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Rodrigo Andrés Cárdenas

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Lauren Julius Harris
Major Professor's Signature

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Rodrigo Andrés Cárdenas

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Abstract

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Rodrigo Andrés Cárdenas

Because infant care is essential to human survival and reproductive success, it has been hypothesized that humans have evolved biological and cognitive mechanisms to facilitate adults' interest in and responsiveness to infants in ways leading to care-giving. Evidence for such mechanisms comes from studies showing that adults have attentional-emotional biases, and make distinctive physiological, neural, and hormonal responses, to infants, specifically to those physical features and behaviors that distinguish them from older humans. These biases also are normally stronger in women than in men, consistent with the hypothesis that women, due to their central role in infant care, have evolved a greater and more stable sensitivity to infants. However, despite evidence that infants constitute a special stimulus category, the nature of the cognitive mechanisms underlying interest in infants is still largely unexplored. This dissertation examines whether one such mechanism is visual attention toward infants, and, if so, how it is expressed (e.g., in overall looking time, face-recognition, and initial deployment of attention) and whether and how it is associated with adults' self-described interest in infants. Seven studies with young adults were conducted to address these questions. Studies 1-5 were preliminary and assessed the reliability/validity of three questionnaire-based measures of interest in infants and the characteristics of the sample of faces used in the main studies. Study 6, the first main study, used eye-tracking to measure subjects' visual attention while they

viewed an adult face (a man or woman) paired with an infant face (a boy or girl). Subjects also completed the interest-in-infants questionnaires and a face recognition test. As indexed by the number and length of fixations, the results showed that women looked more at infant than at adult faces of either sex, whereas men looked more at infant faces only when paired with an adult male face. Women also reported greater interest in infants than men. The interest scores, however, were consistently associated with visual attention toward infants only for men (possibly due to a range restriction in women's interest scores). The results thus suggest that women's interest in infants as indexed by visual attention and self-report is more stable and higher than men's. Face recognition scores were not associated with interest-in-infants scores, perhaps because of the difficulty of the recognition task. Study 7, the second main study, examined whether infant faces have a greater effect than adult faces on the initial deployment of attention – the so-called "prior-entry effect". The results suggested that infant faces do not have this effect or at least that it is smaller than that reported for other emotional stimuli, such as angry faces. There also was no association between individuals' point of subjective simultaneity and their self-reported interest in infants, consistent with the negative evidence from the prior entry task. The results thus suggest that the attentional and neural effects reported in other studies are unlikely to appear during the initial deployment of attention. Overall, the results suggest that women's interest in infants is more stable than men's, consistent with the hypothesis about the evolution of sex differences. They also show that oculomotor behavior can be successfully used to assess individual differences, including sex differences, in interest in infants.

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Chapter 1: Introduction

All animal species with complex nervous systems face a fundamental and complex information-processing problem: their environment contains vast amounts of information that cannot be exhaustively processed by the animal's limited capacity cognitive system. As a result, only some information receives further processing, other information is partially processed, and still other information is ignored altogether. The problem is that not all information has the same survival/reproductive value; in other words, the animal faces a complex landscape of inherent costs and benefits every time it processes some information and ignores other information. Making the landscape even more complex is that the costs and benefits are not necessarily stable across time, and sometimes even information that is ignored can be important (e.g., by minimizing informational interference). Thus, not only is cognition effortful (e.g., in energy and time spent and in risks taken), it also requires an allocation of limited resources, an allocation that can be extremely difficult because of the complexity of the decision-rules. For all these reasons, it has been hypothesized that through evolution, certain information-processing mechanisms have been selected that are more efficient at processing information that is recurrently relevant (beneficial) for a species; that is, certain attention and memory systems became tuned to attend to and to remember information most relevant for survival and reproductive success (e.g., Nairne, Pandeirada, & Thompson, 2008; New, Cosmides, & Tooby, 2007). Given the survival/reproductive value of attending to and remembering information about infants, the possibility thus arises that there are attentional/memory biases toward infant information that could facilitate a caregiver's response, particularly in time-sensitive situations that can place an infant at risk.

Human infants are secondarily altricial (Martin, 2007; Portmann, 1941), which means that their survival depends on intensive parental and alloparental care, with mothers and other females typically having the more central roles (e.g., Clutton-Brock, 1991; Hewlett, 1992; Hrdy, 1999). Because infant care is essential to human survival, it has been hypothesized that, over the course of human evolution, a variety of biobehavioral mechanisms have evolved to facilitate adults' interest in and responsiveness to infants in ways normally leading to care-giving (e.g., Babchuk, Hames, & Thompson, 1985; Lorenz, 1971). Evidence for such mechanisms comes from studies showing that adults have attentional-emotional biases, along with physiological, neurological, and hormonal responses, to features and behaviors that make infants look "cute" and "attractive," and that these biases are normally stronger in women than in men (see Chapter 2).

Despite ample evidence that infants constitute a special stimulus category for humans and that infants are more salient for women, the nature of the cognitive mechanisms underlying interest in infants is still largely unexplored; that is, there has been little work to demonstrate experimentally that there are cognitive mechanisms tuned to detect, encode/store, and process infant-related information and how they may vary as a function of individual differences in interest in infants.

The question raised in this dissertation is whether one of the cognitive mechanisms is expressed through visual attention to faces, and, if so, does it behave as a function of a variety of individual differences indexed by self-report questionnaires?

Seven studies were designed to address this question. The first five were preliminary, the last two were the main studies: Studies 1 and 2 tested the reliability and estimated the validity of the self-report measures of interest in infants; Studies 3, 4, and 5 assessed certain potentially important characteristics of a sample of infant and adult faces to be used in the main studies, including their perceived arousal value, dominance, masculinity/femininity, distinctiveness, and attractiveness; and the main studies, 6 and 7, examined whether specific oculomotor behaviors are associated with the visual processing and subsequent recognition of infant faces, whether infant faces capture attention over adult faces using a visual prior entry task, and, finally, whether the behavioral data (eye movements, recognition, and attentional capture) are associated with psychosocial indices of interest in infants.

What follows is an overview of the dissertation. Following this Introduction (Chapter 1), Chapter 2 reviews the psychosocial and biological correlates of interest in infants in humans and nonhuman primates, and identifies factors that affect individual, especially sex-related, differences in this interest. It therefore highlights the idiosyncrasies and commonalities of human infant care compared to other mammals and nonhuman primates. It also provides illustrations of factors that are related to adults' interest in infants, including, but not limited to the adult's sex, age, parental status, hormonal status, relationship to the infant, and mating and reproductive strategies (e.g., whether one is interested in having children in the short-term vs. long-term or simply not interested). Thus, although sex differences in interest in infants are expected, with women being more interested than men, there also should be variability within each sex, and possibly more in males than in females.

Chapter 3 describes three questionnaires that were developed to measure subjects' interest in and willingness to interact with infants. It includes a discussion of the psychometric properties of these measures, along with preliminary evidence of their construct validity based on how the interest in infants questionnaires relate to other questionnaires (e.g., desire to have children). Finally, it describes additional questionnaires that were used to measure other variables, such as mating strategies, that might contribute to individual differences in performance in the studies and in interest in infants.

Chapter 4 describes the face database used in the main studies (studies 6 and 7). It explains how the faces were obtained, the criteria used for their selection, and what computer graphic techniques were used to make them suitable for use. The chapter also discusses the limitations of standardization of a database that includes infants and adult faces of both sexes; Methods and procedures used for data collection are described, and the results are presented and discussed.

Chapter 5 describes Study 6, on individual differences in visual processing and memory of infant and adult faces. It discusses how eye movements can be used as indexes of attention, in particular, how the location and duration of fixations tend to cluster in the more interesting and informative regions of the visual stimuli. Taking advantage of the intrinsic and intricate relation between oculomotor behavior, attention, and how visual information is represented in real time, the study used eye-tracking to measure the looking times and fixation locations of men and women, all nulliparous-heterosexual undergraduates, while they viewed a sequence of pairs of faces, with each pair consisting of one adult face (either a man or a woman) and one infant face (either a boy or a girl). Subjects then completed questionnaires designed to measure their interest in infants and subsequently received a recognition memory task at the end. Faces were presented in pairs consisting of an adult and an infant face in order to measure oculomotor behavior in contexts where infant faces are competing for attentional resources. The chapter discusses the results in terms of sex differences in oculomotor behavior and face recognition and in how the differences are related to the psychosocial measures used in the study.

Chapter 6 describes Study 7 – on visual prior entry for infant faces. There is evidence that people are predisposed to attend to emotional stimuli (e.g., a fearful face), even when told not to do so. Recent studies, using the dot-probe-task, show that infant faces can produce covert shifts of spatial attention; however, although the task is sensitive enough to detect shifts of attention (e.g., Brosch, Sander, Pourtois, & Scherer, 2008; Brosch, Sander, & Scherer, 2007), its temporal resolution at face onset (when the faces are first presented) is insufficient for determining precisely when and how infant faces capture attention. To allow measurement of the time course of initial attentional deployment, Study 7 uses a prior entry task, a method with better temporal resolution during face onset. The task assumes that those items that capture attention are perceived as appearing earlier than items that do not capture attention. The chapter describes the methods used and the results, along with a discussion of the results in terms of the psychosocial measures used in the study.

The last chapter, Conclusions, returns to the general issues presented in the Introduction and expanded in subsequent chapters. It highlights the value of studying the cognitive basis of individual differences in interest in infants using evolutionary theory as a heuristic tool, and it summarizes the major findings of Studies 6 and 7 and discusses their contributions to the literature along with their limitations. It also discusses the importance of understanding the factors that contribute to individual differences in interest in infants from an applied science perspective. Finally, directions for future studies are proposed.

Chapter 2: Individual Differences in Interest in Infants

As described earlier, given that offspring survival is critical for reproductive success and that human infants require intensive and extensive care, it is likely that humans are endowed with specialized cognitive mechanisms attuned to facilitate infant care. This chapter reviews the psychosocial and biological correlates of interest in infants in humans and nonhuman primates, and identifies factors that affect individual, especially sex-related, differences in this interest.

High Costs of Care for Human Infants

In general, primate infants are costly to rear because they require high amounts of energy and care (e.g., feeding, grooming, carrying, protecting from predators) and because the primate's slow pace of maturation requires care over an extended period of time (Kaplan & J. Lancaster, 2003; Kramer, 2005; J. Lancaster & C. S. Lancaster, 1987; Lee & Kramer, 2002). By these criteria, human infants and children are the most costly by far. At birth, they are about 3 times fatter than expected for a mammal of their size (Hrdy, 2009, 1999) and, compared to closely related primates of similar size, take twice as long as to reach maturity and to produce children on their own (Hrdy, 2009; Kramer, 2005). In addition to these costs, there are costs in mating opportunities with others. Despite all these costs, humans reproduce at significantly faster rates, as indexed by interbirth intervals, than the average for Great Apes. For orangutans, the interbirth interval is about 8 years, for chimpanzees over 5, and for gorillas about 4 years, whereas for humans living in populations with natural fertility, it is closer to 3 years (Galdikas & Wood, 1990; Sear & Mace, 2008; Sellen, 2007).

Role of Cooperative Breeding

The fact that humans can reach higher than expected reproductive rates despite the high cost of rearing human infants highlights the critical role of cooperative breeding in human populations, that is, allomaternal care with provisioning (e.g., share suckling). This is another characteristic that sets humans apart from the Great Apes. All four – chimpanzees, gorillas, orangutans, and gibbons -- have continuous-care-and-contact mothering; in other words, after birth the mother is the sole provider of direct and continuous care for the infant, with whom she remains in continuous contact – a behavior due largely to her possessiveness and not to the lack of interest of potential care givers (Hrdy, 2009). In contrast, humans are cooperative breeders, meaning that a substantial portion of infant care is provided by someone other than the mother or the father, usually a close relative. Another indication of the species difference is in the mother's willingness to let other individuals hold her infant. The earliest this has been observed in wild chimpanzees is when the infant is 3 and one-half months old, and in wild orangutans, 5 months; in human mothers it can be observed immediately after birth (Hrdy, 2009). Still another difference is in shared suckling which is not observed in wild apes but is common in humans, being documented in about 87% of foraging societies described in the Human Relations Area Files (Hewlett, 1989a, cited by Hrdy, 2009). And still another example is the wide-spread practice of human wet-nursing, a wide-spread practice that was institutionalized in France in the 18th and 19th centuries (e.g., in Paris, there was a formal registry of wet-nurses, Sussman, 1977).

Although alloparental care is uncommon among Great Apes, it is common across the order Primates, with about 45% of species showing it in some form. However, only about 20% of species, including humans, show both alloparenting and provisioning (cooperative breeding) (Hrdy, 2009).

In the vast majority of primates, fathers do not provide direct infant-care; instead, they protect the troop from other males attempting to kill the infant. In this sense, primates follow the norm for mammalian species, since only about 5 percent of mammals show male parenting (Clutton-Brock, 1989). Thus, in most alloparental primates, mothers rely on other females (typically close kin) for infant caregiving. In primate species that show cooperative breeding, such as *Callitrichidae* (most marmosets and tamarins), fathers play a substantial role in parental care (Fernandez-Duque, Valeggia, & Mendoza, 2009). By contrast, in humans, across cultures, mothers are the greatest contributors to direct infant care –about 50% of the direct care (Kramer, 2005; Marlowe, 2005), with siblings, grandmothers, and the father contributing to lesser extents (Marlowe, 2005). In fact, by some analysis, fathers have little or no effect on infant survival (Sear & Mace, 2008). The variable impact of male parenting in humans indicates that male parental investment is *facultative* rather than *obligate;* that is, although not required for the offsprings' survival, it seems to enhance their survival and reproductive success (Geary, 2008). Several conditions affect the likelihood of male parental investment, including the degree to which it contributes to offspring survival and reproductive success, certainty of paternity, and the cost of loss of mating opportunities with other females. Thus, although men on average show less interest in infants than women, under certain conditions such differences might be reduced or even absent (e.g., in new fathers with a monogamous reproductive strategy).

Infanticide

Another fundamental difference between humans' and other apes' parental behavior is that only humans are known to commit parental infanticide. In other primates, although infanticide is one of the most common causes of infant mortality, it typically is carried out not by the parent but by a male trying to increase his mating opportunities by speeding up the sexual availability of the mother or by another mother trying to reduce rivals of her own offspring. Indeed, not only is parental infanticide not found in nonhuman great Apes, maternal investment and care are almost guaranteed however unviable an infant appears to be, whereas in humans, as well as in other cooperative breeders, infanticide can be carried out by the mother when the infant is suspected not to be viable or when sufficient alloparenting is unavailable (Daly & Wilson, 1984; Hausfater & Hrdy, 1984; Hrdy, 1999, 2009). This suggests that although women are more likely to be more interested in infants than males, their interest may depend on the socioecological conditions that the woman faces. The implication is that since human infants are born without the certainty of parental care, they have to be especially appealing to the mother (or allomothers) in order to elicit that care; in particular, they must show that they are viable and therefore worth the investment (Hrdy, 2009, 1999).

What Makes Infants Appealing?

The evidence of parental infanticide notwithstanding, most human adults in fact find human infants appealing and attractive. In a seminal paper published in (1943; reprinted in 1971), the Austrian ethologist Konrad Lorenz(1971) introduced the concept of *Kindchenschema* (or baby schema), according to which certain physical and behavioral characteristics of infants attract and induce care-giving behaviors in adults. Lorenz intuitively suggested that these characteristics included "a relatively large head, predominance of the brain capsule, large and low-lying eyes, bulging cheek region, short and thick extremities, a springy elastic consistency, and clumsy movements" (Lorenz, 1971, p. 154). He believed that infant features trigger "innate releasing mechanisms," that is, neurophysiologically hardwired pattern of behaviors associated with affection and nurture (Gould, 1980; Lorenz, 1971; Tinbergen, 1951).

Subsequent studies have generally supported Lorenz's intuition. For instance, most adults rate images of infants as cuter and more attractive than images of adults (e.g., Fullard & Reiling, 1976; Maestripieri & Pelka, 2002), and their ratings have been independently linked to specific infant features, including the size and position of the eyes, size of the forehead, length of the nose, and shape of the head (Alley, 1981; Brooks & Hochberg, 1960; Glocker, Langleben, Ruparel, Loughead, Gur, et al., 2009; Hildebrandt & Fitzgerald, 1979b; Hückstedt, 1965; Sternglanz, Gray, & Murakami, 1977).

Along with attractiveness ratings, several behavioral indicators and other self-report measures (such as mood) are also associated with exposure to the infant schema. Adults smile more when looking at infant images (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Hildebrandt & Fitzgerald, 1978), look longer at cuter than at less cute infants (Hildebrandt & Fitzgerald, 1981, 1978), are more likely to use babytalk (e.g., high-pitched vocalizations accompanied by the use of diminutives and simplified short-sentence structures) when interacting with children with more infant-like features (Zebrowitz & Brownlow, 1992), and are more willing to take care of cuter than less cute infants (Glocker, Langleben, Ruparel, Loughead, Gur, et al., 2009). Cuter infants also have been found to receive more caregiver-attention in a group program for infants (Hildebrandt & Cannan, 1985).

Studies have also examined specific psychophysiological correlates of the infant schema, in particular, autonomic activity such as pupil dilation, heart rate, and skin conductance. A pilot-study of pupillary dilation (greater dilation indicating greater arousal) in six nulliparous adults (2 women) found that the women had greater pupil dilation than the men when looking at infant pictures compared to looking at "control patterns" (Hess & Polt, 1960). Another study with a large sample of children and adolescents (Bernick, 1966) also found greater pupil dilation when subjects viewed infant pictures, but this time, although girls expressed higher preference for infant pictures, boys showed greater pupil dilation. The discrepancy between studies might be due to differences in sample size and subject age, but it might also be related to the imperfect measuring techniques used in both studies (Bradley, Miccoli, Escrig, & Lang, 2008) (e.g., pupils were photographed and sampled at a lower rate than is now possible using modern, video-based, infrared eye-tracking systems).

Personality characteristics also affect physiological responses and sensitivity to infants. When watching videos of infants who are either smiling, crying, or quiescent, young nulliparous women with high empathy (in contrast to women with lower empathy based on their scores on the Mehrabian and Epstein, 1972, empathy questionnaire) show higher skin conductance responses, a trend toward greater cardiac responsiveness, and a higher expressed desire to pick up and hold the infants (Wiesenfeld, Whitman, & Malatesta, 1984).

Physiological responses also change depending on the infant's emotional status. When watching videos of babies smiling or crying, children and parents show cardiac deceleration when the babies are smiling and acceleration when they are crying (Frodi & Lamb, 1978; Frodi, Lamb, Leavitt, & Donovan, 1978).

Physiological responses are also affected by parity (parenthood status) and the filial relationship between the viewer and the infant. For instance, mothers show higher skin conductance responses (Hildebrandt & Fitzgerald, 1981; Wiesenfeld & Klorman, 1978) and cardiac acceleration (Wiesenfeld & Klorman, 1978) when looking at pictures of their own newborns than at pictures of unfamiliar infants.

In a more cognitive domain, the infant schema also appears to produce covert shifts of spatial attention (Brosch et al., 2008; Brosch et al., 2007). These studies used the dot-probe-task, in which two faces (in this case an infant face and an adult face, both with neutral expression) are presented simultaneously for a short time (e.g., 100 milliseconds) and then turned off, after which a small dot appears briefly in the location previously occupied by one of the faces. Adults are typically faster (Brosch et al., 2007) or more accurate (Brosch et al., 2008) at detecting the dot when it appears in the location occupied by the infant face; that is, people seem to improve because their attention was directed, or captured, by the infant face. Given that infant faces are more emotionally arousing than adult faces (e.g., Brosch et al., 2007), this finding is consistent with reports that emotional stimuli have important effects on perception and attention (Öhman, Flykt, & Esteves, 2001; Phelps, Ling, & Carrasco, 2006).

Generalization Effect to Other Species

Lorenz (1971) suggested that the infant schema also affects our perception of other species. Indeed, adults, especially women, tend to prefer images of infant animals over images of adult animals (Berman, Cooper, Mansfield, Shields, & Abplanalp, 1975; Fullard & Reiling, 1976). This preference for the infant schema has also shaped the appearance of cultural artifacts such as cartoons (Eibl-Eibesfeldt, 2007; Gould, 1980; Pittenger, 1990), the teddy bear (Hinde & Barden, 1985; Morris, Reddy, & Bunting, 1995), and perhaps the domestication of some animals (Byrne, 2005; Lorenz, 1971). It even appears to affect one's ability to perform care-giving acts: viewing images of cute animals (puppies and kittens) enhances fine-motor dexterity on a task demanding carefulness (the game Operation) (Sherman, Haidt, & Coan, 2009). However, although infant-animal faces are appealing, they do not induce the attentional capture effect found for human infant faces when compared to adult human faces (Brosch et al., 2007).

Sex Differences

Consistent with the female's more central role in infant-care (Babchuk, Hames, & Thompson, 1985; Clutton-Brock, 1991; Hewlett, 1992; Hrdy, 1999), women and girls normally show higher interest in and responsiveness to infants than do men and boys (Blakemore, 1981; Bradley, Codispoti, Sabatinelli, & Lang, 2001; Feldman, Nash, & Cutrona, 1977; Feldman & Nash, 1978; Fullard & Reiling, 1976; Maestripieri & Pelka, 2002). For example, among the behaviors listed earlier, women are more likely to use baby talk than men (Zebrowitz & Brownlow, 1992), girls and women tend to prefer images of human infants and baby animals and to give them higher cuteness ratings (e.g., Fullard & Reiling, 1976; Maestripieri & Pelka, 2002; Sherman et al., 2009), girls, especially if older than 5 years, are more willing than boys to interact with a baby (Berman & Goodman, 1984; Frodi & Lamb, 1978), women report to have more experience in childcare (Gilpin, 1988; Gilpin & Glanville, 1977, 1985), be more willing to take care of infants (Glocker, Langleben, Ruparel, Loughead, Gur, et al., 2009), are more likely to look at infants (Robinson, Lockard, & Adams, 1979), to pick up and hold them (Harris, Spradlin, & Almerigi, 2007), are more sensitive to differences in cuteness in infant faces (Lobmaier, Sprengelmeyer, Wiffen, & Perrett, 2010; Sprengelmeyer et al., 2009), are faster and more accurate in recognizing infant facial expressions (Babchuk et al., 1985), and, for mothers compared to fathers, show better auditory recognition of their infants cries (Green & Gustafson, 1983).

The sex differences described above, although generally robust, also show inconsistencies developmentally; that is, they are not always found in different age groups. The reason is possibly due, in part, to complex interactions between biobehavioral and sociocultural variables and to differences in methods and research designs (Berman, 1980; Fitzgerald, Mann, & Barratt, 1999). For example, in some domains, the sex differences occur less regularly when fathers are involved, since fatherhood seems to enhance men's interest in infants. Indeed, for face recognition of their newborn infant, fathers may be even more accurate than mothers (Kaitz, Good, Rokem, & Eidelman, 1988).

Hormones

Hormones have also been examined to understand the psychobiological underpinnings of human infant care, and, by implication, the adult hormonal responses to infants. In mammals, several hormones are involved in parental care, including oxytocin, arginine-vasopresin, prolactin, estrogen, and progesterone (Insel & Young, 2001). Such endocrine changes regulate pregnancy, birth, and lactation as well as parental care (Flinn, Ward, & Noone, 2005). The specific role of these hormones, however, varies across species, sexes, and the organism's experience and context (Fleming & Gonzalez, 2009; Flinn et al., 2005). Given that some hormones are involved in parental behavior, it is not surprising that some appear to affect interest in infants and the salience of infant cues.

In humans, most studies have assessed the role of hormones in parental behavior during pregnancy, birth, and the postpartum period, mainly because endocrine changes related to infant care are most evident during those reproductive phases. The evidence shows that over this period, some infant cues become more salient for caregivers, and that these changes sometimes are linked to hormonal changes, although the effects are complex and dependent on many factors, such as sex, experience, parity (prior maternal experience), age, and early life experiences (Fleming & Gonzalez, 2009).

Despite the substantial individual differences among mothers in the pattern of parental feelings and in behavioral and hormonal responses, studies show that throughout pregnancy and from pregnancy to postpartum, maternal responsiveness increases (Fleming, Ruble, Krieger, & Wong, 1997). Mothers, for instance, are able to recognize their infants through multiple sensory cues, even after little experience with them. For example, even if fathers do outperform mothers in the visual face recognition of their newborns (Kaitz et al., 1988), mothers can recognize their newborn through a variety of modalities, from seeing their photographs (Kaitz et al., 1988), hearing their cries (Green & Gustafson, 1983), touching their skin and hand (Kaitz, Lapidot, Bronner, & Eidelman, 1992), and smelling their odor (Kaitz, Good, Rokem, & Eidelman, 1987; Porter, Cernoch,

& McLaughlin, 1983; Russell, Mendelson, & Peeke, 1983). Mothers also give higher hedonic ratings to infant odors than nonmothers and nonfathers (Fleming et al., 1993); fathers (Russell et al., 1983) and mothers with higher levels of postpartum cortisol also show more attraction toward and better recognition of their infant's odors (Fleming, Steiner, & Corter, 1997).

Changes in autonomic function that are correlated with hormonal changes also are affected by multiple variables, such as parity and age. For instance, new mothers, compared to nonpostpartum women, show greater empathy for infant cries; more empathic mothers also show increased heart rate and elevated levels of cortisol (Stallings, Fleming, Corter, Worthman, & Steiner, 2001). These are results for adults. In teen-age mothers, the changes are minimal (Giardino, Gonzalez, Steiner, & Fleming, 2008).

The association between cortisol and maternal behavior appears to be curvilinear; in other words, medium levels of cortisol seem to be positive, low and high levels detrimental, for maternal behavior. Any such effects also are evident only at early postpartum stages (Fleming & Gonzalez, 2009). The involvement of cortisol, however, suggests a potential functional role for cortisol because cortisol is activated during high arousal states and has been shown to enhance attention, perception, memory, and emotional processing (Erickson, Drevets, & Schulkin, 2003).

In males, married men with children tend to have lower levels of testosterone than single men and married men without children (Berg & Wynne-Edwards, 2001; Gray, Parkin, & Samms-Vaughan, 2007; Muller, Marlowe, Bugumba, & Ellison, 2009; Storey, Walsh, Quinton, & Wynne-Edwards, 2000).

Neural Mechanisms

Our understanding of the neuroanatomy of parental behavior has been advanced fundamentally through studies of rodents, sheep, and nonhuman primates, and, most recently for humans, through neurofunctional imaging. The literature on nonhumans highlights the critical role of basal forebrain structures, such as the media preoptic area (MPOA), the ventral bed nucleus of the stria terminalis (vBNST) and its projections into the midbrain (ventral tegmental area [VTA]) and hindbrain (periaqueducal gray [PAG]), and sensory, limbic, and cortical system that project into MPOA/vBNST (Fleming & Gonzalez, 2009; Numan, 1994; Swain, Lorberbaum, Kose, & Strathearn, 2007). What the literature shows is that lesions in these regions and projections induce disruptions in maternal behavior.

Neuroimaging studies on humans are still in their formative stages, since the number of studies and samples are small, have used a mix of methods, stimuli (e.g., infant vocalizations, photographs of infant faces, videos of infants, depictions of a variety of emotional valences, and stimuli from the subjects' own or someone else's infant), and subjects (e.g., parents, non-parents, only women). However, although activation patterns vary depending on the task, methods, and population sampled, the literature shows that some structures are recurrently involved when people assess infant stimuli. The structures include the cingulate gyrus (Bartels & Zeki, 2004; Glocker, Langleben, Ruparel, Loughead, Valdez, et al., 2009; Lorberbaum et al., 2002; Swain et al., 2007), thalamus (Leibenluft, Gobbini, Harrison, & Haxby, 2004), insula (Glocker, Langleben, Ruparel, Loughead, Valdez, et al., 2009; Seifritz et al., 2003), orbitofrontal cortex (Glocker, Langleben, Ruparel, Loughead, Valdez, et al., 2009; Kringelbach et al., 2008; Nitschke et al., 2004), amygdala (Leibenluft et al., 2004; Ranote et al., 2004; Zebrowitz, Luevano, Bronstad, & Aharon, 2009), precuneus (Glocker, Langleben, Ruparel, Loughead, Valdez, et al., 2009; Ranote et al., 2004), and fusiform gyrus (Bartels & Zeki, 2004; Kringelbach et al., 2008; Ranote et al., 2004; Zebrowitz et al., 2009). These structures are found to be involved, among other functions, in reward, arousal and motivation, planning and social empathy/altruism, and attention (Fleming & Gonzalez, 2009; Glocker, Langleben, Ruparel, Loughead, Valdez, et al., 2009; Swain et al., 2007).

Some studies also have found individual differences in brain activity, depending on sex and parental status (Seifritz et al., 2003), and whether the infant stimuli (face or vocalization) belong to one's own infant or someone else's.

Since the structures involved also have been found to vary depending on the specific tasks and stimuli used, it may be appropriate to frame the results in terms of a distributed neural network akin to recent models of face perception (Gobbini & Haxby, 2007; Haxby, Hoffman, & Gobbini, 2000), where structures are co-dedicated to visual analysis (dynamic and static facial features for recognition), the representation of person knowledge about the face (e.g., episodic memories, attitudes, mental states), and the emotional response that the face elicits.

Summary

In sum, comparative and human data reveal a number of factors that affect adults' interest in infants, including but not limited to the adult's sex, age, parental status, hormonal status, relationship to the infant, and mating and reproductive strategies (e.g., whether interested in having children in the short-term vs. long-term or simply not interested). Thus, although in the 7 new studies to be described here, sex differences are expected, with women typically being more interested in infants than men, the possibility of finding considerable variability within each sex, perhaps even more in males than in females, should not be discounted. When interpreting the data, we therefore must keep in mind that the convenience sample used (nulliparous undergraduate students) is not representative of all the reproductive stages in humans. The results could be different if parenthood and other variables were to have been included.

Chapter 3: Psychosocial Measures of Individual Differences in Interest in Infants

This chapter describes the first two studies of the dissertation. Each was designed to assess the content and psychometric properties of the three questionnaires used in Studies 6 and 7 to quantify factors that could contribute to individual differences on the visual attention tests. The three questionnaires, *Interest in Infants*, *Job Preference*, and *Interaction with Infants*, were designed to measure how subjects perceive their interest in infants and their willingness to interact with them.

Studies 1 and 2

Studies 1 and 2 were designed to test the reliability and to estimate the validity of the new instruments. In Study 1, performed on-line, subjects completed the *Interest in Infants*, the *Job Preference* questionnaire, and the *Desire for Parenthood* questionnaire, which was included to assess the validity of the interest in infants questionnaires. In Study 2, performed in the laboratory, subjects completed the *Interaction with Infants* and *Job Preference* questionnaires[1].

Subjects for Study 1 were 217 women (Mean age = 19.49, *SD* = 1.58 years) and 112 men (*M* = 19.94, *SD* = 2.26 years) Michigan State University undergraduates. The sample included 303 Whites (215 women), 32 Black, or African-Americans (26 women), 8 Hispanic or Latinos (6 women), 30 Asians (18 women), and 9 subjects with "Other"

[1] Statistical analyses reported in this dissertation were conducted with R (R Development Core Team, 2009). Descriptive statistics and reliabilities were computed using the *psych* package (Revelle, 2009). Signal detection theory scores were computed with the *sdtalt* package (Wright, 2009; Wright, Horry, & Skagerberg, 2009). Multilevel models were calculated using the *lme4* package (Bates & Maechler, 2009), and the regression coefficients' p-values based on the t-statistic were estimated with the *languageR* package (Baayen, 2009), which reports the values by implementing a Markov chain Monte Carlo sampling (10,000 by default). Mixed-models ANOVAs were computed with IBM SPSS Statistics (version 18.0.1).

ethnic background (6 women). One woman and one man each reported having 1 child; the remaining subjects were childless.

Subjects in Study 2 were 63 women (Mean age = 19.08, *SD* = 1.22 years) and 27 men (*M* = 19.93, *SD* = 1.27 years) Michigan State University undergraduates. The sample included 72 Whites (49 women), 6 Blacks, or African- Americans (5 women), 1 Hispanic or Latino man, 4 Asian women, 1 American Indian or Alaska Native woman, and 6 subjects with "Other" ethnic background (4 women). All subjects were childless.

Interest in Infants

The *Interest in Infants* questionnaire consists of 21 items about infants, 11 of which asked how intellectually interesting they are (e.g., "it is fascinating to try to communicate with babies") and 10 that asked how physically attractive they are (e.g., "only parents find their babies beautiful"). Despite this two-dimensional conceptualization, a confirmatory factor analysis did not show the expected factor structure for both men and women; instead the two extracted factors corresponded to non-reversed-scored and reversed-scored items respectively; therefore, the questionnaire was treated as one-dimensional. The questionnaire originally had 22 items, but 1 intellectual-interest item ("babies are pretty easy to figure out") was removed because it showed poor association with the other items (i.e., correlation *M* = -.03, *SD* = .06).

To minimize the effect of the infant's age on perceived attractiveness (Hildebrandt & Fitzgerald, 1979b), subjects were told that the questionnaire items referred to infants of about 6 months of age. The 6 months age was chosen as a midpoint between newborns, many of whom are not particularly attractive, and 1-year-olds, who often are at peak attractiveness. Subjects rated how much they agree with each statement on a 7-point scale (from 1= "strongly disagree" to 7= "strongly agree"). The questionnaire was presented on a computer, and subjects responded at their own pace.

The questionnaire showed good internal consistency (women: $\alpha = .92$; men: $\alpha = .9$). A one-way between-subjects ANOVA showed a main effect of sex, $F(1,381) = 54.89$, $p < .001$, $\eta_p^2 = 0.13$, indicating that women had significantly higher scores ($M = 5.33$, $SD = 0.83$) than men ($M = 4.63$, $SD = 0.88$).

Job Preference Questionnaire

The *Job Preference* questionnaire assessed the subjects' preference for an infant-care job compared to their average preference for 6 other jobs at similar wages (e.g., child care, house keeper, waiter/waitress), according to the Occupational Employment Statistics of the US Bureau of Labor Statistics (2008).

Subjects were told that all jobs required the same time and effort and were asked to rate their preference for each job on a seven-point scale (from 1= "strongly dislike" to 7 = "strongly like").

As part of the same online study, subjects who answered the Interests in Infants questionnaire also answered the Job Preference questionnaire.

Preference ratings were examined with a mixed-design ANOVA with job type (infant care, other jobs) as a within-subjects factor and sex of the subject (male, female) as a between-subjects factor. The analysis showed that job type was not significant, $F(1,381) = 3.47$, $p = .06$, indicating that when men's and women's preference for the infant care job and other jobs were combined, their preferences were similar. The overall similarity, however, can be attributed mostly to their similar preferences for non-infant-care jobs (Men: $M = 3.99$, $SD = 0.82$; Women: $M = 4.12$, $SD = 0.86$) because a significant interaction between job type and sex, $F(1,381) = 61.10$, $p < .001$, $\eta_p^2 = 0.13$, indicated that women had higher preference for the infant-care job ($M = 5.08$, $SD = 1.78$) than men ($M = 3.4$, $SD = 1.88$).

Desire for Parenthood

The *Desire for Parenthood* questionnaire was based on the *Desire to Have Children* questionnaire (Rholes, Simpson, Blakely, Lanigan, & Allen, 1997). Because the latter, provided by Rholes (personal communication), was written for married couples, it was modified for administration to unmarried subjects. The new questionnaire included 8 items from the original questionnaire about the importance of having children (e.g., "Without children, I would feel unfulfilled"), and 1 new item, which compared the importance subjects' give to having children over having a stable partner. Subjects rated each statement on a 7-point scale (from 1 = "strongly disagree" to 7 = "strongly agree").

The questionnaire showed good reliability (women: $\alpha = .86$; men: $\alpha = .77$). A one-way between-subjects ANOVA showed a small effect for sex, $F(1,381) = 3.89$, $p = .049$, $\eta_p^2 = 0.01$, indicating that women had slightly higher scores ($M = 4.75$, $SD = 1.19$) than men ($M = 4.5$, $SD = 0.97$).

Validity of Interest in Infants and Job Preference questionnaires

The validity of the questionnaires was assessed by examining the correlations across questionnaires. Higher positive correlations were expected between the *Interest in Infants*, *Job Preference*, and *Desire for Parenthood* questionnaires; lower correlations were expected between these measures and the average preference for non-infant-care jobs (since non-infant-care jobs included jobs that involved "care," i.e., adult- and child-care jobs. As summarized in Table 1, the correlation matrix confirmed these expectations, with at least some of these relations (e.g., the desire for parenthood and the preference for an infant-care job) being stronger in women.

Table 1. Zero-Order Correlations Across Questionnaires by Sex of Subjects

Women (N=271)	interest	infant-care job	other jobs
infant-care job	.53 ***		
Other jobs	.18 **	.28 ***	
Desire for parenthood	.62 ***	.47 ***	.23 ***
Men (N=112)	**interest**	**infant-care job**	**other jobs**
infant-care job	.53 ***		
Other jobs	.29 **	.28 **	
Desire for parenthood	.34 ***	.25 **	-.003

*$p < .05$; **$p < .01$; ***$p < .001$

Interaction with Infants

The *Interaction with Infants* questionnaire was modeled after one designed by Maestripieri and Pelka (2002). The original questionnaire was modified in order to find out whether interest varies as a function of the infant's emotional state, that is, whether individual differences are more evident when the subject is asked to interact with an infant in distress as opposed to an infant in a positive mood. Three emotional states were described: negative (crying), neutral (lying quietly), or positive (happy). The following scenario was presented:

"Several of your friends and some people you do not know are getting together and have invited you to join them. As you enter the room where they have gathered, you notice that in the corner of the room there is a baby lying in a car seat. The baby appears to be about 6 months old. After you enter the room, how likely is it that you would do each of the following?"

Three different situations were described (e.g., "if the baby is lying quietly, I would"), each followed by 6 descriptions of possible behaviors that subjects may engage in as a reaction to the infant's presence (e.g., "ignore the baby", "go over and look at the baby"). Subjects were asked to indicate, on a 7-point scale (from 1="extremely unlikely" to 7= "extremely likely"), how likely they are to respond in these ways, with higher scores indicating more positive behaviors towards the infant.

Subjects answered the questionnaire, at their own pace, on a computer in a laboratory setting.

After deleting one item from the Negative emotion subscale because of its low and negative correlation with other items (correlation $M = .14$, $SD = .15$), the total questionnaire internal consistency was good (women: $\alpha = .93$; men: $\alpha = .90$) as was the reliability for each of the subscales (Negative: women: $\alpha = .73$, men: $\alpha = .71$; Neutral: women: $\alpha = .90$, men: $\alpha = .88$; Positive: women: $\alpha = .90$, men: $\alpha = .83$).

Ratings were examined with a mixed-design ANOVA with emotional state of the infant (negative, neutral, positive) as a within-subjects factor and sex of the subject (male, female) as a between-subjects factor. The analysis showed a main effect for emotional state, $F(2,176) = 1.06$, $p < .001$, $\eta_p^2 = 0.11$, indicating that subjects reported more positive responses as the infant's emotional state became more positive (see Table 2), a pattern not affected by the sex of the subject, $F(2,176) = 0.22$, $p = .8$. Although women's scores were higher than men's, the main effect for sex was not significant, $F(1,88) = 2.35, p = .13$, perhaps due to a smaller sample size for men.

Table 2. Means and (Standard Deviations) of Positive Behaviors of Men and Women for Interacting with an Infant Under Three Different Emotional States

Infant's emotional state	Men (N=27)	Women (N=63)
Negative	4.88 (0.92)	5.13 (1.01)
Neutral	5.07 (1.14)	5.43 (1.33)
Positive	5.31 (0.82)	5.70 (1.01)

Subjects also answered the *Job Preference* questionnaire, so that its relationship with infant-care jobs and non-infant care jobs could be assessed. If the measure is valid, it was expected to show stronger correlations with infant-care jobs than non-infant-care jobs.

A mixed-design ANOVA with job type (infant care, other jobs) as a within-subjects factor and sex of the subject (male, female) as a between-subjects factor showed no main effect for job type, $F(1,88) = 1.15, p = .29$, indicating that for the combined scores for men and women, subjects did not show a preference for either type of jobs. However, this was mostly due to the men's and women's similar preferences for non-infant-care jobs (Men: $M = 4.02$, $SD = 0.77$; Women: $M = 3.95$, $SD = 0.86$) as shown in the significant interaction between job type and sex, $F(1,88) = 11.86, p = .001, \eta_p^2 = 0.12$, indicating that women preferred infant-care jobs ($M = 4.90$, $SD = 1.99$) while men prefered non-infant care jobs (infant-care job preference: $M = 3.52$, $SD = 1.67$). There was a small main effect of sex, $F(1,88) = 6.20, p = .015, \eta_p^2 = 0.07$, indicating that, overall, women gave higher ratings than men (largely due to their higher preference for infant care jobs). The results thus replicate those obtained with the larger sample of the online study.

The overall pattern of correlations, summarized in Table 3, confirmed the expectation that the Interaction with Infants questionnaire would correlate more strongly with the infant-care job than with non-infant-care jobs for both men and women. Subscales of the Interaction with Infants questionnaire followed the same pattern in women, but less clearly in men.

Table 3. Zero-Order Correlations Between the Job Preference and Interaction with Infants Questionnaires

Women (N=66)	Infant care	other jobs	Negative	Neutral	Positive
Other jobs	.27 **				
Negative	.58 ***	.05			
Neutral	.56 ***	.13	.61 ***		
Positive	.51 ***	.03	.67 ***	.79 ***	
Total	.62 ***	.08	.84 ***	.92 ***	.92 ***
Men (N=27)	**Infant care**	**other jobs**	**Negative**	**Neutral**	**Positive**
Other jobs	.41 *				
Negative	.36	.19			
Neutral	.53 **	.35	.64 ***		
Positive	.35	-.13	.40 *	.56 **	
Total	.51 **	.20	.82 ***	.91 ***	.75 ***

*$p < .05$; **$p < .01$; ***$p < .001$

Revised Sociosexual Orientation Inventory

Sociosexuality is generally understood as the willingness to engage in uncommitted sex and, therefore, provides an indicator of mating tactics and thus a way to assess how individual differences in mating tactics relate to interest in infants (e.g., people with higher willingness to engage in uncommitted sexual relationships may show lower interest in parental investment and therefore lower interest in infants). Sociosexual orientation was assessed with the *Revised Sociosexual Orientation Inventory (SOI-R)* (Penke & Asendorpf, 2008). Based on the original inventory (Simpson & Gangestad, 1991), it includes three subscales (with three items each) for assessing past sociosexual behavior, sociosexual attitudes, and sociosexual desire. The inventory has good psychometric properties, including construct and predictive validity (see Penke & Asendorpf, 2008 for details).

Self-Perceived Mate Value Scale

The *Self-Perceived Mate Value Scale* (Langton, Honeyman, & Tessler, 2004) consists of 8 items that ask subjects to rate on a 7-point scale (from 1 = "strongly disagree" to 7 = "strongly agree") the reactions they usually receive from the opposite sex in terms of their mate value (e.g., "Members of the opposite sex are attracted to me"). The scale shows good reliability (e.g., men: $\alpha = .91$, $M = 3.23$, $SD = 1.01$; women: $\alpha = .93$, $M = 3.84$, $SD = 1.13$) (Penke & Asendorpf, 2008) and provides an indicator of information that people might be using to adjust their mating tactics. For instance, men who perceive themselves as having higher mate value tend to have higher scores in the SOI (Clark, 2006), but this is not the case for women (Clark, 2006; Mikach & Bailey, 1999). This information therefore could help to explain the relationship, if any, between sociosexuality and interest in infants.

Chapter 4: Composition and Characteristics of Facial Stimuli

This chapter describes the face database used in Studies 6 and 7. It explains how the faces to be used in these studies were obtained, the criteria used for their selection, the computer graphic techniques that were used to make them suitable for use, and then the 3 studies (3-5) that assessed whether the faces retained their age, sex, and affective characteristics after being standardized.

Facial Stimuli

The face images were frontal views of the faces of young adults and infants, all Whites with neutral expressions. The young adult faces (24 men, 24 women) were selected from the *Productive Aging Lab Face Database* (Minear & Park, 2004) and the *FERET* database (Phillips, Moon, Rizvi, & Rauss, 2000). The infant faces (24 boys, 24 girls, 3 to 6 months old) were taken from the website *Flickr* (www.flickr.com). The age of the adult faces was determined from information in the databases. The age of the infant faces was determined from information in the website (for some, the age was specifically given; for others, it was estimated by comparing the date when the picture was taken with the date of pictures of the infant's birth). In the few cases where information about an infant's or adult's face was unavailable, an independent rater confirmed that these faces were similar in age to other faces in the pool. Faces also were selected so that, within each age and sex category, they showed similar levels of masculinity/femininity and attractiveness (independent raters, as described below, rated the faces on these and other dimensions).

The adult faces appeared without glasses or jewelry, and, for male faces, without substantial facial hair. Non-facial salient marks that may affect recognition, such as moles and blemishes, were removed using the clone stamp tool in Adobe Photoshop 9.0.2. All color images were transformed to grey-scale.

Faces were standardized to have identical orientation and similar inter-pupil distance, and only the face outline was visible (hair, ears, and original background were removed). Although inter-pupilar distances were standardized across faces, natural age- and sex-related craniofacial morphological variations (e.g., Ferrario, Sforza, Poggio, & Schmitz, 1998; Ursi, Trotman, McNamara, & Behrents, 1993; Weston, Friday, & Liò, 2007) led to size variations in the faces. Average area measures, calculated with ImageJ 1.42q (Rasband, n.d.), are summarized in Table 4.

Table 4. Pixel Area of Each Face Category

		Area
Face category	N	*M* (*SD*)
Boys	24	24733.17 (1236.61)
Girls	24	24436.88 (1340.20)
Men	24	31429.29 (913.73)
Women	24	24857.71 (1185.56)

A one-way ANOVA was used to examine pixel area group differences and showed that the groups differed, $F(3,92) = 197.20, p < .001, \eta_p^2 = .865$. Tukey HSD post-hoc comparisons showed that the difference was due to men's faces having a larger area than boys', girls', and women's faces (all p values $< .005$), with the scores for the last three groups not being significantly different from each other ($p > .05$).

Consequently, area measures will be included in models attempting to fit the behavioral data of Studies 6 and 7.

To minimize the effect of image statistics in the results for Studies 6 and 7, the luminance and relative contrast of faces were also adjusted to approximate the average luminance-contrast of adult faces. Adjustments were made by creating an average face of the adult faces and applying its image statistics to each face in the dataset. Any non-face area of the image region (188 x 250 pixels) was filled with a grey background (RGB: 192, 192, 192).

Given that humans are more sensitive to the contrast of middle spatial frequencies, the faces also were filtered to extract 8 spatial frequency bands (< 4, 4-8, 8-16, 16-32, 32-64, 64-128, 128-256, >256 pixels/cycle band) in order to examine their relative contribution to the behavioral results of Studies 6 and 7. The subjective/apparent contrast was calculated by dividing the standard deviation of the luminance by the mean luminance of each filtered image (Delplanque, N'diaye, Scherer, & Grandjean, 2007). Filtered images were produced and measurements were made with ImageJ 1.42q. Measurements are summarized in Table 5.

A MANOVA showed that the apparent contrast varied across groups at all frequency bands (including the unfiltered image). The results are summarized in Table 6. Post hoc Tukey HSD tests showed that at lower frequency bands (less than 64 pixels/cycle), adult faces, and especially male faces, have greater apparent contrast than infant faces, and that the reverse is true, especially for boy faces, at higher frequency bands (64 and higher pixels/cycle).

Table 5. Means and (Standard Deviations) of Apparent Contrast for Each Frequency Band by Sex of the Face

Frequency Bands (pixels/cycle)	Boys	Girls	Men	Women
Unfiltered	0.213 (0.019)	0.215 (0.017)	0.225 (0.007)	0.217 (0.008)
< 4	0.042 (0.007)	0.045 (0.007)	0.053 (0.005)	0.053 (0.004)
4 - 8	0.037 (0.004)	0.039 (0.005)	0.047 (0.004)	0.046 (0.003)
8 - 16	0.052 (0.005)	0.055 (0.006)	0.064 (0.003)	0.060 (0.003)
16 - 32	0.064 (0.005)	0.068 (0.005)	0.075 (0.004)	0.069 (0.004)
32 - 64	0.060 (0.007)	0.060 (0.005)	0.068 (0.006)	0.063 (0.005)
64 - 128	0.053 (0.015)	0.045 (0.018)	0.037 (0.009)	0.040 (0.009)
128 - 256	0.032 (0.008)	0.030 (0.008)	0.022 (0.005)	0.025 (0.004)
> 256	0.008 (0.003)	0.007 (0.004)	0.006 (0.002)	0.005 (0.002)

Table 6. F-statistics, Effect Sizes, and Significant Group Differences for Unfiltered and Filtered Frequency Bands

Frequency Bands (pixels/cycle)	*F*	η_p^2	Significant group differences Tukey HSD
Unfiltered	3.476 *	0.10	m > b
< 4	24.079 **	0.44	m,w > b,g
4 - 8	33.576 **	0.52	m,w > b,g
8 - 16	30.160 **	0.50	m,w > b,g
16 - 32	23.951 **	0.44	m > g,w > b
32 - 64	9.250 **	0.23	m > b,g,w
64 - 128	6.957 **	0.19	b > m,w
128 - 256	10.894 **	0.26	b,g > m; b > w
> 256	4.397 *	0.13	b > m

* p < .05, ** p < .001
b=boys, g=girls, m=men, w=women

It is important to keep in mind that although image standardization is commonly used in visual perception studies to unconfound the effect of low-level visual processing, a potential problem is that making the image-set more homogenous could reduce the number of cues available for discriminating sex and age (e.g., color, which normally is darker for adult male faces). If so, image standardization of, for instance, infant images could diminish their potential for eliciting emotional responses by reducing the salience of one or another of the characteristic infant features.

Face Ratings

Along with computer graphic processing and image statistics, faces were rated by independent judges on dimensions known to affect face recognition and attention, such as attractiveness, distinctiveness, masculinity/femininity, arousal, valence, and dominance (e.g., Lang, Bradley, & Cuthbert, 2008). Some of these ratings were collected to confirm that faces retained their age, sex, and affective characteristics after standardization; other ratings were collected to confirm that faces elicited some of the known effects in the face recognition task, such as distinctiveness (see Chapter 5).

Study 3

Valence, Arousal, and Dominance Ratings

The purpose of Study 3 was to collect valence, arousal and dominance ratings. *Valence* is understood as the dimension that distinguishes positive (pleasant) from negative (unpleasant) emotional states, *arousal* distinguishes highly exciting states from relaxed states, and *dominance* distinguishes situations of being in control from situations of being dominated.

Although valence and arousal have received more study, dominance ratings were included, since they are part of the rating system of the International Affective Pictorial

System or IAPS (Lang et al., 2008), one of the most widely used sets of pictorial stimuli in studies that examine how emotion affects cognition (e.g., memory).

Subjects

The subjects, 100 women (mean age = 20.31, *SD* = 1.57 years) and 40 men (*M* = 20.9, *SD* = 2.27 years), all Michigan State University undergraduates, participated for course credit. The sample included 107 Whites (74 women), 19 Blacks or African Americans (14 women), 2 Hispanic or Latino women, 9 Asians (7 women), 1 Native Hawaiian or Other Pacific Islander woman, and 2 women with "Other" ethnicity. Three women and one man reported having 1 child; the rest of the subjects reported being childless.

Procedure

Ratings were collected through an online study that used the Self-Assessment Manikin or SAM (Lang, 1980). It consists of three series of figures that illustrate the intensity of the emotional dimensions valence, arousal, and dominance. The valence dimension is measured with figures that range from happy (9 = "positive") to unhappy (1 = "negative") as shown by facial expression; in arousal, from excitement (9 = "high arousal") to relaxed (1 = "low arousal"), as shown by open vs. closed eyes and by "activity" in the mid-body; and in dominance, from 1 = "dominated" to 9 = "in control," as shown by overall size. Examples of each dimension are shown in Figure 1.

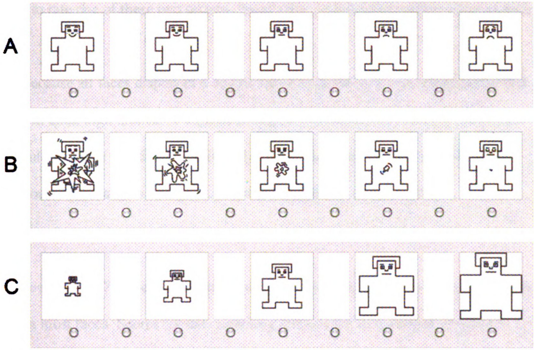

Figure 1. The Self-Assessment Manikin (SAM) Used to Acquire Ratings of (A) Valence, (B) Arousal, and (C) Dominance (Lang et al., 2008). Images were obtained from PXlab website (Irtel, 2007) [Note: Dominance images are not identical to the original scale].

Subjects were first told how to use the SAM scales followed by a surprise quiz to ensure that they understood (only those who answered the quiz correctly were allowed to continue; otherwise, they were given the instructions again and then re-tested). Subsequently, on each trial, subjects were first shown the message, "Get ready to rate the next face" (presented for 150 ms), which then was replaced by a face (presented for 5000 ms), and then was followed by the SAM scales (presented until the subject responded).

To minimize fatigue effects, the total pool of 96 faces was pseudo-randomly divided into two groups, each group containing the same number of faces from each sex-age category (i.e., 12 boys, 12 girls, 12 men, 12 women), and subjects were randomly assigned to rate one of these two groups. Faces were presented in random order to each subject.

Because all faces displayed a neutral facial expression, it was not expected that they would elicit high arousal or valence ratings; it was expected, however, that infant faces would be more emotionally salient than adult faces and therefore would receive higher arousal and valence ratings (e.g., Brosch, Sander, & Scherer, 2007).

Results

Scores from 7 subjects (6 women) were removed because they failed to provide ratings on most faces. Scores for the remaining subjects are summarized in Table 7.

Table 7. Means and (Standard Deviation) for Valence, Arousal, and Dominance Ratings for Each Face Category by the Sex of the Subject

Face	Valence		Arousal		Dominance	
Category	Men	Women	Men	Women	Men	Women
Boys	5.37 (0.70)	5.20 (0.47)	5.20 (1.19)	5.31 (1.17)	5.13 (0.65)	4.77 (0.52)
Girls	5.30 (0.41)	5.33 (0.41)	4.77 (0.68)	4.89 (0.89)	4.63 (0.73)	4.36 (0.53)
Men	3.97 (0.51)	4.55 (0.47)	4.92 (0.71)	4.85 (0.71)	3.96 (0.57)	3.79 (0.47)
Women	4.22 (0.33)	4.58 (0.35)	5.19 (0.71)	4.98 (0.69)	4.29 (0.47)	3.81 (0.40)

Valence ratings were examined with a mixed-design ANOVA with sex of the subject (male, female) as a within-subjects factor and sex (male, female) and age (infant, adult) of the face as between-subjects factors. The analysis showed a main effect for age of the face, $F(1,92) = 136.30$, $p < .001$, $\eta_p^2 = .60$, indicating that infant faces received higher valence ratings ($M = 5.30$, $SD = 0.45$) than adult faces ($M = 4.33$, $SD = 0.36$). A main effect for sex of the subject, $F(1,92) = 18.11$, $p < .001$, $\eta_p^2 = .16$, showed that women's ratings were higher ($M = 4.92$, $SD = 0.55$) than men's ($M = 4.71$, $SD = 0.80$). This effect was qualified by a significant interaction between sex of the subject and the age of the face, $F(1,92) = 31.92$, $p < .001$, $\eta_p^2 = .26$, showing that although women's and men's valence ratings for infant faces were similar, for adult faces men's ratings were lower than women's. All other main effects and interactions were not significant (all p values > .05).

Similarly, arousal ratings were examined with a mixed-design ANOVA with sex of the subject (male, female) as a within-subjects factor and sex (male, female) and age (infant, adult) of the face as between-subjects factors. The analysis showed that men's and women's ratings across face categories were not significantly different from each other, $F(1,92) = 0.87$, $p = .77$. However, as indicated by a small but significant interaction between sex of the subject and age of the face, $F(1,92) = 8.11$, $p = .005$, partial $\eta_p^2 = .08$, women gave higher arousal ratings to infant faces than to adult faces and men did the reverse. All other main effects and interactions were not significant (all p values > .05).

Finally, dominance ratings were examined with a mixed-design ANOVA with sex of the subject (male, female) as a within-subjects factor and sex (male, female) and age (infant, adult) of the face as between-subjects factors. The analysis showed a main effect for sex of the subject, $F(1,92) = 39.23$, $p < .001$, $\eta_p^2 = .3$, indicating that, across faces, men felt more dominant ($M = 4.5$, $SD = 0.75$) than women ($M = 4.18$, $SD = 0.63$). There was also a main effect for age of the face, $F(1,92) = 56.98$, $p < .001$, $\eta_p^2 = .38$, with subjects feeling more dominant when judging infant faces (M = 4.72, SD = 0.59) than adult faces (M = 3.96, SD = 0.43). There also was a small interaction between sex and age of the face, $F(1,92) = 9.89$, $p = .002$, $\eta_p^2 = .09$, indicating that subjects felt more dominant when judging boys' faces than girls' faces, whereas for adult faces, subjects felt slightly more dominant when judging women's faces than men's faces. All other main effects and interactions were not significant (all p values > .05).

It is difficult to make a meaningful comparison between the results of these ratings and the normative ratings on the AIPS because the images in the AIPS and the faces used in this dissertation were not standardized in the same way and because not all face categories are represented in the IAPS (e.g., there are no suitable images of White women with neutral facial expression). In addition, subjects rating IAPS images are exposed to a much wider variety of emotional content (e.g., images of mutilated bodies and erotic images). Nonetheless, a sample of images from the IAPS was selected to compare with some of the ratings. Images were of 9 infants with relative neutral expression and 4 images of men with neutral expression. The normative values given to those images by men and women in the IAPS were extracted, and 3 mixed-design ANOVAs were conducted to compare the ratings for valence, arousal, and dominance. Table 8 summarizes the results.

Table 8. Means and (Standard Deviations) of Valence, Arousal, and Dominance Ratings by Face Category and Sex of the Subject

	Valence		Arousal		Dominance	
Face category	Men	Women	Men	Women	Men	Women
Infants (n = 9)	8.01 (0.62)	6.97 (0.74)	4.79 (0.55)	4.08 (0.44)	6.82 (0.51)	6.46 (0.66)
Male (n = 4)	4.71 (0.17)	5.63 (1.16)	2.65 (0.37)	4.10 (0.61)	5.84 (0.59)	5.59 (0.71)

The analysis showed that across faces, men and women had similar valence ratings, $F(1,11) = 0.13, p = .73$; however, a significant interaction between sex of subject and age of the face, $F(1,11) = 31.08, p < .001, \eta_p^2 =.74$, showed that men's ratings were more dissimilar for infant and adult faces than women's ratings. Valence ratings also were higher for infant faces, $F(1,11) = 33.81, p < .001, \eta_p^2 = .76$.

For arousal, women gave higher ratings than men, $F(1,11) = 4.82, p = .051, \eta_p^2 = .31$. In addition, a significant interaction between sex of subject and age of the face, $F(1,11) = 40.73$, $p < .001, \eta_p^2 = .79$, showed that men's ratings were more dissimilar for infant and adult faces than women's. Finally, arousal ratings were higher for infant faces, $F(1,11) = 18.00, p =.001, \eta_p^2 = .62$.

For dominance, men and women gave similar ratings, $F(1,11) = 1.78, p = .21$; they also reported feeling more dominant when looking at infants' faces than men faces, $F(1,11) = 10.76, p = .007, \eta_p^2 = .49$.

Thus, there are some similarities in the overall pattern of ratings between the IAPS and the standardized face stimuli used in this dissertation, with infant faces receiving higher ratings across dimensions. This result is similar to the results of another study (Brosch et al., 2007). However, in the current study (Study 3), although infant faces received higher arousal ratings, the difference was not significant.

Study 4

Masculinity/femininity, Attractiveness ratings

Attractiveness can affect attention because attractive faces are looked at longer than less attractive faces (Aharon et al., 2001; Landolt, Lalumiere, & Quinsey, 1995), and more often induce covert shifts of attention (Sui & Liu, 2009). Because the masculinity-femininity dimension is an important component of facial attractiveness (Rhodes, 2006), in Study 4, ratings also were collected on attractiveness and masculinity-femininity of faces.

Subjects

Forty-nine women (Mean age = 19.94, *SD* = 1.66 years) and 46 men (*M* = 20.37, *SD* = 2.22 years), all Michigan State University undergraduates, participated for course credit. The sample included 74 Whites (34 women), 7 Black or African American women, 3 Hispanic or Latinos (1 woman), 8 Asians (5 women), and 1 American Indian or Alaska Native man, 1 Native Hawaiian or Other Pacific Islander woman, 1 woman who reported "Other" for ethnic background. All subjects were childless.

Procedure

Subjects rated the attractiveness of each face on a 7-point scale from 1 = "very unattractive" to 7 = "very attractive", and rated the femininity/masculinity on a 7-point scale from 1 = "very feminine" to 7 = "very masculine".

The procedure was identical to the one used for valence, arousal, and dominance ratings, except that instead of the Self-Assessment Manikin scales, subjects saw and answered, after each face, the attractiveness and masculinity scales.

Results

Average ratings are summarized in Table 9.

Table 9. Mean and (Standard Deviations) of Attractiveness and Masculinity Ratings by Face Category and Sex of Subjects

	Men		Women	
Face category	Attractiveness	Masculinity	Attractiveness	Masculinity
Boys	3.92 (0.48)	4.15 (0.43)	4.33 (0.71)	4.14 (0.62)
Girls	3.87 (0.52)	4.00 (0.46)	4.28 (0.72)	4.03 (0.47)
Men	3.57 (0.49)	5.95 (0.40)	3.89 (0.72)	6.11 (0.41)
Women	3.51 (0.70)	2.74 (0.59)	3.65 (0.80)	2.56 (0.62)

Attractiveness ratings were examined with a mixed-design ANOVA with sex of subject (male, female) as a within-subjects factor and sex (male, female) and age (infant, adult) of face as between-subjects factors. The analysis showed a main effect for sex of subject, $F(1,92) = 57.02$, $p < .001$, $\eta_p^2 = .38$, indicating that women gave higher attractiveness ratings ($M = 4.04$, $SD = 0.78$) than men ($M = 3.72$, $SD = 0.57$). A small interaction between sex of subject and age of face, $F(1,92) = 4.68$, $p = .033$, $\eta_p^2 = .05$, indicates that men's and women's ratings were slightly more similar for adult faces (men: $M = 3.54$, $SD = 0.60$; women: $M = 3.77$, $SD = 0.76$) than for infant faces (men: $M = 3.90$, $SD = 0.49$; women: $M = 4.31$, $SD = 0.71$). A main effect of age of face, $F(1,92) = 12.50$, $p = .001$, $\eta_p^2 = .12$, showed that infant faces received higher ratings ($M = 4.1$, $SD = 0.56$) than adult faces ($M = 3.66$, $SD = 0.66$). All other main effects and interactions were not significant (all p values > .05).

Masculinity ratings were also analyzed with a mixed-design ANOVA with sex of subject (male, female) as a within-subjects factor and sex (male, female) and age (infant, adult) of face as between-subjects factors. The analysis showed that there was not a significant main effect for sex of subject, $F(1,92) = 0.01$, $p = .92$; that is, women and men gave similar masculinity ratings in general. However, a small interaction between sex of face and sex of subject, $F(1,92) = 5.44$, $p = .022$, $\eta_p^2 = .06$, indicated that men gave slightly higher ratings for female faces (men: $M = 3.37$, $SD = 0.83$; women: $M = 3.30$, $SD = 0.92$) but did the reverse for male faces (men: $M = 5.05$, $SD = 0.99$; women: $M = 5.13$, $SD = 1.12$). An additional small interaction between sex of subject and sex and age of face, $F(1,92) = 8.47$, $p = .005$, $\eta_p^2 = .08$, indicated that although men and women gave similar ratings for boys' and girls' faces, for women's faces, men gave slightly higher masculinity ratings than women did, and for men's faces, women gave slightly higher ratings than men did (see Table 9).

A small effect of age of face, $F(1,92) = 7.06$, $p = .009$, $\eta_p^2 = .07$, showed that adult faces received higher ratings than infant faces (adults: $M = 4.34$, $SD = 1.78$; infants: $M = 4.08$, $SD = 0.47$). Most of the variance was accounted for, as expected, by the main effect of sex of the face, $F(1,92) = 319.89$, $p < .001$, $\eta_p^2 = .78$, with male faces receiving higher masculinity ratings ($M = 5.09$, $SD = 1.05$) than female faces ($M = 3.33$, $SD = 0.86$), and by an interaction between sex of face and age of face, $F(1,92) = 273.83$, $p < .001$, $\eta_p^2 = .75$, with infant faces receiving similar masculinity ratings (boys: $M = 4.14$, $SD = 0.5$; girls: $M = 4.01$, $SD = 0.45$) whereas adult faces did not (men: $M = 6.03$, $SD = 0.38$; women: $M = 2.65$, $SD = 0.58$).

In sum, although face standardization removed cues used in sex recognition (e.g., hair, color), the faces retained a sufficient number of features that identified them as male or female, which allowed subjects to correctly perceive higher levels of masculinity for male faces than for female faces. In addition, the analyses confirmed that male and female faces did not differ significantly in attractiveness, thereby minimizing possible attractiveness effects in how people respond to adult faces in Studies 6 and 7.

Study 5

Distinctiveness and sex identification

Because Study 6 includes a face recognition task and because distinctiveness affects face recognition (e.g., Cohen & Carr, 1975; Going & Read, 1974; Valentine & Bruce, 1986), in Study 5, the faces' distinctiveness ratings were collected to control statistically for this variable. According to face space models of face recognition (Valentine, 1991), this effect is produced by our knowledge (experience) with a population of faces. Individual faces are understood as points, normally distributed in a Euclidean multidimensional space defined by various physiognomic features used to encode faces (e.g., nose size, face shape, race). Typical faces are more commonly encountered and closer to the central tendency of the normal distribution, while distinctive faces are more distant and infrequent. A typical face therefore is harder to remember because it is encoded in a space with a high density of points, making it harder to distinguish from other points, whereas atypical faces are encoded in a region with a lower density of points, and therefore can be recognized more accurately and faster. For instance, caricatures, which exaggerate the distinctive features of faces, are more easily recognized than the original faces (e.g., Benson & Perrett, 1991; Rhodes, Brennan, & Carey, 1987).

In addition, although masculinity/feminity ratings are a close approximation of how people perceive the sex of faces, the two judgments are not identical (e.g., Hoss, Ramsey, Griffin, & Langlois, 2005), since male and female faces can each have different levels of masculinity/femininity. Therefore, in Study 5, subjects also were asked to classify the sex of the face to ensure that, for instance, a male face was perceived as a man and not as a women with high levels of masculinity.

Subjects

Eighty-four women (mean age = 19.67, *SD* = 1.32 years) and 88 men (*M* = 19.49, *SD* = 1.21 years), all undergraduate students at Michigan State University, participated for course credit. The sample included 147 Whites (71 women), 16 Black or African Americans (11 women), 7 Asians (1 woman), 1 American Indian or Alaska Native woman, and 1 man who reported "Other" for ethnic background. Two of the women had children.

Procedure

Ratings were collected following a similar procedure to the one used in the other-face ratings, except that after each face was presented, a distinctiveness and a sex-classification scale appeared.

The distinctiveness scale was adapted for the age of the face, since, for instance, an infant face could be more distinctive in a row of adults. For each adult face subjects were asked, "How easy it is to spot this face in a crowd of adults?", and for each infant face, "How easy it is to spot this face in a crowd of babies?" Subjects responded on a 7-point scale from 7= "very easy" to 1 = "very difficult".

For sex classification, subjects were asked, “Is this face male or female?”, where 1= “male”, 0= “female”.

Results

Distinctiveness and sex scores for each face were averaged across subjects according to the sex of the subject. Table 10 summarizes the results by each face category.

Table 10. Mean (and Standard Deviation) of Distinctiveness Ratings and Sex Classification Scores for Each Face Category by Sex of the Subject

	Men		Women	
Face category	Distinctiveness	Sex	Distinctiveness	Sex
Boys	3.91 (0.36)	0.63 (0.21)	3.93 (0.43)	0.68 (0.24)
Girls	3.77 (0.48)	0.54 (0.17)	3.78 (0.50)	0.57 (0.23)
Men	4.68 (0.35)	0.97 (0.04)	4.52 (0.38)	0.97 (0.04)
Women	4.35 (0.43)	0.11 (0.15)	4.36 (0.40)	0.08 (0.14)

Distinctiveness and sex ratings were examined in separate mixed-design ANOVAs, with sex of subject (male, female) as a repeated-subjects factor and sex of face (male and female) and age of face (infant and adult) as between-subjects factors.

For distinctiveness ratings, there was a main effect of sex of face, $F(1,92) = 6.14$, $p = .015$, $\eta_p^2 = .06$, showing that male faces in general received slightly higher distinctiveness scores. There was also a main effect of age of face, $F(1,92) = 62.08$, $p < .001$, $\eta_p^2 = .4$, showing that adult faces received higher distinctiveness ratings than infant faces. Men’s and women’s ratings were not significantly different from each other, and all other interactions were not significant.

For sex ratings, the analysis showed a main effect of sex of face, $F(1,92) = 215.24$, $p < .001$, $\eta_p^2 = .70$, indicating, as expected by how the scale was scored, that male faces received higher sex scores than female faces. There also was a main effect of age of face, $F(1,92) = 5.15$, $p = .025$, $\eta_p^2 = .05$, indicating that adult faces received lower scores ($M = 0.53$, $SD = 0.45$) than infant faces ($M = 0.61$, $SD = 0.21$). There was no main effect of sex of subject, $F(1,92) = 1.63$, $p = .21$, indicating that, in general, men and women gave similar scores. The analysis also showed an interaction between sex of face and age of face, $F(1,92) = 135.96$, $p < .001$, $\eta_p^2 = .60$, indicating that adult faces have more dissimilar sex scores (men: $M = 0.97$, $SD = 0.04$; women: $M = 0.09$, $SD = 0.14$) than infant faces (boys: $M = 0.66$, $SD = 0.22$; girls: $M = 0.56$, $SD = 0.19$). In addition, there was an interaction between age of face and sex of subject, $F(1,92) = 9.00$, $p = .003$, $\eta_p^2 = .09$, indicating that women gave slightly higher sex scores to infant faces ($M = 0.63$, $SD = 0.24$) than men ($M = 0.59$, $SD = 0.19$), but for adult faces, woman ($M = 0.52$, $SD = 0.46$) and men ($M = 0.54$, $SD = 0.45$) gave similar sex scores. No other interactions were significant or approached significance.

Sex discriminability was calculated for each subject with *A '*, a bias-free (i.e., it controls for a possible tendency of guessing one sex over another when unsure) measure of discriminability, like *d'*, except that it also can be computed when subjects have hits or false alarms of 1 or 0. *A '* of 0.5 indicates chance performance and values closer to 1 indicate higher discriminability. *A '* was computed by arbitrarily defining "hits" as the response "male" for male faces, and "false alarms" as the response "male" for female faces. Average scores are summarized in Table 11.

Table 11. Means and (Standard Deviations) of A' and B'' Scores for Sex Classification of Infant and Adult Faces by Sex of Subject

Measure	Men: Infant faces (n=71)	Men: Adult faces (n=72)	Women: Infant faces (n=74)	Women: Adult faces (n=74)
A'	0.57 (0.16)	0.96 (0.04)	0.59 (0.15)	0.97 (0.04)
B''	-0.06 (0.16)	-0.43 (0.59)	-0.12 (0.19)	-0.36 (0.71)

Four two-tailed one-sample t-tests showed that both men and women had *A'* scores significantly above chance, that is, higher than 0.5 (Men: infant faces, $t(70) = 3.68$, $p < .001$, adult faces, $t(71) = 90.02$, $p < .001$; Women: infant faces, $t(73) = 5.29$, $p < .001$, adult faces, $t(73) = 110.51$, $p < .001$).

A mixed design ANOVA with age of face (infant, adult) as a within-subjects factor and sex of subject (male, female) as a between-subjects factor, showed a main effect of age of face, $F(1, 143) = 895.11$, $p < .001$, $\eta_p^2 = .86$, indicating that subjects were better at correctly discriminating the sex of adult faces than the sex of infant faces. Neither sex of subject, $F(1, 143) = 1.12$, $p = .292$, nor its interaction with age of face, $F(1, 143) = 0.18$, $p = .674$, were significant, indicating that for both adult and infant faces, women and men had similar sensitivities.

Response biases were calculated for each subject with *B''* and are summarized in Table 11. *B''* values range from -1 to 1, where 0 indicates no response bias (i.e., no more likely to guess "male" or "female") values greater than 0 indicate a conservative bias (i.e., more willing to guess "female") and values lower than 0 indicate a liberal bias (i.e., more willing to guess "male"). For adult faces, 45 subjects (25 women) had perfect scores so their *B''* were assumed to be 0.

Four one-sample two-tailed t-tests showed that both men and women had biases to classify faces as males when uncertain, that is, their scores were significantly lower than 0 (for men: infant faces, $t(70) = 3.03$, $p = .003$, adult faces, $t(71) = 6.26$, $p < .001$; for women: infant faces, $t(73) = 5.15$, $p < .001$, adult faces, $t(48) = 5.3$, $p < .001$).

A mixed design ANOVA with age of face (infant, adult) as a within-subjects factor and sex of subject (male and female) as a between-subjects factor showed a main effect of age of face, $F(1, 143) = 36.65$, $p < .001$, $\eta_p^2 = 0.20$, indicating that subjects had a stronger guessing bias for adult faces. Neither sex of subject, $F(1, 143) = 0.006$, $p = .937$, nor its interaction with age of face, $F(1, 143) = 1.48$, $p = .225$, were significant, indicating that for both adult and infant faces, women and men had similar guessing biases. The stronger guessing bias for adult faces, however, must be interpreted with caution because most subjects performed at ceiling for adult faces; any small false alarms therefore will produce high *B''* (e.g., subject 104 had a hit rate of .416 and a false alarm of .583 for infant faces and a hit rate of 1 and false alarm of .083 for adult faces, which led to a *B''* close to 0 for infant faces but a value of -1.0 for adult faces). An alternative way of dealing with hit rates of 1 or false alarms of 0 is to add a flattening constant of .5 and then compute *C* (a more commonly used measure of bias). This method showed again significant biases to guess “male” for each face category: the bias, however, was higher for infant faces than adult faces.

The analysis also showed that one woman’s face was problematic because it tended to be classified as male (i.e., sex classification responses were coded as 1 for male responses and 0 for female responses, and the mean sex score for this face was .66 for men and .67 for women). It also received the highest masculinity scores among women.

In general, however, the ratings for faces drawn from the face-database are comparable to several findings in the face research literature, namely, that subjects reacted to our face stimuli in ways similar to how other subjects have reacted to other face sets. For instance, the bias to respond "male" has also been found with adults' and children's faces for both adult and child subjects (Cheng, O'Toole, & Abdi, 2001; Rossion, 2002; Wild et al., 2000). The same has been found for infant faces (Hildebrandt & Fitzgerald, 1977; Nagy, Németh, & Molnár, 2000). Thus, even though several dimensions of the faces were standardized (e.g., removal of hair) and a relatively narrow range of variability was chosen (e.g., attractiveness and emotional expressions), the faces conserved many of the properties of natural (unprocessed) faces.

Chapter 5: Study 6 -- Individual Differences in Visual Processing of Infant and Adult Faces

Visual attention and eye-movements

Because visual acuity declines abruptly outside the fovea, our eyes move continuously, in the form of discrete saccades, across visual stimuli so that, with each fixation, we can extract fine detailed information from the visual array, information that we then encode into short- and long-term memory (Henderson, 2007). Although attention and fixation can be dissociated, as demonstrated in the laboratory (e.g., Posner, 1980), in everyday life they are tightly linked (e.g., Corbetta et al., 1998; Findlay & Gilchrist, 2003; Henderson, 2003, 2007; Shepherd, Findlay, & Hockey, 1986). As we move our eyes, our attention is directed to the location of the current fixation and to the location of the next fixation (Henderson, 2007; van Diepen & d'Ydewalle, 2003). Such patterns of saccades and fixations are determined by a complex interaction of top-bottom and bottom-up processes, consisting of the physical properties of the visual world, such as color and spatial frequency, and cognitive factors, such as our knowledge, experience, and intentions (Becker, Pashler, & Lubin, 2007; Torralba, Oliva, Castelhano, & Henderson, 2006; Yarbus, 1967). The study of eye movements, therefore, provides a window into how we perceive and represent visual information in real time.

In general, the location and duration of a fixation tend to cluster in the more interesting and informative regions of the visual stimuli, such as regions with high spatial frequency or regions that are semantically relevant for a given task (Henderson, 2003). Thus, regions recruiting more and longer fixations are assumed to receive more cognitive processing (Rayner, 1998) and, in turn, to affect how visual stimuli are represented and remembered (Henderson, Williams, & Falk, 2005).

Eye movements also can be used to study individual differences, since eye movement studies have found reliable individual differences in complex visual tasks (e.g., Andrews & Coppola, 1999; Castelhano & Henderson, 2008; Rayner, Li, Williams, Cave, & Well, 2007). For example, in a free-viewing task, persons more interested in infants might be expected to look at infant images more often and for longer periods of time, and even, perhaps, to fixate on certain facial features relatively longer. To the extent that such persons attend more to infant images, they may also be able to remember them better.

The goal of Study 6 was to find out whether individual differences in interest in infants is associated with differential exploratory oculomotor behavior for faces of different ages (infants vs. adults) and different sexes (male vs. female). Although it is possible that adult and infant faces elicit distinctive oculomotor responses from people with different interest in infants, the direction of the effect may be task-specific. Thus, on free-viewing tasks, people with more interest would be expected to fixate longer and more often on infant faces than adult faces; on other more cognitively-demanding-tasks, however, such as memory tasks, the direction of the effect may be diminished or even reversed. For instance, if infant faces are more salient to people with more interest in infants, it is possible that the greater salience will facilitate processing efficiency, so that infant faces will require fewer and/or briefer fixations for them to be remembered.

Study 6 was designed to test this hypothesis by examining subjects' eye movements while they performed a free-viewing task of several pairs of faces, one of an adult, one of an infant (the design, therefore, assumes that both stimuli are competing for attentional resources). Subjects then were given the interest-in-infants and other questionnaires, and a face-recognition test. The prediction was that people with more interest in infants will show more fixations, longer viewing durations, and have higher recognition scores for infant faces than people less interested in infants.

Subjects

The subjects were 32 men (mean age = 19.38, SD=1.18) and 31 women (M=19.29, SD = 1.68 years), all undergraduates at Michigan State University, who participated for course credit. All were White and reported having normal or corrected to normal vision. None were parents, and 1 woman reported that she was expecting a child. The sample was selected from a slightly larger sample (69 subjects) based on their descriptions of their sexual feelings and sexual fantasies on two 7-point Kinsey scales (Kinsey, 1948). The 63 selected reported being completely heterosexual (N=58) or predominantly heterosexual (N=5). The intent was to simplify the interpretation of any potential differences in the attentional effects of same vs. opposite-sex-adult faces.

Procedure

The study was divided in three parts. In the first part (free-viewing task), subjects saw a sequence of pairs of adult and infant faces while their eye movements were recorded. In the second part (delay period), subjects answered a series of self-report questionnaires. In the third part (face recognition), subjects' memory for the faces they saw in the free-viewing task was tested. All testing was performed in dimly lit, sound-attenuated booths.

Free-viewing Task. In the free-viewing task, subjects' eye movements were monoculary recorded at a sampling rate of 500Hz using the head mounted video-based eye tracking system EyeLink II (SR Research Ltd., Mississauga, Ontario, Canada). Before starting the experimental trials, the manufacturer's procedures were used to calibrate the eye tracker and to validate the eye positions. For calibration, subjects were asked to fixate on a sequence of 9 points that appeared at different locations in the display; the eye tracker was adjusted if necessary until the average tracking error was less than 0.4 degrees of visual angle. The validation procedure assessed the accuracy of the system in predicting gaze position from pupil position using an identical random sequence of 9 points in the display. Once the eye positions were validated, subjects were shown the sequence of faces. Throughout the eye tracking part of the study, measurement accuracy was reassessed before each trial by asking subjects to fixate on a dot in the center of the screen. If accuracy was low, the eye tracker was recalibrated.

Subjects were told that "we are interested in learning about how people look at faces. You will see a series of pairs of faces while we record your eye movements. You do not have to do anything, just look freely at the faces and the program will change the pictures every 6 seconds."

Subjects saw a sequence of 24 pairs of faces, each consisting of one adult face (a man or woman) and one infant face (a boy or girl). To minimize face-specific-effects (e.g., that certain faces, independent of age, are more visually salient), adult and infant faces were randomly paired and randomly presented to each subject. For each pair, one face ($\sim 8^{o}$ X 10.5^{o}) was shown 6.5^{o} above the fixation point, the other 6.5^{o} below fixation. These locations were chosen to minimize any possible confound with known laterality effects for emotional stimuli; that is, emotional stimuli tend to be more salient in the left visual hemispace (e.g., Borod, Zgaljardic, Tabert, & Koff, 2001). This decision, however, also led to discarding pupilometry as a measure of interest in infants because of the substantial error associated with the use of head-mounted systems, namely, larger average pupil size for fixations at the bottom than at the top of the screen (Pomplun, Sunkara, Fairley, & Xiao, n.d.).

Each face pair was presented for 6 s, meaning that each face could be looked at for 3 s, assuming that subjects divided their looking times equally between the members of a pair (3 s also is comparable to the presentation time given in other face recognition studies; e.g., Hsiao & Cottrell, 2008). It was assumed that limiting the presentation time to 3 s per face made the face recognition task difficult, and that a difficult task was more likely than an easy task to show individual differences. The images display location (above or below fixation), age (adult or infant) and sex (male or female) were counterbalanced across the 24 trials.

The stimuli were presented on a 19.7-inch CRT monitor placed 30 cm from the subject. The display resolution was set to 1024 x 768 pixels with a refresh rate of 85 Hz. Subjects completed this part of the study in about 10 minutes.

Delay Period. During the delay period, subjects answered all questionnaires: Demographics, Self-Perceived Mate Value, Sexual Orientation Inventory-Revised, Interest in Infants, Desire for Parenthood. The questionnaires were presented in the same order for all subjects in a computer station adjacent to the eye-tracker station, and were told to answer them at their own pace. This part was completed in about 13 minutes.

Face Recognition. In the test phase, subjects were shown the 48 faces presented in the free-viewing task plus 48 foils. To further minimize face-effects, faces were divided into two sets, with the study set for half the subjects corresponding to the foils for the other half.

The test phase began 20 minutes after the free-viewing task was completed. Faces were presented individually in random order. Subjects were instructed to press "Y" if they had seen the face and to press "N" if they had not, and to respond as quickly and accurately as possible. Each trial began with the presentation of a central fixation cross, for 1000 ms, followed by a face, which remained on the screen until the subject responded. This part of the study was completed in about 5 minutes.

Results

Questionnaires

Interest in Infants. The interest in Infant questionnaire showed good internal consistency for both sexes (men: $\alpha = .91$; women: $\alpha = .95$). Women's scores ($M = 5.46$, $SD = 0.98$) were higher than men's ($M = 4.73$, $SD = 0.82$) as shown in a two-tailed independent samples Welch t-test, $t(58.58) = 3.23$, $p = .002$.

Job Preference Questionnaire. Preference ratings were examined with a mixed-design ANOVA with job type (infant care, other jobs) as a within-subjects factor and sex of subject (male, female) as a between-subjects factor. The analysis showed that the main effect of job type was not significant, $F(1,61) = 0.64$, $p = .427$, mostly because of women's and men's similar preferences for non-infant-care jobs (Men: $M = 4.28$, $SD = 0.80$; Women: $M = 4.15$, $SD = 0.77$). On the infant-care job, however, women's preferences (M = 5.29, SD = 1.87) were higher than men (M = 3.5, SD = 1.93) as indicated by the significant interaction between job type and sex, $F(1,61)$= 17.93, $p <$ .001, $\eta_p^2 = .23$.

Interaction with Infants. The results of the Interaction with Infants questionnaire are summarized in Table 12. In general, the questionnaire showed good internal consistency for both sexes. The only scale with reliability lower than the standard figure of 0.7 was, for women, the subscale of interaction when the infant's emotional state was negative. Because the departure from the standard was minimal, the subscale was included in the multivariate analysis.

Table 12. Descriptive Statistics and Sex Differences of the Interaction with Infants Questionnaire

	Men			Women			Sex difference		
	α	M	SD	α	M	SD	t	df	p
Positive	.88	4.97	1.03	.93	5.99	1.19	3.62	59.117	<.001
Neutral	.88	4.61	1.29	.9	5.65	1.22	3.28	60.96	<.001
Negative	.77	4.33	1.2	.67	5.5	0.88	4.45	56.852	<.001
Total	.92	4.64	1.02	.92	5.71	0.92	4.40	60.686	<.001

Desire for parenthood. The Desire to Have Children questionnaire also showed good internal consistency for both sexes (men: α = .86; women: α = .82). As indicated by a two-tailed independent samples Welch t-test, $t(60.99) = 2.5$, $p = .015$, women had a slightly higher desire to have children (M = 5.24, SD = 1.04) than men (M = 4.57, SD = 1.09).

Self-Perceived Mate Value. The Self-Perceived Mate Value scale showed good internal consistency for both sexes (women: α = 0.94; men: α = 0.91). A two-tailed independent sample Welch t-test showed no significant difference between men (M = 5.04, SD = 1.07) and women (M = 5.09, SD = 1.14), $t(60.47) = 0.16$, $p = .87$.

The Revised Sociosexual Orientation Inventory. Table 13 summarizes the inventory statistics for the Revised Sociosexual Orientation Inventory. The inventory showed good reliabilities on all subscales and significant sex differences, with men scoring higher than women on the total scale as well as on the attitude and desire subscales. These results are comparable to those previously reported for this questionnaire (Penke & Asendorpf, 2008).

Table 13. Descriptive Statistics and Sex Differences of the Sociosexuality Measures

	Men			Women			Sex difference		
	α	M	SD	α	M	SD	t	df	p
Behavior	.86	2.47	1.36	.86	2.05	1.12	-1.35	59.50	=.019
Attitude	.93	5.85	2.36	.87	2.89	1.98	-5.39	59.78	<.001
Desire	.76	5.58	1.74	.84	2.44	1.19	-8.38	54.92	<.001
Total	.85	4.64	1.42	.83	2.46	1.09	-6.82	57.96	<.001

Eye movements

Eye movements were analyzed by creating a region of interest for each face in the display. Three measures of interest were considered: location of first fixation, duration of viewing time for each face, and total number of fixations that each face received.

First fixation location. Since more "attentionally grabbing" objects are more likely to be looked at first, the analysis asked whether the first fixation was to the infant or the adult face. The results showed neither: instead, most subjects looked first at the image located above the fixation point (average proportion of trials for men = .78, and for women = .87).

A multilevel logistic regression therefore was used to examine the probability of subjects looking at the infant image first based on three variables: the image's top-bottom location (0: bottom, 1: top), the pairs shown (boy and man, boy and woman, girl and man, girl and woman), and sex of subject, and the interaction between these variables. A variety of models showed that the only significant predictor (in logits) was whether the image was located on top, $\beta = 2.94$, se = .13, $p < .001$. To further measure the effect of image location, a subsequent analysis was performed with a subsample of 12 subjects (10 men) who did not show a strong bias to look at the top first. None of the models reached statistical significance. Thus, given the strong top-down bias of the first-fixation measure, no further analyses with this variable were conducted.

Total viewing duration for infant faces. The next analysis examined each subject's total viewing duration to infant faces compared to adult faces, and more specifically, how the presence of a given adult face (male or female) affected viewing duration to infant faces. Total viewing duration was defined as the sum of duration scores across all fixations on each face; total duration for infant faces therefore was calculated by subtracting, on each trial, the viewing time for adult faces from the viewing time for infant faces. Thus, longer viewing durations for infant faces are indicated by positive scores, longer viewing durations for adult faces by negative scores.

Table 14 summarizes the mean viewing durations for each condition for men and women separately.

Table 14. Mean and Standard Deviation of Infant Viewing Duration for each Experimental Condition by Sex of Subject

	Men		Women	
Condition	M	SD	M	SD
boy with man	405.13	1318.40	429.80	1203.45
boy with woman	-27.84	995.95	744.93	1014.88
girl with man	716.16	1250.88	346.20	1063.42
girl with woman	-245.62	793.30	407.36	986.80

The average infant viewing duration scores for each condition were analyzed with a mixed-design ANOVA with experimental condition (boy with man, boy with woman, girl with man, girl with woman) as a within-subjects factor and sex of subject (man, woman) as a between-subjects factor. A Mauchly's test showed a violation of the sphericity assumption ($\chi^2(5) = 21.94$, $p = .001$); therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = 0.78$). The results showed a small main effect for condition, $F(2.34, 135.7)= 3.84, p = .018, \eta_p^2 = .062$, indicating that infant viewing varied across conditions, being particularly lower for the girl with woman condition (boy with man: $M = 417.47$, $SD = 1251.55$; boy with woman: $M = 358.54$, $SD = 1070.34$; girl with man: $M = 531.18$, $SD = 1166.08$; girl with woman: $M = 80.87$, $SD = 946.76$). This effect, however, was qualified by an interaction between condition and sex of subject, $F(2.34, 135.7) = 7.6, p < .001, \eta_p^2 = .12$, indicating that men looked longer at the infant faces only when they were paired with an adult male face; when the infant was presented with an adult female face, men look longer at the adult face. Women, on the other hand, had similar infant viewing times across conditions.

Although there was no main effect for sex of subject, $F(1, 58) = 1.44, p = .235$, after removing 3 outliers who were consistently above or below +/- 2.5 SD, there was a small effect of sex, $F(1,55) = 5.73$, $p = .02$, $\eta_p^2 = .09$, with women having longer viewing times than men (men: $M = 135.9$, $SD = 680.51$; women: $M = 510.59$, $SD = 480.61$). The removal of the outliers did not change the significance or direction of the other effects.

Relation between viewing duration for infant faces and image statistics. A series of multilevel regressions were performed to determine whether there was an association between the total viewing duration for infant faces and the image statistics (e.g., area, apparent contrast, spatial frequency). Trials represented the first level in all models while subjects represented the grouping variable.

In all models, differences scores were used as predictors (e.g., the apparent contrast difference between the infant and adult faces was used to predict the total viewing duration for infant faces). None of the image statistics or their interactions with sex and experimental condition reached statistical significance on likelihood ratio tests (all $p > .05$). Therefore, image statistics were not further included in multilevel models.

Relation between total viewing duration for infant faces and questionnaires. Graphic examination of scores showed that two women consistently departed from the mean distribution of scores. These "outliers," however, behaved in the direction predicted: one women, the one who was pregnant, scored high on the interest in infants questionnaire and had very long infant viewing times; the other woman scored low on the questionnaire and had very short infant viewing times. Because these two subjects nevertheless had a significant effect on several of the regression models, it was decided to exclude them from the multivariate analysis in order to better represent the results of the other 29 women in the sample. The 2 "outliers" also suggest the possibility that the sample was affected by a range restriction, at least for women.

A series of multilevel regression models were fitted to the data in order to identify questionnaire variables significantly associated with the total infant viewing duration, that is, above and beyond the already established relationship between experimental condition and sex of subjects. Thus, based on the mixed-model ANOVA, a reference multilevel regression model was defined with infant view duration as dependent variable predicted by condition (boy-man, boy-woman, girl-man, girl-woman), sex of subject, and their interaction. In contrast to the ANOVA analysis, data were analyzed at the trial level (first level) for each subject (subject as grouping second level variable); that is, trial scores were not averaged (without additional covariates, a trial level analysis will not change the results provided by the mixed-design ANOVA).

This first step analysis showed that, compared to the base-model, adding the preference for infant jobs was significant ($\chi^2(1) = 5.54$, $p = .019$), as well as the interaction between preference for infant jobs and the experimental conditions ($\chi^2(3) = 10.63$, $p = .014$), the interaction with preference for infant jobs and sex of subject ($\chi^2(1) = 4.10$, $p = .043$), and the three-way interactions ($\chi^2(3) = 11.94$, $p = .007$). Adding subjects' preference for other non-infant care jobs to the base model ($\chi^2(1) = 0.96$, $p = .326$) or their interactions ($\chi^2(7) = 10.78$, $p = .148$) was not significant.

Adding the Interaction with Infants scores to the base-model was not significant ($\chi^2(1) = 0.45$, $p = .502$); however, adding the interaction between experimental condition and Interaction with Infants questionnaires showed marginal significance ($\chi^2(3) = 7.62$, $p = 0.054$). Finally, adding the behavioral scale of the sexual orientation inventory (SOI-

Behavioral) to the base-model was not significant ($\chi^2(1) = 1.25$, $p = 0.26$), but its interaction with experimental condition was significant ($\chi^2(3) = 13.62$, $p = 0.003$).

A second step in the analysis defined a reference model with infant jobs as a predictor. Adding the interaction-with-infants scores to the model did not significantly improve the model ($\chi^2(1) = 1.46$, $p = .227$) or its interactions ($\chi^2(15) = 12.26$, $p = .659$). Likewise, adding SOI-Behavioral to the model did not significantly improve the model ($\chi^2(1) = 0.30$, $p = .581$) or its interactions ($\chi^2(15) = 18.40$, $p = .242$). Therefore, the final model included only the scores on the preference for an infant care job. The model, a 2-level random-intercepts model in which trials are nested within subjects, is summarized in Table 15. In the model, men and condition 1 (boy-men) are used as the reference categories. To facilitate the interpretation of coefficients, infant job scores were centered at the mean preference for men (therefore unit changes are understood as change above or below the men's mean scores). Figure 2 illustrates the predicted viewing duration for infant faces of subjects with a preference for the infant job equivalent to the average preference of male subjects (average interest) and subjects whose preference is 1 unit above the average preference of male subjects (higher interest).

Table 15. Summary of a 2-level Random-Intercepts Model of Subjects Looking Time Toward Infant Faces

Variable	*b*	*SE*	*t*	
(Intercept)	405.133	157.196	2.577	*
Condition 2	-432.978	179.370	-2.414	*
Condition 3	311.022	179.370	1.734	
Condition 4	-650.756	179.370	-3.628	**
Women	9.454	284.783	0.033	
Condition 2 x Women	826.951	324.954	2.545	*
Condition 3 x Women	-313.118	324.954	-0.964	
Condition 4 x Women	599.172	324.954	1.844	.
Infant job	368.665	83.055	4.439	**
Condition 2 x Infant job	-270.171	94.771	-2.851	**
Condition 3 x Infant job	-68.347	94.771	-0.721	
Condition 4 x Infant job	-390.123	94.771	-4.116	**
Infant job x Women	-360.253	126.062	-2.858	**
Condition 2 x Infant job x Women	227.379	143.844	1.581	
Condition 3 x Infant job x Women	46.337	143.844	0.322	
Condition 4 x Infant job x Women	445.247	143.844	3.095	**

. $p = .06$. *$p < .05$. **$p < .01$.

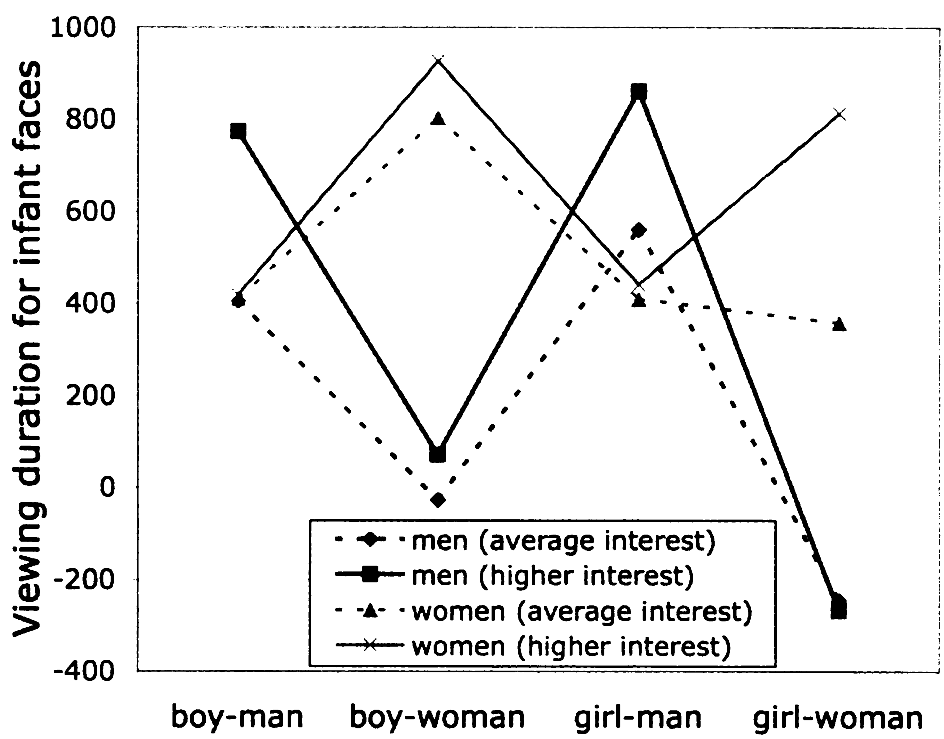

Figure 2. Predicted Viewing Duration for Infant Faces.

The models shows that, as noted in the ANOVA model, men look longer at infants only when their faces are paired with same-sex faces, that is, faces of adult males. Women also look longer when infant faces are presented with same-sex faces (adult female faces), although these changes were not always significant and less pronounced than those shown by men. The coefficients also indicate that the effects of interest in infants (as indicated by scores on the infant job questionnaire) are more evident for men when the infant faces are presented with an adult male face. The effects on self-reported interest in women are modest across conditions, with the exception of condition 4.

Total number of fixations for infant faces. As another indicator of interest, each subject's total number of fixations to infant faces compared to the number of fixations to adult faces was examined on each trial, using a binomial model in which fixations on infant faces were scored as "successes" and fixations on the adult faces as "failures." A multilevel binomial regression with fixations on infant faces as the dependent variable predicted by experimental conditions and sex of the subject, showed a significant effect of experimental conditions ($\chi^2(3) = 17.05$, $p < .001$). There was no main effect of sex of subject ($\chi^2(1) = 3.22$, $p = .07$), but its interaction with experimental conditions was significant ($\chi^2(3) = 42.29$, $p < .001$). The coefficients, summarized in Table 16, show that men were more likely to fixate on the infant face when it was paired with an adult male face. Women, in contrast, were more likely to fixate on the infant face than the adult face in all experimental conditions.

Table 16. Summary of a 2-level Random-Intercepts Model of Subjects' Fixations Toward Infant Faces

Variable	*b*	*SE*	*z*	
(Intercept)	0.109	0.051	2.14	*
Condition 2	-0.179	0.053	-3.35	**
Condition 3	0.112	0.054	2.08	*
Condition 4	-0.221	0.054	-4.12	**
Women	-0.012	0.072	-0.17	
Condition 2 x Women	0.310	0.075	4.14	**
Condition 3 x Women	-0.110	0.075	-1.47	
Condition 4 x Women	0.244	0.075	3.25	*

. $p = .06$. *$p < .05$. **$p < .01$.

Relation between total fixations for infant faces and image statistics. Binomial multilevel regressions were used to determine whether there was an association between the total fixations for infant faces and the image statistics (e.g., area, apparent contrast, spatial frequency). Trials represented the first level in all models while subjects represented the grouping variable. In all models, none of the image statistics or their interactions with sex and experimental condition reached statistical significance on likelihood ratio tests (all p > .05). Therefore, image statistics were not further included in multilevel models.

Relation between total fixations for infant faces and questionnaires. A series of binomial multilevel regression models were fitted to the data in order to identify questionnaire variables significantly associated with the total number of fixations for infant faces that were above and beyond the already established relationship between experimental conditions and sex of subject. A reference model was defined with fixations in infant faces vs. fixations on adult faces as the dependent variable predicted by experimental condition (boy-man, boy-woman, girl-man, girl-woman) and sex of subject, and with subject as a random effect.

Compared to the reference-model, adding the preference for the infant care job almost reached statistical significance ($\chi^2(1) = 3.742$, $p = .053$), but not its interaction with sex of subject ($\chi^2(1) = 2.26$, $p = .132$), with the experimental conditions ($\chi^2(3) = 3.84$, $p = .278$), or the three-way interactions ($\chi^2(3) = 3.17$, $p = 0.366$). Adding subjects' preference for other non-infant-care jobs was not significant ($\chi^2(1) = .09$, $p = .758$). In addition, compared to the reference model, adding the Interaction with Infants scores was not significant ($\chi^2(1) = 0.11$, $p = .742$) and neither was its interaction with sex of subject ($\chi^2(1) = 0.02$, p = .887). However, its interaction with experimental conditions almost reached significance ($\chi^2(3) = 7.68$, p = .053). None of the other questionnaires showed a significant relationship with the number of fixations toward infant faces.

A second step in the analysis combined the effects of preference for the infant care job and the interaction with infant questionnaire. In this model only the preference for infant care job remained a significant predictor. Therefore, the more parsimonious model was chosen and the interaction with infant questionnaire was removed. The model coefficients are summarized in Table 17.

Table 17. Summary of a 2-level Random-Intercepts Model of Subjects' Fixations Toward Infant Faces as Predicted by Their Interest in Infants

Variable	*b*	*SE*	*z*	
(Intercept)	0.108	0.050	2.162	*
Condition 2	-0.179	0.053	-3.351	**
Condition 3	0.112	0.054	2.084	*
Condition 4	-0.221	0.054	-4.119	**
Woman	-0.063	0.075	-0.847	
Infant job	0.029	0.015	1.969	*
Condition 2 x Woman	0.310	0.075	4.141	**
Condition 3 x Woman	-0.110	0.075	-1.464	
Condition 4 x Woman	0.244	0.075	3.252	**

. $p = .06$. *$p < .05$. **$p < .01$.

Along with the already noted effects of experimental condition and its interaction with sex of subject, the models shows that people with a higher preference for the infant job are more likely to fixate more often on the infant face than the adult face.

Face recognition

The face recognition data were first analyzed using traditional methods from signal detection theory (e.g., Stanislaw & Todorov, 1999) by calculating *A'* scores for each subject on each face category (boys, girls, men, women). Data are presented in this form first because it facilitates comparing the results with other face recognition studies and because a multilevel model (without covariates) showed similar results.

A' scores, summarized in Table 18, were analyzed with a mixed-model ANOVA with age of face (adult, infant) and sex of face (male, female) as within-subjects factors, and sex of subject (man, woman) as a between-subjects factor. The analysis showed a main effect of age of face, $F(1,59) = 8.56$, $p = .005$, $\eta_p^2 = .13$, indicating that both men and women have greater signal sensitivity for adult faces ($M = .69$, $SD = .11$) than infant faces ($M = .64$, $SD = .10$). An interaction between sex of the face and age of the face,

$F(1,59) = 11.59$, $p = .001$, $\eta_p^2 = .16$, showed that the effect of age was mostly due to female faces; that is, men and boys' faces showed similar *A'* scores (men: $M = .66$, $SD = .16$; boys: $M = .67$, $SD = .1$), and woman and girls' faces showed very different scores (women: $M = .72$, $SD = .14$; girls: $M = .60$, $SD = .16$). An interaction between age of face and sex of subject, $F(1,59) = 4.29$, $p =.043$, $\eta_p^2 = .07$, showed that, for men, *A'* scores were similar for adult and infant faces (adults: $M = .67$, SD = .1; infants: $M = .65$, $SD =.1$), but for women, adult faces had higher scores than infant faces (adult: $M = .71$, $SD = .1$; infant: $M = .62$, $SD = .11$). Other main effects (sex of subject, sex of face) and their interactions were not significant (all $p > .253$).

Table 18. Mean and Standard Deviation *A'* Scores by Face category and Sex of the Subjects

	Men		Women	
Face	*M*	*SD*	*M*	*SD*
Boys	.68	.11	.66	.10
Girls	.63	.16	.58	.16
Men	.65	.15	.67	.18
Women	.69	.14	.75	.14

To examine whether the experimental condition affected the likelihood that an infant face was recognized (i.e., if recognition changed when the face was paired with a man's face compared to when it was paired with a woman's face, only those trials were examined on which the subject actually saw the face in the free-viewing task. Logistic multilevel regressions showed that neither the main effects of experimental condition

($\chi^2(3) = 7.24$, $p = .065$), sex of subject ($\chi^2(1) = 0.35$, $p = .553$), nor their interaction ($\chi^2(1) = 2.54$, $p = .467$) were significant.

Table 19. Proportion of Trials, by Face Category, in which a Face was Classified as Seen or as a New Face

Response	Boys	Girls	Men	Women
New face	.43	.50	.51	.51
Seen face	.57	.50	.49	.49

A multilevel logistic regression showed that subjects were more likely to classify boy faces as seen faces ($\beta = 0.298$, $z = 3.18$, $p = .001$) than girls' faces ($\beta = -0.298$, $z = -2.70$, $p = 0.007$). The proportion of trials in which a face was classified as seen is shown in Table 19. An additional model showed that adult faces of both sexes, in contrast, were equally likely to be classified as seen ($p > .05$).

Additional multilevel regression analyses assessed whether the distinctiveness of faces (see Chapter 4) will contribute to subjects likelihood of saying "seen" to a given face. The reference model included as predictors whether the face was seen (not-seen as a reference category), the face type (boys as a reference category), and their interaction. The first level included trial variables and the second level included subjects and the variable "seen" as a random slope. Adding distinctiveness significantly improved the model ($\chi^2(1) = 37.59$, $p < .001$) and its interaction with face type ($\chi^2(4) = 41.35$, $p < .001$). The model, summarized in Table 20, shows an effect of distinctiveness, indicating that people are more accurate with more distinctive faces, that is, are less likely to say "not-seen" if a more distinctive face was not seen and to say "seen" if the face was seen.

It also shows, consistent with the average *A'* scores, that subjects are less accurate on girls faces and that the effect of distinctiveness was strongest for more distinctive girl faces. Adding sex of subject or its interaction with other variables did not significantly improve the model (all $p > .05$).

Table 20. Summary of a 2-level Random-Intercepts Model of Subjects' Face Recognition Responses

Variable	*b*	*SE*	*z*	
(Intercept)	-0.779	0.109	-7.182	**
Girls	-0.314	0.139	-2.256	*
Men	0.231	0.154	1.500	
Women	-0.351	0.135	-2.608	**
Seen face	1.113	0.122	9.122	**
Distinctiveness	-0.295	0.091	-3.228	**
Seen face x Distinctiveness	0.403	0.079	5.076	**
Seen face x Girls	-0.182	0.161	-1.127	
Seen face x Men	-0.593	0.191	-3.098	**
Seen face x Women	0.014	0.176	0.079	
Distinctiveness x Girls	-0.339	0.106	-3.199	**
Distinctiveness x Men	-0.036	0.122	-0.297	
Distinctiveness x Women	-0.119	0.113	-1.048	

. $p = .06$. *$p < .05$. **$p < .01$.

Face recognition and oculomotor behavior. The relation between subjects' responses during the face recognition test and oculomotor behavior during the free-viewing task was examined by selecting subjects' responses only for those faces they actually saw in the free-viewing task. Multilevel logistic regression models were used to predict the likelihood that subjects will classify an infant face as seen. Predictors included the number of fixations to the infant face, number of fixations to the adult face, a difference score between these numbers, whether the face was paired with a man's or woman's face, the sex of the subject, and a variety of interactions between these variables. None of these models reached statistical significance (all ps < .05). Similar models were tested that incorporated the viewing duration times, but because these models failed to converge, formal statistical analysis could not be performed.

Similar models were implemented to predict the "recognition" likelihood of adult faces. These models showed that the number of fixations to infant faces ($\chi^2(1) = 4.52$, $p = .033$), to adult faces ($\chi^2(1) = 20.35$, $p < .001$), or a difference score between the two ($\chi^2(1) = 15.31$, $p < .001$), significantly changed the likelihood of subjects reporting that they had seen the adult face in the free-viewing task. For instance, the more fixations made to an infant face compared to an adult face (i.e., a positive difference score), the lower the likelihood that the adult face was classified as seen in the recognition test ($\beta = -0.045$, $z = -3.92$, $p < .001$). Adding the experimental conditions, sex of subject, or their interactions as predictors, did not significantly improve these models (all $p > .05$).

Models that examined the relationship between viewing duration for adult faces and the likelihood of classifying adult faces as seen failed to converge.

Face recognition and questionnaires. The relation between subjects' face recognition and their questionnaire responses was examined by analyzing the likelihood that a subject reported having seen a face based on whether it was presented in the free-viewing task, whether it was an adult or an infant face, its distinctiveness, and the questionnaire response. The focus of this analysis was on the interaction between these factors, that is, whether the recognition of infant faces was affected by the subject's questionnaire score. The results showed that the only questionnaire scores that were related to the dependent variable was the Interaction with Infants questionnaire; however, removing the interaction of Interest with Infants from the model (i.e., whether the Interaction with Infant scores affected the accuracy for recognition of infant faces) did not significantly affect the model ($\chi^2(2) = 1.08$, $p = .582$). Therefore, no further analyses of this relationship were conducted.

Discussion

The results showed that all the three interest-in-infants questionnaires had good psychometric properties and behaved as expected, with women expressing more interest in infants than men as shown by their higher scores on all three questionnaires.

The results also showed that oculomotor behavior could be successfully used to assess individual differences, including sex differences, in interest in infants, as some measures of interest were consistently, and in the predicted direction, associated with oculomotor behavior. Thus, women looked longer at and fixated more often on infant than at adult faces of either sex, whereas men looked longer at, and fixated more often on infant faces only when paired with an adult male face. The two measures of oculomotor behavior, although not perfectly correlated with each other, therefore showed similar patterns of results. Notably, none of these patterns were accounted for by low level measures, such as relative contrast or spatial frequency.

The results also were in the predicted direction with respect to the relation between oculomotor behavior and the Interest in Infants questionnaires. Subjects reporting higher interest in infants were more likely to look longer and to fixate more often at infant faces. The association between questionnaire scores and the different oculomotor measures also showed some qualifications in how these variables are related to each other. For infant viewing time, although women reported greater interest in infants than men, their scores were not consistently associated with their looking times toward infant faces, possibly because of the restricted range of their interest scores, with most scores concentrated in the higher end of the scale. When they were significantly associated, however, as in condition 4, it was in the predicted direction, that is, women with higher interest in infants looked longer at infant faces. In contrast, men's scores, consistent with their eye-tracking results, were significantly associated with their looking times toward infants only when the infant face was paired with the face of an adult male. For the measure of the number of fixations toward infant faces, the association with interest in infants questionnaires was weaker than the association with looking times. The only questionnaire variable showing some degree of association with fixations was the preference for the infant job on the Infant Job questionnaire, with subjects with higher preference being more likely to fixate more often on the infant face, an effect not qualified by significant interactions between interest in infants measures, experimental conditions, and sex of subject.

In sum, although oculomor behaviors toward infant faces showed some reliable degree of association with scores on the Interest in Infants questionnaires, there are inconsistencies in the pattern of results. One possible reason may simply be that some oculomotor measures are more directly associated with interest in infants than others. Another possibility is that the regions of interest used in the study were insufficiently precise, so that not all measures gave the same results. For instance, it could be that people with higher interest in infants are more likely to fixate on those facial regions that are more diagnostic of the infant's emotional state, such as the mouth and eyes. A finer-grained analysis will be needed to assess this possibility.

Another question about the association between interest in infants and oculomotor behavior has to do with the fact that only some Interest in Infants questionnaires were associated with eye movements. A possible reason is that the questionnaires targeted different dimensions of interest. For example, one important difference between the Job Preference, Interaction with Infant, and Interest in Infants questionnaires is that only the first two assess the subject's willingness to interact with an infant. Nonetheless, only the Job Preference questionnaire showed a more consistent association with oculomotor behavior. One possibility for this discrepancy is that the Interaction with Infant questionnaire asks people to imagine interacting with a stranger's infant. This could introduce a confound, since some people, despite being interested in infants, may worry that the parent would see this particular interaction as overly intrusive. In contrast, for the Job Preference questionnaire, interaction is not only socially acceptable, it is expected as a part of the job.

Overall, then, two of the three measures of oculomotor behavior were associated with interest in infants, both of which were consistently associated in the predicted direction.

On the face recognition test, some of the results also were as predicted, namely that nulliparous adults will be better at recognizing adult faces than infant faces, given their greater experience and higher degree of expertise with adult faces and given that adult faces are more distinctive, and that more distinctive faces are typically more memorable. The association, although weak, between fixations and recognition for adult faces was also expected as the number of fixations is positively correlated with face recognition. Several aspects of the results, however, are problematic. For infant faces, no association was found between fixations and recognition accuracy and, overall, the recognition scores were low compared to other studies (e.g., Hsiao & Cottrell, 2008, reported A' recognition scores of .8 when subjects were allowed to fixate only twice on faces). Thus, it appears that the task was more difficult than intended. Several factors are likely to have contributed to the subjects' low performance, including the decision to not present the faces individually in the free-viewing task, to present them for only a brief time (meaning that the task was too difficult), to standardize the faces to minimize any effects of low level vision, and to not instruct the subjects to study the faces in preparation for a recognition task. The absence of an association between face recognition scores for infant faces and interest in infants therefore may have been a product of the overall low recognition performance, that is, of a floor effect. A different task, in which subjects are actually instructed to study the faces, may help to expand the range of scores and increase the likelihood of finding the predicted association between performance and interest in infants.

Chapter 6: Study 7 -- Visual prior entry for infant faces

We come finally to the last study, Study 7,on visual prior entry for infant faces. There is evidence that motivationally significant stimuli can capture attention, in other words, that people are predisposed to attend to emotional stimuli (e.g., a fearful face) even when told not to do so (e.g., Eastwood, Smilek, & Merikle, 2003; Öhman, Flykt, & Esteves, 2001; Vuilleumier & Schwartz, 2001) and that emotional stimuli affect early vision, that is, that people show better contrast sensitivity after briefly (75 ms) seeing fearful faces than neutral faces (Phelps et al., 2006).

Recent studies show that infant faces, another type of emotionally significant stimulus, can produce covert shifts of spatial attention (Brosch et al., 2008; Brosch et al., 2007). These studies used the dot-probe-task, in which two faces (an infant face and an adult face, both with neutral expression) are presented simultaneously for a short time (100 ms) and then turned off, after which, following a short delay period of variable length (100-300 ms), a small dot briefly appears in the location previously occupied by one of the faces. Participants are typically faster and more accurate at detecting the dot when it appears in the location occupied by the emotional face (in this case the infant face); that is, people seem to improve their performance because their attention was directed, or captured, by the emotional stimulus. Although the task is sensitive enough to detect shifts of attention, its temporal resolution at face onset (when the faces are first presented) is insufficient for determining precisely when and how infant faces capture attention because participants are allowed to respond only after about 200 milliseconds following face offset. To allow measurement of the time course of initial attentional deployment, Study 7 therefore used a method with better temporal resolution during face onset.

According to the doctrine of prior entry (Titchener, 1908), stimuli that are attended immediately at onset are perceived prior to unattended stimuli because attended stimuli receive processing priority. Although this doctrine has a long history in experimental psychology, only recently have methods been developed that convincingly show the existence of the effect (e.g., Shore, Spence, & Klein, 2001; West, Anderson, & Pratt, 2009), that is, that attended stimuli receive priority in perceptual processing and that the effect is not simply due to a response bias (e.g., subjects choosing one response option when unsure). Visual prior entry is typically measured by a temporal order judgment (TOJ) in which the subject reports which of two items appeared first on the display. Items are generally presented in asynchrony; that is, one item appears first, and after a brief and varied delay (stimulus onset asynchrony, SOA) the second item appears. Since items that are more attentionally salient are assumed to facilitate perception, attended items will be perceived as appearing first, and, by varying the SOA, it is possible to estimate the length of time that the less salient image must precede the more salient image in order for them to be perceived as appearing simultaneously (point of subjective simultaneity, PSS). To minimize the impact of response biases (i.e., the tendency to choose one type of stimulus when unsure which one appeared first), typically half of the subjects are asked to report which item appeared first and the other half are asked which item appeared second.

Recently,West et al., (2009), using schematic faces and photographs of faces, found a prior entry effect for angry faces, such that angry faces were perceived earlier than neutral faces. The PPS for the angry faces ranged from 7.85 to 18.26 ms, with photographs showing a larger effect than schematic faces.

In Study 7, West et al., 2009, procedure was adapted to see whether infant faces, compared to adult faces, also show prior entry effects.

Subjects

The subjects were 26 men (mean age = 19.81, *SD* = 1.74 years) and 29 women (*M* = 19.2, *SD* = 1.24), all undergraduate students at Michigan State University, who participated for course credit. All were White and reported having normal or corrected to normal vision. None were parents.

Stimuli

Eight faces (2 boys, 2 girls, 2 men, and 2 women) were chosen from the stimulus pool so that the faces in each category had similar attractiveness. In addition, a mask was created by producing an average face of the 4 adult faces with a morphing software. To compensate for the difference in the length of adult and infant faces, the face length for the mask was resized to represent the average between them. The resizing was done so that all facial features were also slightly shrunk and shifted towards the center of the face, making their size and location closer to the average for adult and infant features.

Procedure

The study was in two parts: the prior entry task in part 1, the questionnaires in part 2.

Stimuli were presented on a CRT monitor. The display resolution was set to 1024 x 768 pixels with a refresh rate of 85 Hz. Subjects sat at a distance of 44 cm from the display.

A typical sequence is shown in Figure 3. Each trial began with a fixation cross (0.6^{0} X 0.6^{0}) with two placeholder boxes (3.2^{0} X 4.55^{0}) centered at 4.9^{0} from fixations. Subjects were told to fixate on the cross throughout the experiment and to allocate their attention equally to both boxes.

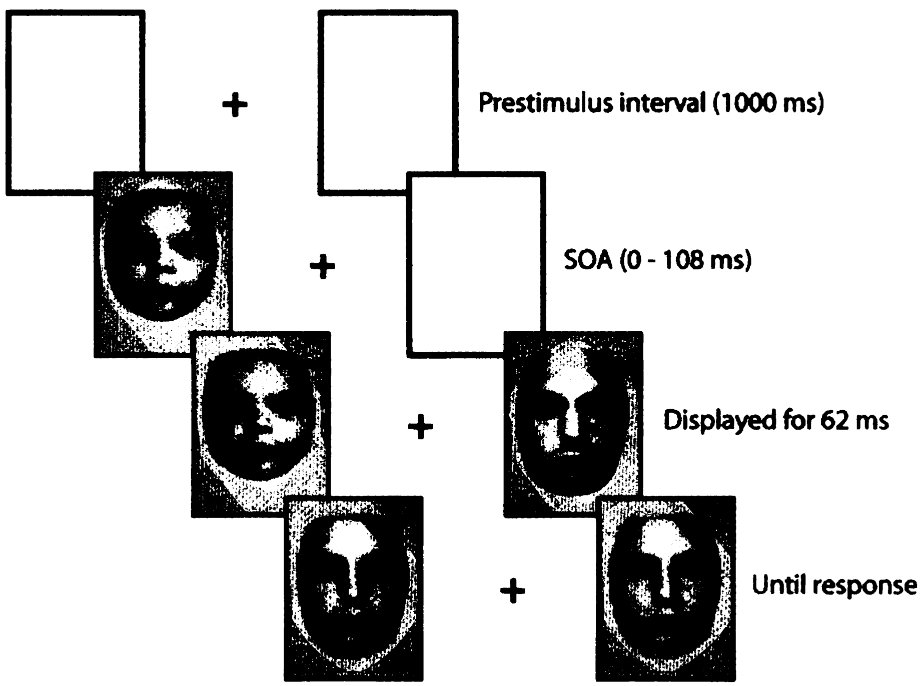

Figure 3. Trial Sequence Used in Experiment 7.

After 1,000 ms, an infant (boy or girl) and an adult face (man or woman) appeared on the screen, each in one of the two placeholders. On 9% of the trials the faces appeared simultaneously (stimulus onset asynchrony (SOA) of 0 ms); on the remaining

91%, one face preceded the presentation of the other face by one of 5 stimulus onset asynchronies (12, 24, 48, 60, or 108 ms). Face categories (boy or girl, man or woman), order of appearance (adult or infant appearing first), SOA, and location (left, right) were counterbalanced across trials. After the faces appeared, they remained on the screen for 62 ms and then were masked by the average face. The mask remained on screen until subjects responded by pressing one of two keys on the keyboard.

To control for response biases, subjects were divided into two groups (group 1 with 13 men and 15 women; group 2 with 13 men and 14 women). Subjects were instructed to indicate which face appeared first on the screen (group 1) or which face appeared second on the screen (group 2). Subjects responded "the face at the left" by pressing the *z* key and "the face at the right" by pressing the / key. After the subject's response, a white background was displayed for 1,000 ms before the next trial began.

Before the experimental trials began, subjects completed 16 practice trials with SOA of 170 and 220 ms. Only adult faces (and none of those used in the experimental trials) were used in the practice trials. The experiment consisted of 352 trials divided into 8 blocks of 44 trials. Subjects were allowed to take small breaks between blocks. Subjects completed the experiment in about 16 minutes.

In part 2, subjects answered, individually, all questionnaires: Demographics, Self-Perceived Mate Value, Sexual Orientation Inventory-Revised, and Interest in Infants. All subjects answered the questionnaires in the same order and in the same computer station, and were instructed to answer at their own pace. This part was completed in about 13 minutes.

Results

Questionnaires

Questionnaire results are presented in combined form for Group 1 and Group 2. Because two subjects experienced computer problems while answering the questionnaires, the degrees of freedom vary slightly across questionnaires.

Interest in Infants. The Interest in Infants questionnaire showed good internal consistency for both sexes (men: $\alpha = .90$; women: $\alpha = .90$). Women's scores ($M = 5.08$, $SD = 0.77$) were higher than men's ($M = 4.59$, $SD = 0.84$) as shown in a two-tailed independent samples Welch t-test, $t(50.21) = 2.18$, $p = .033$.

Job Preference Questionnaire. Job Preference ratings were examined with a mixed-design ANOVA with job type (infant care, other jobs) as a within-subjects factor and sex of subject (male, female) as a between-subjects factor. The analysis showed that the main effect of job type was not significant, $F(1,51) = 0.01$, $p = .922$, mostly because of women's and men's similar preferences for non-infant-care jobs (Men: $M = 4.27$, $SD = 0.65$; Women: $M = 4.04$, $SD = 0.88$). On the infant-care job, however, women's preferences ($M = 5.26$, $SD = 1.85$) were higher than men ($M = 3.0$, $SD = 1.55$) as indicated by the significant interaction between job type and sex, $F(1,51) = 20.29$, $p < .001$, $\eta_p^2 = .29$.

Interaction with Infants. The results of the Interaction with Infants questionnaire are summarized in Table 21. The questionnaire showed good internal consistency for both sexes, with the exception of the negative subscale for men. All subscales, except the positive subscale, showed sex differences, with women scoring higher than men. Based on these results only the total scale was used as it has better reliability and shows a clear sex difference.

Table 21. Descriptive Statistics and Sex Differences of the Interaction with Infants Questionnaire

	Men			Women			Sex difference		
	α	M	SD	α	M	SD	t	df	P
Positive	.90	5.21	1.07	.91	5.72	1.02	1.77	50.64	.082
Neutral	.88	4.48	1.27	.85	5.40	1.43	2.89	48.07	.006
Negative	.62	4.68	0.88	.71	5.30	0.87	2.57	50.86	.013
Total	.92	4.79	0.96	.93	5.47	0.87	2.72	50.03	.009

Desire for parenthood. The Desire to Have Children questionnaire also showed good internal consistency for both sexes (men: $\alpha = .83$; women: $\alpha = .83$). As indicated by a two-tailed independent samples Welch t-test, $t(50.86) = 0.50$, $p = .61$, women ($M = 4.57$, $SD = 1.01$) and men ($M = 4.43$, $SD = 1.03$) had similar desire to have children.

Self-Perceived Mate Value. The Self-Perceived Mate Value questionnaire also showed good internal consistency (men: $\alpha = .89$; women: $\alpha = .92$). A two-tailed independent sample Welch t-test showed no significant difference between men ($M = 4.49$, $SD = 1.17$) and women ($M = 5.06$, $SD = 1.21$), $t(51)=1.73$, $p = .089$.

The Revised Sociosexual Orientation Inventory. The Revised Sociosexual Orientation Inventory also showed good internal consistency on all subscales and as well as significant sex differences, with men scoring higher than women on the total scale as well as on the attitude and desire subscales. The results are summarized in Table 22.

Table 22. Descriptive Statistics and Sex Differences of the Sociosexuality Measures

	Men			Women			Sex difference		
	α	M	SD	α	M	SD	t	df	p
Behavior	.78	1.94	1.07	.87	2.07	1.05	0.47	50.86	=.637
Attitude	.85	4.04	2.27	.87	2.88	1.95	-1.99	49.27	=.051
Desire	.85	4.76	2.12	.77	2.83	1.62	-3.72	46.79	<.001
Total	.80	3.58	1.36	.91	2.59	1.40	-2.60	50.99	<.001

Prior Entry

On the prior entry task, trials with response-times greater than 2,500 ms were removed from the analysis (3.2% of group 1 data and 4.6 % of group 2 data).

Given that prior entry effects occur at the short SOAs, subjects' accuracy was assessed only for the longer SOAs, which were not expected to be difficult. For SOA 60, average-accuracy was 91% for group 1 (87% for men, 94% for women) and 91% for group 2 (87% for men, 94% for women). For SOA 108, group 1 accuracy was 96% (95% for men, 96.9 % for women) and for group 2 was 93.3% (96.5% for men, 90.4% for women). One woman from group 2 had below 70% accuracy, so her data were removed from further analyses.

Logistic regressions were fitted to each subject's responses in order to calculate the PSS, that is, the interval needed for both stimuli to be perceived as appearing simultaneously. The PSS was computed as the point at which the subject was equally likely to report seeing each target as appearing first (or second). Positive PSS indicate that the infant face is perceived earlier; negative values indicate that the adult face is perceived earlier.

For group 1, a one-sample two-tailed t-test, $t(27)= 0.90$, $p = .3738$, showed that the average PSS ($M = 1.003$, $SD = 5.87$) was not significantly different from zero. Although men had higher PSS values ($M = 3.25$, $SD = 5.55$) than women ($M = -0.94$, $SD = 5.59$), the difference was not significant based on a two-sample two-tailed Welch t-test, $t(25.491) = -1.986$, $p = .059$. By contrast, for group 2, a one-sample two-tailed t-test, $t(25)= -3.39$, $p = .002$, showed that the average PSS ($M = -6.07$, $SD = 9.12$) was significantly smaller than zero, indicating a prior entry effect for adult faces. Although men had slightly smaller PSS values ($M = -3.72$, $SD = 5.78$) than women ($M = -8.43$, $SD = 11.31$), this difference, likewise, was not significant based on a two-sample two-tailed Welch t-test, $t(17.86) = -1.335$, $p = .198$. Given that the PSS values were in opposite directions for both groups, that is, positive for group 1, negative for group 2, the results, instead of showing a prior entry effect, therefore showed a response bias effect.

Even though a prior entry effect was absent for the entire sample, a series of linear regressions were fitted to the data on the possibility that PSS values were associated with interest in infants or the other individual differences. None of the models reached statistical significance (all $p > .05$).

Discussion

Experiment 2 examined whether infant faces show visual prior entry and therefore early attentional capture. The results did not show this effect for infant faces. They instead showed evidence of a response bias; that is, subjects chose one of the face categories more often when unsure which face appeared first. In addition, and more critical to our hypothesis, there was no association between PSS and measures of interest in infants and other individual differences questionnaires. It is unlikely that the negative results reflected insufficient statistical power. Although West et al., (2009) did not report standard deviations or effect sizes, effect sizes can be roughly estimated based on the magnitude of the standard errors graphed in their figure 4. Given their sample sizes (12-14 subjects), the effect sizes were likely to be approximately 0.5 for schematic faces and closer to 1.0 for photographs. Since the sample in the current study was 28 subjects for group 1 and 27 subjects for group 2, it should have achieved a power of at least .8 for similar effects. If there are any visual prior entry effects for infant faces, they therefore are likely to be much smaller than the ones found for angry adult faces.

Until such effects are found, the results suggest that the reported attentional orientation effects of infant faces (Brosch et al., 2008; Brosch et al., 2007) are not likely to occur during the initial attentional deployment but rather after 50 ms.

Chapter 7: Conclusions, Limitations, and New Directions

As summarized in Chapter 1, human infant care is essential to human survival but also shows, compared to other mammals, some of the most remarkable idiosyncrasies of the human species. Even though rearing human infants is far more costly than in most mammals, humans are able to reach higher than expected reproductive rates, a fact that highlights the role of cooperative breeding in human populations and, more specifically, of allomaternal care with provisioning. Because of the high costs of infant care, the idiosyncracies of human parental behavior, and the vital benefits of infant survival, it has been hypothesized that, over the course of human evolution, a variety of biological and cognitive mechanisms have evolved that facilitate adults' interest in and responsiveness to infants in ways normally leading to care-giving. As summarized in Chapter 2, evidence for such mechanisms comes from studies indicating that adults show attentional-emotional biases, along with physiological, neural, and hormonal responses, toward specific features and behaviors that make infants look "cute" and "attractive." Despite evidence that infants constitute a special stimulus category for humans, however, the nature of cognitive mechanisms underlying interest in infants is still largely unexplored.

The goal of this dissertation was to find out whether one such cognitive mechanism is revealed in visual attention, and whether and how visual attention is related to subjects' self-reports of interest in infants and other subject characteristics. Studies 1 and 2 assessed the reliability and validity of three questionnaires designed to estimate subject's interest in infants, each measuring a different dimension of interest, including the willingness to interact with infants. The results show that these questionnaires have good reliability and validity. Evidence of their validity was seen in their association with other related constructs, such as willingness to have children, but also with the behavioral measures used in Study 6; that is, some of the questionnaires were associated, and in the predicted direction, with oculomotor behaviors that are also seen as reflecting interest in infants. Studies 3-5 assessed the characteristics of the face-stimuli used in the dissertation, in particular, whether the faces retained their age, sex, and affective characteristics after being standardized. The results confirmed that the faces conserved many of the properties of natural (unprocessed) faces and therefore that they were suitable for being used in Studies 6 and 7.

Study 6 examined the exploratory oculomotor behavior toward infant and adult faces, and Study 7 examined whether infant faces have a greater effect than adult faces on the initial deployment of attention. Both studies investigated how such behaviors correlate with subjects' self-reports of interest in infants and other subject characteristics.

Study 6 showed a clear difference in men's and women's reactions to infant and adult faces. Women looked longer at and fixated more often on infant than at adult faces of either sex. Men, in contrast, looked longer at and fixated more often on infant faces only when they were paired with an adult male face. On the self-reports measures of interest in infants, women also reported greater interest in infants than men; their scores, however, were not consistently associated with their looking times toward infant faces. In contrast, men's scores, consistent with their eye-tracking results, were significantly associated with their looking times toward infants only when the infant face was paired with the face of an adult male. Overall, the results suggest that women's interest in infants as indexed by their oculomotor behavior and self-reports is more stable and higher than men's.

As was speculated in Chapter 2, men could be more likely to show the effects of individual differences inasmuch as their interest in infants and parental investment are even more conditional than women's. As reviewed in Chapter 2, an abundance of evidence, including the results of Studies 1 and 2, shows that women are typically more interested in infants and have a greater role in infant care than men. Although fatherhood typically increases men's interest and role in infant care, some studies show that fathers nonetheless have little or no effect on infant survival (Sear & Mace, 2008), which further supports the hypothesis that male parental investment is *facultative* rather than *obligate*, that is, although not required for the offsprings' survival, it can enhance their survival and reproductive success (Geary, 2008), and suggests that men's interest and parental investment are more likely to be more affected by a large range of factors (e.g., reproductive strategies) than women's. Study 6 also showed that oculomotor behavior can be successfully used to assess individual differences, including sex differences, in interest in infants, as subjects with greater interest looked longer and made more fixations than subjects with less interest.

Study 7 showed that infant faces do not appear to show a prior entry effect or at least that the effect is likely to be smaller than the effect reported for other emotional stimuli, such as angry faces. Study 7 results also failed to show an association between individuals' point of subjective simultaneity (PSS) and their self-report interest in infants, further indicating the lack of evidence that interest in infants affects the early deployment of attention toward infant faces. The results thus suggest that the attentional and neural effects reported in other studies, effects typically recorded 100 ms after stimulus presentation, are not likely to be evident during the initial deployment of attention.

Overall, the results further support the finding that women are more likely than men to be interested in infants and suggest that they deploy their attention in a manner consistent with this sex difference. Hrdy (2009) argues that because a woman's decision to have and raise a child is highly conditional on whether ecological conditions are favorable for having a viable offspring, it is inaccurate to characterize women as having a "maternal instinct" or to assume that their responses to infants come in the form of fixed response patterns. Although our results do not directly speak to this issue, we agree with Hrdy's point that women involvement in infant care is conditional. At the same time, we also want to stress that under favorable ecological conditions women are more involved and more interested than men in infant care. In our sample, for instance, although both men and women expressed similar desire to have children, only women showed a consistently higher interest in infants across the self-report and behavioral measures. Thus, although there are important individual differences within each sex, sex differences in interest in infants seem particularly robust. In other words, although I agree that women's behavior toward infants should not be seen as fixed response patterns, the results of the current studies also agree with the view that women, compared to men, are in general more attuned to infants and thus more likely to interact with and respond to infants. The results therefore are consistent with the hypothesis that women, due to their central role in infant care, have evolved a greater and more stable sensitivity to infants.

Limitations of Studies, Further Analyses, and Directions for New Research

Use of Undergraduates

A probable limitation of all studies was their use of a convenience sample of undergraduate students. Undergraduates, of course, are not representative of all the reproductive stages in humans. Future studies therefore should include parents and persons planning or expecting to be parents. Because both groups would expect to have greater interest in infants than nulliparous subjects, they ought to provide for a more powerful test for estimating the validity of the oculomotor and other measures used in the current studies. In this regard, it may be relevant that in the scores for the one subject in the sample who reported to be expecting a child, there was an even stronger association between the oculomotor and questionnaire measures than was found for the rest of the sample.

Further analyses of current data

Several additional analyses of the current data are planned. For instance, to improve data reliability, factor analysis will be used to merge all of the interest-in-infants questionnaires into a single measure that will be used in latent variable modeling through Structural Equation Modeling.

In addition, although common measures of oculomor behavior were used in this dissertation, the eye-tracking data collected contain a wealth of data warranting further study. For example, the first fixation location data will be revisited by examining whether subjects who fixate initially at the top face fixate longer (or have more fixations) before fixating on the bottom image when the top face is an infant than when it is an adult, and whether any such differences are related to the sex of the subject and interest-in-infants scores.

Facial Expression

Future studies also should assess the role of facial expressions in the perception of and attention toward infant faces. Since the ability to respond appropriately and effectively to an infant's needs depends on how well the infant's emotional state can be understood, varying the emotional state of infant faces (e.g., neutral vs. distressed) could be a way to enhance some of the sex-related and other individual differences found in Study 6. As a first step in this direction, in the near future we plan to reanalyze the data by using smaller regions of interest that are able to show eye movements on specific facial features (e.g., eyes, mouth) that are typically more diagnostic for determining the face's emotional state.

Hormonal Changes

Given the substantial hormonal changes that women experience during pregnancy as well as the endocrine changes documented for fathers, it will be of interest to ask whether these oculomotor behaviors are also affected by endocrine fluctuations. For example, how do hormonal changes, such as those occurring during pregnancy or during the menstrual cycle, affect cognitive mechanisms associated with interest in infants, and what are the effects in persons with endocrine disorders or with normal endocrine changes associated with aging? Recent work has shown that oxytocin enhances the recognition of adult faces (Rimmele, Hediger, Heinrichs, & Klaver, 2009). Given its role in maternal behavior, the possibility arises that oxytocin will also enhance the recognition of infant faces.

Refinement of Oculomotor Measures

A goal of further studies will be to refine these oculomotor measures so as to enhance their sensitivity to these individual differences. For Study 6, two aspects of the design need improvement. One of the measures of attention used was the location of the first fixations. Subjects showed a strong bias to fixate first on the top face of the display, independently of whether the face was of an adult or an infant. Most likely, this bias is a product of, or generalization from, reading practices, which, whether the text is read from left to right or right to left, begin in all alphabets at the top of the page. Similarly, computer content (e.g., internet content) typically begins at the top of the screen. Because, as mentioned earlier, Study 6 used a top-bottom layout to control for laterality (left-right) effects, the top-down scan bias greatly diminished the usefulness of the first fixation measure. A possible improvement would be to make the location of faces unpredictable by having them appear in random locations following an imaginary ring.

Another oculomotor measure that had been planned for use was pupil dilation. The top-down layout, however, prevented its use because pupil measures with head mounted systems, especially when the camera is located below the eye, are highly susceptible to effects of the subject's gaze angle. In addition, because the pupil diameter usually requires about 4 s to stabilize after display luminance changes, reliable use of pupilometry would require a specialized experimental design. One possibility, for a future study, is to use specialized calibration algorithms, such as neural-networks, that allow the eye tracker to calibrate its measures based on the subject's gaze angle (e.g., Pomplun, Sunkara, Fairley, & Xiao, n.d.).

It is clear that this research is only the first step toward adequately characterizing the cognitive mechanisms involved in individual differences in interest in infants. It is important, however, to note that understanding these cognitive mechanisms is not only worthwhile from a basic science perspective but also from its potential significance for application and remediation. For instance, there is substantial evidence that physical appearance affects social interactions (Jackson, 1992; G. Rhodes & Zebrowitz, 2002), including interaction with infants and children. Thus, on the premise that physical attractiveness signals infant health, studies find that parental investment is affected by the infant's physical appearance (J. Mann, 1992; Waller, Volk, & Quinsey, 2004), and, in fact, across cultures, "deformed" infants are at greater risk of infanticide (Craig, 2004; Daly & Wilson, 1984; Kellett, 1992). Relatedly, physically more attractive children receive less severe punishments and more affective maternal responses than do less attractive children (Dion, 1972; Langlois, Ritter, Casey, & Sawin, 1995). Indeed, the risk of maltreatment increases in children with cranial/facial proportions that make them look older than their actual age, possibly because adults expect them to show socioemotional behavior of older children (McCabe, 1984). For another example, women's mental health is critically important for the mother-infant interaction, as shown, for example, by the association between postpartum depression (Wisner, Parry, & Piontek, 2002) with a diminished interest in infants, which presumably is among the factors with negative consequences for mother-infant interaction and, ultimately, for the infant's cognitive and socioemotional development (Murray, Fiori-Cowley, Hooper, & Cooper, 1996). From these examples, the possibility thus arises that a better understanding of the cognitive and biobehavioral mechanisms underlying interest in infants not only can improve our understanding of how these mechanisms translate into actual care-giving behavior, but how, through the development of new screening and assessment tools, persons at risk for poor care-giving can be identified earlier so that effective interventions can be instituted before care-giving fails.

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