involved with both forms of regulatory control, and thus infants develop the ability to perform both behaviours in unison.

1.16. Is emotion matching linked to emotion regulation ability?

One key question is whether the infants who are emotion matchers are also emotion regulators. Although studies have investigated emotion regulation strategy usage, no study to date has investigated a link between matching and regulatory behaviour.

1.17. Discussion of proposed hypotheses

Considering emotion matching and emotion regulation research to date, a number of key theoretical questions are yet to be answered. This thesis will consider some of the main theoretical questions outlined, and each of the studies will present clear hypotheses that attempt to further our understanding of the learning and developmental processes involved in emotion matching and emotion regulation.

Study one states the main hypothesis that infants are able to match emotional expressions from early infancy. Previous literature has already established that both infants and monkeys alike share a preference for processing faces, or face-like objects (Sugita, 2009; Tanaka & Farah, 1993). Indeed, Sugita (2009) highlighted that macaque monkeys hold some basic representation of a face from birth in order to be able to match corresponding expressions early in infancy. Sugita (2009) further claimed that it is through a mechanism of proprioception that further knowledge about face structure and matched behaviour is acquired. In conclusion, Sugita (2009) notes that facial imitation is "special" due to the fact that matched behaviours occur without being able to see one's own face, whereas for most other forms of matching, infants can see themselves performing the matched behaviour. Similarly, a number of other researchers, such as Piaget (1962) and Meltzoff and Moore (1997), purport that the main mechanism through which infants learn is via imitation, or a "like me" correspondence mechanism of learning. If study one's hypothesis is accurate, the presence of such matching behaviour would provide important information regarding the processes through which infants learn early in infancy, and due to the longitudinal nature of the First Steps project, any developmental changes in these behaviours can be identified. Furthermore, any changes in emotion matching over time may provide some support for Ruys and Stapel's (2009) theory of emotion, which reports an unconscious unfolding of emotion responses, whereby the same stimulus can evoke different responses, initially a global emotional response and then more specific and fine-grained responses. It is possible that study one may demonstrate such an unfolding response whereby initially a global emotion response is observed, and then as infants age their ability to demonstrate specific emotional responses becomes apparent.

Study two stipulates the main hypothesis that emotion matching is a behaviour distinct from other forms of matching and imitation. This hypothesis is based on literature reporting effects of emotional contagion, and extrapolates that emotion matching is a different matching behaviour from other forms of matching and imitation due to the emotional component involved in a match (Hatfield, et al. 1994). Failing to find evidence of a link between different forms of matching behaviour, may have substantial ramifications for the existing belief regarding how learning occurs and develops early in infancy, primarily that imitation is not the sole, or potentially main, mechanism with which infants learn. Previous literature has already highlighted some issues with imitative explanations of facial matching, for example, the correspondence problem highlighted by Ray and Heyes (2011). The correspondence problem highlights that there is no clear, proven explanation as to how infants (or animals) are able to use what they observe in another, into being expressed as their own behaviour. Indeed, if study two's hypothesis is correct, this result may form the basis of an explanation as to how a correspondence occurs between what is observed and what is produced, at least in regard to emotion matching, and this may then translate to other imitative behaviours later in infancy.

Study three reports the main hypothesis that infants use both spontaneous blinking and gaze aversion as emotion regulation strategies, but that the preference for which of these strategies are used may vary over time as other regulatory systems, such as attention, develop. Evidence of such regulatory strategies being used from 3-months-old, may provide further information regarding how infants learn to regulate emotion independent of their caregivers, and how that process emerges over time. Very little pre-existing knowledge is known about how infants start to regulate emotion and how that ability develops over time.

Following the prediction that infants regulate emotion from 3-months-old, studies four and five attempt to identify any factors that may contribute to individual differences in regulatory behaviour. Study four's hypothesis predicts that shy infants are more likely to regulate emotion compared to their more confident counterparts. Whilst study five's hypothesis states that infants who are emotion regulators will display higher levels of attention control. Evidence of either shyness, or higher levels of attention control, contributing to regulatory ability would provide some insight into individual differences that may influence the development of regulatory behaviour in infancy. Research has already established some individual differences in emotion regulation among an adult sample, whereby individuals with Social Anxiety Disorder demonstrated increase use of avoidance compared to a matched control sample, yet no research has explored individual differences among an infant sample (Werner et al. 2011).

Finally, study six attempts to establish a link between emotion matching and emotion regulation behaviours. The hypothesis states that infant ability to regulate emotion early in infancy predicts infant ability to match emotional expressions later in infancy. More specifically, that infants who are emotion regulators early in infancy are less likely to match sad expressions later in infancy. If evidence were found to support this hypothesis, it is possible that infants who are better regulators learn over time to specifically direct their regulatory ability to regulating the intensity of sad emotions compared to happy emotion, due to happy emotions being enjoyable and rewarding. This would provide substantial insight into the mechanisms involved in infants learning and regulation of emotional experiences, and may explain why subjectively it appears that regulation is primarily used to regulate unpleasant experiences compared to positive experiences.

Chapter Two: Emotion Matching

Key Questions to Address:

Do infants emotion match, and does this ability alter according to valence of expression?

Does emotion matching decline with age?

What are the processes behind emotion matching?

Are there gender differences in emotion matching?

Is emotion matching linked to other forms of early imitative behaviour?

2.1. Study One: Emotion Matching in Infancy

Emotion matching is the ability to accurately copy the same facial configuration of another with, or without, experiencing the associated internal emotional state. From a young age, infants appear sensitized to displays of emotional expression (Nelson, 1987). Developing the ability to perceive and match emotional expressions in infancy is foundational to social development. It enables infants to form meaningful social relationships, particularly with their primary caregivers, before their ability to use language develops (Papousek & Papousek, 2002). Although a number of studies have investigated the development of emotion matching in infancy, most have reaped inconsistent results.

A debate has emerged as to the age at which infants first match emotional expressions. Some researchers claim that emotion matching is an innate ability. Field, Woodson, Greenberg, and Cohen (1982) noted that neonates with an average of 36-hours-old were able to both discriminate and match emotional expressions. This result supports Meltzoff and Moore's (1977) claim that infants aged 12- to 21-days-old displayed an innate ability to match non-emotional facial expressions of mouth opening and tongue protrusion. However, attempts to replicate Field et al.'s (1982) results have failed to demonstrate emotion matching in neonates (Kaitz, Meschulach-Sarfaty, & Auerbach, 1988). Others have since proposed that young infants are only able to discriminate between emotional expressions, and that the ability to match develops much later in infancy. Research has found that infants are capable of discriminating expressions at 3-months-old when tested using a visual habituation paradigm, but no actual evidence of matching at 3-months-old was found (Young-Brown, Rosenfeld, & Horowitz, 1977). Montague and Walker-Andrews (2001) provided evidence to support this claim, reporting that at 4-months-old infants could only discriminate emotional expressions, and failed to match emotional expressions.

Emotion matching may also be influenced by valence of expression, with Haviland and Lelwica (1987) demonstrating that 10-week-old infants matched joy and anger expressions but not sadness. Moreover, Caron, Caron, and Maclean (1988) reported that infants could only discriminate between happy and sad expressions and had difficulty discriminating angry expression. Vaish, Grossman, and Woodward (2008) noted a negativity bias in emotional development, claiming that infants are naturally more attentive to, and influenced by, negative stimuli as a result of their increased evolutionary significance. Others have highlighted that negative reinforcement results in quicker learning in order to avoid extinction (Logue, Ohpir, & Strauss, 1981; Ohman, & Mineka, 2001). Whilst some researchers support that infant ability to discriminate and match differs according to the valence of expression, others imply that valence has no impact on infant matching ability. For instance, Field et al. (1982) noted that infants matched all expressions that were displayed to them: happy, sad, and surprised.

Few researchers have investigated the longitudinal changes in emotion matching as infants age, and little is known about how emotion matching ability alters after infants first demonstrate that they are able to match emotional expressions. Fontaine (1984) investigated the changes in matching non-emotional facial expressions from 3-weeks-old to 6-months-old. Results showed an increase in facial matching behaviours, peaking at 2-months-old, followed by a perpetual decrease in matching. Similarly, Field, Goldstein, Vega-Lahr, and Porter (1986) noted that the matching of emotional expressions declined in 40% of infants between 2- to 6-months-old. Furthermore, a decline with age in matching has also been noted for non-emotional facial expressions, such as tongue protrusions (Jacobson, 1979; Maratos, 1973). Although little research has investigated the changes in facial matching in early infancy, the aforementioned studies have nevertheless identified a decrease in facial matching with age.

Longitudinal changes in emotion matching may provide some indication of a shift in the processes underlying emotion matching in infancy. Research to date has posited that initially emotion processing is automatic but as infants age they develop controlled emotion processing allowing them to selectively engage, or inhibit, a matching response (Leppanen & Nelson, 2006). McIntosh, Reichmann-Decker, Winkielman, and Wilbarger (2006) provided some evidence of a distinction between automatic (subcortical pathway) emotion processing and controlled (cortical pathway) emotion processing using an emotion matching task. Results demonstrated that only automatic emotion matching was impaired in individuals with Autistic Spectrum Disorder whereas controlled emotion matching remained unaffected. In contrast, a matched control group demonstrated both automatic and controlled emotion processing. Although research supports a dual pathway account of emotion processing, little is known about the age at which infants are first able to demonstrate controlled emotion matching.

A number of the inconsistent results in emotion matching literature may be partly due to methodological differences as researchers have adopted different approaches to investigating emotion matching in infancy. Initially, researchers utilised visual habitation paradigms, but more recently researchers have adopted a new method of assessing emotion matching. For instance, in a successful attempt to engage and retain infant attention during task presentation, Montague and Walker-Andrews (2001) portrayed their matching paradigm as a familiar game of peek-a-boo. The format in which expressions were modelled has also varied considerably across studies. Demonstrations of expressions differed from live presentations to video recordings and even static photographs. Sato and Yoshikawa (2007) highlighted the importance of displaying visual dynamic stimuli, noting that emotion matching responses primarily occurred immediately after the onset of dynamic changes in modelled expressions. Finally, some emotion expression displays are confounded by the presentation of analogous vocalisations (Montague & Walker-Andrews, 2001). This produces a confusing result as it is unclear whether infants are purely matching expressions, or responding to the tone of the model's speech.

This current study attempts to assess emotion matching ability over the course of infancy, primarily addressing when emotion matching develops and how it varies with age. In order to longitudinally assess infant emotion matching ability, the same emotion elicitation peek-a-boo paradigm was adopted at 3, 6 and 14 months. This enabled the examination of whether: 1) infants are able to match emotional expressions; 2) matching changes across 3, 6 and 14 months; and 3) valence of emotion affects matching performance.

2.1.1. Method

Participants

This study was part of First Steps, a longitudinal study investigating the imitative, communicative, and motoric development of 37 infants from birth to 18-months-old. A-priori calculations revealed that a sample size of at least 26 would be required for the number of comparisons conducted, and to achieve a large effect size and power of >.80. Pregnant women were recruited during their last trimester through the National Childbirth Trust (NCT), the National Health Service (NHS) and other local organisations. All infants were born healthy and to full gestation. The sample consisted of 18 female and 19 male infants. Infants were tested at 3 months (M=92 days, range = 75 to 101 days), 6 months (M=181, range = 174 to 198 days), and 14 months (M = 426, range = 412 to 441 days).

Apparatus

During testing infants sat on their mother's lap directly opposite, and 1 metre apart from, the seated experimenter. Two cameras (Sony Mini DV DCR-PR110E) recorded the experiment; one camera focused on the infant's face, and the second camera focused on the experimenter's face. A quad linked the two video feeds to enable simultaneous recording.

Design

The study was a within-subjects design. Emotion matching was assessed by comparing the rate of expression production (happy and sad) during modelling of the same expression (match), compared to during the modelling of the opposite expression (mismatch). The dependent variables were rate per minute of happy and sad emotion matching behaviour. The variable happy matching is the rate of happy matching during happy modelling, whereas the variable happy mismatch is the rate of happy matching during sad modelling. Similarly, the variable sad matching is the rate of sad matching during sad modelling, whereas the variable sad mismatch is the rate of sad matching during happy modelling. Testing occurred at 3, 6, and 14 months. The testing ages were selected based on previous literature and piloting the study on various aged infants. The first time point, 3 months, was selected as it was the first age that infants appeared to clearly attend to the stimulus and have the visual capacity to see what expressions the experimenter was modelling. The second time point, 6 months, was selected based on literature noting that there is a change in infant attention development from 3 to 6 months, therefore, an associated change in matching behaviour may emerge as infants develop the ability to selectively disengage attention from a stimulus and redirect attention elsewhere (D'Entremont, Hains, & Muir, 1997). The final testing age, 14 months, was selected to try and ensure that the same paradigm could be applied to all testing ages. Piloting data assessing 12 infants aged 14, 15, and 16 months, revealed that after 14 months it became problematic trying to maintain infant attention using the paradigm. Beyond this age, infants became increasingly fidgety and more interested in tasks that involved objects or toy use. Therefore, 14 months was selected as the oldest age that the same paradigm could be administered without loosing infant attention.

Procedure

An adult experimenter presented expressions live in the format of a structured game of peek-a-boo (Figure 2.1.). Following a familiarisation trial in which the experimenter displayed a neutral expression to the attentive infant, happy and sad expressions were dynamically modelled, with the intensity of the expression varying cyclically three times across a display period of eight seconds. A happy expression was defined as raising the corners of the mouth (both or either side), engaging the Zygomatic Major muscle, producing a U-shaped mouth (Figure 2.2.). A sad expression was defined as depressing the corners of the mouth (both or either side), producing an inverted U-shaped mouth. The raising and protrusion of the lower lip and chin also aided definition of a sad expression. At the end of the display, the experimenter covered her face with her hands and called the infant's name in a neutral tone to engage attention before the next display.

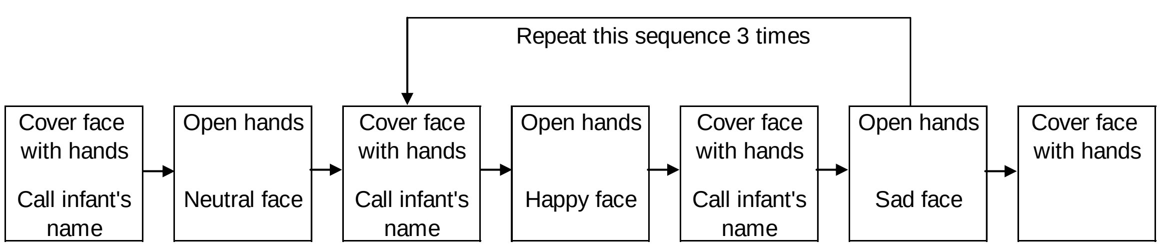

Figure 2.1. Illustration of Task Presentation

Coding

Happy and sad expressions were coded using the operational definition stated above. Only the infant's mouth movements were coded. The coding was conducted both in real time and frame-by-frame from a recording in which only the infant was visible. Mouth movements attributable to vocalisations, sucking, raspberries, tongue protrusion, or excessive dribble were excluded. A secondary blind coder reviewed 11% of the sample (4 infants), reaching agreement of 82% at 3 months, 92% at 6 months, and 93% at 14 months.

Figure 2.2. Illustration of Modelled and Matched Expressions

2.1.2. Results

Each emotion matching variable (happy and sad) was calculated as a rate per minute variable due to the slight variation in trial lengths. Rate per minute scores were generated by first calculating the total duration of the 3 happy trials, and then the total duration of the 3 sad trials. These 2 total durations were then each divided by 60 to create comparable durations. The number of expressions occurring within these trials was then noted and divided by the comparable duration length. This created two differing rates for each behaviour (happy and sad); a rate of matching (expressions occurring during modelling the same expression); and a rate of mismatching (expressions occurring during modelling the opposite expression). The mean rate per minute, and standard error of both the happy and sad emotion matching data was calculated based on the untransformed data at each age (Table 2.1.).

Table 2.1. *Descriptive Statistics (mean rate per minute and standard error) of Untransformed Emotion Matching Data*

	Happy		Sad	
Months	Match	Mismatch	Match	Mismatch
3	14.10 (1.30)	8.90 (1.14)	19.72 (1.71)	8.75 (1.28)
6	10.79 (1.24)	2.20 (0.61)	6.99 (0.91)	6.03 (1.10)
14	7.15 (0.76)	2.34 (0.70)	4.20 (0.66)	4.18 (0.83)

Preliminary analysis noted that the data was positively skewed, so a square root transformation, adding a constant of 1 to all data points, was calculated to reduce the skewness of the data. Despite the data remaining slightly skewed, the use of parametric tests (ANOVAs) was deemed appropriate due to the robustness of ANOVAs and the small degree of skewness. Two separate repeated measures ANOVAs were conducted. One investigated the rate of happy expressions during the happy modelling period (happy match), compared to the rate during the sad modelling period (happy mismatch). Initial analyses revealed no significant between subjects effects of gender or order ($F(1,33)= .265$, $p>.05$; $F(1,33)=.014$, $p>.05$), so the data was collapsed across these variables for subsequent analyses. A second ANOVA investigated the rate of sad expressions during the sad modelling period (sad match), compared to the rate during the happy modelling period (sad mismatch). Initial analyses revealed no significant effects of gender or order ($F(1,33)=.395$, $p>.05$; $F(1,33)=.2.037$, $p>.05$), so the data was collapsed across these variables for subsequent analyses.

To assess whether infants engage in happy matching, a repeated measure ANOVA was conducted on the transformed data. Results show a significant main effect of condition, where happy expressions are produced more during happy modelling than sad modelling conditions ($F(1,36)= 44.622$, $p<.01$), and a significant main effect of age, where happy mismatch production reduced as infants age ($F(1,36)= 34.601$, $p<.01$). Furthermore, a significant interaction was noted, where infants consistently matched happy expressions over time, whilst mismatching decreased ($F(1,36)=3.222$, $p<.05$). Transformed rates of happy matching and happy mismatching are illustrated in Figure 2.3. The range of happy matching transformed scores varied from 1 to 5.91 matches at 3 months, 1 to 5.44 matches at 6 months, and 1 to 4.86 matches at 14 months. In contrast, the range of mismatches (producing sad expressions during happy modelling) varied from 1 to 5.17 at 3 months, 1 to 4.47 mismatches at 6 months, and 1 to 4.85 mismatches at 14 months. Scatterplots depicting each infant's happy matching behaviour at each month are recorded in Appendix 3, along with graphical depictions of each participant's longitudinal happy matching trajectories in Appendix 5.

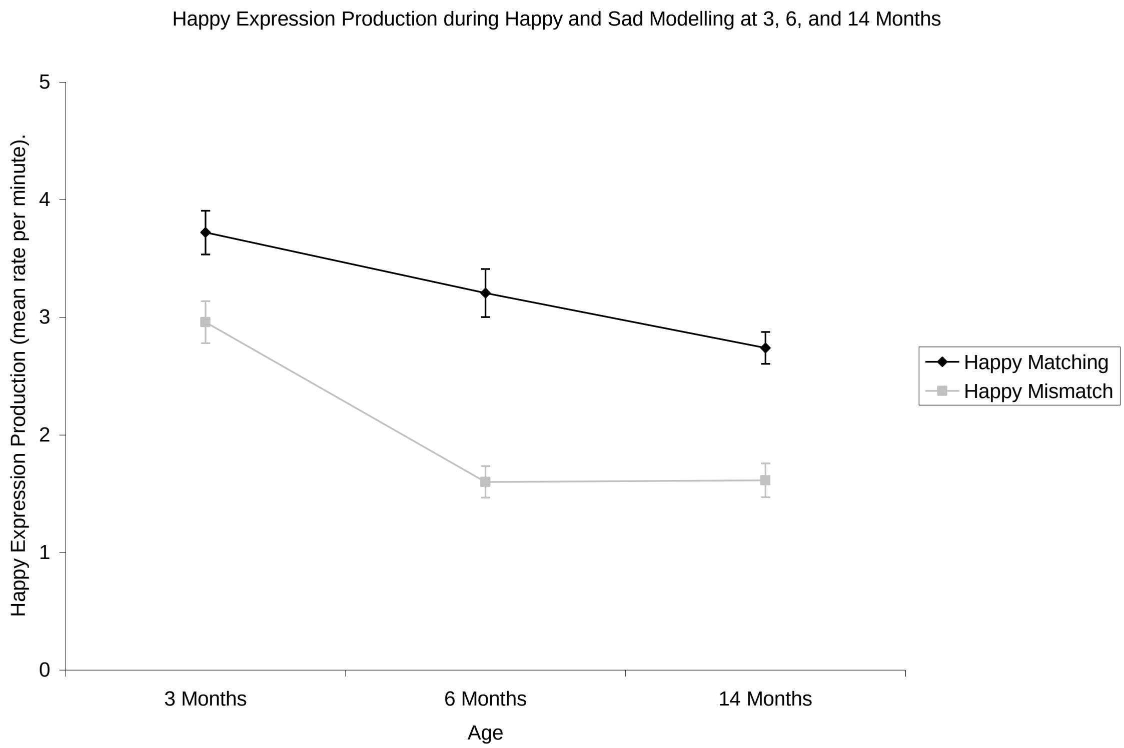

Figure 2.3. Happy Expression production during Happy Modelling (happy matching) and Sad Modelling (happy mismatch) over time

To assess whether infants engage in sad matching, a repeated measures ANOVA was conducted on the transformed data. Results show a significant main effect of condition, where sad expressions are produced more during sad modelling than happy modelling (F(1,36)=11.723, p<.01), and a significant main effect of age, whereby sad expression production decreased as infants age (F(1,36)=45.749, p<.01). Furthermore, a significant interaction was noted whereby sad matching declined with age, whilst sad mismatching remained at a roughly constant rate (F(1,36)=9.825, p<.01). Transformed rates of sad matching and sad mismatching are illustrated in Figure 2.4. The range of sad matching transformed scores varied from 1.81 to 7.15 matches at 3 months, 1 to 4.9 matches at 6 months, and 1 to 4.21 matches at 14 months. In contrast, the range of mismatches (producing happy expressions during sad modelling) varied from 1 to 5.17 at 3 months, 1 to 4.73 mismatches at 6 months, and 1 to 4.48 mismatches at 14 months. Scatterplots depicting each infant's sad matching behaviour at each month are recorded in Appendix 4, along with graphical depictions of each participant's longitudinal sad matching trajectories in Appendix 5.

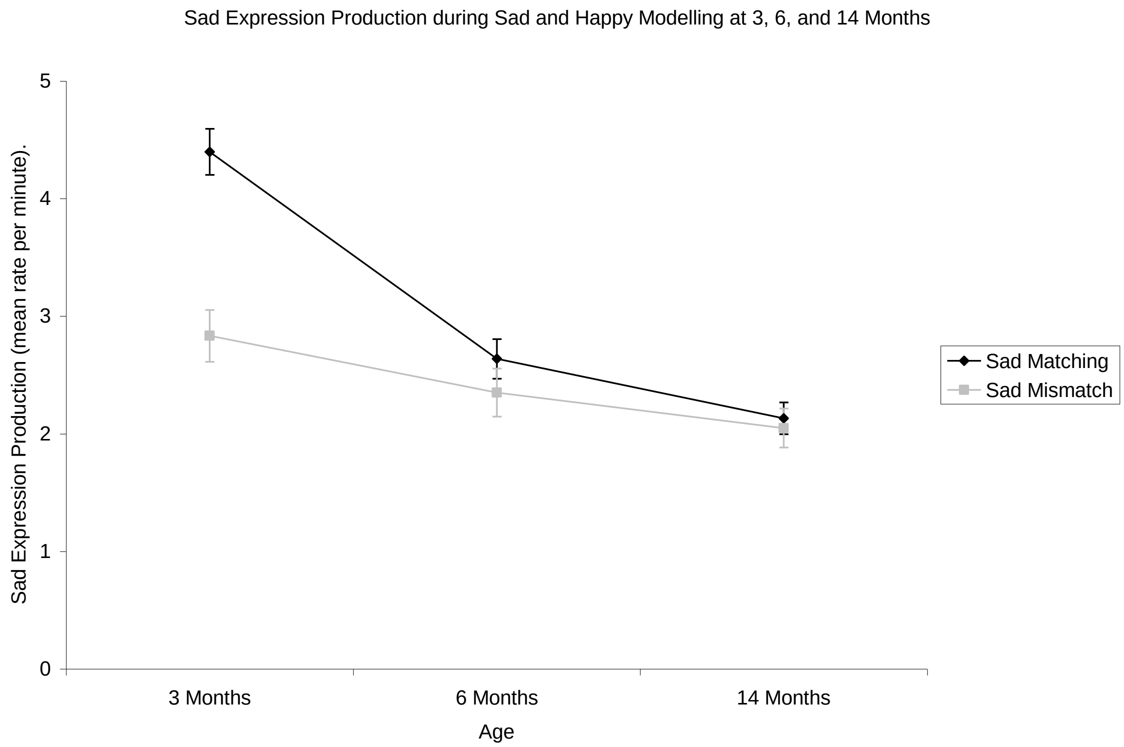

Figure 2.4. Sad Expression production during Sad Modelling (sad matching) and Happy Modelling (sad mismatch) over time

2.1.3. Discussion

We investigated infant ability to match emotional expressions of happy and sad from 3- to 14-months-old. We did this by utilising a peek-a-boo emotion elicitation paradigm to ensure that infants maintained engagement with the task across all age points. This enabled the investigation of changes in emotion matching across infancy, and the impact of valence of expression on matching ability.

The results obtained show that infants matched emotional expressions from 3-months-old. This evidence is supported by previous claims of emotion matching being present early in infancy; thus supporting Field et al.'s (1982) demonstration of happy, sad and surprise emotion matching in neonates. It is further supported by evidence of infant ability to discriminate between happy and sad expressions at 4- to 5-months-old (Caron et al., 1988). However, it conflicts with some claims that at 3 months infants are only able to discriminate expressions and cannot match until later in infancy (Young-Brown et al., 1977). Nevertheless, this current study clearly demonstrates that infants are able to match emotional expressions at 3 months; this implies that infants are capable of social engagement, and are socially learning from those around them at just 3-months-old.

The current study's findings indicate that infants matched both positive and negative valence expressions. Previous research has demonstrated inconsistent results as to which expressions infants match but these inconsistent results could be due to which emotional expressions were displayed. In this current study, happy and sad expressions were chosen due to the polarity and unambiguous nature of these two expressions. When happy or sad expressions are presented, the immediate response of infants is to reciprocate with a happy or a sad expression, whereas other expressions, such as anger, are ambiguous and it is unclear what response should be made. Previous research has investigated ambiguous expressions, such as anger, and failed to demonstrate matching, or even the ability to distinguish anger expressions from happy and sad expressions (Caron et al., 1988). In contrast, the present study shows that infants clearly distinguished happy and sad expressions. Furthermore, other studies report evidence of a negativity bias in emotion processing, whereby infants are more attuned to negative stimuli in their environments due to the associated evolutionary significance of such stimuli (Logue et al., 1981; Vaish et al., 2008). However, this current study demonstrates that infants are capable of matching both positive and negative expressions. It would appear that the negativity bias in emotion processing does not transcend to emotion matching.

Although infants matched emotional expressions independent of valence at 3 months, a different developmental trajectory emerged for sad and happy expressions beyond 3 months. Results indicated that emotion matching of sad expressions declined with age, whilst, happy matching remained consistent across all ages. The sad matching developmental trajectory is similar to previous research demonstrating an initial peak, followed by a decline, in facial matching with age (Field et al., 1986; Fontaine, 1984). However, the decline reported in these aforementioned studies could be explained in terms of the paradigms that they used; notably static displays that failed to continue to engage the infant's attention across assessment time points. In contrast, the use of the dynamic displays of emotion, in the format of a game of peek-a-boo in the current study, ensured that engagement continued throughout the duration of the task and that the task was appropriate for multiple aged infants. Therefore, the apparent selective decrease in emotion matching may instead indicate a shift from using automatic emotion processing at 3 months to using controlled emotion processing from 6 months, whereby infants can selectively inhibit sad emotion matching and consciously match happy emotional expressions. Furthermore, the decision to continue to match happy emotional expressions from 6 months may be as a result of the infant understanding that if they produce an emotional expression, the same expression is likely to be reciprocated and displayed back to them (Rochat, Striano, & Blatt, 2002). Therefore, infants may be more likely to continue matching a positive modelled expression that will result in a positive response from a social partner. A continued consistency in happy matching may also be explained in terms of the experience of receiving maternal positive reinforcement. Accordingly, Malatesta and Haviland (1982) noted that mothers only directed positive expressions towards their infants from 3- and 6-month-old, and ignored any of their infant's negative, undesired expressions.

Interestingly no gender effects were found. Previous literature on emotion processing has reported finding that females are generally better at processing emotion compared to their male counterparts (Dimberg & Lundquist, 1990; Hampson, van Anders, & Mullin, 2006). Surprisingly no such difference was noted in this current study, and this may partly be due to the age at which infants were assessed; for their first assessment date infants were only 3-months-old. The fact that there is no evidence of gender differences early in infancy with regard to emotion matching, may imply that gender differences reported in other studies may not be due to innate differences, but instead be a result of socialisation factors, or differences in how, and what, different gender infants learn.

In conclusion, the current study demonstrates that infants are capable of emotion matching of happy and sad expressions from 3 months. Although infants matched both happy and sad expressions, matching of these expressions appeared to follow a different developmental trajectory. Happy matching appeared to remain at a consistent level over time, whereas, sad matching appeared to decrease. This is one of the first longitudinal studies to identify the developmental changes in emotion matching, and more specifically demonstrating the differences in development according to the valence of expression. The results also provide some insight into changes in the processes that underlie emotion matching early in infancy; primarily that infants appear to develop the ability to consciously and selectively match from 6-months-old.

2.2 Study Two: Emotion Matching and other forms of Early Imitative Behaviour

Study one demonstrated that infants are able to match emotional expressions at 3-months-old, but, little is known about whether emotion matching is linked to other forms of early matching behaviour. Previous research investigating the links between different forms of matching, and how they may interrelate, have only engaged minor consideration by researchers and have reaped inconsistent results (Kugiumutzakis, 1985; Masur, 1987; Snow, 1989). However, of particular interest, is whether emotion matching is linked to non-emotional facial matching early in infancy, or whether there is an inherent difference between these different forms of matching, and what this difference might imply in terms of early learning mechanisms.

One early form of matching behaviour demonstrated by infants is that of facial imitation. Meltzoff and Moore (1977) demonstrated infant ability to match non-emotional facial expressions of mouth opening and tongue protrusion at just 12- to 21-days-old. Meltzoff and Moore (1977) claimed that this demonstrated an innate ability that enabled infants to equate their own behaviours with those observed in a social partner. Other researchers have provided further evidence for the existence of facial imitation early in infancy (Ainsfeld, 1991; Gardner & Gardner, 1970; Jacobson, 1979). Meltzoff and Moore (1977) proposed that imitation is the primary mechanism through which infants learn early in life. Yet, some disagree as to the presence of facial imitation early in infancy, claiming that the ability to facially imitate develops much later, between 8- to 12-months-old (Piaget, 1962; Uzgiris, 1972). Furthermore, attempts to replicate Meltzoff and Moore's (1977) seminal findings have often failed to be successful (Hayes & Watson, 1981; Koepke, Hamm, Legerstee, & Russell, 1983). However, if imitation is not present early in life, another mechanism for learning may be in place prior to that of imitation.

A second early form of matching behaviour demonstrated by infants is auditory-oral matching. Auditory-oral matching is the copying of the mouth movements associated with modelled vocalisations, but without matching the vocalisations. One of the first to investigate this behaviour was Chen, Striano, and Rakoczy (2004). Chen et al. (2004) presented infants with a modelled display of "a" and "m" vocalisations to assess whether infants matched the mouth movements associated with these vocalisations, those of mouth opening ("a") and mouth clutching ("m"). Chen et al. (2004) noted that infants, aged between 24 hours and 7 days, matched both mouth opening and mouth clutching in response to "a" and "m" vocalisations respectively.

Some research claims that links may exist between early forms of matching behaviour. Piaget (1962) proposed that gestural and vocal imitation followed a similar developmental progression; a progression characterised by six stages of imitative development. Further evidence of links between different forms of matching behaviour was established by Masur and colleagues in the 1980s. In one such study, Masur (1987) noted a relationship between vocal and object-mediated imitation, but other researchers have only found interrelations within a single modality of imitation, rather than across different modalities of imitation. Snow (1989) only identified interrelations within the modality of vocal imitation, whereby frequency of partial vocal imitation correlated with frequency of full vocal imitation. Snow (1989) concluded that interrelations did not exist between different modalities of matching, and critically that imitativeness was a domain specific skill.

To support Snow's (1989) arguments, others studies claim that links between different forms of matching behaviour do not exist. Kugiumutzakis (1985) espoused that each modality of imitation developed differently and independently. Snow (1989) further failed to find interrelations across modalities of imitation, namely between vocal and gestural imitation, and vocal and object imitation. Furthermore, Uzgiris and Hunt (1975) only managed to establish that a low correlation existed between gestural and vocal imitation.

Emotion matching may be different from other forms of matching. A debate has emerged as to whether emotion matching involves a different mechanism to that of facial imitation. Some claim that emotion matching can be explained in terms of emotional contagion rather than imitation (Hatfield, Cacioppo, & Rapson, 1992). An emotional contagion explanation involves the infant essentially "catching" the emotion that they are matching. It is unclear as to whether emotion matching involves the infant purely matching an emotional expression, or actually also experiencing the associated emotion. Hatfield, Cacioppo, and Rapson (1994) outlined a facial feedback explanation, claiming that a combination of imitation, synchrony, and facial feedback resulted in individuals "catching" the emotions of others. A number of studies have provided support for a contagion facial feedback explanation for emotion matching (Darwin, 1890; Strack, Martin, & Stepper, 1983; Tomkins, 1980; Zajonc, Murphy, & Inglehart, 1989).

Both facial imitation and auditory-oral matching were assessed as part of the longitudinal First Steps project. Hilbrink, Sakkalou, Ellis-Davies, Fowler, and Gattis (2011) investigated the group level effects, and individual differences, in both of these forms of early matching. In a facial imitation task, infants were presented with displays of mouth opening and tongue protrusion at 2-months-old, in an attempt to replicate Meltzoff and Moore's (1977) study. In an auditory-oral matching task, infants were presented with displayed vocalisations of "a" and "m" at 2-, 3-, and 4-months-old in an attempt to replicate Chen et al.'s (2004) study. Results demonstrated that at the group level infants failed to match in either task. However, Hilbrink et al. (2011) proceeded to analyse the data at the individual level and established that some infants could be classed as imitators and others non-imitators, although a group level effect was not observed.

This current study attempts to address whether links exist between early forms of matching behaviour. We propose that emotion matching will not be linked to other forms of matching due to a unique affective element involved in matching emotional expressions. Infant emotion matching ability assessed at 3 and 6 months in study one, was compared to infant facial imitation assessed at 2 months, and infant auditory-oral matching assessed at 2, 3, and 4 months, as reported in Hilbrink et al. (2011).

2.2.1 Method

Participants

Infants were recruited as part of First Steps with the sample consisting of 37 infants, 18 female and 19 male. However, for the analyses with the auditory-oral matching task, the sample reduced to 36 due to one infant leaving the study. Facial imitation was assessed when infants were 2 months as reported by Hilbrink et al. (2011). Auditory-oral matching was assessed when infants were 2 months (M = 60 days, range = 46 to 66 days), 3 months (M = 92 days, range = 75 to 101 days), and 4 months (M = 121 days, range = 111 to 128 days) as reported by Hilbrink et al. (2011). These variables were compared to the emotion matching task data in study one at 3 months (M=92 days, range = 75 to 101 days) and 6 months (M=181, range = 174 to 198 days).

Design

The study was a within-subjects design. Individual differences in emotion matching were assessed in relation to other forms of early matching behaviours, that of facial imitation and auditory-oral matching. The dependent within-subject variables were rate per minute of happy and sad emotion matching behaviour on the emotion matching task, rate per minute of mouth opening and tongue protrusion on the facial imitation task, as reported in study one, and rate per minute of mouth opening and mouth clutching on the auditory-oral matching task, as reported in Hilbrink et al.’s (2011) study. These rates allowed for the classification of whether infants were emotion matchers or emotion non-matchers, or facial imitators or facial non-imitators, and auditory-oral matchers or non-auditory-oral matchers.

Procedure

To assess links between different matching behaviour during early infancy, infants who were matchers and non-matchers on the emotion matching task were compared to infants who were imitators and non-imitators on the facial imitation, and matchers or non-matchers on the auditory-oral matching task.

Coding

Definitions of emotion matchers and non-matchers were based on infant performance on the emotion matching task at 3 and 6 months. Infants were classed as matchers if they demonstrated consistent matching, or an increase in matching across the two time points. Infants were classed as non-matchers if they demonstrated no matching, or a decrease in matching, across time points. For the facial imitation task, definitions of imitators and non-imitators were based on the task performance at 2 months. In Hilbrink et al.'s (2011) study infants were identified as imitators if they matched one or more facial expression and non-imitators if they failed to match either facial expression. For the auditory-oral matching task, definitions of imitators and non-imitators were based on a composite score of task performance across the 2, 3 and 4 month testing dates. In Hilbrink et al.'s (2011) study, infants were noted as imitators if they demonstrated consistent imitation, or an increase in imitation across time, and non-imitators if they demonstrated no imitation, inconsistency in imitation, or a decline in imitation across time.

2.2.2 Results

2.2.3 Is emotion matching related to non-emotional facial imitation?

A total of 24 infants were identified as matchers, and 13 infants as non-matchers on the emotion regulation task. Due to the differing number of matchers and non-matchers, the raw data was transformed into percentages to show the proportion of infants who demonstrated imitative and non-imitative ability on Hilbrink et al.'s (2011) facial imitation task (Figure 2.5.).

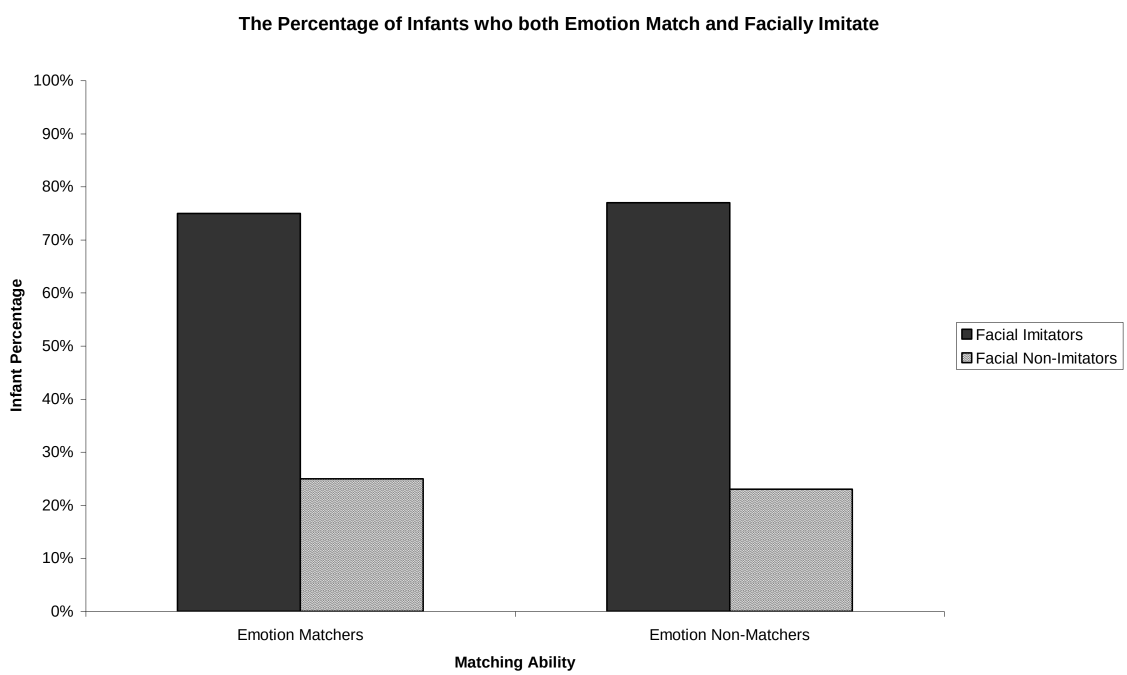

Figure 2.5. Emotion Matching and Imitation of Mouth Opening and Tongue Protrusion

A Chi-Square Goodness-of-Fit test indicated that there was no significant relationship between infants who were emotion matchers and non-matchers, and whether they were also imitators or non-imitators, on Hilbrink et al.'s (2011) reproduction of Meltzoff and Moore's (1977) task ($\chi^2(1)=.110$, $p>.05$).

2.2.4. Is emotion matching related to auditory-oral matching?

A total of 23 infants were identified as matchers, and 13 as non-matchers, on the emotion regulation task. Due to the differing number of matchers and non-matchers, the raw data was transformed into percentages to illustrate the proportion of infants who were matchers or non-matchers on the auditory-oral matching task (Figure 2.6.).

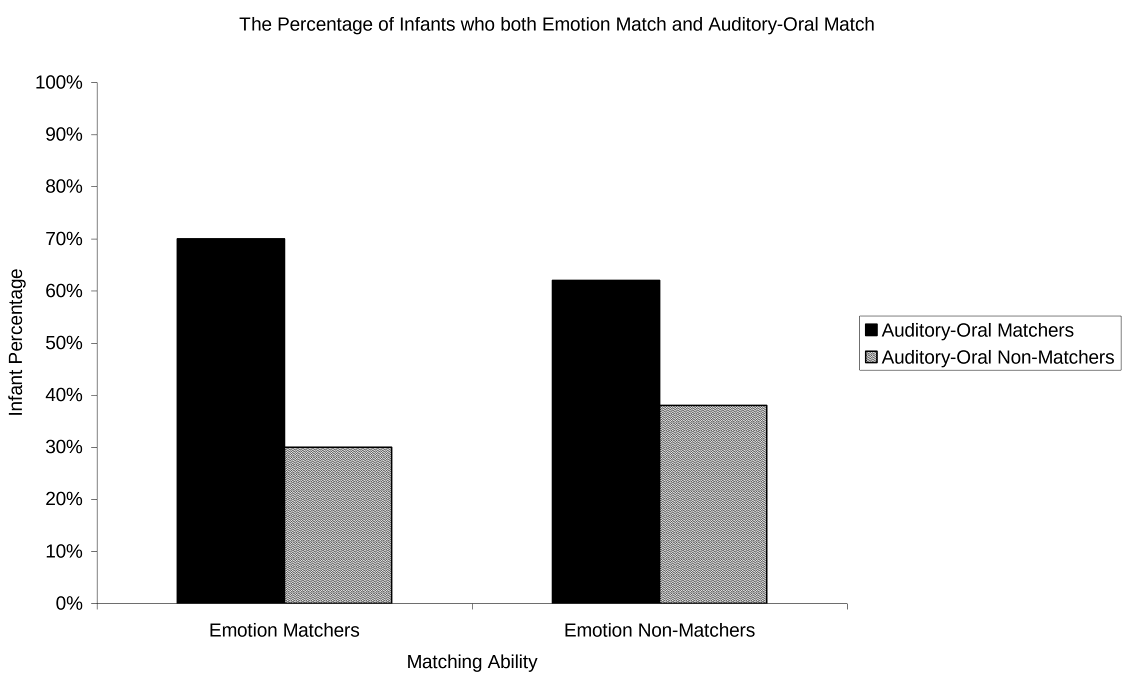

Figure 2.6. Emotion Matching and Imitation of "a" and "m"

A Chi-Square Goodness-of-Fit test indicated that there was no relationship between infants who were emotion matchers and non-matchers, and whether they are also auditory-oral matchers or auditory-oral non-matchers, on a reproduction of Chen et al.'s (2004) task ($\chi^2(1)$=w.426, p>.05).

2.2.5. Discussion

This current study attempted to address whether emotion matching in early infancy is related to other forms of early matching behaviour. We investigated relations between infants classed as emotion matchers or non-emotion matchers on an emotion elicitation task, and whether the same infants were also identified as facial imitators and auditory-oral matchers during Hilbrink et al.'s (2011) study.

Results demonstrated that there was no relationship between infants who were classed as emotion matchers on the emotion elicitation task, and whether they were also identified as facial imitators or auditory-oral matchers. This result implies that there is no link between infant matching ability. Previous research has already presented claims that different modalities of matching are not significantly linked (Kugiumutzakis, 1985; Snow, 1989; Uzgiris & Hunt, 1975). More specifically, results demonstrate that there is no link between matching behaviours performed within the same modality. The current study assessed three forms of facial matching, failing to find a relationship between them. Both non-emotional facial imitation and auditory-oral matching were compared to emotion matching; no links between these different matching behaviours were established. This result conflicts with Snow's (1989) claim that the only relationship in matching behaviour was within the same modality.

The fact that emotion matching and other forms of facial matching do not appear linked may suggest that an entirely different mechanism exists for emotion matching, compared to non-emotion facial imitation. Rather than an imitative mechanism existing behind emotion matching, such as those proposed by Meltzoff and Moore (1997) or Piaget (1962), an emotion contagion explanation, espoused by Hatfield et al. (1994), may be provided. The affect associated with modelled displays of emotion may evoke an emotional response in the infant, thus resulting in a matched emotional expression. In order to try and establish whether an emotional contagion explanation can truly be provided, further investigation and data is warranted. However, one noteworthy point is that Hilbrink et al. (2011) failed to find any group level significant effects of infants imitating on either replication of Meltzoff and Moore's (1977), or Chen et al.'s (2004), task. In contrast, study one clearly demonstrates that emotion matching is evident from 3-months-old, implying that with the First Steps' sample emotion matching is evident before facial imitation. Therefore, not only does emotion matching appear to be a different form of learning than imitation, but it occurs earlier in infancy than imitation which previous researchers (Meltzoff and Moore, 1977; Piaget, 1962) espoused to be the first social learning mechanism that infants adopt. A second noteworthy point relates to the sample size adopted for this comparison, although in total 36 infants were assessed, due to subdividing theses infants into imitators and non-imitators and then again into matchers and non-matchers, the original sample size of 36 is split roughly into four. Although the original sample of 36 is more than adequate to test for large effect sizes, the subdivision of the original sample would mean that it would be difficult to reach a substantial effect size with the limited sample in each group. Unfortunately, due to the nature of the comparisons using the First Steps' data, it was not possible to increase sample sizes post hoc.

In conclusion, it would appear that the ability to match one behaviour early in infancy, does not necessarily translate to being able to match other behaviours, even if they are within the same modality. The apparent null relationship between emotion matching and other forms of facial matching further distinguishes emotion matching from other forms of imitation. A different explanation for emotion matching appears to be required compared to that for other forms of facial matching. Furthermore, the presence of emotion matching early in infancy, and the absence of imitation, implies that traditional imitative explanations of learning in infancy may need to be reassessed or expanded to incorporate mechanisms that may precede imitative learning. However, due to the small sample sizes, to truly conclude that emotion matching is not related to other forms of matching behaviour a larger sample size should be adopted.

Chapter Three: Emotion Regulation

Key Questions to Address:

Emotion Regulation: The self verses other?

Which emotion self-regulation strategies do infants employ?

Does emotion regulation depend on valence?

Is temperament linked to emotion regulation ability?

Is emotion regulation linked to other forms of regulatory behaviour?

3.1. Study Three: Regulation Begins with the Blink of an Eye: Infants Regulate their Own Emotions from 3 Months

Acquiring the ability to regulate emotions is a critical task of development. Emotion regulation involves the monitoring and control of affective experience, including re-direction of attention. By directing attention toward or away from an emotional stimulus, individuals can modify the intensity of emotions: focusing attention on a stimulus maintains or enhances the intensity of an emotional experience, whereas redirecting attention away from a stimulus reduces, or attenuates, an emotional experience (Derryberry & Rothbart, 1988). Adults have a large repertoire of emotion regulation behaviours, ranging from explicit strategies such as mindfulness or walking away from a situation, to less conscious and in some cases automatic behaviours such as blinking or averting gaze (Arch & Craske, 2010; Kendon, 1967). Adults can also select and employ emotion regulation strategies according to the requirements of a situation. During an unpleasant conversation with a client or supervisor, for example, an adult might want to walk away, but label that response as inappropriate, inhibit it, and instead choose to take ten deep breaths.

The development of emotion regulation is a long process, beginning in infancy and continuing throughout childhood, adolescence and adulthood. By the school years, and perhaps even earlier, children are capable of learning explicit emotion regulation strategies such as counting to ten in situations where they feel frustrated, or recalling happy memories in situations where they feel sad or lonely (Zeman, Cassano, Perry-Parrish, & Stegall, 2006). Some aspects of emotion regulation, such as breastfeeding and thumb-sucking, are present in early infancy, but such behaviour reflects a combination of instinct, accident, and environmental support (Kopp, 1982; 1989). Executive aspects of emotion regulation, such as monitoring and planning, take months or even years to develop (Kochanska, Coy, & Murray, 2001; Kopp, 1982). Across development, monitoring and planning shift from external, adult-guided regulation to internal, self-controlled regulation (Fox & Calkins, 2003; Kopp, 1989).

One strategy for emotion regulation during infancy is gaze aversion. Adults avert gaze to regulate the intensity of an emotional experience with a social partner, and over the last few decades, studies have shown that infants do the same (Field, 1981; Kendon, 1967; Mangelsdorf, Shapiro & Marzolf, 1995). Studies of gaze aversion during infancy have primarily examined whether infants respond to an aversive stimulus, such as excessive stimulation or a sudden cessation of interaction, with an increased rate of gaze aversion compared to a baseline period, during which infants are presented with a neutral or mildly positive stimulus (Field, 1981; Mangelsdorf et al., 1995). These studies have shown that infants use gaze aversion to regulate negative emotions from 5 to 6 months, and provide some evidence of its presence earlier in infancy, but only to regulate distress.

We investigated the hypothesis that infants utilise a second behaviour, spontaneous blinking, to regulate the intensity of emotional experience with a social partner. Adults normally blink 15 to 20 times per minute, but blink more frequently when processing demands increase, including periods of increased emotional intensity (Doughty & Naase, 2006; Karla, Ruusuvirta & Wikgren, 2009; von Cramon & Schuri, 1980). Infants blink just 2 to 5 times per minute due to a more stable tear film, and this lower rate of blinking has led to the widespread assumption that spontaneous blinking is not utilized as a regulatory response during infancy (Lawrenson, Birhah & Murphy, 2005). Recently, however, researchers have demonstrated that infants do blink more frequently in response to rapidly moving stimuli (Bacher & Allen, 2009). Here we examine whether infants, like adults, might employ spontaneous blinking in response to emotional intensity. If infants do so, we can conclude that spontaneous blinking is a mechanism for emotion regulation in infants.

Although in theory emotion regulation enables individuals to modulate emotional experience independent of valence, most studies of emotion regulation during infancy and childhood have focused on negative emotions such as anger, distress, fear, and sadness (Buss & Goldsmith, 1998; Buss & Kiel, 2004; Field, 1981; Kopp, 1989). One problem with examining emotion regulation exclusively in the context of negative emotion is that regulation behaviours terminating negative encounters might simply be an automatic response to stress, akin to the fight-or-flight response (Cannon & Cranefield, 1915). By contrast, observing similar regulatory behaviours in the context of both positive and negative emotional arousal allows scientists to infer a higher level of regulation.

Stifter and Moyer (1991) investigated whether 5-month-olds avert gaze during positive interactions, and found evidence that this was indeed the case. Mothers were instructed to cover their faces with their hands, call the infant's name, and then play peek-a-boo for 90 seconds. Infant smiles were identified, and gaze aversions occurring within 1 second of a smile were scored to ensure that gaze aversions resulted from positive, rather than negative, emotion. Infant smiles were categorised as low, moderate, or high intensity, and the frequency of gaze aversions across those categories were compared. Infants produced more gaze aversions following high and moderate intensity smiles than low intensity smiles, indicating that gaze aversions were related to intensity of positive emotional experience.

Importantly, Stifter and Moyer (1991) also demonstrated a closer link between infant emotion and regulation than most previous studies by developing an analytic approach examining emotion regulation following infants' own emotional expressions. Stifter and Moyer's (1991) procedure and subsequent results demonstrated that infants avert gaze not simply in response to a certain type of externally presented stimulus, but in response to their own emotions. Other studies of infant emotion regulation evaluated regulatory behaviours such as gaze aversion only in terms of the emotions presented by a social partner, such as an experimenter or the infant's mother (e.g. Field, 1981). Such a design allows inferences about regulation in response to the emotions of others, but does not allow a direct inference about infant regulation in response to their own emotions.

Emotion Regulation

In the current study, we compare infants' use of gaze aversion and spontaneous blinking to regulate their own emotions, both positive and negative, from 3 to 14 months. To elicit infant emotions, we used a controlled experimental paradigm similar to the peek-a-boo game used by Stifter and Moyer (1991), with some important differences: the game was conducted by a trained experimenter who displayed happy and sad emotions on alternate peek-a-boo trials. We then scored infant emotional expressions, both happy and sad, and assessed the frequency of spontaneous blinking (SB) and gaze aversion (GA) occurring within one second of infant expressions compared to those occurring during a baseline when infant expressions were neutral. A mirrored set of analyses were conducted based on the experimenter's expressions to assess whether infants were more likely to regulate following their own versus another's emotions. Our experimental design thus incorporates contrasting conditions and temporal analysis, both of which Cole, Martin, and Dennis (2004) deemed necessary to accurately assess emotion regulation.

Infants were assessed longitudinally at 3, 6, and 14 months. The same experimental paradigm was administered at each time point to examine whether: 1) infants use SB as an emotion regulation strategy, 2) SB and GA emerge synchronously or if one strategy emerges earlier, 3) infants regulate positive and negative emotional experiences in similar ways, and 4) whether regulation differs following infants' own emotional expressions versus those of a social partner.

3.1.1. Method

Participants

This study was part of First Steps, a longitudinal study looking at the imitative, communicative, and motoric development of 37 infants from birth to 18 months. A-priori calculations revealed that a sample size of at least 26 would be required for the number of comparisons conducted, and to achieve a large effect size and power of >.80. Pregnant women were recruited during their last trimester through the National Childbirth Trust (NCT), National Health Service (NHS), and other local organisations. All infants were born healthy and to full gestation. Infants were assessed at 3-, 6-, and 14-months-old. The sample consisted of 18 female, and 19 male infants. Infants were tested at 3 months (M = 92 days, range = 75 to 101 days), at 6 months (M = 181 days, range = 174 to 198 days), and at 14 months (M = 426 days, range = 412 to 441 days). One infant was excluded from the experimenter's expression analysis due to technical problems recording the experimenter's expressions.

Apparatus

During testing infants sat on their mothers' laps directly opposite, and 1 metre apart from, a seated experimenter. Two cameras (Sony Mini DV DCR-PR110E) recorded the experiment; one camera focused on the infant's face and the second camera focused on the experimenter's face. A quad linked the two video feeds to a DV recorder to enable simultaneous recording.

Emotion Regulation

Procedure

An adult experimenter presented expressions live in a structured game of peek-a-boo. Following a familiarisation trial in which the experimenter displayed a neutral expression to the attentive infant, happy and sad expressions were dynamically displayed, with the intensity of the expression varying cyclically three times across a display period of eight seconds. At the end of the display, the experimenter covered her face with her hands and called the infant's name in a neutral tone to engage attention before the next display. The experimenter only called the infant's name between trials, and no other vocalisation occurred during the procedure. The presentation of happy and sad emotional expressions was alternated across trials, and which emotion was presented first was counterbalanced.

Design

The study was a within-subjects design. Emotion regulation strategy usage was assessed following happy and sad infant emotional expressions occurring within 1 second of producing an emotional expression (regulation period) compared to the remainder of the trial (baseline period). The within-subjects dependent variables were rate per minute of emotion regulation (SB and GA). The onset times of happy and sad emotional expressions were identified to establish each regulation period. A happy expression was defined as raising the corners of the mouth (both, or either side), engaging the Zygomatic Major muscle, producing a U-shaped mouth. A sad expression was defined as depressing the corners of the mouth (both, or either side), producing an inverted U-shaped mouth. The raising and protrusion of the lower lip and chin also defined a sad face. Data was collected as part of the emotion matching paradigm outlined in study one, where testing occurred at 3, 6, and 14 months.

Coding

Infant SB and GA were coded for the entire trial. SB was defined as the rapid closing of the eyelid past the centre of the eye, followed by the rapid opening of the eyelid. GA was defined as a look away from the experimenter's face lasting more than 1 second; this excluded saccadic eye movements from analysis. A blind secondary coder scored 10% of the sample (4 infants per age group). Agreement was 81% at 3 months, 94% at 6 months, and 90% at 14 months.

To enable identification of each regulation period, infants' happy and sad emotional expressions were also coded using the operational definition stated above. This coding was conducted both in real time and frame-by-frame from a recording in which only the infant was visible. The regulation period was defined as the 1-second interval following the onset of an infant's emotional expression. The baseline period was defined as the inverse of the regulatory periods, that is, the sum of all non-regulatory periods during the trial. Each emotion regulation rate per minute variable was generated by first calculating the total duration of all regulation periods, and then the total duration of all baseline periods. These 2 total durations were then each divided by 60 to create comparable durations. The number of regulation strategies (either SB or GA) was then noted and divided by the comparable duration length. This created two differing rates for each behaviour (SB and GA); a rate of regulation (regulatory behaviours occurring within 1 second of all infants produced expressions); and a baseline rate (regulatory behaviours occurring during the remainder of the trials). A similar comparison was adopted for the evaluation of regulation following experimenter emotions.

3.1.2. Results

Each emotion regulation variable (SB and GA) was calculated as a rate per minute for the regulation periods (the 1 second windows following an emotional expression), and for the baseline period (the remainder of the trial). This created a comparable measure for baseline and regulation periods, despite their differing durations. The mean rate per minute, and standard error of the data, for both SB and GA at each age was calculated based on the untransformed data (Tables 3.1. and 3.2.). Preliminary analyses revealed that these rate-per-minute variables were positively skewed, so a square root transformation, adding a constant of 1 to all data points, was calculated to reduce the skewness of the data. Despite the data remaining slightly skewed, the use of parametric tests (ANOVAs) was deemed appropriate due to the robustness of ANOVAs and the only slight degree of skewness.

3.1.3. Emotion regulation following own expression

Repeated measures ANOVAs were conducted on the transformed data. These analyses assessed whether SB and GA rates increased following infants production of emotional expressions compared to when infants displayed neutral expressions. Transformed rates of SB and GA following infants' expressions are illustrated in Figures 3.1 and 3.2. Video stills of the relation between infant emotion and regulation are shown in Figure 3.3.

Emotion Regulation

Two separate repeated measures ANOVAs were conducted for each emotion regulation strategy, one investigating emotion regulation following the infants' expressions, and a second investigating emotion regulation following the experimenter's expressions. For both SB and GA, initial analyses revealed no significant effects of gender ($F(1,34)=.434, p>.05$; $F(1,34)=1.324, p>.05$), or valence ($F(2,33)=1.789, p>.05$; $F(2,33)=3.297 p>.05$), so the data was collapsed across these variables for subsequent analyses.

Table 3.1. *Infant Regulatory Behaviours following Own Emotional Expressions (mean rate per minute and standard error of untransformed data)*

	SB		GA	
Months	Regulation	Baseline	Regulation	Baseline
3	7.03 (1.00)	3.68 (0.65)	6.64 (0.88)	6.08 (0.76)
6	9.78 (1.57)	3.64 (0.54)	11.77 (1.45)	5.73 (0.58)
14	7.85 (1.25)	5.70 (0.63)	10.92 (1.51)	5.80 (0.39)

To assess whether SB functions as a self-regulatory strategy in infancy, a repeated measures ANOVA was conducted on the transformed SB data. This revealed a main effect of condition (regulation versus baseline), whereby SB was higher following infants' emotional expressions compared to the neutral baseline ($F(1,36)= 22.657, p<.01, \eta p^2= .386$). There was no main effect of age, nor a condition by age interaction ($F(1,36)=1.087, p>.05, \eta p^2=.029$; $F(1,36)=2.079, p>.05, \eta p^2=.058$). Transformed rates of SB during the regulation period ranged from 1 to 4.95 at 3 months, 1 to 5.94 at 6 months, and 1 to 5.57 at 14 months. In contrast, transformed rates of SB during the baseline period ranged from 1 to 3.84 at 3 months, 1 to 4.46 at 6 months, and 1 to 4.21 at 14 months.

A repeated measures ANOVA was also conducted on the transformed GA data to establish whether GA also functions as a self-regulatory strategy in infancy. This revealed a main effect of condition, whereby GA was higher following infants' emotional expressions compared to the neutral baseline ($F(1,36)=14.189$, $p<.01$, $\eta p^2=.283$). There was no main effect of age, nor a condition x age interaction ($F(1,36)=2.251$, $p>.05$, $\eta p^2=.059$; $F(1,36)=2.365$, $p>.05$, $\eta p^2=.062$). Transformed rates of GA during the regulation period ranged from 1 to 4.85 at 3 months, 1 to 5.94 at 6 months, and 1 to 6.40 at 14 months. In contrast, transformed rates of GA during the baseline period ranged from 1 to 4.25 at 3 months, 1 to 4.03 at 6 months, and 1 to 3.90 at 14 months.

Figures 3.1. and 3.2. suggest that SB emerges early, but declines, whereas GA appears to emerge later in infancy. To assess the emergence of SB and GA, planned comparisons tested the effects at each age to identify when the two regulatory behaviours are first observed. Paired t-tests (adjusted for multiple comparisons with Bonferroni correction) demonstrated age related changes in self-regulatory behaviour. SB rates were significantly higher following infants' emotional expressions compared to the neutral baseline at 3 and 6 months, but not at 14 months ($ts(36)=3.144$, $p_{-rep}=.974$; 3.417, $p_{-rep}=.979$; $.736$, $p_{-rep}=.538$ respectively). GA rates were significantly higher following infants' emotional expressions compared to the neutral baseline at 6 and 14 months but no difference is evident at 3 months ($t(36)=3.17$, $p_{-rep}=.974$; $t(36)=2.46$, $p_{-rep}=.929$; $t(36)=.442$, $p_{-rep}=.385$). Scatterplots demonstrating each participant's use of SB and GA as regulation strategies are noted in Appendix 6 and 7, along with line graphs depicting each infant's individual trajectory and regulation usage over time in Appendix 8.

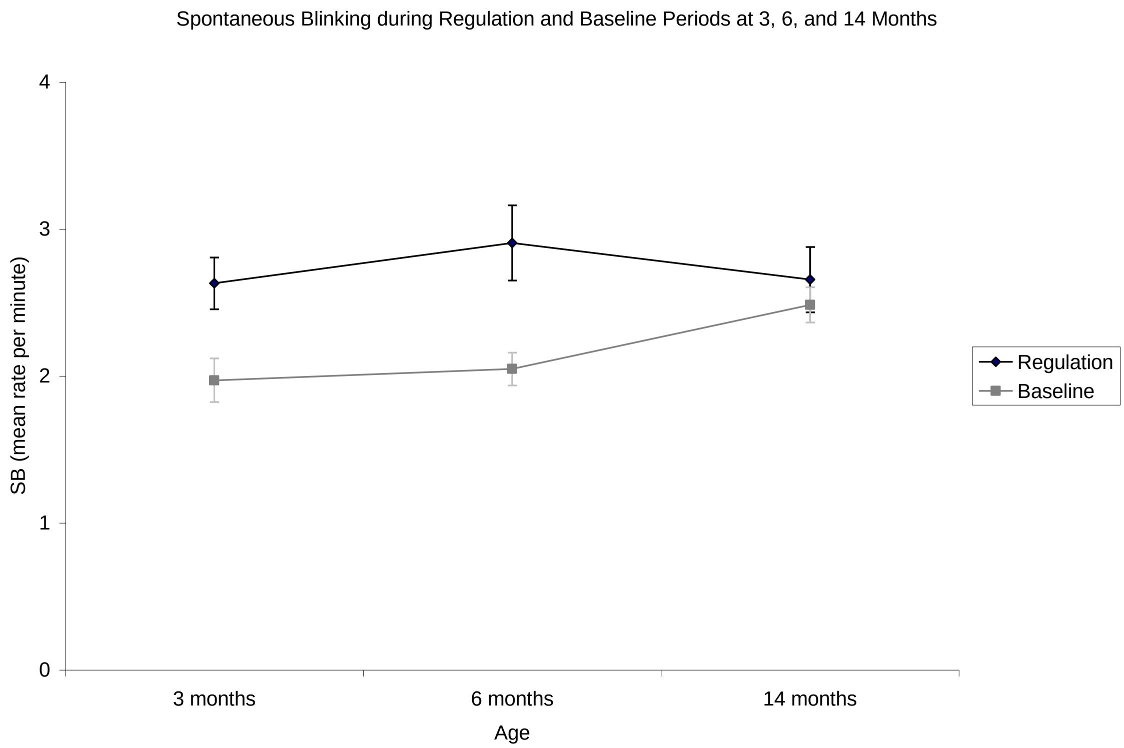

Figure 3.1. Infants' use of SB as a Regulatory Strategy

Emotion Regulation

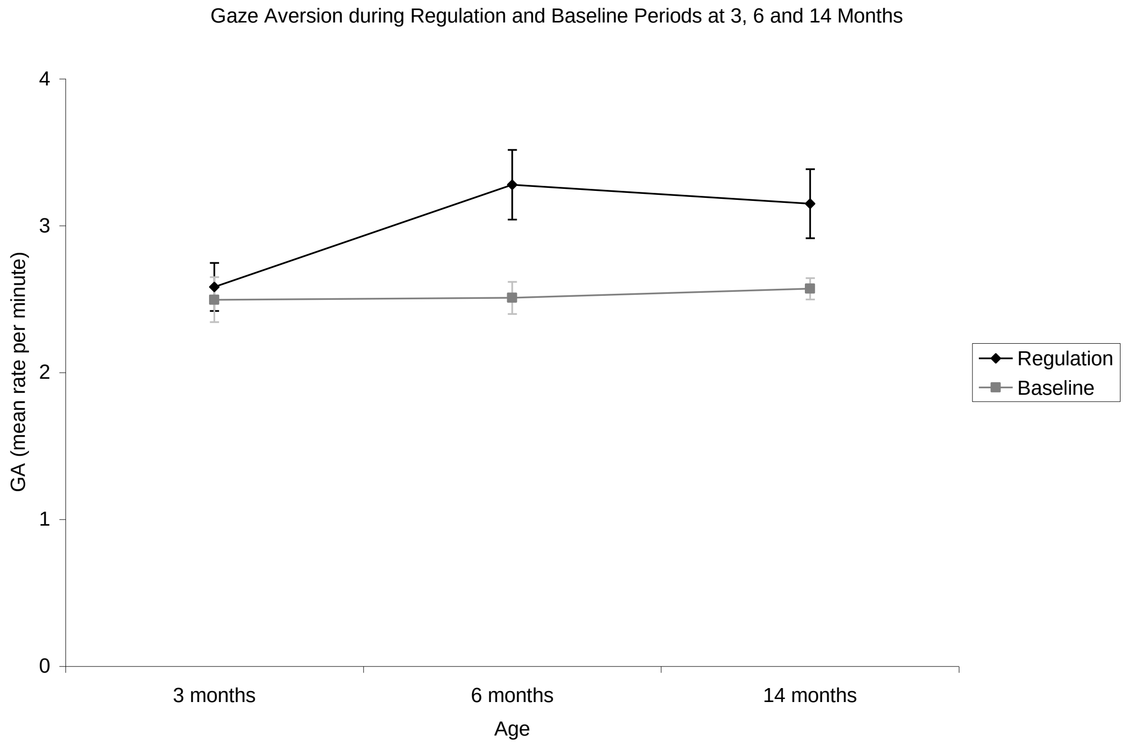

Figure 3.2. Infants' use of GA as a Regulatory Strategy

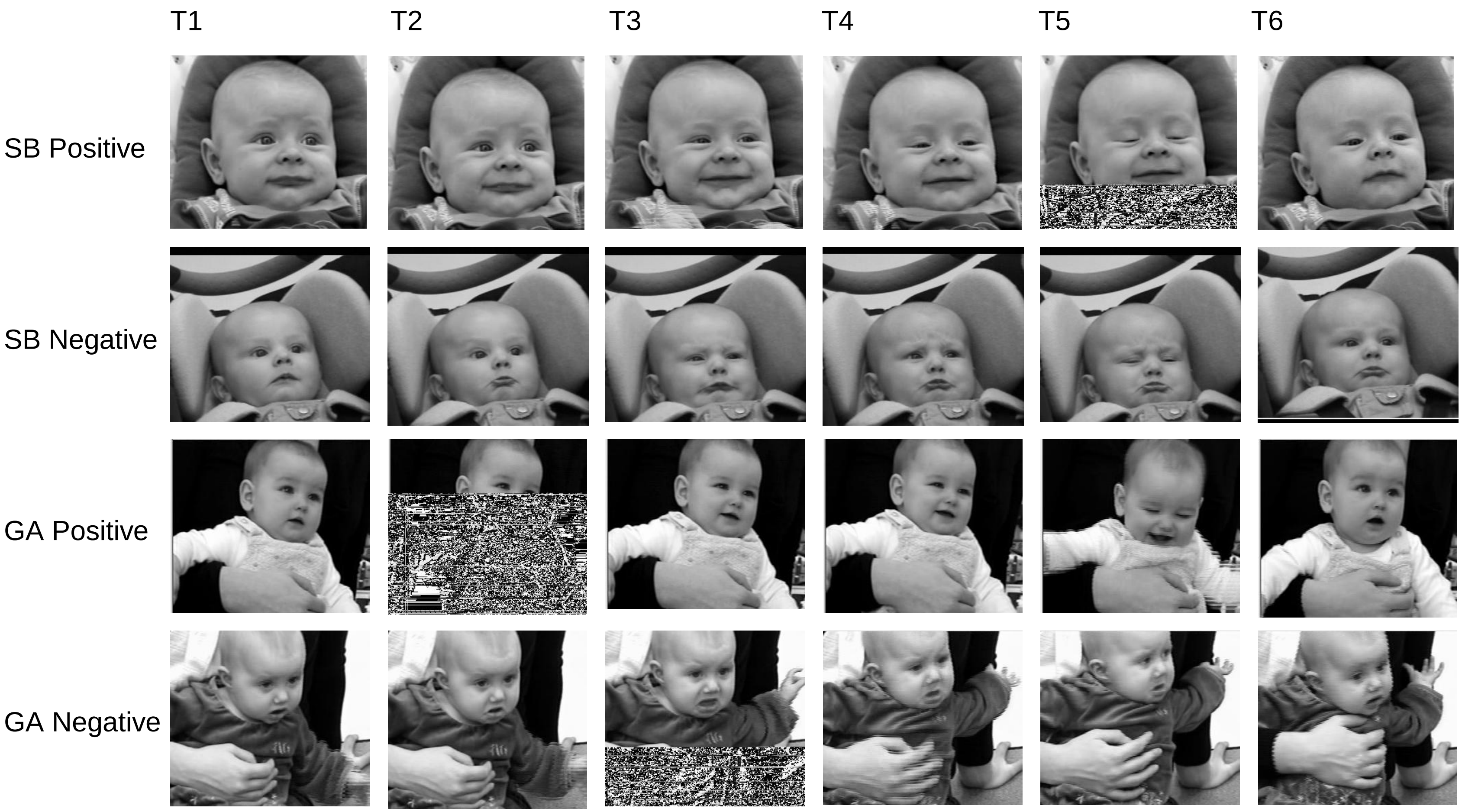

Figure 3.3. Infants demonstrating SB and GA as an Emotion Self-Regulation Strategies to their Own Positive and Negative Emotions. The photos were taken from every second frame of video recorded at a rate of 25 frames per second. As the photos demonstrate, infant regulation follows infant emotion in close temporal conjunction.

3.1.4. Emotion regulation following others' expression

Table 3.2. notes the untransformed and transformed rates of SB and GA following experimenter expressions. To assess whether infants also regulate following the emotional expressions of others, a repeated measures ANOVA was conducted on the transformed SB and GA data. This revealed a small but significant main effect of condition for SB, whereby SB was higher during the baseline than during the regulation period ($F(1,35)=22.320$, $p<.01$, $\eta p^2=.389$). There was no main effect of age, nor a condition x age interaction for SB ($F(1,35)=.950$, $p>.05$, $\eta p^2=.029$; $F(1,35)=1.407$, $p>.05$, $\eta p^2=.039$). A repeated measures ANOVA on the transformed data revealed no main effects of age or condition for GA ($F(1,35)=.215$, $p>.05$, $\eta p^2=.006$; $F(1,35)=1.032$, $p>.05$, $\eta p^2=.029$). A significant condition x age interaction for GA was observed ($F(1,35)=6.862$, $p<.01$, $\eta p^2=.164$). Overall the effects of regulation following experimenter emotions were small and inconsistent.

Table 3.2. *Infant Regulatory Behaviours following Experimenter Expressions (mean rate per minute and standard error of untransformed and transformed data)*

	Untransformed Data				Transformed Data			
	SB		GA		SB		GA	
Months	Regulation	Baseline	Regulation	Baseline	Regulation	Baseline	Regulation	Baseline
3	2.16 (0.15)	2.37 (0.18)	8.33 (1.07)	5.07 (0.62)	1.76 (0.04)	1.81 (0.05)	2.82 (0.20)	2.35 (0.13)
6	1.95 (0.16)	2.48 (0.13)	5.83 (1.04)	8.21 (0.69)	1.70 (0.05)	1.85 (0.04)	2.36 (0.19)	2.96 (0.12)
14	2.22 (0.19)	2.70 (0.12)	5.89 (0.81)	6.71 (0.57)	1.77 (0.05)	1.92 (0.03)	2.43 (0.17)	2.70 (0.11)

3.1.5. Discussion

We investigated whether infants use spontaneous blinking to regulate their own emotions, and when this emerges. We compared the emergence of spontaneous blinking with a known infant regulatory behaviour, gaze aversion. To do so, we tested infants at 3, 6, and 14 months in an emotion-eliciting, structured interaction with a trained experimenter, and compared the rate of SB and GA immediately following infants' happy and sad emotional expressions with the rate of those behaviours during baseline periods in the interaction. This approach enabled us to identify whether regulatory behaviours increase in response to positive and negative self-produced emotions, and when such regulation emerges.

As expected, infants utilised GA to regulate the intensity of emotional experience with a social partner from six months onward. This result is consistent with previous research reporting that infants adopt GA as a regulation strategy from around four to six months (Field et al., 1981; Mangelsdorf et al. 1995). Interestingly, infants did not use GA to regulate emotional experience at three months, suggesting that the use of GA develops between three and six months.

Our study methods allowed us to identify a second behaviour used by infants to regulate the intensity of emotional experience: spontaneous blinking. Infants used SB to regulate emotion whilst interacting with a social partner from three months onward. This is the first demonstration of SB as a regulation strategy in infancy. Although previous research identified changes in SB rate in response to non-social stimuli, such as, looming objects, none have investigated SB as a regulatory response to social or emotional stimuli (Bacher & Allen, 2009; Bacher & Smotherman, 2004). The use of SB to regulate emotion may rely on a more primitive system that developed in response to physical threats, and co-opt that system for responses to emotional arousal.

Comparisons between SB and GA at the three ages tested suggest a relation between the two: at 3 months, infants used SB but not GA; at 6 months, infants used both SB and GA; and at 14 months infants used GA but not SB. Interestingly, this shift in regulatory behavior coincides with well-documented changes in attention control (Abelkop & Frick, 2003; Kopp, 2002; Posner & Rothbart, 2000; Rothbart & Bates, 1998; Ruff & Rothbart, 2001). Infants orient to highly salient stimuli reflexively from birth, but have difficulties disengaging from stimuli to reorient attention elsewhere until four to six months (Atkinson, Hood, Wattambell, & Braddick, 1992; Frick, Colombo & Saxon, 1999; Johnson, Posner, & Rothbart, 1991). Around 14 weeks infants become increasingly capable of controlled attention shifts, and by 18 weeks, that the ability appears to stabilise (Butcher, Kalverboer & Geuze, 2000; Hunnius & Geuze, 2004; Hunnius, Geuze & van Geert, 2006). Combined behavioural and physiological evidence suggest that these behavioural changes reflect a shift from a sub-cortical to a cortical system for attention control at around four to six months (Atkinson, 2000; Johnson, 2010). Infants may use SB to regulate emotional experience before they are capable of disengaging attention from stimuli, and use GA to regulate emotional experience once they are capable of doing so.

Importantly, regulation did not differ for positive and negative emotions, or by gender. The same patterns of regulatory behaviour were observed for both emotions. Although most studies have focused on investigating regulation following negative expressions, few have addressed whether a difference exists in regulation following positive and negative expressions (Mangelsdorf et al., 1995). If emotion regulation only occurred in response to negative emotions, such regulatory behaviour might indicate an automatic response to stress akin to fight-or-flight. Because infant regulation follows both positive and negative emotions, we can infer that the behaviours observed here reflect a higher level of regulation. Furthermore, the fact that there were no gender difference in emotion regulation implies that both female and male infants use emotion regulation strategies equally. Similarly to study one, due to the previous literature noting a difference in how male and female infants process emotion, this result is surprising (Dimberg & Lundquist, 1990; Hampson, van Anders, & Mullin, 2006). This current study's result further supports the view that infants, independent of gender, learn to match and regulate emotion in the same way.

To evaluate whether the observed regulation was a response to infant emotions, or to the mere exposure to emotions, we also compared SB and GA immediately following experimenter expressions with SB and GA during the rest of the trial. No increase in regulatory behaviour was observed in response to the experiments' expressions. In fact, for this comparison regulatory behaviour was higher during baseline period. We view this result with some caution as it may be a consequence of the baseline: our procedure for defining the baseline meant that the baseline for experimenter expressions overlapped with a period in which infants were producing emotions, resulting in self-regulatory responses consistent with our main result. Nonetheless, the lack of evidence for regulation following exposure to emotions combined with the clear evidence of regulation immediately following self-produced emotions suggest an interesting possibility: regulation may initially emerge in response to felt emotions, and somewhat later generalise to observed emotions.

In conclusion, this research is the first to demonstrate that infants use SB to regulate their own emotions. It confirms previous reports that infants use GA to regulate their own emotions from around six months, and highlights a potential shift in regulation, paralleling the shift in attention control from a sub-cortical to cortical system. It establishes that regulation occurs in response to both positive and negative emotions. Regulation begins with the blink of an eye, allowing infants to become independent in managing emotional experience.

3.2. Study Four: Emotion Regulation and Temperament

Study three highlighted that infants are capable of emotion regulation at 3-months-old, however, it is important to also assess the individual differences in regulation ability which may be lost when only analysing data at the group level. One important contributor to individual differences is temperament. Previous research has established links between differences in temperament and emotion processing, facial discrimination, and attention (Battaglia et al, 2004; Brunet, Mondloch, & Schmidt, 2010; Todd & Dixon, 2010).

One particular aspect of temperament, shyness, may contribute to individual differences in infant's emotion regulation strategy usage. Typically, shy individuals demonstrate avoidant behaviours during social interactions, such as avoiding face and eye contact of those with whom they are interacting (Pilkonis, 1977). Shyness and emotion regulation may be linked as both of the regulation strategies assessed in study two, increased gaze aversion and spontaneous blinking, are characteristic behaviours of shyness. Therefore, it can be hypothesised that infants who are labelled as emotion regulators may also demonstrate increased scores of temperament shyness, due to the nature of the emotion regulation strategies that were assessed. Furthermore, infants who are shy in temperament may demonstrate an increase in prototypical shy behaviours as they naturally have a lower threshold to endure emotional responses before regulation strategies are adopted. Therefore, shyness may just be a manifestation of a lower regulatory threshold. This lower threshold may result in increased regulatory responses in infants who score higher on temperament shyness, and may at least partially explain any potential increases in observed regulatory behaviours in shy individuals.

A measure of infant temperament is that of the Early Childhood Behaviour Questionnaire (ECBQ); one temperament construct within the ECBQ is that of shyness. The ECBQ provides a score for shyness by assessing maternal reports of infant inhibited responses and discomfort during uncertain, or novel, social scenarios. Putman, Garstein, and Rothbart (2006) investigated the reliability of the ECBQ as a measure of temperament and concluded that it had a reliable and consistent factor structure.

Data from the First Steps longitudinal assessment of infant emotion regulation ability was compared to maternal reports of temperament shyness. The hypothesis questions whether infants who are emotion regulators also score higher on an ECBQ measure of temperament shyness.

3.2.1. Method

Participants

The data was gathered as part of First Steps with recruitment procedures outlined in study two. The sample consisted of 18 female, and 19 male infants. Infants were assessed on their emotion regulation ability at 3 month (M=92 days, range = 75 to 101 days) and 6 months (M=181, range = 174 to 198 days), whilst maternal reports of temperament shyness were collected at 15 months (M=456, range = 444 to 465 days).

Design

The study was a between-subjects design. Individual differences scores of temperament shyness were assessed in relation to emotion regulation ability. The between-subjects variable was whether infants were classed as emotion regulators or non-regulators, based on their performance at 3 and 6 months in study two. The dependent variable was infant scores on the ECBQ measure of temperament shyness collected from mothers at 15 months (see Appendix A.1.).

Procedure

Infants were classed as either emotion regulators or non-regulators, based on the data collected in study three. Maternal ratings of ECBQ temperament shyness were compared to infant regulation ability, to establish whether any differences were observed in temperament scores for regulators and non-regulators.

Coding

Definitions of emotion regulators and non-regulators were based on the 3 and 6 month assessment points, creating a composite measure of regulation. Infants were labeled as regulators if they utilized the same, or an increase, in emotion regulation strategy usage. Infants were labeled as non-regulators if they used no regulation strategy, a decrease in regulation strategy usage, or inconsistency in regulation strategy usage.

Infant level of shyness was calculated based on maternal reporting on the shyness subscale in the ECBQ. The shyness subscale in the ECBQ was measured by 12 items; each item was rated on a 7 point scale, where mothers marked the extent to which their infant performs the behaviours outlined in the description of each item. The scale varied from the mother recoding that the infant never produces the described behaviour (a score of 1), to always producing the behaviour (a score of 7). An ECBQ shyness score was calculated using the ECBQ scoring criteria so that each infant had a comparable score of temperament shyness (see Appendix A.2.).

3.2.2. Results

Infants classed as either regulators or non-regulators were compared on scores of ECBQ temperament shyness. A total of 29 regulators were compared to a total of 8 non-regulators after defining regulation ability across the 3 and 6 month age points. This created a greater number of non-regulators, compared to classifying infants as regulators and non-regulators based on a single time point (such as at 14 months), enabling a more meaningful comparison between the two groups.

Table 3.3. *Mean ECBQ Shyness Scores of Regulator and Non-Regulator infants*

	Mean Shyness	Std. Error Mean	Range
Regulator	3.34	0.16	1.82 - 5.83
NonRegulator	2.61	0.16	2 - 3.33

An independent samples t-test was conducted to compare regulators' and non-regulators' scores on temperament shyness. Figure 3.4. demonstrates the results indicating that infants who are regulators score significantly higher on the ECBQ shyness scale of temperament than infants classed as non-regulators ($t(35)=2.270$, $p<.05$). A Cohen's *d* effect size was calculated revealing a large effect size of 1.06 for this result.

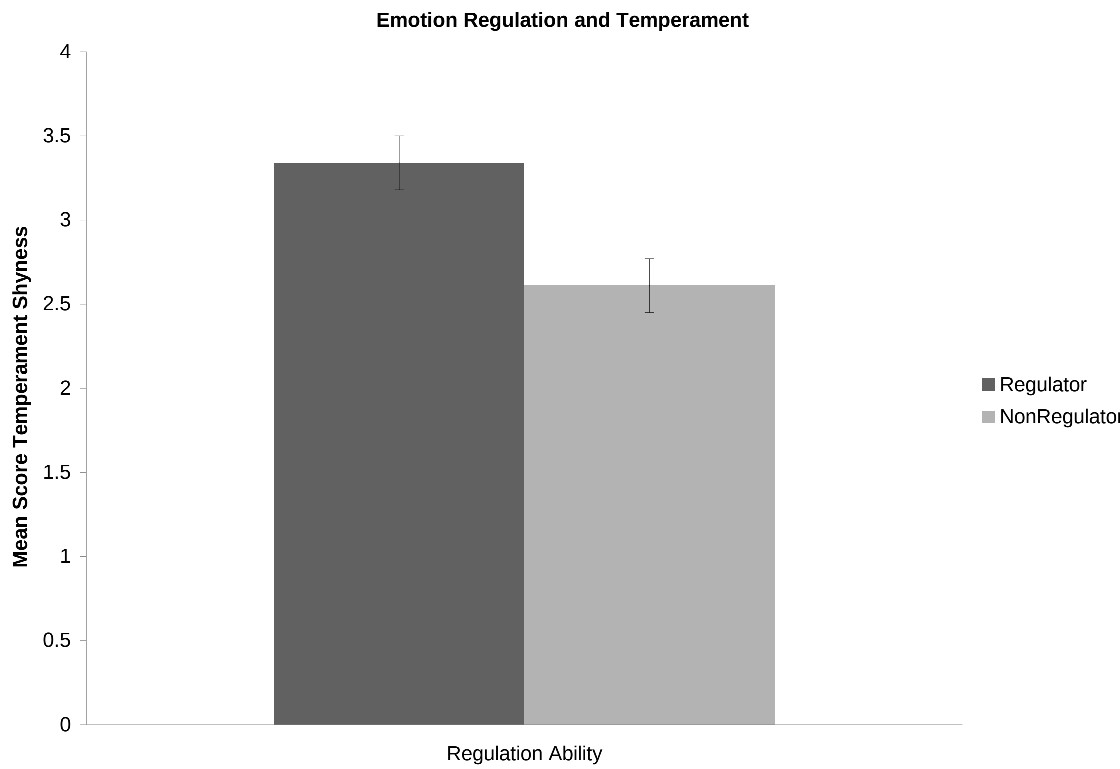

Figure 3.4. Regulators Vs. Non-Regulators Scores of ECBQ Temperament Shyness

3.2.3. Discussion

Results denote that infants who are emotion regulators score higher on temperament shyness compared to infants who are non-regulators. It would appear that shy infants are more likely to engage in emotion regulation strategy usage to modify discomforting states during social interactions. This result is supported by the fact that shy infants typically engage in regulation strategies, such as gaze aversion, to modify their discomfort during social interactions (Pilkonis, 1977).

One potential explanation for this study's result is that infants who are shy may find it harder to deal with emotion, especially during social interactions, and thus have a lower regulation threshold and demonstrate more regulatory behaviours, compared to their more extroverted counterparts. Although this finding highlights a link between emotion regulation and shyness, it does not indicate that the observed group level effect of regulation is carried by all infants who score higher on temperament shyness. The range of scores noted in Table 3.3 illustrates that some regulators scored low on temperamental shyness. In fact, the lowest score of shyness is from an infant who is classed as a regulator. Therefore, not all infants who are regulators are shy infants. This study demonstrates that a greater proportion of shy infants are regulators compared to non-regulators, but the relationship is not prescriptive; regulation and temperament are related but the association is not deterministic. Other environmental or innate factors are likely interacting with these variables and mediate this relationship.

Overall, some individual differences in regulatory behaviour can be accounted for by infant level of temperament shyness, and perhaps each infant's own regulation threshold. However, this result may partly be due to the overlap between behaviours that are classed as emotion regulation strategies and behaviours that are typical characteristics of shyness, such as GA. In conclusion, it would appear that infants who are shy are more likely to engage in, and demonstrate, regulatory behaviours.

3.3. Study Five: Emotion Regulation and other forms of Regulatory Behaviour

Study three identified that the ability to regulate emotion is present from 3-months-old. Emotion regulation is a specific form of regulatory behaviour but there are many other forms of regulatory behaviour that develop during infancy. It is possible that the other forms of regulatory behaviour assessed in the First Steps project may relate to emotion regulation, especially those relating to the development of attention control due to the disengaging nature of the regulation strategies assessed in study three.

One form of regulatory behaviour assessed in the First Steps project is that of attention control. Attention control develops slowly over the course of infancy, with infants progressing from exhibiting limited attention ability to making controlled attention shifts. In the first few months, when infants are only able to attend and track salient stimuli, one assessment of attention control is to observe the duration of time that infants spend engaged or unengaged with a stimulus. It is not until between 3 to 6 months that infants become capable of selective and controlled shifts to regulate their attention (D'Entremont, Hains, & Muir, 1997). As attention control develops further, enabling infants to engage in joint visual attention, another assessment of attention control is to note infant performance on a proximal gaze following task; this measures infant joint attention ability. Joint attention allows infants to attend to the same visual stimuli as a social partner whilst transferring their attention back and forth from the jointly attended stimulus to the social partner. The ability to selectively engage, and periodically disengage and reorient attention between a stimuli and a social partner, provides evidence of a developed attention control system and effective attention regulation.

Another regulatory behaviour assessed in the First Steps project is inhibition. The ability to inhibit a response demonstrates a certain level of regulatory control. A classic demonstration of the ability to inhibit an established response is the A-not-B task; this involves the experimenter repeatedly placing an object in one of two locations. After a number of trials, the experimenter then places the object in the second location. If the infant repeatedly continues to search at the original location they are said to demonstrate the 'perseverative error'. Although Piaget (1954) originally devised the task to highlight infant ability to recognize object permanence, many researchers now claim that performance on the A-not-B task can demonstrate inhibitory control (Diamond, Cruttenden & Niederman, 1994).

Both forms of regulation, attention control and inhibition, are assessed to see whether these different forms of regulatory behaviour relate to emotion regulation. If regulatory behaviours are linked, one would expect infants who are regulators to demonstrate a higher level of attention control and inhibition. In contrast, one would expect infants who are non-regulators to demonstrate lower levels of attention control, and the inability to inhibit a learned response.

3.3.1. Method

Participants

Participants were recruited as part of First Steps. The sample consisted of 37 infants: 18 female, and 19 male. For the attention control measure, infant duration of unengagement was assessed at 2 months (M=60 days, range= 46 to 66 days), and proximal gaze performance at 5 months (M=152 days, range = 138 to 163 days). These measures were compared to the emotion regulation task data at 3 months (M=92 days, range = 75 to 101 days), 6 months (M=181, range 174-198 days) respectively. For the inhibition measure, infant inhibition performance was assessed at 12 months (M=365 days, range = 354 to 375 days), and compared to the emotion regulation task data at 14 months (M=426, range = 412 to 441 days).

Design

The study was a between-subjects design. Individual differences in emotion regulation were assessed in relation to other forms of regulatory behaviour, those of attention control and inhibition. The independent variable was whether infants were classed as regulators or non-regulators in study three. The dependent variables were infant duration of unengagement, performance on the proximal gaze following task, and level of inhibitory control.

Procedure

To assess differences in attention control, infants who were either regulators or non-regulators were compared on their duration of unengagement during an interaction with their mother at 2 months. The definitions of regulator and non-regulator were based on infant performance at 3 months on the emotion regulation task in study three. Differences in attention control between infants who were either regulators or non-regulators were compared on their performance on a proximal gaze following task at 5 months. The definitions of regulator and non-regulator were based on infant performance at 6 months on the emotion regulation task in study three. To investigate differences in inhibition, infants who were regulators or non-regulators were compared on their performance on an A-not-B task at 12 months. The definitions of regulator and non-regulator were based on infant performance at 14 months on the emotion regulation task in study three.

Coding

Definitions of emotion regulators and non-regulators were based on the 3, 6, or 14 month assessment points in study three. Infants were labeled as regulators if they utilized one or more emotion regulation strategy. Infants were labeled as non-regulators if neither emotion regulation strategy was employed. Duration of unengagement was based on the duration that the infant was unengaged during a 10 minute interaction with their mothers. A median split divided the durations into groups: brief unengagement, and extended unengagement. The median split occurred at the point of 154 seconds, where the range in scores varied from 4 to 524 seconds of unengagement. Although median splits can result in groups being split considerably above or below their mean, in this case the mean was of 184 seconds, which considering the range of data is not a large difference from that of the median. A median split into 3 groups was nonetheless considered, using the two tails as comparison groups, however, due to the relatively small sample size, an additional split was considered to lower the power of the comparison, so a traditional median split into two dichotomous groups was used.

For the proximal gaze following task, infants were either coded as having no proximal gaze following, proximal gaze following or checking back, and multiple checking back. No proximal gaze following demonstrates no attention control, where the infant does not focus on anything during the maternal interaction. Proximal gaze following demonstrates some attention control, where the infant follows an object and retains attention on that object. Similarly, checking back demonstrates some attention control, where the infant engages with an object but also checks back to their mother once during the interaction. Finally, multiple checking back demonstrates advanced attention control, where an infant maintains attention on an object but at the same time consistently disengages and reorients attention at intervals towards their mother.

For the A-not-B task, inhibition was coded based on whether infants passed or failed the A-not-B task. Infants passed the A-not-B task if they inhibited their established behaviour and looked to the new location, whereas, infants failed the A-not-B task if they demonstrated a 'perseverative error' (i.e. continued to look to the established location).

3.3.2. Results

3.3.3. Emotion Regulation and Attention Control – Maternal Interaction

A total of 26 infants were identified as regulators, and 11 as non-regulators, at 3 months. Due to the differing number of regulators and non-regulators, the raw data was transformed into percentages to illustrate the proportion of infants who demonstrated brief and extended unengagement during maternal interactions (Figure 3.5.).

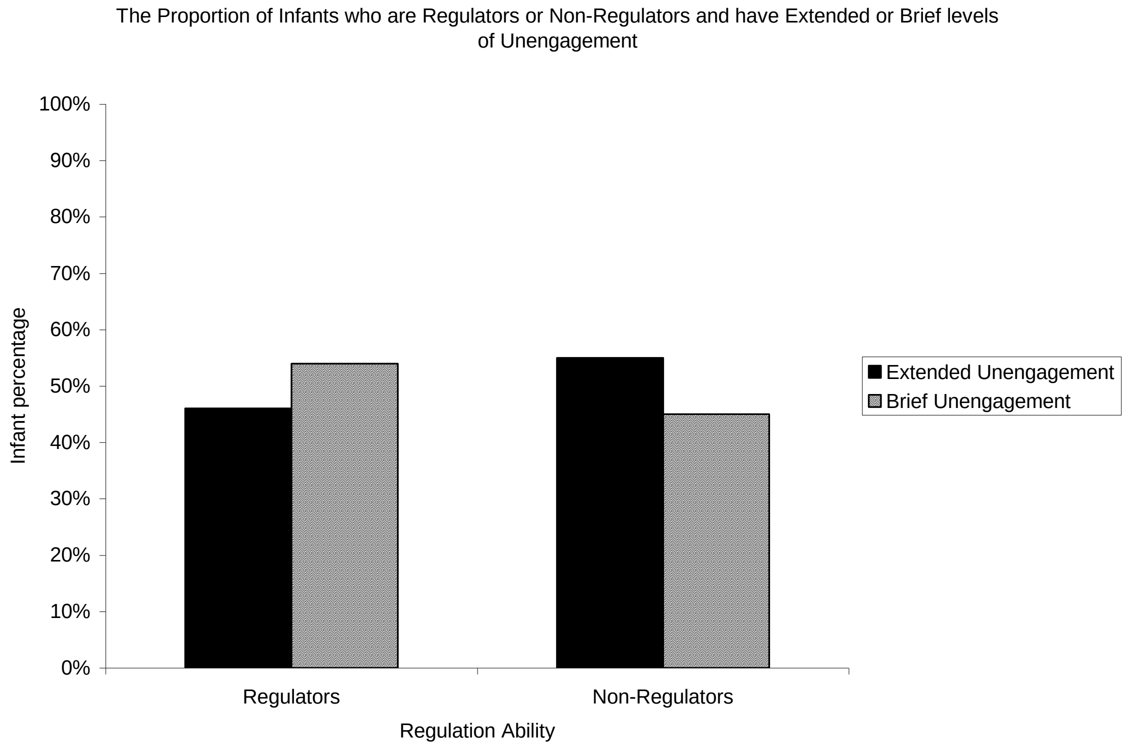

Figure 3.5. Regulation Ability and Attention Control (as measured by level of unengagement)

A Chi-Square Goodness-of-Fit test indicated that there was no significant relationship between infants who were regulators and those who were non-regulators in terms of level of unengagement (χ^2(1)1.620, p>.05).

3.3.4. Emotion Regulation and Attention Control - Proximal Gaze Following Task

A total of 29 infants were identified as regulators, and 8 as non-regulators, at 6 months. Due to the differing number of regulators and non-regulators, the raw data was transformed into percentages to illustrate the proportion of infants who demonstrated no proximal gaze following, proximal gaze following or checking back, and multiple checking back on the proximal gaze following task (Figure 3.6.). Table 3.4. demonstrates the level of attention development according to the specific emotion regulation strategies adopted.

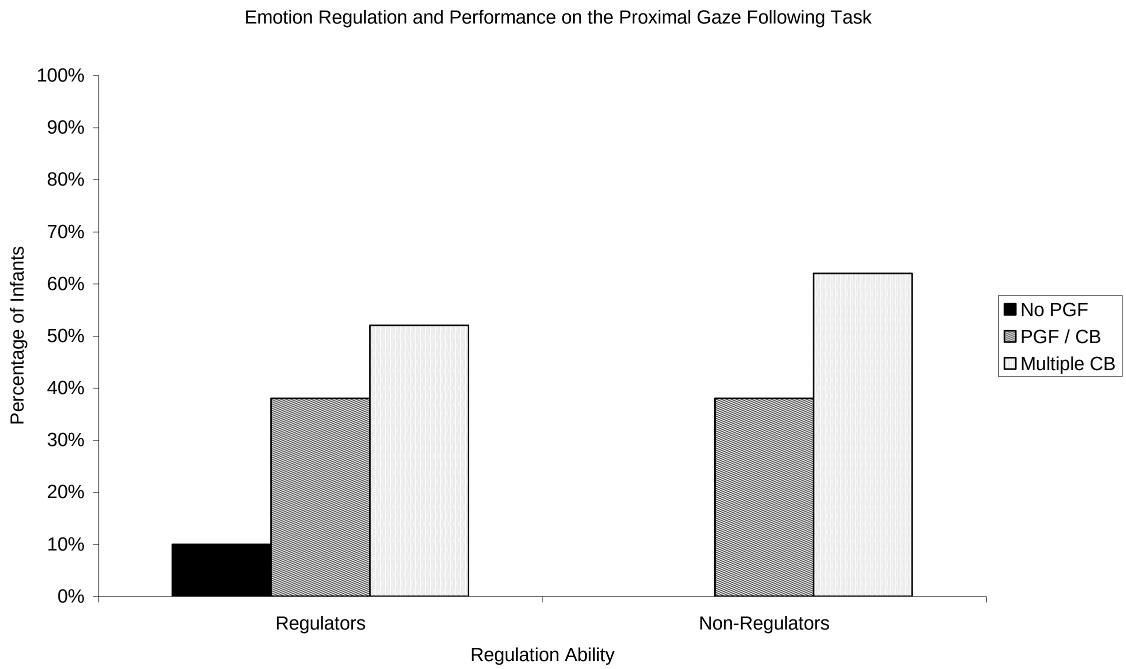

Figure 3.6. Emotion Regulation and Attention Control (as measured using the Proximal Gaze Following Task)

Table 3.4. *Level of Attention Development by Regulation Strategy Adopted*

Level of Attention Development	GA & SB / GA	SB	Neither
No Proximal Gaze Following	9%	17%	0
Proximal Gaze Following / Checking Back	26%	83%	38%
Multiple Checking Back	65%	0	62%

A Chi-Square Goodness-of-Fit test indicated that there was a significant relationship between performance on the proximal gaze following task and regulation ability, whereby more non-regulators exhibited higher levels of attention control than regulators (χ^2(2)110.877, p<.01). Infants who were regulators and demonstrated no proximal gaze following accounted for 5%, whereas non-regulators accounted for 0%. Infants who were regulators and demonstrated proximal gaze following or checking back accounted for 19%, as did non-regulators. Infants who were regulators and demonstrated multiple checking back accounted for 26%, compared to non-regulators who accounted for 31%.

3.3.5. Emotion Regulation and Inhibitory Control – A-not-B task

A total of 26 infants were identified as regulators, and 11 as non-regulators, at 14 months. Due to the differing number of regulators and non-regulators, the raw data was transformed into percentages to illustrate the proportion of infants who passed or failed the A-not-B task (Figure 3.7.).

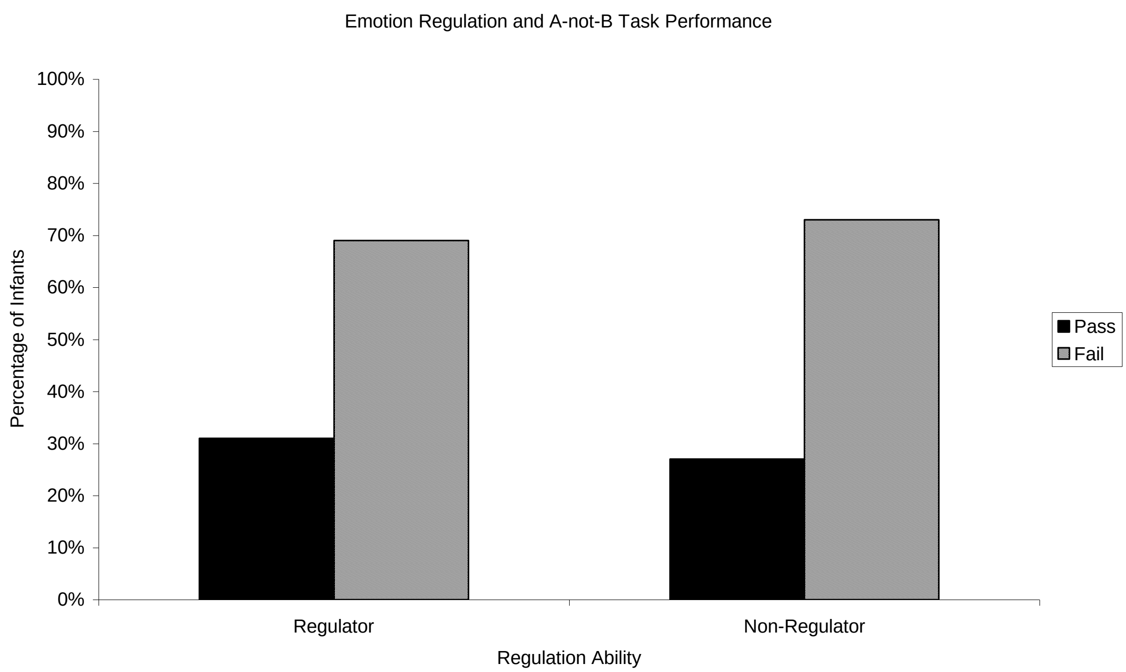

Figure 3.7. Emotion Regulation and Attention Control (as measured using the A-not-B Task)

A Chi-Square Goodness-of-Fit test indicated that there is no significant relationship between infants who are emotion regulators and those who are non-regulators at 14 months and performance on the A-not-B task at 12 months ($\chi^2(1).389$, $p>.05$).

3.3.6. Discussion

Results from these analyses demonstrate that there is no significant relationship between emotion regulation and other forms of regulatory control demonstrated in infancy; namely attention control, and inhibition. In fact, the results from the proximal gaze following task indicate that a negative relationship between emotion regulation and attention control might exist. There are four possible explanations for the results. Firstly, the development of different forms of regulatory behaviour do not relate to one another. Secondly, assessments of attention control and inhibition are not accurate measures of regulatory control. Thirdly, that two emotion regulation strategies are combined. Fourthly, emotion regulation observed in study two is not actually a form of regulation.

A possible explanation for the results is that the measures of attention and inhibition do not tap in to the correct aspect of these regulatory behaviours to make a meaningful comparison to emotion regulation. One of the suggestions identified in study two was that changes in emotion regulation strategy usage could be associated with changes in attention development. However, these analyses demonstrate that there is no positive relationship between either measure of attention, and emotion regulation. It is still possible that attention is related to emotion regulation, but just not the measures of attention that were assessed here. Perhaps linking the age at which infants are first able to disengage attention would be better associated with any changes in emotion regulation strategy usage.

Another possible explanation for the result obtained is that the two emotion regulation strategies are combined to form the emotion regulation variable. The data in study two demonstrates that emotion regulation can be achieved by using strategies that may not rely as heavily on attention development, namely SB. The definition of regulators included infants who were only utilizing SB to regulate emotion, a strategy that does not require any particular level of attention control. Therefore, the expected link between emotion regulation and attention may only be apparent when considering emotion regulation strategies that rely on attention development, such as GA. When looking at the results of the proximal gaze following task according to emotion regulation strategy usage, it becomes evident that the use of gaze aversion as an emotion regulation strategy is mostly adopted by infants who have demonstrated the highest attention level on the task, namely multiple checking back (65%). In contrast, none of the infants who utilized SB as their sole regulatory strategy demonstrated multiple checking back. Yet, infants who were classed as non-regulators also displayed a high proportion of multiple checking back (62%).

A final explanation for the results is that emotion regulation observed in study two is not actually regulation. It is possible that SB and GA are behaviours that occur in response to a stimulus presentation or due to arousal. However, as both behaviours occur immediately after an infant produces an emotion expression, and not in relation to the experimenter's modelled expression, it is unlikely that increases in SB and GA are anything other than emotion regulation behaviours.

Overall, the results do not display any clear evidence of a link between infants who are emotion regulators and their performance on other measures of regulatory behaviour. The most likely explanation for these results is that emotion regulation is a regulatory behaviour that differs from other forms of regulation.

Chapter Four: Relationship between Emotion Matching and Emotion Regulation

Key Questions to Address:

What are the processes behind emotion matching?

Is emotion matching linked to emotion regulation ability?

4.1. Study Six: Emotion Matching and Emotion Regulation in Early Infancy

Study one and three have already highlighted that from 3-months-old, infants engage in both emotion matching and emotion regulation, however, little is known about how these behaviours relate to one another. Examining the relationship between these behaviours may provide some insight into the processes behind them.

Research has demonstrated a dual pathway account of emotion processing. McIntosh, Reichmann-Decker, Winkielman, and Wilbarger (2006) examined the different processes behind emotion matching in a facial electromyography study investigating emotion processing in individuals with, and without, Autistic Spectrum Disorder (ASD). McIntosh et al. (2006) proposed a dual pathway account of emotion processing, consisting of an automatic, unconscious sub-cortical pathway and a controlled, conscious cortical pathway. Results from McIntosh et al. (2006) noted that individuals with ASD only demonstrated controlled conscious emotion matching, and failed to demonstrate automatic, unconscious emotion matching compared to a control group. This provides clear evidence of a distinction between the two processes behind emotion matching. Further research by Adolphs (2006) supports this dual pathway account, adding that both pathways feed information about the observed facial expression into the amygdala which results in an associated emotional response.

As most research into the dual pathway account of emotion processing has been conducted on adolescents or adults, it is not clear whether both the cortical and subcortical pathways are developed and utilised from birth. However, Leppanen and Nelson (2006) posited that only the subcortical automatic pathway is present from birth, whilst the cortical controlled pathway develops later and is dependent on experience. Therefore, it is possible that infants initially demonstrate a reflexive and automatic response to emotion matching, and then later in infancy controlled emotion matching develops. This may be linked to the apparent decline in matching as infants age; shifting from frequent automatic matching of emotional expressions to consciously choosing which expressions they match (Field, Goldstein, Vega-Lahr, & Porter, 1986; Fontaine, 1984).

The current study investigates the development of a controlled pathway in emotion matching by looking at the relationship between emotion matching and emotion regulation. Emotion regulation is a controlled process that involves regulating internal affective states through avoidant behaviours, such as gaze aversion (GA) and spontaneous blinking (SB). Emotion regulation usage may be linked to the development of more controlled processes behind emotion regulation as it involves inhibitory responses. Evidence from study one has already demonstrated that from 6-months-old a change emerges in matching behaviour. This may indicate that at around 6 months there is a shift in the processes underlying matching, changing from predominantly using automatic reflexive responses to controlled responses. Interestingly, study one only noted a decline in sad matching from 6-months-old. If emotion matching early in infancy is automatic and matching sad expressions is unpleasant, and regulation is a controlled response to inhibit that automatic response, it can be hypothesised that regulation ability early in life can predict, or is related to, infant ability to match, or inhibit, sad expressions later in life. The same relationship would not be expected between regulation early in life and later happy matching, as study one demonstrated that happy matching remained constant across 3, 6 and 14 month time points.

Infants were assessed across 3 and 6 months on their regulatory behaviour, and at 14 months on their matching ability on an emotion elicitation task. The aim of the study was to examine whether infants identified early in infancy as emotion regulators, or non-regulators, then differed on their later matching ability. Specifically, the aim of the study is to establish whether infants who are regulators early in infancy are less likely to match sad expressions later in infancy, as a result of having more control over inhibiting matching responses.

4.1.1. Method

Participants

The data was gathered as part of First Steps and recruitment procedures were that of study three. The sample consisted of 37 infants, 18 female and 19 male. Infants were assessed on their emotion regulation ability at 3 months (M=92 days, range = 75 to 101 days) and 6 months (M=181, range 174 to198 days). Infant ability to match emotion expressions was assessed at 14 months (M = 426, range = 412 to 441 days).

Design

The study was a between-subjects design. Infant emotion regulatory ability across 3 and 6 months was assessed in relation to their emotion matching ability at 14 months, to identify whether infants classed as emotion regulators or non-regulators early in infancy was related to whether infants were classed as matchers or non-matchers later in infancy.

Procedure

Data was collected as part of the emotion elicitation task described in studies one and three. For the first longitudinal analysis, overall emotion regulation ability was assessed in relation to later emotion matching ability. Following this assessment, regulatory behaviour was examined in relation to later happy matching ability and then separately in relation to later sad matching ability.

Coding

For the assessment of emotion regulation, using data gathered in study three, infant ability to regulate emotion across 3 and 6 months provided the basis for whether infants were classified as regulators or non-regulators. Infants were classed as regulators if they displayed the same, or an increase, in regulatory behaviour across the 3 and 6 month time points. In contrast, infants were classed as non-regulators if they displayed no, or a decrease, in regulatory behaviour across the 3 and 6 month time points. For the first analysis investigating links between early regulation and later overall matching ability, infants were classed as overall matchers if they matched either, or both, emotional expressions at 14 months, and infants were classed as non-matchers if they matched neither expression. For the second analysis investigating the relationship between early regulation and later happy matching ability, infants were classed as happy matchers if they matched just happy expressions at 14 months, and non-matchers if they matched no expression. For the third analysis investigating the relationship between early regulation and later sad matching, infants were classed as sad matchers if they matched just sad expressions at 14 months, and non-matchers if they matched no expression. All data regarding emotion matching ability at 14 months is based on that collected and reported in study one.

4.1.2. Results

Due to the categorical nature of the variables, Chi-square analyses attempted to identify the relationships between early regulation and later matching ability. As the sample sizes of regulators and non-regulators was quite uneven, for each analysis the raw data was converted into proportions so that meaningful comparison could be made.

4.1.3. Can emotion regulation ability across 3 and 6 months predict emotion matching at 14 months?

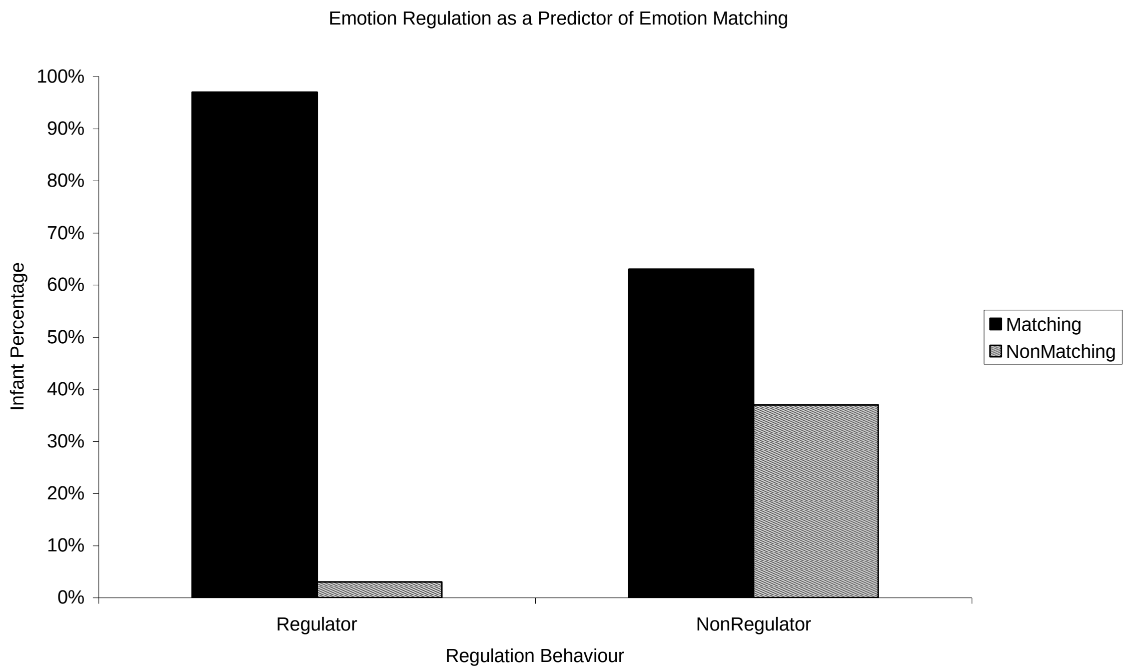

Figure 4.3. Infant Ability to Regulate Emotion across 3 and 6 Months and Overall Emotion Matching Ability at 14 Months

A Chi-Square Goodness-of-Fit test indicated that there was a significant relationship between regulatory ability early in infancy and overall emotion matching performance at 14 months, whereby a higher proportion of regulators exhibited matching than non-regulators ($\chi^2(1)36.125$, $p<.01$). Infants who were regulators and matchers accounted for 48.5%, whereas non-regulators who were matchers accounted for 31.5%. Infants who were regulators and non-matchers accounted for 1.5%, and infants who were non-regulators and non-matchers accounted for 18.5%.

4.1.4. Can emotion regulation ability across 3 and 6 months predict happy matching at 14 months?

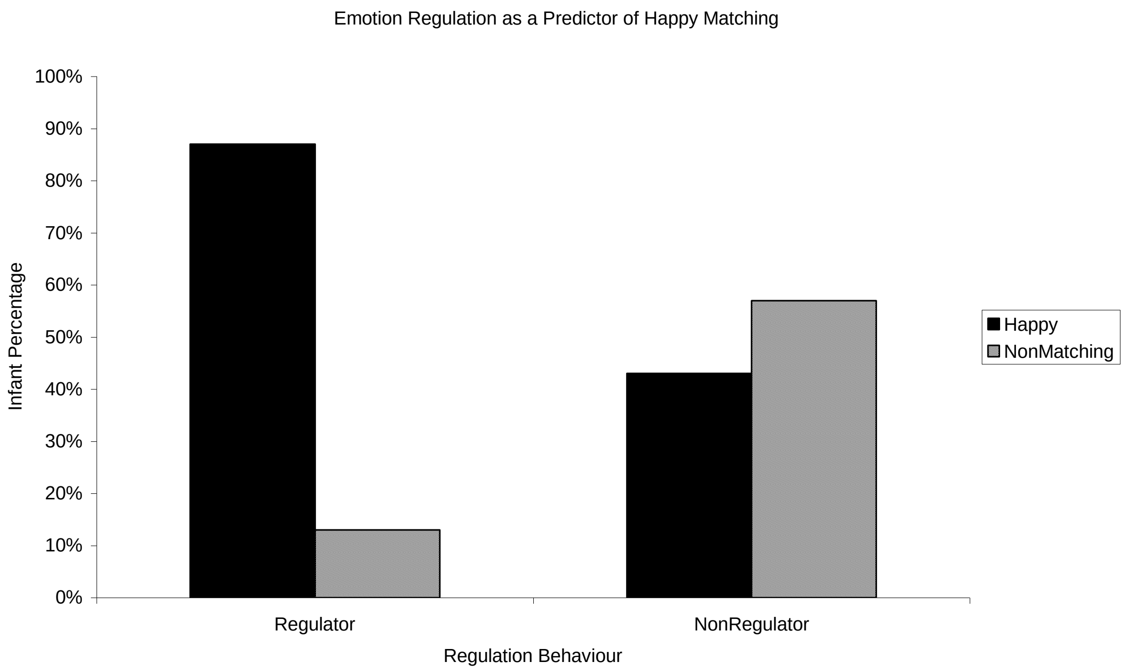

Figure 4.4. Infant Ability to Regulate Emotion across 3 and 6 Months and Happy Emotion Matching Ability at 14 Months

A Chi-Square Goodness-of-Fit test indicated that there was a significant relationship between regulatory ability early in infancy and happy emotion matching performance at 14 months, whereby more regulators exhibited happy matching than non-regulators ($\chi^2(1)42.549$, $p<.01$). Infants who were regulators and happy matchers accounted for 43.5%, whereas non-regulators who were happy matchers accounted for 21.5%. Infants who were regulators and non-matchers accounted for 6.5%, and infants who were non-regulators and non-matchers accounted for 28.5%.

4.1.5. Can emotion regulation ability across 3 and 6 months predict sad matching at 14 months?

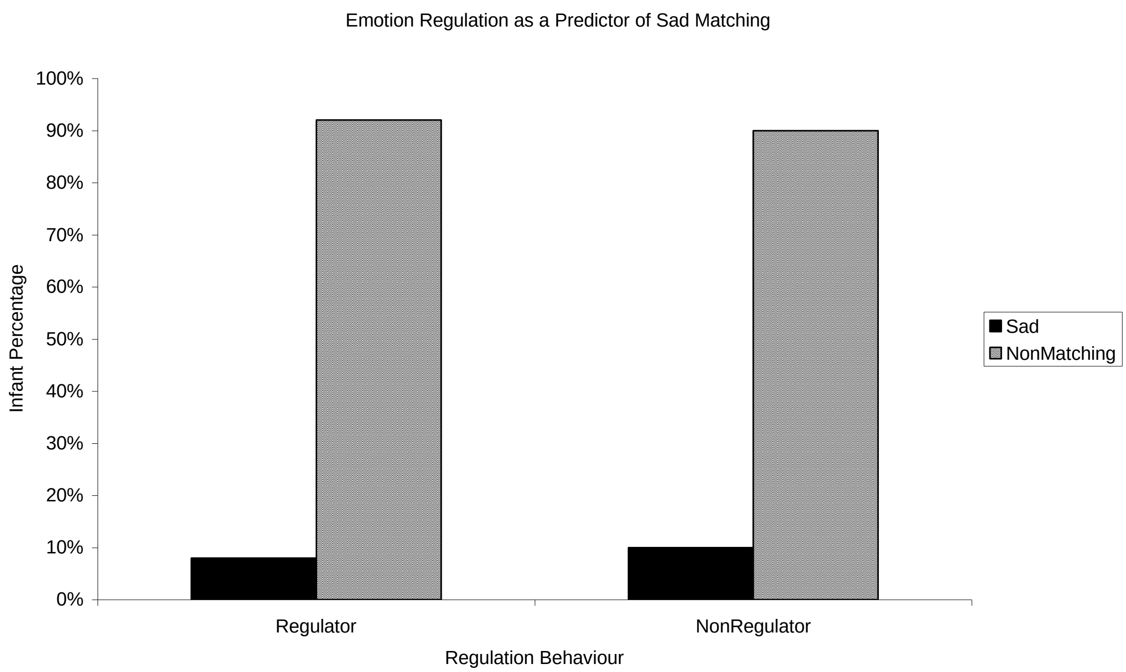

Figure 4.5. Infant Ability to Regulate Emotion across 3 and 6 Months and Sad Emotion Matching Ability at 14 Months

A Chi-Square Goodness-of-Fit test indicated that there was no significant relationship between regulatory ability early in infancy and sad emotion matching performance at 14 months ($\chi^2(1)0.68$, $p>.05$). Infants who were regulators and sad matchers accounted for 4.2%, whereas non-regulators who were sad matchers accounted for 5.3%. Infants who were regulators and non-matchers accounted for 43.2%, and infants who were non-regulators and non-matchers accounted for 47.4%.

4.1.6. Discussion

The current study examined the longitudinal relationship between emotion regulation ability early in infancy and emotion matching at 14 months, in an attempt to establish any predictive longitudinal links between these behaviours that may provide some insight into the processes behind emotion matching. Previous research, reported in study one, demonstrated that from 6-months-old infants selectively matched emotional expressions according to valence, whereby sad matching declined with age and happy matching remained stable. This selectivity may indicate a shift from automatic processing to controlled processing of emotions. The current study attempted to address whether individual differences in regulation ability (a behaviour that involves a controlled response) can determine later emotion matching, whereby infants demonstrating controlled regulatory behaviour may later demonstrate the ability to inhibit sad matching through a controlled form of emotion processing.

Results from the current study failed to find a significant relationship between early emotion regulation ability and sad matching at 14 months. There was no difference between infants who were regulators and those who were non-regulators and their ability to inhibit sad matching. Both regulators and non-regulators demonstrated equally low levels of sad matching and high levels of non-matching. This result demonstrates that infants are not matching sad expressions at 14 months, indicating that they are consciously choosing not to match sad expressions. However, this conscious choice cannot be explained according to inhibiting matching through regulatory behaviours.

The results demonstrated a significant relationship between early emotion regulation ability and happy matching at 14 months, whereby infants who were regulators were more likely to be happy matchers than non-matchers later in infancy, whereas non-regulators demonstrated no significant difference between matching and non-matching ability. Therefore, it would appear that emotion regulation predicts happy matching. One potential explanation is that infants with the ability to regulate selectively choose to match happy emotional expressions, perhaps due to the positive associations and rewards and associated with displaying a happy face.

The current study also demonstrates a relationship between emotion regulation and total matching, similar to that relating to happy matching, whereby infants who are regulators engage in more overall matching compared to non-matching, whereas non-regulators demonstrated no significant difference between matching and non-matching ability. It is possible that this relationship is driven by the links between emotion regulation and happy matching, as by 14 months infants only significantly match happy expression. This result also establishes that if we had not considered happy and sad matching separately, we would have failed to identify the different relationships (or lack of relationships) between happy and sad matching variables and early regulation ability.

Overall, early regulation was not found to be linked to later inhibitory responses to sad matching, but a relationship between regulation and selectively choosing to happy match has been established. Unfortunately, these results provide little conclusive evidence to further our understanding of the automatic and controlled processes behind emotion matching and the inhibitory response required to avoid matching sad emotional expressions.

Chapter Five: General Discussion

Data was collected as part of the First Steps project to investigate the development of emotion matching, and emotion regulation, over the course of infancy. This thesis has attempted to elucidate our understanding of these behaviours and their developmental trajectories. A number of key questions were identified in chapter one, and here we discuss how the research reported in this thesis has furthered our understanding and has attempted to provide some answers to these theoretical questions.

5.1. *Do infants emotion match, and does this ability alter according to valence of expression?*

Study one demonstrated that infants were able to match emotional expressions of happy and sad from 3-months-old. This result is supported by previous research claiming that neonates are able to match a variety of emotional expressions from birth and from evidence of facial imitation early in infancy (Field, Woodson, Greenberg, & Cohen, 1982; Meltzoff & Moore, 1977). Furthermore, it would appear that infants do not just discriminate between emotional expressions, as Montague and Walker-Andrews (2001) posited, and instead are able to engage in meaningful social interactions, matching the emotional expressions displayed to them by their social partner. However, study one only investigated infant ability to match happy and sad expressions due to the unambiguity of the expressions; it is unknown to what extent 3-month-old infants would be able to match ambiguous expressions, such as anger or fear. Previous research investigating emotion matching has often found conflicting results as to whether infants are able to match ambiguous expressions (Caron, Caron, & Maclean. 1988).

Interestingly, study one also highlighted that there was no effect of valence on matching at 3-months-old; infants matched both happy and sad expressions. However, an effect of valence emerged from 6-months-old, where infants continued to match happy expressions, whilst sad matching declined. This selectivity in matching is to some extent unanticipated in the previous research literature. A number of researchers have suggested that a negativity bias exists in emotional development, whereby infants attend more readily to, and learn quicker from, negative stimuli (Logue, Ohpir, & Strauss, 1981; Ohman, & Mineka, 2001; Vaish, Grossman, & Woodward, 2008). The emergent positive selectivity in emotion matching may be explained in terms of infants wanting to maintain a positive interaction and avoid a negative interaction.

Emotion matching was not assessed from birth, due to aforementioned practical and developmental issues, so pre-existing disputes over nature versus nurture in emotion matching could not clearly be addressed, however, the results from study one still provide crucial information regarding infant ability to match early in infancy, and the extent to which infants are affected by their environments and the emotional displays around them. This has important ramifications as to the extent to which infants learn, and absorb, emotions from those around them, and how caregiver emotion displays early in infancy potentially contribute to infants learning experiences in the first few month of life. For example, if an infant is brought up in home where those around them frequently display positive emotional expressions, and rarely display negative emotional expressions, their learning experience could be quite different from infants who are exposed to predominantly negative emotional expressions. Future research could examine how matching ability and response differs in infants who have been bought up by mothers who are quite content and emotionally stable, compared with those bought up by mothers who suffer with depression. Research has already established that individuals suffering from depression have impairments in processing and labelling emotional expression, to what extent this effects infant ability to learn about emotions from their depressed mothers in unknown (van Wingen et al., 2010).

5.2. *Does emotion matching decline with age?*

Study one showed that emotion matching selectively declined with age, whereby infants continued to match happy expressions across all assessment ages, but only significantly matched sad expressions at 3-months-old. Previous research demonstrated that rates of imitation declined within the first 6 months, although none investigated the effects of valence on developmental trajectories of emotion matching (Fontaine, 1984; Field, Goldstein, Vega-Lahr, and Porter, 1986; Jacobson, 1979; Maratos, 1973). Results from study one thus provides new evidence that declines in emotion matching ability are selective, whereby sad matching seems to follow the declining rate of matching outlined in previous studies, whereas happy matching seems to be relatively consistent across time. This differing trajectory could be explained in terms of infants starting to understand the emotional affordances associated with each expression. Infants may continue to copy happy expressions in an attempt to maintain positive, rewarding social interactions, and stop copying sad expressions to avoid negative social interactions. By 6 months, this newly developed selectivity in matching may provide some indication of a shift between a reflexive form of matching, apparent at 3 months, to more of a controlled and conscious response from 6 months. This shift may allow infants to select, or inhibit, their matching responses. Such a selective decline in matching provides important information as to how pre-existing early infant learning theories need to be adjusted to incorporate the uncovered positive bias in matching. Pre-existing learning theories, such as those by Meltzoff and Moore (1997) and Piaget (1964), fail to incorporate the effect of valence and affective reward in learning, which study one clearly establishes as an important factor as to whether infants match behaviours, especially from 6-months-old when infants have started to gather substantial affective experience.

5.3. *What are the theories behind emotion matching?*

Study two failed to establish a link between infant ability to emotion match and infant ability to facially match non-emotional expressions. This null result, however, may provide some indication that the mechanisms behind these two forms of matching could be different. It is possible that the emotion component involved in the match adds an extra element that takes this form of matching beyond traditional imitative theory explanations offered by Meltzoff and Moore (1997). Further evidence for emotion matching requiring a different theory from those for imitation comes from evidence in study three. Study three demonstrated that infants utilise emotion regulation strategies immediately after they produce emotional expressions. This provides some evidence that infants go beyond just matching the emotion expression presented to them, and adopt regulatory behaviours to modify affective states that accompany their matched expressions. This evidence further suggests that an emotional contagion theory of emotion matching, such as that proposed by Hatfield Cacioppo, and Rapson (1994), may best explain emotion matching behaviour in infants and that pre-existing learning theories fail to account for affective learning and the importance that it plays early in infancy.

5.4. *What are the processes behind emotion matching?*

Study one indicated that rates of emotion matching declined from around 6-months-old. This apparent decline in emotion matching ability may provide some evidence as to the processes behind emotion matching and their developmental trajectories. Previous research, such as by Leppanen and Nelson (2006), highlighted a dual pathway account of emotion processing, whereby emotion matching in infancy involves a subcortical reflexive response from birth, and then later infants develop a cortical controlled response choosing what and when they match. Evidence from study one demonstrated a shift in rates of matching between 3 and 6 months, which may indicate a shift from reflexive and frequent matches to infrequent controlled matches. Furthermore, study six attempted to elucidate our understanding of the processes behind matching, but failed to establish the hypothesised relationship between early regulatory behaviour and later sad non-matching. However, results from study six supported results from study one, indicating that infants generally did not match sad emotional expressions at 14 months but did match happy emotional expressions. This in itself demonstrates a controlled approach to emotion matching later in infancy, rather than infants just reflexively and automatically matching all expression.

Results from study one imply that learning in infancy is not a stable, set process and instead may change and alter as infants develop and learn from their environment.

Rather than the same mechanism of learning occurring at all ages, the actual process of learning itself may propagate and develop new, and perhaps more efficient learning processes through which infants may develop more complex and selective responses. More research is required to learn how the transition between learning processes develops and changes, both at the observed and at the physiological level. Results from such research need to be incorporated into a new model of learning, as traditional established learning theories to some extent fail to incorporate the extent to which prior learning experience may shape and alter infants learning, even at the physiological level at which the process and mechanisms of learning occur.

5*.5. Are there gender differences in emotion matching?*

Study one demonstrated no effects of gender on emotion matching ability. Research to date has provided some evidence of gender differences in emotion matching, yet gender differences can sometimes be questionable or inconsistent (Ahadi, Rothbart, & Ye, 1993). As study one reported no evidence of a gender difference, this suggests that both males and females match and express emotional expressions in the same way. A number of studies have identified male infants in particular as being worse matchers compared to their female counterparts (Dimberg & Lundquist, 1990; Hampson, van Anders, & Mullin, 2006). However, study one found that female and male infants were equally responsive during all three assessment ages. To be sure that gender differences do not influence emotion matching, replications of study one would need to be conducted using substantially larger sample sizes. However, if results obtained also demonstrate that emotion matching is not influenced by gender, it is possible that the ages at which study one assessed infants is a contributing factor. It is also possible that gender differences are largely due to socialisation factors, and that due to the young ages at which emotion matching was assessed, any differences in emotion matching attributed to gender may not develop until much later in infancy when infants may have been exposed to further gender socialisation factors.

5.6. *Is emotion matching linked to other forms of matching behaviour?*

Results from study two indicated that there was no significant relationship between emotion matching ability and other forms of facial matching. Previous research has identified links between different forms of imitation (Kugiumutzakis, 1985; Masur, 1987; Snow, 1989). However, results from study two imply that emotion matching is not related to non-emotional matching. This null result may suggest that a different explanation is warranted for emotion matching behaviour compared to non-emotion matching behaviour. If the same theories and mechanism account for both behaviours, a relationship between the two forms of matching may be expected. As there is no relationship between the two, it is thus possible that different theories and mechanisms may explain the two behaviours. It may be that emotion matching involves more of an emotional contagion explanation, rather than an imitative explanation, but further research would be required.

The fact that Hilbrink et al. (2011) did not find evidence early in infancy of facial imitation, or auditory oral matching, in the same infants that displayed emotion matching early in infancy, might suggest that current theories of infant development, and the mechanism through which infants learn, need to be reassessed. One proposed change is to explore the notion that emotion matching may be a mechanism through which infants learn, and that it occurs before other forms of matching and imitation develop. The affective element involved in emotion matching may result in infants being more attentive to the displays of emotion, and subsequently be more likely to start to engage in matching behaviour than other facial displays which do not involve an affective response.

Due to the longitudinal nature of the First Steps project, evidence of the order in which different matching behaviours appear to develop provide an insight into how, and potentially why, infants first start to copy the behaviours of those around them. Rather than just adopting a "like me" stance, as noted by Meltzoff and Moore (1997), the First Steps Project highlights that displays of emotion are matched before that of non-emotional facial displays. This would suggest that a "like me" explanation of matching would not only involve comparing whether a visual, superficial facial display matches, but also whether the internal emotion displayed matches, along with the infant having an awareness of what it means to feel a particular emotion, as the affective element is the only clear difference between the two categories of facial matching that distinguishes whether or not something is matched.

Evidence from this research might be best explained in terms of a new learning theory. The results presented may support that infant learning is initiated through a mechanism of emotional contagion, due to the fact that emotion matching and imitation appear unrelated. However, rather than infants initially comparing others' behaviours to that of their own, infants may start by observing emotions in others and "catching" those emotions. From this point infants may learn what it feels like to experience an emotion and present the associated display of emotion as a response (the match). It is through this mechanism that infants first learn to learn from others and respond through matching. Essentially, emotion may be the mediator between what is observed and what is displayed in terms of initial matching behaviour. Without this mediator early in infancy, infants fail to make the link between what is observed and what they display, as is evident from the lack of facial matching in Hilbrink et al.'s (2011) research. Only as infants age, and through affective experience, may this mediated link weaken and to some extent a direct link between observation and matching develops, before infants start to match behaviours that they are yet to understand and cannot internally experience. Essentially, infants have learnt through emotion matching that to match is to learn about the world around them. To start with, infants require clear unambiguous feedback, and sometimes even affective reward (as in happy matching and the associated happy emotional experiences) as to what each match means, until they become able to match behaviours without such feedback. Initially, emotion may provide the missing element that first instigates and motivates an infant to match, which to some extent becomes redundant or unnecessary as infants age and develop further. Such an explanation of matching, and the mechanisms through which infants learn, may provide a whole new perspective to the established learning theories and transform the importance of, and the way in which, matching and emotion is viewed in infancy and may offer a potential answer to how observed behaviour first corresponds to own matched responses.

5.7. Emotion regulation: the self versus other?

Study three demonstrated that from 3-months-old, infant use of regulatory behaviours increases immediately after they match an emotional expression compared to a baseline. The same result was not found in response to the experimenter's expression. Most research to date has explored infant ability to regulate following the presentation of an affective stimulus, or in response to others' affective states (Fox & Calkins, 2003; Kopp, 1989). However, study three is the first study to explore and identify that infants are capable of, and engage in, self-regulation from 3-months-old. This finding implies that infants possess at least a basic sense of self in order to regulate their own affective states. Furthermore, it identifies that infants are capable of regulating their own affective states early in life rather than solely relying on others, predominately their caregivers, to comfort and regulate their affective states for them. Moreover, study three establishes that infants start to become independent and self-regulatory from 3-month-old, if not before, whereas previous literature into regulatory behaviour does not identify this independence as emerging until much later in infancy (Kochanska, Coy, & Murray, 2001; Kopp, 1982). Overall, the results from study three challenge pre-existing beliefs as to the independence and reliance of young infants on their caregivers, especially in regard to emotion regulation.

5.8. Which emotion self-regulation strategies do infants employ?

Results from study three identified both spontaneous blinking and gaze aversion as emotion regulation strategies that are utilised in infancy. Although previous research has also identified GA as a regulatory behaviour in infancy, no study to date has investigated SB as a regulatory behaviour (Field, 1981; Kendon, 1967; Mangelsdorf, Shapiro & Marzolf, 1995). Interestingly, study three noted that not only is SB a regulatory behaviour, but that it is adopted earlier in infancy than GA, which is only significantly utilised from 6 months. This shift in strategy usage may be partly explained in terms of attention system development, however, results from study four report that no relationship was found between infants who were regulators or non-regulators and their performance on attention control, or on inhibition tasks (Abelkop & Frick, 2003; Kopp, 2002; Posner & Rothbart, 2000; Rothbart & Bates, 1998; Ruff & Rothbart, 1996). This null result may indicate that the shift between emotion regulation strategy usage is not related to attention development, or it may be simply that the measures of attention used in the First Steps study do not represent the aspects of attention that may relate to regulatory behaviour.

Study three's identification of SB as a previously unidentified emotion regulation strategy, highlights the limited scope and investigation into self-regulation strategies in infancy to date. Little, if any, investigation has occurred to establish if infants can regulate their own emotions early in infancy or whether they are solely reliant on others to comfort them. However, now it is apparent that infants, at least to some extent, are capable of self-regulation early in life. Moreover, before study three was conducted, SB was thought to occur predominantly for physiological reasons, replenishing the lipid tear film, or perhaps as a measure of doperminergic system function, yet this study's results establish a new and as yet undiscovered function of SB, creating a whole new reason as to why individuals might blink and which may not just relate to infants but could be generalised to individuals of all ages. Furthermore, future research could explore any other potential emotion regulation strategies that might be adopted by infants, or whether SB is the sole self-regulation strategy adopted by young infants. In addition, self-regulation among infants whose primary caregiver suffers from depression, or other emotional problems, would provide an interesting comparison to establish any learned differences in their usage of self-regulation strategies.

5.9. *Does emotion regulation depend on valence?*

In study three, no effect of valence was noted for emotion regulation strategy usage, despite a number of previous studies reporting regulatory behaviour in response to negative emotions (Buss & Goldsmith, 1998; Buss & Kiel, 2004; Field, 1981; Kopp, 1989). The fact that infants appear to use the same strategies for both positive and negative emotions indicates that regulatory behaviours are not utilised just to terminate a negative encounter, and instead may be utilised when the intensity of an encounter becomes too much, whether that be positive or negative in valence. The results of study three, further supports a concept that emotion regulation, rather than being utilised to cope with negative stimulation, is used to modify extremes in emotion. It would appear that self-regulation functions similarly to a thermostat, whereby if emotion becomes too intensely positive, or too intensely negative, regulation strategies are adopted to maintain a relative balance.

One potential area of future research would be to investigate variations in thresholds of intensity, whereby some infants (such as the infants who score higher on temperament shyness in study four) have a lower threshold with which they can manage emotion before emotion regulation strategies are adopted, compared to those infants who might have higher thresholds of dealing with emotion before regulation strategies are adopted. Furthermore, another area of research for which this result might be applicable, beyond that of infant development, is in the study of bipolar disorder. Individuals with bipolar disorder display extremes in mood from depression to mania. It could be hypothesised that these individuals have problems with their emotion regulation systems, whereby when their individual threshold of dealing with emotion, whatever the valence, is reached and exceeded, no regulatory response is automatically initiated, or it could be that established regulation strategies fail to regulate the experienced emotions. Moreover, recent research has already explored and identified deficits in emotion regulation usage in adults who suffer from alcoholism, and adolescents with borderline personality disorder traits (Berking et al., 2011; Sharp et al., 2011).

5.10. Is temperament linked to emotion regulation ability?

Study four results reported that infants who score higher on temperament shyness are statistically more likely to also be regulators than non-regulators. Previous research has identified that behaviours typical of shyness overlap with regulatory behaviours, such as GA, (Pilkonis, 1977). Although study four identified that shy infants also tend to be regulators, it does not claim that the group level effect of regulation observed in study three is carried by shy infants. One explanation for the findings in study four relates to individual differences in thresholds of dealing with emotions, whereby infants who score highly on ECBQ shyness may engage in more self-regulation strategy usage as they have a lower threshold to experience emotion compared to their more confident counterparts. Such an explanation provides a new perspective on assessing shyness, but also highlights that there are potentially a number of factors to research, that might influence each infant’s threshold of experiencing emotion before emotion regulation strategies are adopted.

5.11. *Is emotion regulation linked to other forms of regulatory behaviour?*

Study five found that emotion regulation ability was not related to other forms of regulation early in infancy, such as measures of attention control or inhibition. Results from study three noted a shift in regulation strategy usage at 6 months; one potential explanation for this shift was increasing attention system control. Previous research has identified that around this age infants become capable of selective and controlled gaze shifts (D'Entremont, Hains, & Muir, 1997). Thus, the null result in study five, failing to link regulation to other forms of regulatory behaviour, was unexpected. This null result may simply demonstrate that emotion regulation is not linked to attention development, and another explanation is required to account for the shift in emotion regulation strategy usage. However, it is also possible that the measure of attention was not the best representation of infant attention system development. Moreover, at 3 months there may be little difference in attention ability as the most significant difference that may relate to regulation, namely that of controlled attention shifts, does not develop until later in infancy. Furthermore, it is possible that the apparent shift in regulatory behaviour may be due to the combined effect of attention development and some other ability that is yet unidentified. Another factor that may have contributed to the null results established in study five is that of sample size; it is possible that with a much larger sample another result may be obtained. In future research, this study could be replicated but with a much larger sample size to account for the subdivision of groups involved in this analysis and the subsequent effect this has on the power of the analysis when sample size is limited.

5.12. *Is emotion matching linked to emotion regulation ability?*

Study six failed to establish a longitudinal relationship between early emotion regulation ability and sad emotion matching later in infancy. However, a significant relationship was noted between early regulatory behaviour and happy emotion matching, whereby infants who are regulators early in infancy tend to be happy emotion matchers later in infancy. These results suggest that, at the least, the ability to match happy expressions at 14 months may be predicted by infant ability to regulate emotional expressions earlier in infancy. One explanation for this result is that regulation is a controlled response, therefore, infants who are regulators engage in more controlled behaviour and select which emotional expressions they choose to match at 14 months.

Further evidence of a link between emotion matching and emotion regulation ability comes from study three; this demonstrated that both GA and SB were utilised as emotion regulation strategies immediately after infants produced emotional expressions. This provides basic evidence of a link between these abilities, indicating that regulatory behaviours are adopted in response to producing emotional expressions, even if rates of regulation and matching over time have not been identified as changing in relation to one another.

Future research could assess the relationship between abilities at one time point, instead of trying to establish a predictive relationship between the two variables. However, it is possible that the rates of the two behaviours are linked. For instance, it is possible that some infants are more efficient regulators than others, therefore, the number of regulation strategies utilised are fewer, despite showing the same number of emotional expressions, than an infant who is a less efficient regulator, and produces a number of regulation strategies. The effectiveness of emotion regulation strategies could be investigated, and perhaps whether there are individual differences in how long it takes for infant expression to normalise following regulation. As study three has established self-regulation in infancy, variations in strategy use, timing of use, and effectiveness could be further explored in this new area of research.

5.13. *Concluding comments*

This thesis demonstrates that infants are able to both match and regulate emotion from 3-months-old. Results indicate that infants are able to engage in reciprocal social interactions through emotion matching at an age when other forms of communication are yet to develop. These findings have important implications for established learning theories, such as those proposed by Meltzoff and Moore (1997) or Piaget (1964), which mark imitation as the first key learning mechanism. Such theories may need to be readdressed to incorporate the fact that emotion matching occurs as a learning mechanism before imitation. Moreover, the presence of self-regulation from 3-months-old suggests that infants are more independent in their ability to regulate affective states than previous research has credited. In addition, results show that SB is utilised as a regulation strategy, which has not previously been identified, and provide further support for the usage of GA as a regulation strategy, shedding light on a previously undiscovered function of SB that can be investigated further. Finally, there is some evidence to indicate a potential longitudinal relationship between early emotion regulation ability and later happy matching ability, providing some insight into the development of a controlled response to selectively matching positive expression. Again this suggests that established learning theories may need to be adjusted to include changes that may occur in social learning processes as infants age and develop.

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Appendices

A.1. Early Childhood Behavior Questionnaire

Early Childhood Behavior Questionnaire

Child's name: ______________________ Child's birthdate: Mo:____ Day:____ Yr:____

Today's date: Month:____ Day:____ Yr:____ Child's age: ______Yrs, ______Months

Relation to child: ______________________ Sex of child (circle one): Male Female

INSTRUCTIONS: **Please read carefully before starting**.

As you read each description of the child's behavior below, please indicate <u>how often</u> the child did this during the <u>last two weeks</u> by circling one of the numbers in the right column. These numbers indicate how often you observed the behavior described during the <u>last two weeks</u>.

never	very rarely	less than half the time	about half the time	more than half the time	almost always	always	does not apply
1	**2**	**3**	**4**	**5**	**6**	**7**	**NA**

The "Does Not Apply" column (NA) is used when you did not see the child in the <u>situation</u> described during the last two weeks. For example, if the situation mentions the child going to the doctor and there was no time during the last two weeks when the child went to the doctor, circle the (NA) column. "Does Not Apply" (NA) is different from "NEVER" (1). "Never" is used when you saw the child in the situation but the child never engaged in the behavior mentioned in the last two weeks. Please be sure to circle a number <u>or</u> NA for <u>every</u> item.

<u>When told that it was time for bed or a nap, how often did your child</u>

1. react with anger? 1 2 3 4 5 6 7 NA
2. get irritable? 1 2 3 4 5 6 7 NA

<u>When approached by an unfamiliar person in a public place (for example, the grocery store), how often did your child</u>

3. remain calm? 1 2 3 4 5 6 7 NA
4. pull back and avoid the person? 1 2 3 4 5 6 7 NA
5. cling to a parent? 1 2 3 4 5 6 7 NA

<u>During everyday activities, how often did your child</u>

6. startle at loud noises (such as a fire engine siren)? 1 2 3 4 5 6 7 NA
7. tap or drum with fingers on tables or other objects? 1 2 3 4 5 6 7 NA
8. get irritated by scratchy sounds? 1 2 3 4 5 6 7 NA
9. become uncomfortable when his/her socks were not aligned properly on his/her feet? 1 2 3 4 5 6 7 NA

<u>After getting a bump or scrape, how often did your child</u>

10. forget about it in a few minutes? 1 2 3 4 5 6 7 NA

<u>While playing outdoors, how often did your child</u>

11. like making lots of noise? 1 2 3 4 5 6 7 NA
12. enjoy sitting quietly in the sunshine? 1 2 3 4 5 6 7 NA
13. want to climb to high places (for example, up a tree or on

the jungle gym)?	1	2	3	4	5	6	7	NA

When s/he was carried, how often did your child

14. like to be held?	1	2	3	4	5	6	7	NA
15. push against you until put down?	1	2	3	4	5	6	7	NA
16. squirm?	1	2	3	4	5	6	7	NA
17. struggle to get away?	1	2	3	4	5	6	7	NA
18. snuggle up next to you?	1	2	3	4	5	6	7	NA

While having trouble completing a task (e.g., building, drawing, dressing), how often did your child

19. get easily irritated?	1	2	3	4	5	6	7	NA
20. become sad?	1	2	3	4	5	6	7	NA

When a familiar child came to your home, how often did your child

21. engage in an activity with the child?	1	2	3	4	5	6	7	NA
22. seek out the company of the child?	1	2	3	4	5	6	7	NA

When offered a choice of activities, how often did your child

23. stop and think before deciding?	1	2	3	4	5	6	7	NA
24. decide what to do very quickly and go after it?	1	2	3	4	5	6	7	NA
25. seem slow and unhurried about what to do next?	1	2	3	4	5	6	7	NA

When asked NOT to, how often did your child

26. run around your house or apartment anyway?	1	2	3	4	5	6	7	NA
27. touch an attractive item (such as an ornament) anyway?	1	2	3	4	5	6	7	NA
28. play with something anyway?	1	2	3	4	5	6	7	NA

During daily or evening quiet time with you and your child, how often did your child

29. enjoy just being quietly sung to?	1	2	3	4	5	6	7	NA
30. smile at the sound of words, as in nursery rhymes?	1	2	3	4	5	6	7	NA
31. enjoy just being talked to?	1	2	3	4	5	6	7	NA
32. enjoy rhythmic activities, such as rocking or swaying?	1	2	3	4	5	6	7	NA

During everyday activities, how often did your child

33. become distressed when his/her hands were dirty and/or sticky?	1	2	3	4	5	6	7	NA
34. notice that material was very soft (cotton) or rough (wool)?	1	2	3	4	5	6	7	NA
35. notice low-pitched noises such as the air-conditioner, heater, or refrigerator running or starting up?	1	2	3	4	5	6	7	NA
36. blink a lot?	1	2	3	4	5	6	7	NA
37. get very enthusiastic about the things s/he was going to do?	1	2	3	4	5	6	7	NA

While at home, how often did your child

38. show fear at a loud sound (blender, vacuum cleaner, etc.)?	1	2	3	4	5	6	7	NA
39. seem afraid of the dark?	1	2	3	4	5	6	7	NA

When visiting the home of a familiar adult, such as a relative or friend, how often did your child

40. want to interact with the adult?	1	2	3	4	5	6	7	NA

While bathing, how often did your child

41. sit quietly?	1	2	3	4	5	6	7	NA
42. splash, kick, or try to jump?	1	2	3	4	5	6	7	NA

While playing outdoors, how often did your child

43. look immediately when you pointed at something?	1	2	3	4	5	6	7	NA
44. choose to take chances for the fun and excitement of it?	1	2	3	4	5	6	7	NA
45. not like going down high slides at the amusement park or playground?	1	2	3	4	5	6	7	NA

When s/he was upset, how often did your child

46. change to feeling better within a few minutes?	1	2	3	4	5	6	7	NA
47. soothe only with difficulty?	1	2	3	4	5	6	7	NA
48. stay upset for 10 minutes or longer?	1	2	3	4	5	6	7	NA

When engaged in play with his/her favorite toy, how often did your child

49. play for 5 minutes or less?	1	2	3	4	5	6	7	NA
50. play for more than 10 minutes?	1	2	3	4	5	6	7	NA
51. continue to play while at the same time responding to your remarks or questions?	1	2	3	4	5	6	7	NA

When approaching unfamiliar children playing, how often did your child

52. watch rather than join?	1	2	3	4	5	6	7	NA
53. approach slowly?	1	2	3	4	5	6	7	NA
54. seem uncomfortable?	1	2	3	4	5	6	7	NA

During everyday activities, how often did your child

55. complain about odors on others, such as perfume?	1	2	3	4	5	6	7	NA
56. seem to be bothered by bright light?	1	2	3	4	5	6	7	NA
57. move quickly from one place to another?	1	2	3	4	5	6	7	NA
58. notice the smoothness or roughness of objects s/he touched?	1	2	3	4	5	6	7	NA
59. become sad or blue for no apparent reason?	1	2	3	4	5	6	7	NA

After having been interrupted, how often did your child

60. return to a previous activity?	1	2	3	4	5	6	7	NA
61. have difficulty returning to the previous activity?	1	2	3	4	5	6	7	NA

While watching TV or hearing a story, how often did your child

62. seem frightened by 'monster' characters?	1	2	3	4	5	6	7	NA

When you suggested an outdoor activity that s/he really likes, how often did your child

63. respond immediately?	1	2	3	4	5	6	7	NA
64. run to the door before getting ready?	1	2	3	4	5	6	7	NA

When told that loved adults would visit, how often did your child

65. get very excited?	1	2	3	4	5	6	7	NA
66. become very happy?	1	2	3	4	5	6	7	NA

When taking a quiet, warm bath, how often did your child

67. seem to relax and enjoy him/herself?	1	2	3	4	5	6	7	NA

When s/he couldn't find something to play with, how often did your child

68. get angry?	1	2	3	4	5	6	7	NA

During sleep, how often did your child

69. toss about in the bed?	1	2	3	4	5	6	7	NA
70. sleep in one position only?	1	2	3	4	5	6	7	NA

During quiet activities, such as reading a story, how often did your child

71. swing or tap his/her foot?	1	2	3	4	5	6	7	NA

72. fiddle with his/her hair, clothing, etc.? 1 2 3 4 5 6 7 NA
73. show repeated movements like squinting, hunching up the shoulders, or twitching the facial muscles? 1 2 3 4 5 6 7 NA

<u>While playing indoors, how often did your child</u>

74. like rough and rowdy games? 1 2 3 4 5 6 7 NA
75. enjoy playing boisterous games like 'chase'? 1 2 3 4 5 6 7 NA
76. enjoy vigorously jumping on the couch or bed? 1 2 3 4 5 6 7 NA

<u>In situations where s/he is meeting new people, how often did your child</u>

77. turn away? 1 2 3 4 5 6 7 NA
78. become quiet? 1 2 3 4 5 6 7 NA
79. seem comfortable? 1 2 3 4 5 6 7 NA

<u>When being gently rocked or hugged, how often did your child</u>

80. seem eager to get away? 1 2 3 4 5 6 7 NA
81. make protesting noises? 1 2 3 4 5 6 7 NA

<u>When encountering a new activity, how often did your child</u>

82. sit on the sidelines and observe before joining in? 1 2 3 4 5 6 7 NA
83. get involved immediately? 1 2 3 4 5 6 7 NA

<u>When visiting the home of a familiar child, how often did your child</u>

84. engage in an activity with the child? 1 2 3 4 5 6 7 NA
85. seek out the company of the child? 1 2 3 4 5 6 7 NA

<u>When another child took away his/her favorite toy, how often did your child</u>

86. scream with anger? 1 2 3 4 5 6 7 NA
87. <u>not</u> become angry? 1 2 3 4 5 6 7 NA
88. sadly cry? 1 2 3 4 5 6 7 NA
89. <u>not</u> react with sadness? 1 2 3 4 5 6 7 NA

<u>When engaged in an activity requiring attention, such as building with blocks, how often did your child</u>

90. move quickly to another activity? 1 2 3 4 5 6 7 NA
91. stay involved for 10 minutes or more? 1 2 3 4 5 6 7 NA
92. tire of the activity relatively quickly? 1 2 3 4 5 6 7 NA

<u>During everyday activities, how often did your child</u>

93. pay attention to you right away when you called to him/her? 1 2 3 4 5 6 7 NA
94. seem to be disturbed by loud sounds? 1 2 3 4 5 6 7 NA
95. stop going after a forbidden object (such as a VCR) when you used a toy to distract her/him? 1 2 3 4 5 6 7 NA
96. notice small things, such as dirt or a stain, on his/her clothes? 1 2 3 4 5 6 7 NA

<u>While in a public place, how often did your child</u>

97. seem uneasy about approaching an elevator or escalator? 1 2 3 4 5 6 7 NA
98. cry or show distress when approached by an unfamiliar animal? 1 2 3 4 5 6 7 NA
99. seem afraid of large, noisy vehicles? 1 2 3 4 5 6 7 NA
100. show fear when the caregiver stepped out of sight? 1 2 3 4 5 6 7 NA

<u>When playing outdoors with other children, how often did your child</u>

101. seem to be one of the most active children?	1	2	3	4	5	6	7	NA
102. sit quietly and watch?	1	2	3	4	5	6	7	NA
<u>During daily or evening quiet time with you and your child, how often did your child</u>								
103. want to be cuddled?	1	2	3	4	5	6	7	NA
<u>During everyday activities, how often did your child</u>								
104. seem frightened for no apparent reason?	1	2	3	4	5	6	7	NA
105. seem to be irritated by tags in his/her clothes?	1	2	3	4	5	6	7	NA
106. notice when you were wearing new clothing?	1	2	3	4	5	6	7	NA
107. react to beeping sounds (such as when the microwave or oven is done cooking)?	1	2	3	4	5	6	7	NA
108. show repeated movements like squinting, hunching up the shoulders, or twitching the facial muscles?	1	2	3	4	5	6	7	NA
<u>When being dressed or undressed, how often did your child</u>								
109. squirm and try to get away?	1	2	3	4	5	6	7	NA
110. stay still?	1	2	3	4	5	6	7	NA
<u>When told "no", how often did your child</u>								
111. stop an activity quickly?	1	2	3	4	5	6	7	NA
112. stop the forbidden activity?	1	2	3	4	5	6	7	NA
113. ignore your warning?	1	2	3	4	5	6	7	NA
114. become sadly tearful?	1	2	3	4	5	6	7	NA
<u>Following an exciting activity or event, how often did your child</u>								
115. calm down quickly?	1	2	3	4	5	6	7	NA
116. have a hard time settling down?	1	2	3	4	5	6	7	NA
117. seem to feel down or blue?	1	2	3	4	5	6	7	NA
118. become sadly tearful?	1	2	3	4	5	6	7	NA
<u>When given something to eat that s/he didn't like, how often did your child</u>								
119. become angry?	1	2	3	4	5	6	7	NA
<u>During everyday activities, how often did your child seem able to</u>								
120. easily shift attention from one activity to another?	1	2	3	4	5	6	7	NA
121. do more than one thing at a time (such as playing with a toy while watching TV)?	1	2	3	4	5	6	7	NA
<u>While playing indoors, how often did your child</u>								
122. run through the house?	1	2	3	4	5	6	7	NA
123. climb over furniture?	1	2	3	4	5	6	7	NA
124. <u>not</u> care for rough and rowdy games?	1	2	3	4	5	6	7	NA
125. enjoy activities such as being spun, etc.?	1	2	3	4	5	6	7	NA
<u>When playing alone, how often did your child</u>								
126. become easily distracted?	1	2	3	4	5	6	7	NA
127. play with a set of objects for 5 minutes or longer at a time?	1	2	3	4	5	6	7	NA
128. scratch him/herself?	1	2	3	4	5	6	7	NA
129. tear materials close at hand?	1	2	3	4	5	6	7	NA
<u>Before an exciting event (such as receiving a new toy), how often did your child</u>								
130. get so worked up that s/he had trouble sitting still?	1	2	3	4	5	6	7	NA
131. get very excited about getting it?	1	2	3	4	5	6	7	NA
132. remain pretty calm?	1	2	3	4	5	6	7	NA

133. seem eager to have it right away?	1	2	3	4	5	6	7	NA

<u>When s/he asked for something and you said "no", how often did your child</u>

134. become frustrated?	1	2	3	4	5	6	7	NA
135. protest with anger?	1	2	3	4	5	6	7	NA
136. have a temper tantrum?	1	2	3	4	5	6	7	NA
137. become sad?	1	2	3	4	5	6	7	NA

<u>While playing or walking outdoors, how often did your child</u>

138. notice sights or sounds (for example, wind chimes or water sprinklers)?	1	2	3	4	5	6	7	NA
139. notice flying or crawling insects?	1	2	3	4	5	6	7	NA

<u>When you gave your child an attractive toy, how often did your child</u>

140. grab the object as soon as it was set down?	1	2	3	4	5	6	7	NA
141. look the object over before touching it?	1	2	3	4	5	6	7	NA

<u>When asked to wait for a desirable item (such as ice cream), how often did your child</u>

142. seem unable to wait for as long as 1 minute?	1	2	3	4	5	6	7	NA
143. go after it anyway?	1	2	3	4	5	6	7	NA
144. wait patiently?	1	2	3	4	5	6	7	NA
145. whimper and cry?	1	2	3	4	5	6	7	NA

<u>When being gently rocked, how often did your child</u>

146. smile?	1	2	3	4	5	6	7	NA
147. make sounds of pleasure?	1	2	3	4	5	6	7	NA

<u>While visiting relatives or adult family friends s/he sees infrequently, how often did your child</u>

148. stay back and avoid eye contact?	1	2	3	4	5	6	7	NA
149. hide his/her face?	1	2	3	4	5	6	7	NA
150. "warm up" to the person within a few minutes?	1	2	3	4	5	6	7	NA

<u>When you removed something s/he should not have been playing with, how often did your child</u>

151. become sad?	1	2	3	4	5	6	7	NA

<u>During everyday activities, how often did your child</u>

152. become bothered by sounds while in noisy environments?	1	2	3	4	5	6	7	NA
153. become bothered by scratchy materials like wool?	1	2	3	4	5	6	7	NA
154. notice changes in your appearance (such as wet hair, a hat, or jewelry)?	1	2	3	4	5	6	7	NA
155. appear to listen to even very quiet sounds?	1	2	3	4	5	6	7	NA
156. seem full of energy, even in the evening?	1	2	3	4	5	6	7	NA

<u>When interrupted during a favorite TV show, how often did your child</u>

157. immediately return to watching the TV program?	1	2	3	4	5	6	7	NA
158. <u>not</u> finish watching the program?	1	2	3	4	5	6	7	NA

<u>While being held on your lap, how often did your child</u>

159. pull away and kick?	1	2	3	4	5	6	7	NA
160. seem to enjoy him/herself?	1	2	3	4	5	6	7	NA
161. mold to your body?	1	2	3	4	5	6	7	NA
162. seek hugs and kisses?	1	2	3	4	5	6	7	NA

<u>While a story was being read to your child, how often did s/he</u>

163. enjoy listening to the story?	1	2	3	4	5	6	7	NA

When hearing about a future family outing (such as a trip to the playground), how often did your child							
164. become very enthusiastic?	1	2	3	4	5	6	7 NA
165. look forward to it?	1	2	3	4	5	6	7 NA
166. remain pretty calm?	1	2	3	4	5	6	7 NA
While looking at picture books on his/her own, how often did your child							
167. stay interested in the book for 5 minutes or less?	1	2	3	4	5	6	7 NA
168. stay interested in the book for more than 10 minutes at a time?	1	2	3	4	5	6	7 NA
169. become easily distracted?	1	2	3	4	5	6	7 NA
170. enjoy looking at the books?	1	2	3	4	5	6	7 NA
When tired after a long day of activities, how often did your child							
171. become easily frustrated?	1	2	3	4	5	6	7 NA
When a familiar adult, such as a relative or friend, visited your home, how often did your child							
172. want to interact with the adult?	1	2	3	4	5	6	7 NA
When asked to do so, how often was your child able to							
173. stop an ongoing activity?	1	2	3	4	5	6	7 NA
174. lower his or her voice?	1	2	3	4	5	6	7 NA
175. be careful with something breakable?	1	2	3	4	5	6	7 NA
When visiting a new place, how often did your child							
176. not want to enter?	1	2	3	4	5	6	7 NA
177. go right in?	1	2	3	4	5	6	7 NA
While you were showing your child how to do something, how often did your child							
178. jump into the task before it was fully explained?	1	2	3	4	5	6	7 NA
While you were talking with someone else, how often did your child							
179. easily switch attention from speaker to speaker?	1	2	3	4	5	6	7 NA
During everyday activities, how often did your child							
180. become irritated when his/her clothes were tight?	1	2	3	4	5	6	7 NA
181. notice smells from cooking?	1	2	3	4	5	6	7 NA
182. rock back and forth while sitting?	1	2	3	4	5	6	7 NA
183. notice sirens from fire trucks or ambulances at a distance?	1	2	3	4	5	6	7 NA
When you mildly criticized or corrected her/his behavior, how often did your child							
184. get mad?	1	2	3	4	5	6	7 NA
185. have hurt feelings?	1	2	3	4	5	6	7 NA
When s/he was upset, how often did your child							
186. cry for more than 3 minutes, even when being comforted?	1	2	3	4	5	6	7 NA
187. cheer up within a minute or two when being comforted?	1	2	3	4	5	6	7 NA
188. become easily soothed?	1	2	3	4	5	6	7 NA
When you were busy, how often did your child							
189. find another activity to do when asked?	1	2	3	4	5	6	7 NA

While playing outdoors, how often did your child								
190. want to jump from heights?	1	2	3	4	5	6	7	NA
191. want to go down the slide in unusual ways (for example, head first)?	1	2	3	4	5	6	7	NA
192. enjoy being pushed fast on a wheeled vehicle?	1	2	3	4	5	6	7	NA
193. enjoy sitting down and playing quietly?	1	2	3	4	5	6	7	NA
When playing alone, how often did your child								
194. chew his/her lower lip?	1	2	3	4	5	6	7	NA
195. stick out his/her tongue when concentrating?	1	2	3	4	5	6	7	NA
196. move from one task or activity to another without completing any?	1	2	3	4	5	6	7	NA
197. have trouble focusing on a task without guidance?	1	2	3	4	5	6	7	NA
When given a wrapped present, how often did your child								
198. become extremely animated?	1	2	3	4	5	6	7	NA
When around large gatherings of familiar adults or children, how often did your child								
199. want to be involved in a group activity?	1	2	3	4	5	6	7	NA
200. enjoy playing with a number of different people?	1	2	3	4	5	6	7	NA
When s/he was asked to share his/her toys, how often did your child								
201. become sad?	1	2	3	4	5	6	7	NA

A.2. Early Behaviour Childhood Questionnaire Scoring Criteria – Shyness

SCORING PROCEDURE

Early Childhood Behavior Questionnaire (ECBQ)

Scale scores for the eighteen dimensions represent the mean score of all scale items applicable to the child, as judged by the caregiver. If a caregiver omitted an item, or if the caregiver checked the "Does not apply" response option for an item, the item receives no numerical score and is not factored into the scale score.

Scores are to be computed by the following method:

1) Items indicated with an R on the items-by-scale list below are reverse-scored. Before using them to calculate the scale score, they must be reversed. This is done by subtracting the numerical response given by the caregiver from 8. Thus, a caregiver response of 7 becomes 1, 6 becomes 2, 5 becomes 3, 4 remains 4, 3 becomes 5, 2 becomes 6, and 1 becomes 7.

2) Sum the scores for items receiving a numerical response (do not include items marked "does not apply" or items receiving no response). For example, given a sum of 50 for a scale of 12 items, with one item receiving no response, two items marked "does not apply," and 9 items receiving a numerical response, the sum of 50 would be divided by 9 to yield a mean of 5.56 for the scale score.

Shyness (12 items)
Slow or inhibited approach and/or discomfort in social situations involving novelty or uncertainty.

When approached by an unfamiliar person in a public place (for example, the grocery store), how often did your child

3.R remain calm?
4. pull back and avoid the person?
5. cling to a parent?

When approaching unfamiliar children playing, how often did your child

52. watch rather than join in?
53. approach slowly?
54. seem uncomfortable?

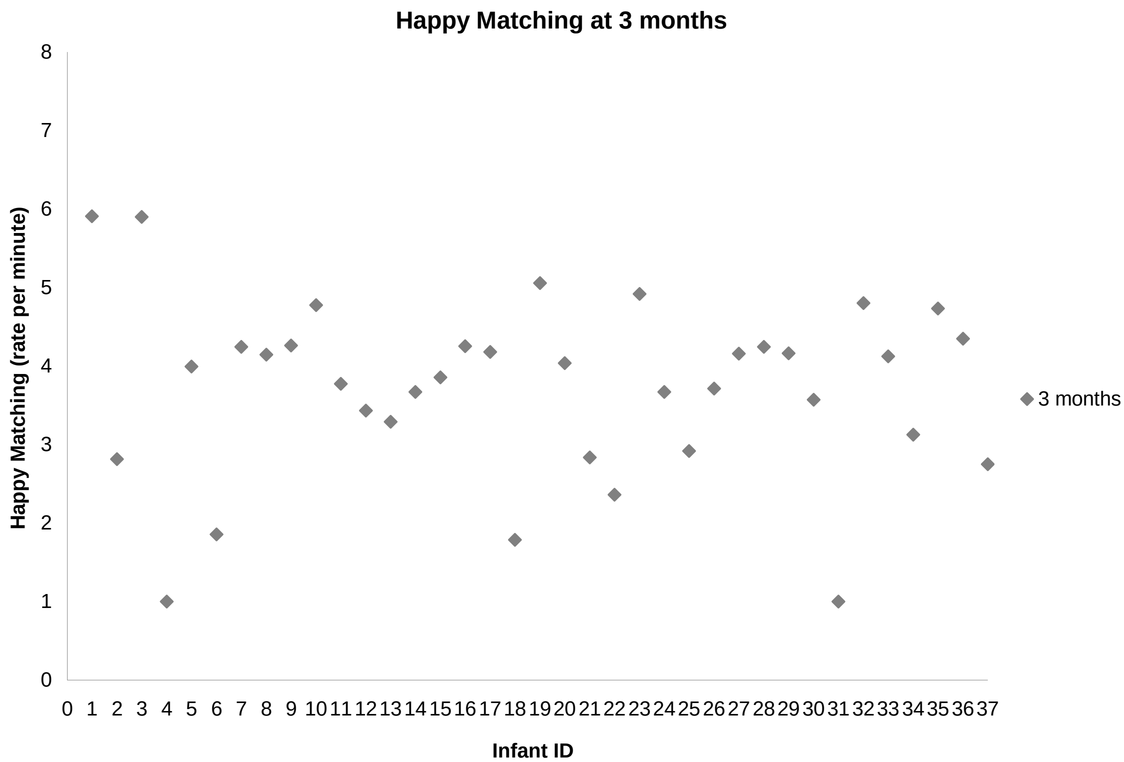
In situations where s/he is meeting new people, how often did your child

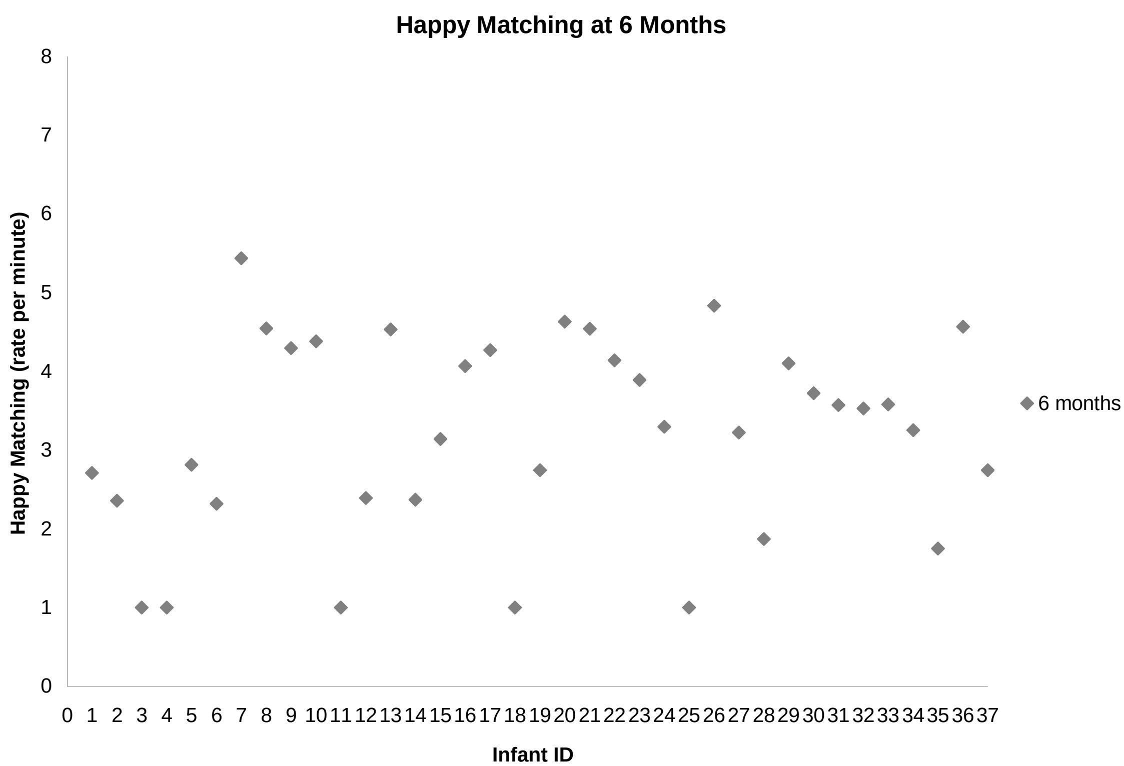
77. turn away?
78. become quiet?
79.R seem comfortable?

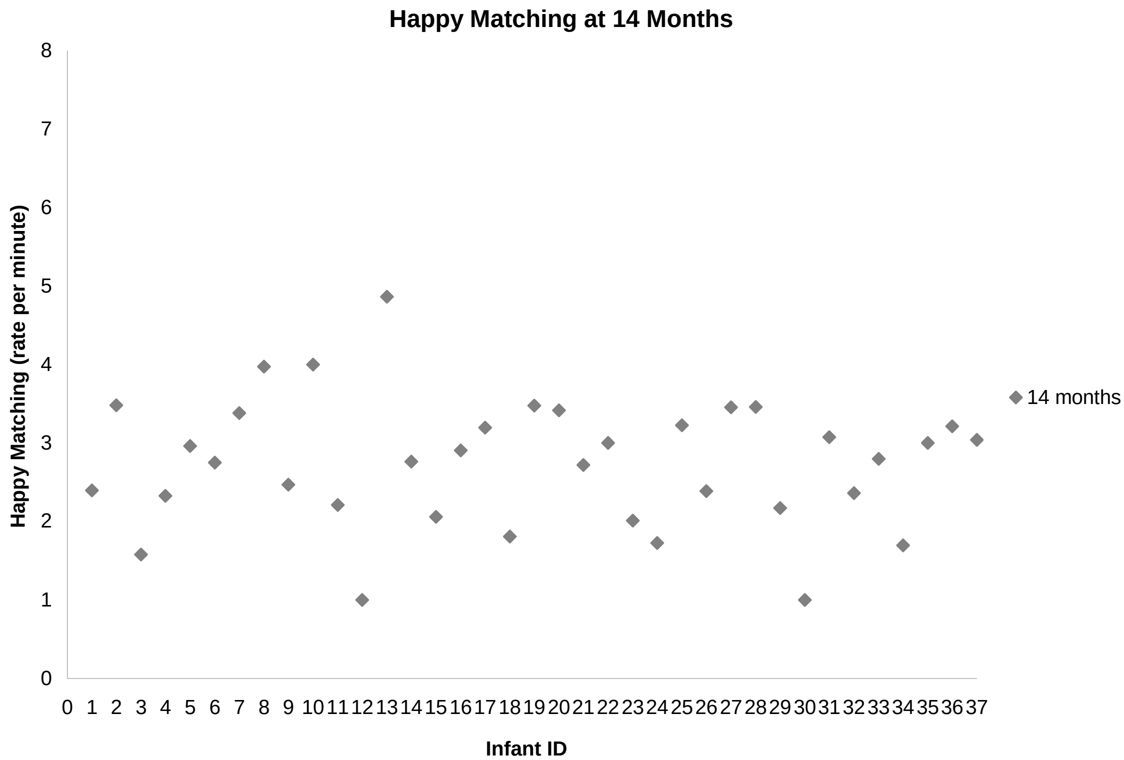
While visiting relatives or adult family friends s/he sees infrequently, how often did your child

148. stay back and avoid eye contact?
149. hide his/her face?
150.R "warm up" to the person within a few minutes?

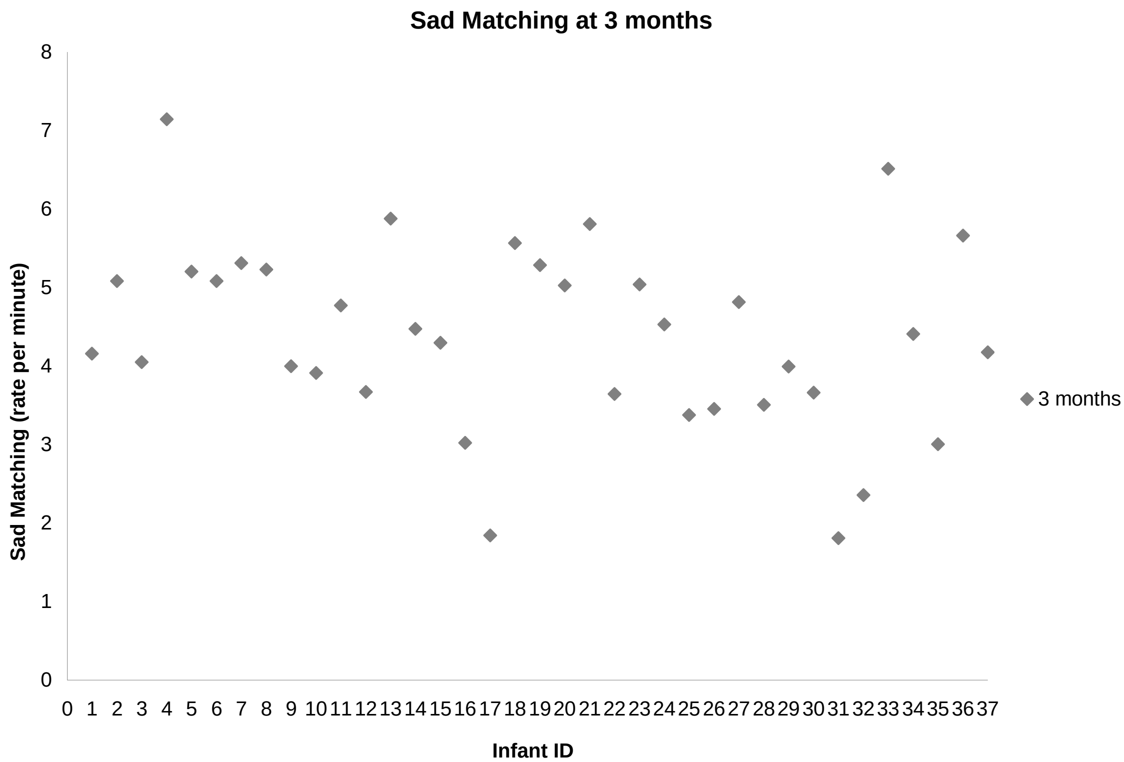
A.3. Happy Matching Individual Rates

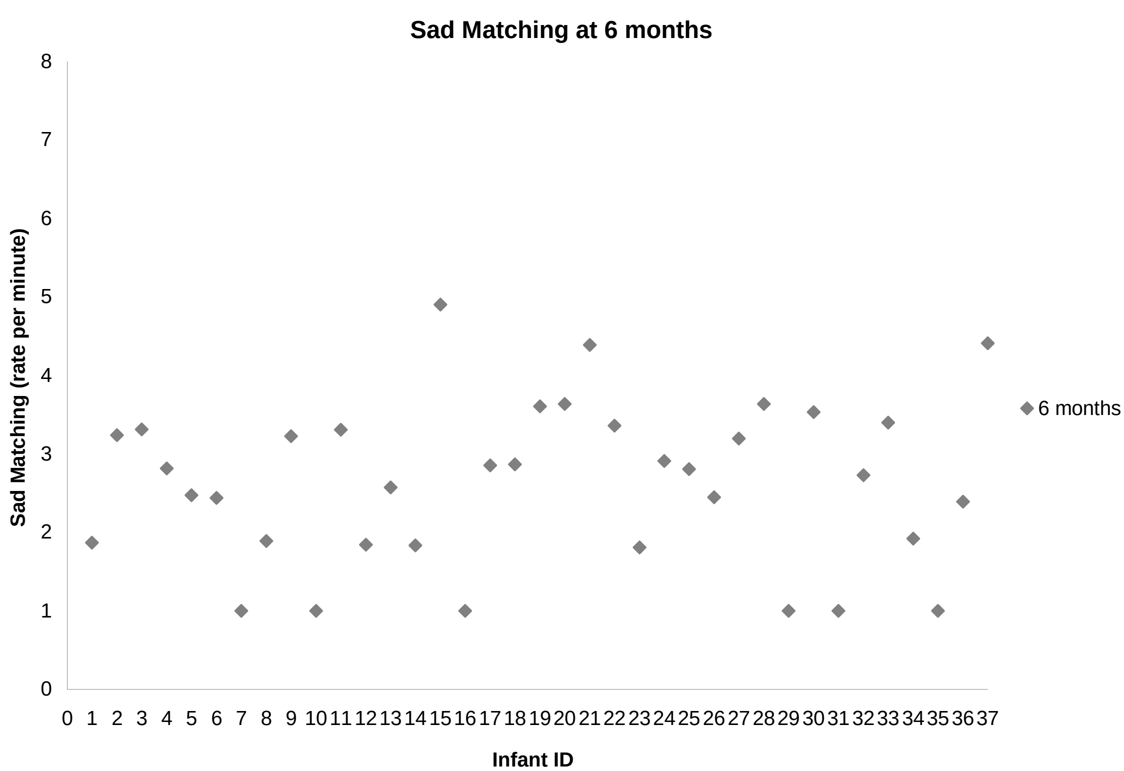


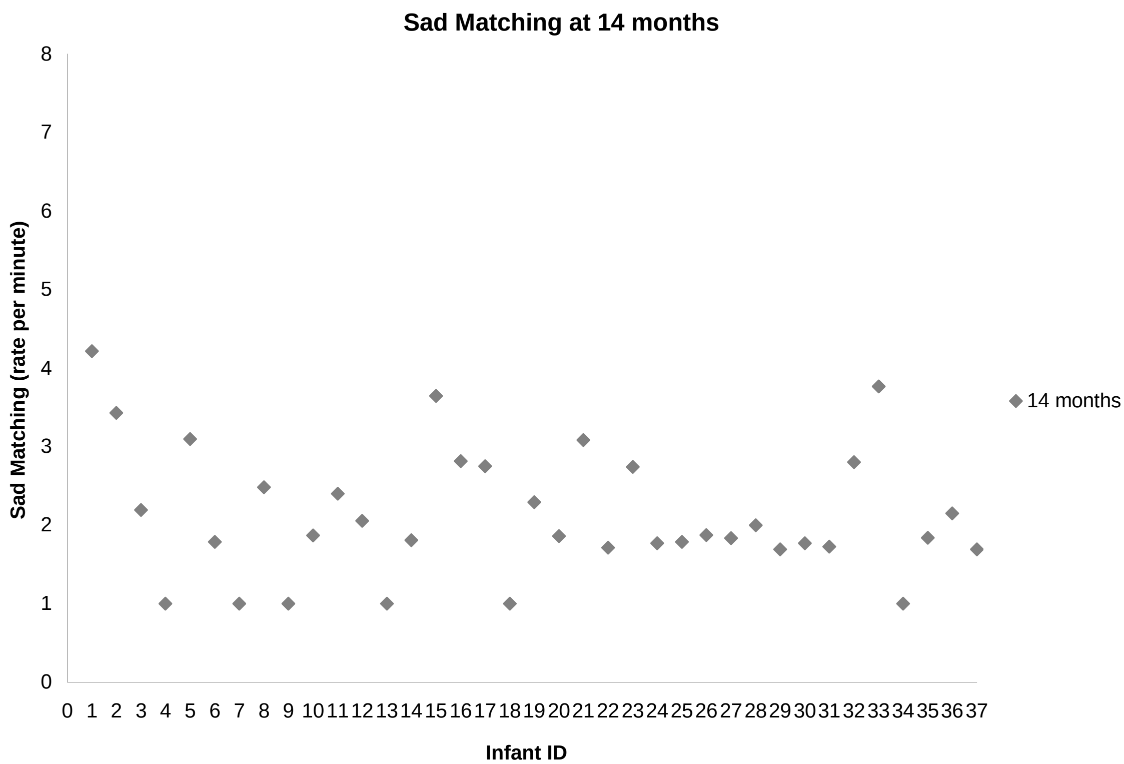



Happy Matching at 14 Months
Happy Matching (rate per minute)
0
1
2
3
4
5
6
7
8
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Infant ID
14 months

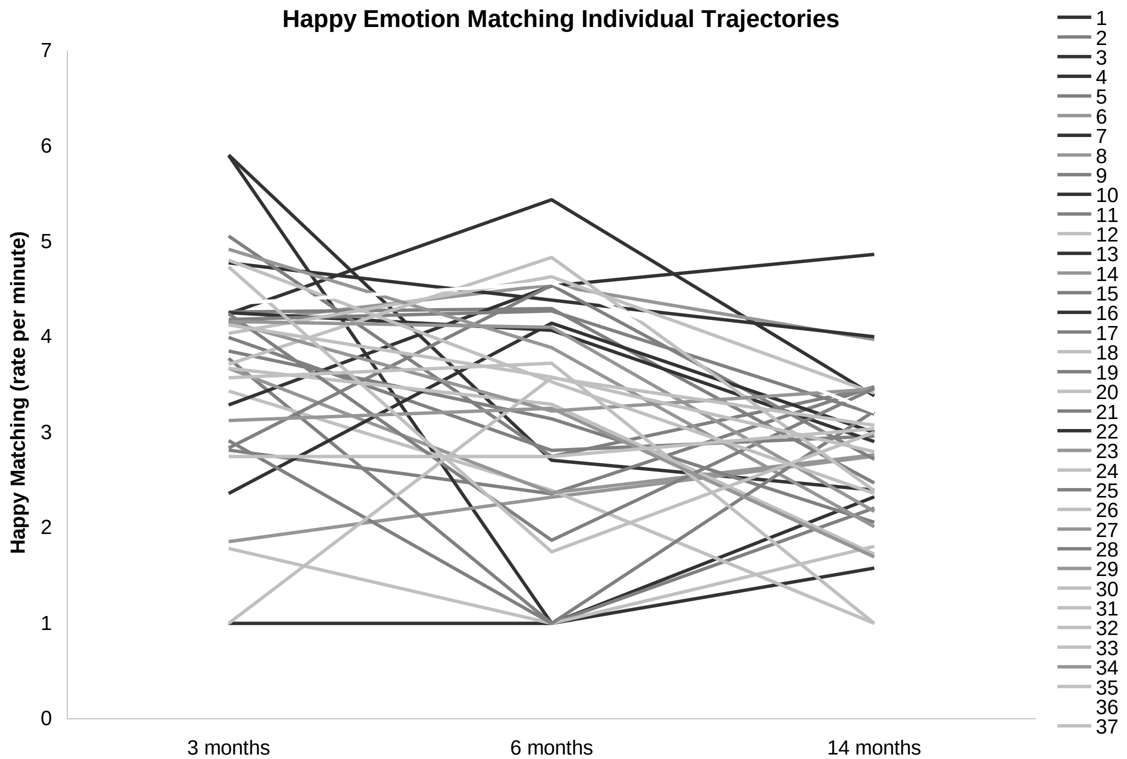
A.4. Sad Matching Individual Rates

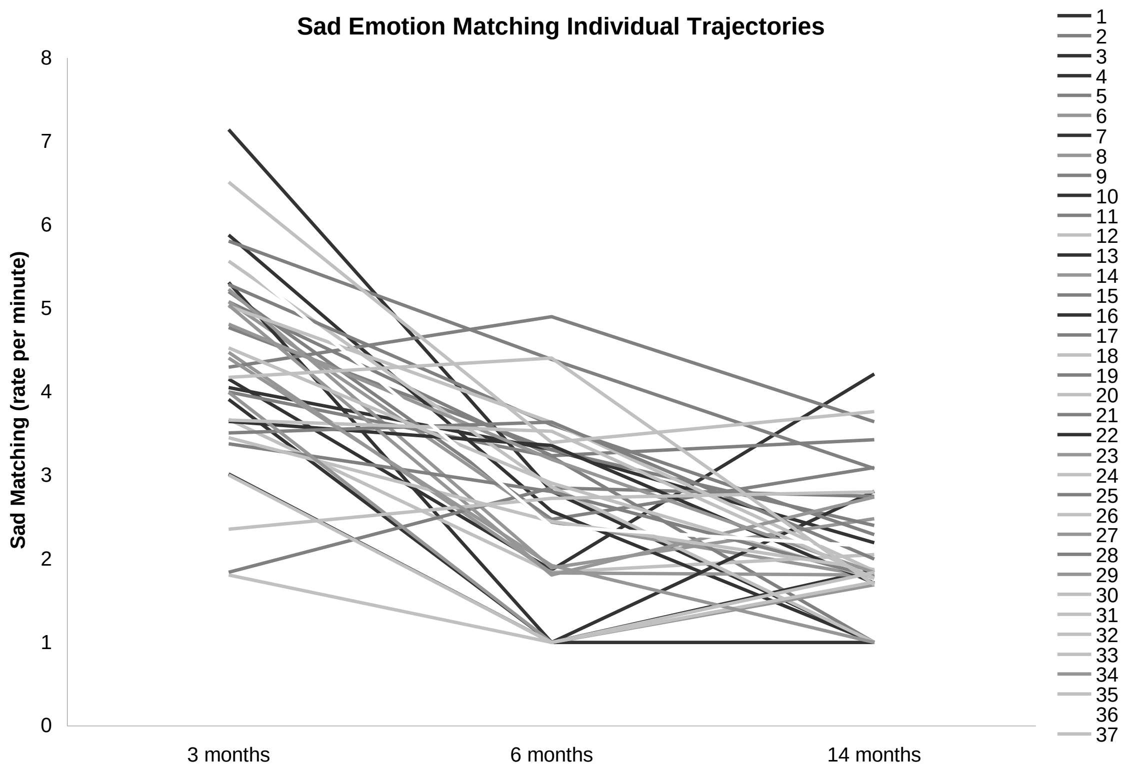




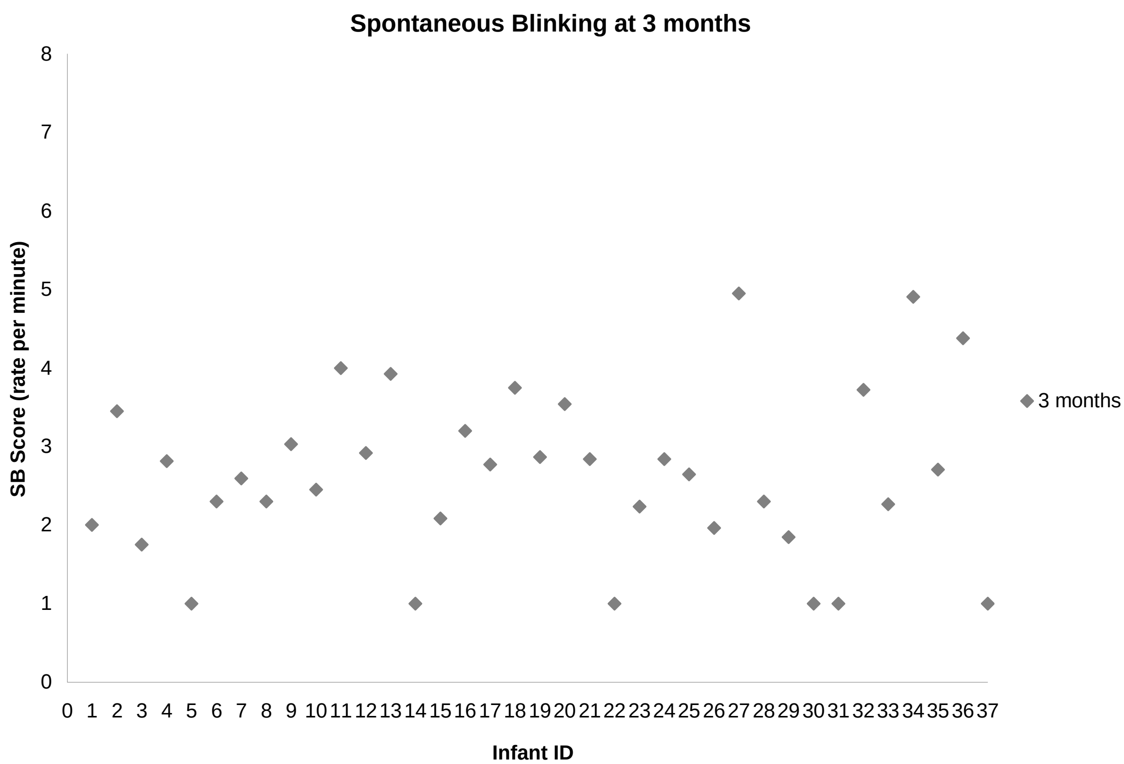


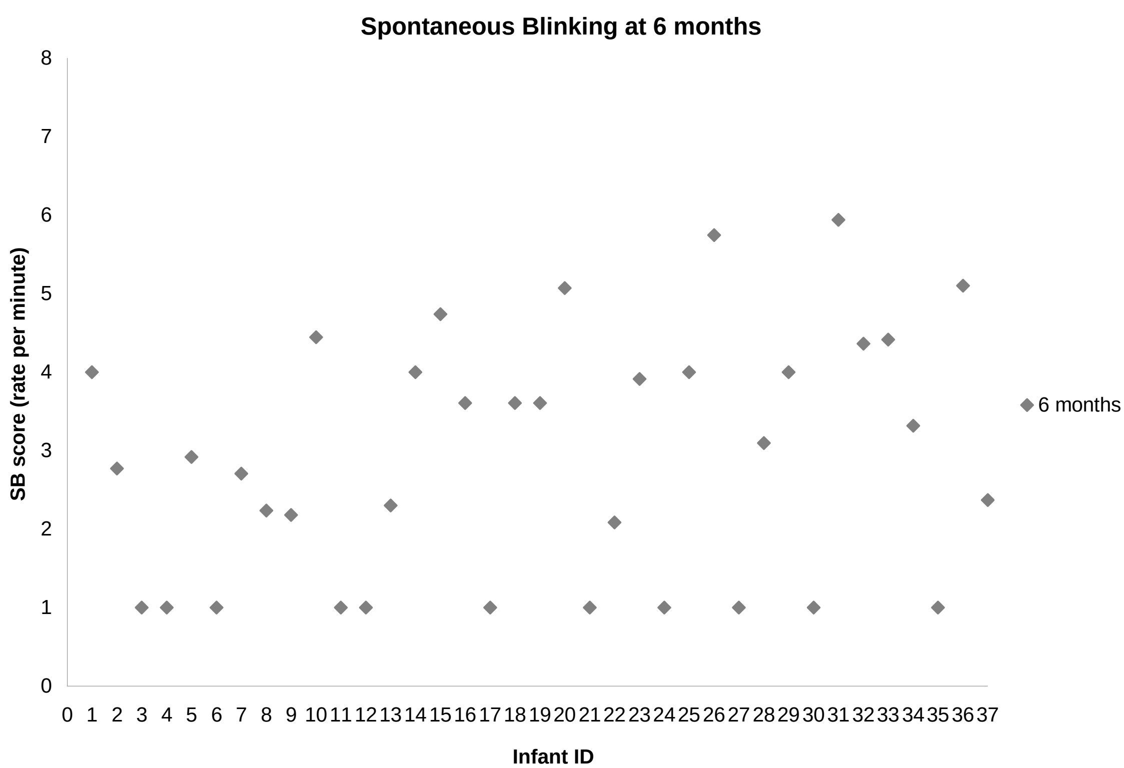
A.5. Individual Trajectories for Happy and Sad Matching

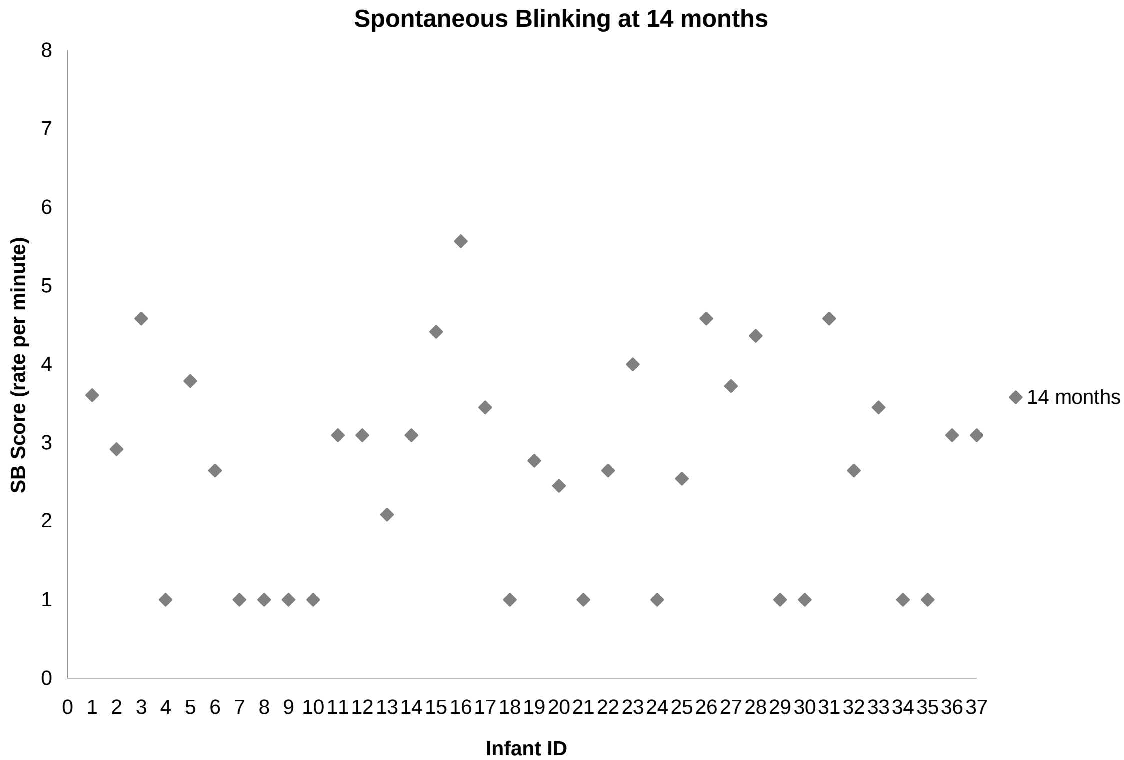




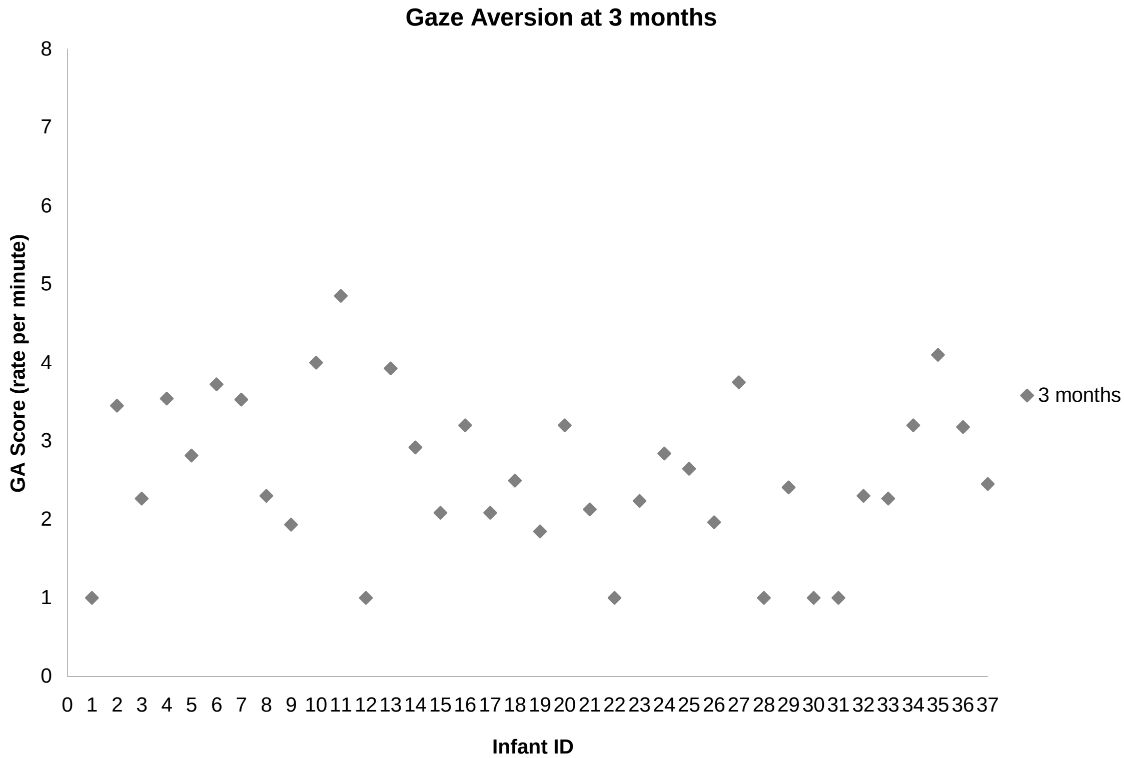
A.6. Spontaneous Blinking Individual Rates

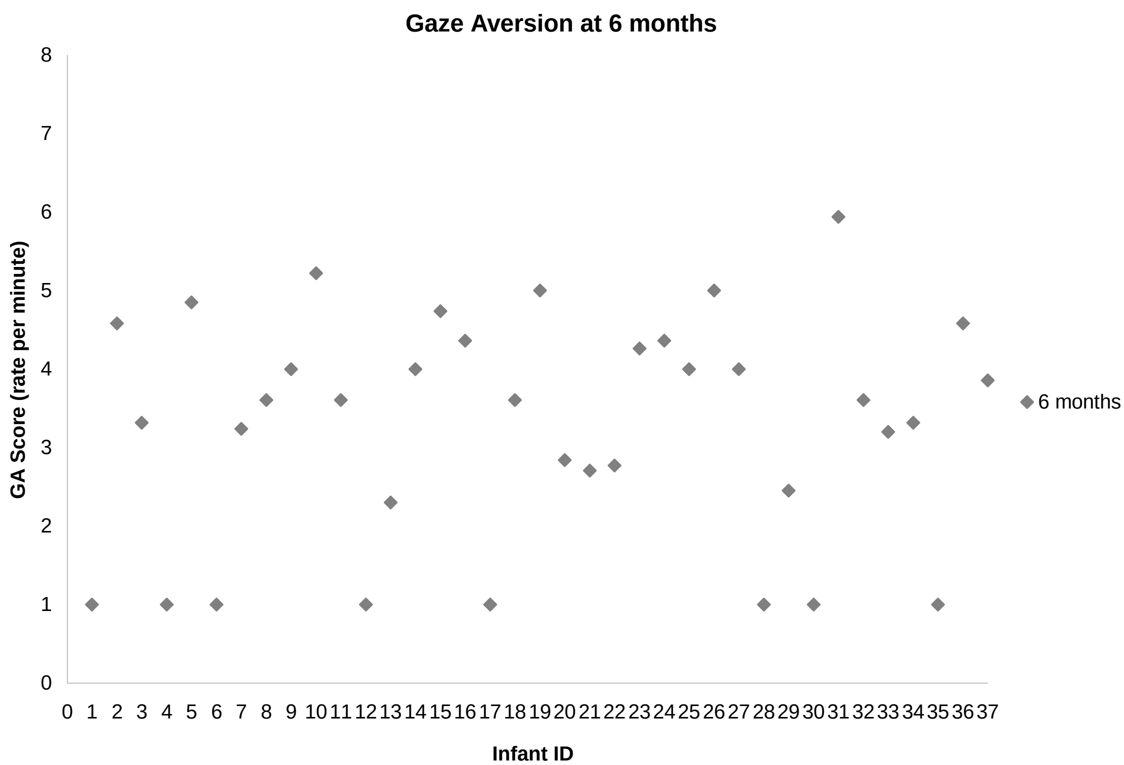

Spontaneous Blinking at 3 months
SB Score (rate per minute)
0
1
2
3
4
5
6
7
8
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Infant ID
3 months

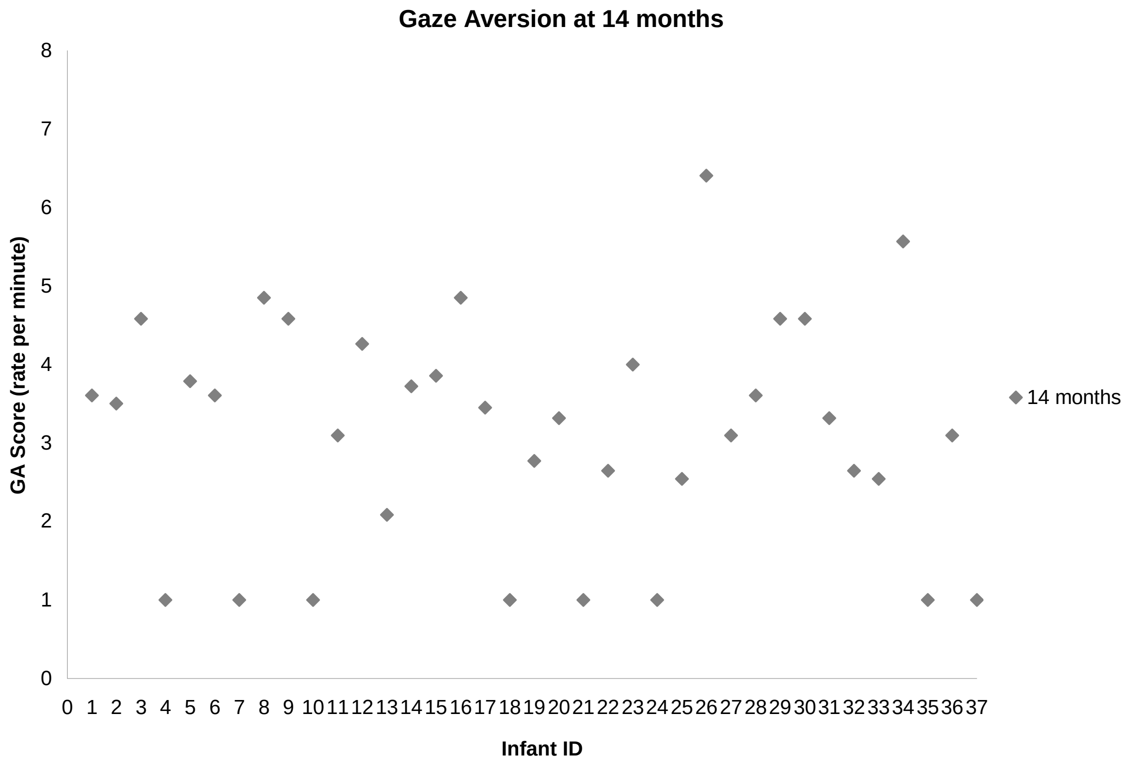

Spontaneous Blinking at 6 months
SB score (rate per minute)
0
1
2
3
4
5
6
7
8
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Infant ID
6 months


Spontaneous Blinking at 14 months
SB Score (rate per minute)
0
1
2
3
4
5
6
7
8
Infant ID
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
14 months

A.7. Gaze Aversion Individual Rates






Gaze Aversion at 14 months
GA Score (rate per minute)
0
1
2
3
4
5
6
7
8
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37
Infant ID
14 months

A.8. Individual Trajectories for Regulation Strategy Usage