DEVELOPING A SUFFICIENT KNOWLEDGE BASE FOR FACES: IMPLICIT RECOGNITION MEMORY FOR DISTINCTIVE VERSUS TYPICAL FEMALE FACES

by

Catherine A. Best

B.A., Dickinson College, 2001

Submitted to the Graduate Faculty of

Arts and Sciences in partial fulfillment

of the requirements for the degree of

Master of Science in Developmental Psychology

University of Pittsburgh

2004

UNIVERSITY OF PITTSBURGH

FACULTY OF ARTS AND SCIENCES

This thesis was presented

by

Catherine A. Best

It was defended on

November 30, 2004

and approved by

Mark S. Strauss, Ph.D, Associate Professor

Carl N. Johnson, Ph.D, Associate Professor

Jana M. Iverson, Ph.D, Assistant Professor

Thesis Advisor: Mark S. Strauss, Ph.D, Associate Professor

DEVELOPING A SUFFICIENT KNOWLEDGE BASE FOR FACES: IMPLICIT RECOGNITION MEMORY FOR DISTINCTIVE VERSUS TYPICAL FEMALE FACES

Catherine A. Best, M.S.

University of Pittsburgh, 2004

ABSTRACT

Research on adults' face recognition abilities provides evidence for a distinctiveness effect such that distinctive faces are remembered better and more easily than typical faces. Research on this effect in the developmental literature is limited. In the current study, two experiments tested recognition memory for evidence of the distinctiveness effect. Study 1 tested infants (9- and 10-month olds) using a novelty preference paradigm. Infants were tested for immediate and delayed memory. Results indicated memory for only the most distinctive faces. Study 2 tested preschool children (3- and 4-year-olds) using an interactive story. Children were tested with an implicit (i.e. surprise) memory test. Results indicated a memory advantage for distinctive faces by three-year-old girls and four-year-old boys and girls. Contrary to traditional theories of changes in children's processing strategies, experience is also a critical factor in the development of face recognition abilities.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

The goal of the present set of studies was to better understand the origins and development of face recognition. Drawing upon both previous and current research on infant face perception and recognition, as well as the research on child and adult face recognition, this research was aimed at exploring the role of experience in the development of face expertise. Thus, the following studies explored two different age groups in order to identify any age-related patterns of development of recognition memory with respect to the amount of experience with faces. Specifically, the present set of studies explored the following developmental question: When is there sufficient experience with faces that children can remember distinctive faces better than less distinctive (i.e., typical) faces?

1.1. Attraction to Faces in Early Infancy

Attraction to faces is present very early in infancy. Even newborns prefer to look at faces rather than objects and prefer to look at face-like patterns rather than un-face-like patterns (Fantz, 1965; Mondloch, Lewis, Budreau, Maurer, Dannemiller, Stephens, & Kleiner-Gathercoal, 1999; Morton & Johnson, 1991; Valenza, Simion, Cassia, & Umilta, 1996; Wilcox, 1969). Similar research (Johnson, Dziurawiec, Bartrip & Morton, 1992; Goren, Sarty, & Wu, 1975) has shown that newborns as young as 9 minutes old will track face-like stimuli farther than scrambled face-like stimuli. Some researchers believe this early attraction to faces may reflect an innate mechanism that serves as a survival tool for newborns. For example, Morton and Johnson (1991) argue that infants' attention to faces at birth is controlled by two operating mechanisms: CONSPEC (i.e., the initial mechanism that controls and constrains all innate information about faces to which the infant requires no previous exposure) and CONLERN (i.e., the later mechanism that controls all learned information about faces to which infants are highly attentive). Morton and Johnson's theory suggests that these two mechanisms help the infant discriminate between faces and non faces. Of further interest, however, is how infants discriminate one face from another face.

1.2. Memory for Faces in Early Infancy

Memory for familiar people is evident early in life. At birth, infants can recognize their mothers' smell (Szur, 1981) and voice (DeCasper & Fifer, 1980). Even in the first few days of life, an infant will look longer at his or her mother's face when it is paired with a comparable (e.g. similar complexion and hair color) female stranger's face (Bushnell, Sai, & Mullin 1989). However, Morton (1993) has suggested that when an infant is shown only internal features of the face, a newborn does not seem to recognize his or her mother's face until he or she is at least 90 days old. Much research has explored the mother-stranger distinction (Bushnell, 2001). Only recently has this mother-stranger distinction been extended to fathers. Quinn, Yahr, Kuhn, Slater, and Pascalis (2002) found that infants raised by their fathers were better at recognizing their own father's face from a stranger's face. Quinn et al.'s (2002) new evidence suggests that an infant's recognition memory for familiar people is not specific to his or her mother's face, but rather to the face of his or her primary caregiver—one to which the infant receives a significant amount of exposure.

Research studies have also focused on when infants begin to remember people other than their immediate caregivers. This research suggests that 4-month-old infants are able to discriminate familiar people from strangers; however, not until 6 or 7 months do infants display robust recognition memories (Fagan, 1973). Relatively little research has focused on how infants begin to use information about internal features of the face to recognize and remember specific people. The literature on adult face recognition provides some clues for answering this question.

1.3. Adult Face Space Framework

Valentine (1991) has suggested that adults store faces in a multidimensional face space. He describes the face space framework as an organized value system that is based on various dimensions of internal facial features. Faces are stored in a normal distribution around a central tendency of facial dimensions according to their values. As a result, faces with similar features are grouped together and faces with more typical features are stored in more dense areas around this central tendency. In other words, faces with average length noses will be closer together within the face space than those faces with more extreme or distinctive featural values (e.g., very short or very long). The value system, as it is theorized, enables typical faces with average features to cluster together in a dense space, while more distinctive or atypical faces are more scattered about the outer edges within the face space, further away from the central tendency (see Figure 1).

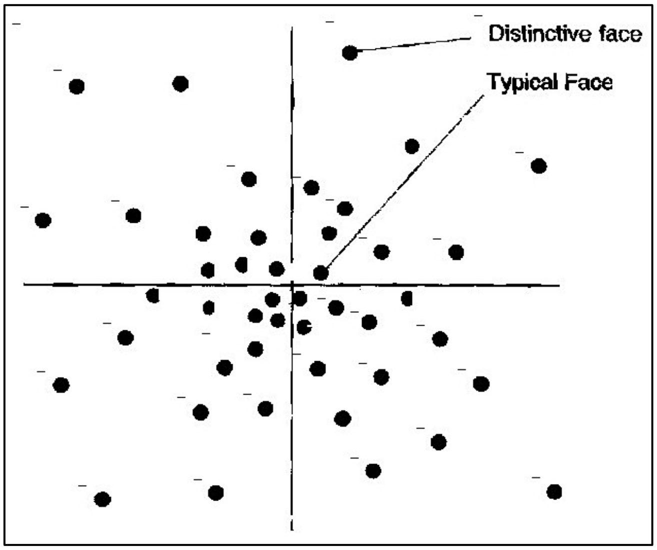

Figure 1: Multidimensional face space. Points within the framework illustrate the difference in density of typical versus distinctive faces (adapted from de Haan, Humphreys, & Johnson, 2002).

Valentine proposes that once it becomes necessary to recall or recognize an individual face, a comparison is made between the face to be identified and the many stored faces within the face space. Recognition accuracy and reaction times are worse for typical than distinctive faces because there is a much greater density of stored typical faces than there is for distinctive faces. Therefore, it is harder to recognize a more typical face (e.g., Bob Costas' or Kevin Spacey's face) than a distinctive face (e.g., Jay Leno's or David Letterman's face). As further evidence for the validity of the face space model, Valentine's (1991) face space has been used to explain several known effects in the adult face perception and recognition literature, specifically, the cross race effect, the caricature effect, and the distinctiveness effect.

1.4. Cross Race Effect, Caricature Effect, and Distinctiveness Effect in Adults

The cross-race effect or other-race effect refers to the notion that the appearances of people of other races seem more similar to each other than the appearances of people in one's own race. The given impression is one in which there is less variability among individual faces of a race other than one's own. First illustrated by Malpass and Kravitz (1969), the cross-race effect has received some research attention in the developmental literature as well (Valentine & Endo, 1992; Chiroro & Valentine, 1995; MacLin & Malpass, 2001).

Several hypotheses have been suggested (Brigham and Malpass, 1985) for why recognition of other races is a difficult task for adults. For instance, perhaps it is a difficult task because of racial prejudice, superficial orienting to other-race faces when encoding, limited contact with other-race faces, or maybe face recognition is an inherently difficult process for certain races. Undoubtedly, faces within one's own race are the most familiar. Thus, through repeated exposure to own-race faces, a person develops a typicality structure in which there are many exemplars as well as an abstract prototype of an average face for one's own race. Adults are well aware of the boundaries of featural values in own-race faces (i.e., what is typical looking and what is less typical looking).

Valentine's (1991) face space model can account for the cross-race effect. Within the multidimensional space that he proposes, featural values of own-race faces will be represented much more frequently than featural values of other-race faces. The featural values of other-race faces will be under-represented with less precision as to where certain featural boundaries are located. Therefore, other-race faces are more distant from the central tendency of the face space.

Furthermore, without experience, a typicality structure is not readily in place to differentiate individual faces in another race. Evidence has shown that the amount of experience an individual has with other races will affect his or her ability to recognize specific faces from those races (Chiroro & Valentine, 1995). This differential experience hypothesis, or contact hypothesis, is supported by a fair amount of research (e.g., Chiroro & Valentine, 1995; Furl, Phillips, & O'Toole, 2002). Debates exist, however, on whether *quality* of contact is more important than *quantity* of contact concerning other race faces.

Research has found that the use of caricatures, whether line drawings or photographic depictions, can enhance recognition memory for faces such that caricatures are recognized more quickly and more accurately than veridical pictures (Rhodes, Brennan, & Carey, 1987; Benson & Perrett, 1991; Rhodes & Tremewan, 1994; Benson & Perrett, 1994; Calder, Young, Benson, & Perrett, 1996; Chang, 1997). A caricature attempts to represent the most prominent or distinctive features of a face and exaggerates them beyond the possible or veridical essence of that face. Ideally, caricatures of people are easy to recognize because they focus their exaggerations on the most distinctive features of a face.

Similarly, Chang (1997) has proposed that the caricature effect can also be explained with Valentine's (1991) face space model. If caricatured faces are stored under similar assumptions to those of distinctive faces, then the caricature featural values will also be in a less dense area that is farther away from the central tendency. Therefore, memory for caricatures will activate distinctive featural values that will narrow the search for finding a stored memory of a particular face, allowing for quick and accurate recognition.

There is also considerable evidence that adults have better recognition memory for faces that are distinctive than for faces that are typical or less distinctive (Light, Kayra-Stuart, & Hollander, 1979; Bartlett, Hurry, & Thorley, 1984; Valentine & Bruce, 1986; Shepherd, Gibbling, & Ellis, 1991; Valentine & Endo, 1992; Chiroro & Valentine, 1995). Experiments with unfamiliar faces find that adults will recognize faces that are distinctive more accurately and more quickly than typical faces. Also, there tends to be a higher false positive rate for memory of typical faces than for memory of distinctive faces (e.g., Light et al., 1979; Bartlett, et al., 1984).

The recognition advantage for distinctive faces can be explained by Valentine's (1991) face space framework. It is assumed that exemplars of faces are normally distributed within the face space. Those faces that are most typical lie closest to the middle of the distribution or to the norm, whereas faces that are more distinctive fall outside of the central tendency of the distribution, away from the norm. Therefore, the representation of typical faces is denser than the representation of distinctive faces. With less similarity among the distinctive exemplars and more similarity among the typical exemplars, it is easier to recognize a specific face that is distinctive, as it is more distant from other exemplars within the face space and is surrounded by less distracter faces (Valentine & Endo, 1992).

1.5. Developmental Evidence for Cross Race Effect, Caricature Effect, and Distinctiveness Effect

With the exception of infancy research, developmental research of these memory effects has focused almost exclusively on children between 5 and 14 years of age. There are very few studies of face recognition in the preschool years. The developmental research has also focused almost exclusively on how the processes that underlie face recognition change. More specifically, it has been argued, based on research that compares recognition of upside down faces to right side up faces, that with development children process faces less featurally and more configurally (e.g. Carey, 1996).

In contrast, there has been very little research on the impact of children's experience with faces and the development of a face space. To date, there are only a few empirical studies addressing issues such as the cross-race effect, the caricature effect, and the distinctiveness effect in children.

In one study of children and cross-race effects, Chance, Turner, and Goldstein (1982) found differences in the recognition of Caucasian and Japanese faces by Caucasian first- through eighth-graders and college students. The Caucasian participants displayed better memory for Caucasian faces than for Japanese faces across all age groups, except for the youngest participants who were five years of age. Instead, five-year-old children showed no difference in their memory for the Caucasian and Japanese faces.

The only study exploring children's recognition memory of caricatures was conducted by Chang, Levine, and Benson (2002) and tested children aged 6 years to 13 years. Their study with children involved two tasks using caricatures. One task tested accuracy and speed of naming each face; the other task tested best likeness judgments (i.e. which face looks more like the target face). The results showed that the youngest children, six years of age, were somewhat sensitive to the distinctive information in caricatured faces; however, the caricature effects they tested strengthened with age, showing that 10- and 13-year-olds perform most similar to the adults' performance.

Prior to Chang et al.'s (2002) research, Johnston and Ellis (1995) have been the only researchers to test children's memory for distinctive versus typical faces. They explored age effects for recognition memory and found that by age seven, children were beginning to show a distinctiveness advantage for memory of unfamiliar faces. However, the youngest age group that Johnston and Ellis tested, five-year-olds, did not show a distinctiveness effect.

1.6. Remaining Developmental Issues to Explore

The literature surrounding the face space model focuses primarily on adults and does not specify how and when the ability to recognize and remember specific faces emerges developmentally. Little research has explored whether infants and young children are able to take advantage of the same facial information that adults use.

It is important to note that the few studies that have explored children's recognition memory for faces have relied exclusively on explicit tasks. All of the children tested by Chance et al. (1982), Chang et al. (2002), and Johnston and Ellis (1995) were given tasks that required skilled strategy use for accurate recognition memory performance. Because much of face perception and recognition happens implicitly, it is unclear whether the same processes are used when face perception and recognition skills are exercised explicitly. Newman (1990) demonstrated that for preschool children, tasks that were more natural and required implicit memory yielded better recall performance than tasks that were more artificial and required explicit memory. Therefore, not only is more research necessary to understand the role that experience plays in the development of face expertise, but different approaches should be used that tap into implicit knowledge of faces.

1.7. Aim of Current Studies

The present studies explored one aspect of the development of face expertise with regard to recognition memory. At what point do infants and young children have the necessary experience with faces such that they can use the distinctiveness of features as an aid in recognition memory? Study 1 addressed the question of whether infants, like adults, have better recognition memory for more distinctive faces than less distinctive faces. A novelty-preference paradigm was used to explore when experience with faces is beneficial to infants' recognition memory for unfamiliar faces. Nine- and ten-month olds were familiarized to life-size color photographs of typical and distinctive female faces and then tested on both their immediate and delayed recognition abilities. Study 2 addressed similar developmental questions by testing preschool children.

2. STUDY 1: INFANTS' RECOGNITION MEMORY

2.1. Method

2.1.1. Participants

Ninety-two healthy, normally developing infants participated in Study 1. Data from 17 infants were excluded because the infants were too fussy to complete the study. Seven infants were influenced by their parents and were subsequently excluded from data analyses. Finally, data from five infants were not included because of technical difficulties. Thus, 63 infants (N = 31 boys, 32 girls) were included in the data analyses. The infants ranged in age from 9-months to 11-months (M = 302 days). Infants were recruited from the city of Pittsburgh, Pennsylvania and surrounding communities. Equal numbers of male and female participants were recruited. The racial, gender, and ethnic characteristics of the proposed participant population reflected the demographics of the area. Recruitment of participants was proportioned to these demographics. No one was excluded because of race, ethnicity, or gender. Infants were excluded if mothers did not carry their child to full term during the pregnancy. Participants were excluded if they were not generally healthy at the time of testing or if they were not developing normally.

2.1.2. Stimuli

The stimuli were chosen from an existing set of photographs. Each stimulus consisted of a full-face, front view, color photograph of a female face against a dark background. Each female face was photographed with a neutral expression while wearing a black robe to conceal clothing and a backwards black baseball cap to conceal any hair that was not already pulled back with a tie. The photographed women were undergraduate psychology students who ranged in age from 18 to 30 years. All photographs were taken with a Kodak Digital Camera and downloaded onto a Gateway PC to create a jpeg file for each photograph.

2.1.3. Stimuli Rating

Seventy-one female faces were rated for distinctiveness by approximately 26 adult raters. Raters were asked to give each face a rating based on its degree of distinctiveness. The raters used a scale of one to seven, where seven equaled “most distinctive” and one equaled “least distinctive.” Raters were told that a distinctive face would be one that stands out in a crowd because it has unusual or unique features or simply an overall uniqueness in appearance. In addition, raters were told that a non-distinctive face would be more typical looking and such a face would not stand out in a crowd, nor have any unusual or unique features, but rather an overall average or typical appearance. Raters were also told not to confuse the idea of distinctiveness with attractiveness. Additionally if the raters recognized a face as someone they knew (i.e. a classmate), they were asked not to give that face a rating.

The 71 faces were divided into three groups based on the mean rating scores for each face. The faces with the lowest ratings comprised the typical group. The faces with medium ratings comprised the neutral group. The faces with the highest ratings comprised the distinctive group. The mean rating of the faces in the typical group was 2.95. The mean rating of the faces in the neutral group was 3.60. The mean rating for the faces in the distinctive group was 4.34. There was no overlap of face ratings in any of these groups. The same faces were used as stimuli for both studies and were selected from each of the three groups.

2.1.4. Stimuli Inclusion

Twenty-three (eight distinctive faces; eight typical faces; seven novel faces) of the 71 rated faces were included in the current studies. Not all faces were considered for inclusion. Rather, distinctive faces were selected from the upper end of the total distribution, while typical faces were selected from the lower end of the distribution. Novel faces were chosen from the middle of the distribution of ratings. A mean rating score was calculated for each set of faces: distinctive group mean = 4.47; typical group mean = 2.82; novel group mean = 3.56. In addition, stimuli were excluded if the image quality was sub-standard after converting the image into a jpeg format.

2.1.5. Apparatus

All infants were tested in the testing booth seated on a caregiver's lap for the duration of the testing procedure. The caregiver sat in a chair approximately 24 inches from two 16-inch computer monitors. The screens were positioned approximately 12 inches apart from one another. The stimuli were displayed on both computer monitors with a display size of 750 by 1024 pixels. A Sony infrared camera was positioned in between both computer monitors to record looking time and left/right preference. The laboratory was completely dark during the testing aside from a small light near the experimenter, who was not visible to the participants.

During testing, the experimenter monitored the visual preferences on a 13-inch Panasonic TV monitor. The novelty preference program recorded the data. The infants were also recorded on a VHS tape to allow for post examination and inter-rater reliability. Sounds for additional attention grabbing means were presented with a speaker positioned in the testing booth.

2.1.6. Familiarization Trials

The infants were shown four different female faces. Half of the infants (distinctive condition) were familiarized to four faces that alternated between two typical and two distinctive faces, such that the first and third faces were always a distinctive face. Thus, during the familiarization the infants in the distinctive condition were shown:

<u>Distinctive Condition</u>

1 Distinctive Face A

2 Typical Face B

3 Distinctive Face C

4 Typical Face D

Following familiarization trials, these infants were tested for their memories of faces in the first and third serial positions (i.e., Face A and Face C). Thus, infants in the distinctive condition were tested only for their memory of distinctive faces.

The other half of the infants (typical condition) were familiarized to four faces that alternated between two typical and two distinctive faces, such that the first and third were always typical faces. Thus, during the familiarization, the infants in the typical condition were shown:

Typical Condition

1 Typical Face A

2 Distinctive Face B

3 Typical Face C

4 Distinctive Face D

Following familiarization, these infants were tested for their memories of the faces in the first and third serial positions (i.e., Face A and Face C). Thus, infants in the typical condition were tested only for their memory of typical faces.

During each familiarization trial, infants in both conditions were shown one face (the same face was displayed on the left and right screens) until they accumulated 15 seconds of total looking time. In between each familiarization trial, an animated tunnel-like screen saver was displayed until the experimenter advanced the program to the next trial.

Based on the research by de Haan, Johnson, Maurer, and Perrett (2001), which showed that 3-month-olds could remember one of four faces after a familiarization period of approximately 30 seconds, it was decided that each familiarization trial should present a face until the infants actually accumulate 15 seconds of looking time. By using a criterion of accumulated looking, the present design ensured that infants looked to each of the four faces for an equal length of time.

2.1.7. Test Trials

All infants were tested for immediate recognition memory and delayed recognition memory. Immediately following the four familiarization trials, infants in the distinctive condition were given recognition memory tests for the first or third distinctive face. After a ten minute delay, these same infants were tested on the first or third distinctive face that was not tested in the immediate memory test. Thus, these infants were tested for their recognition memory for only distinctive faces (see Figure 2).

Familiarization Trials

1	Distinctive Face A
2	Typical Face B
3	Distinctive Face C
4	Typical Face D

Order 1

Immediate Recognition Memory Test Trials

Distinctive Face A	Novel Face X

Delayed Recognition Memory Test Trials

Distinctive Face C	Novel Face Y

Order 2

Immediate Recognition Memory Test Trials

Distinctive Face C	Novel Face X

Delayed Recognition Memory Test Trials

Distinctive Face A	Novel Face Y

Figure 2: Presentation of face stimuli for infants in distinctive condition.

The infants in the typical condition were tested for their immediate recognition memory of the first or third typical face. After a ten minute delay, these infants were tested on the first or third face that was not tested in the immediate memory test. Thus, these infants were tested for their recognition memory for only typical faces (see Figure 3).

Familiarization Trials

1	Typical Face A
2	Distinctive Face B
3	Typical Face C
4	Distinctive Face D

Order 1

Immediate Recognition Memory Test Trials

Typical Face A	Novel Face X

Delayed Recognition Memory Test Trials

Typical Face C	Novel Face Y

Order 2

Immediate Recognition Memory Test Trials

Typical Face C	Novel Face X

Delayed Recognition Memory Test Trials

Typical Face A	Novel Face Y

Figure 3: Presentation of face stimuli for infants in typical condition.

For all infants, test trials consisted of pairing a novel face next to a familiar face. All novel faces were selected from the middle of the distinctiveness distribution. Each test trial presented the faces for 10 seconds. The left and right positions were switched on subsequent test trials for each memory test (i.e., immediate recognition and delayed recognition) to account for any side biases. The fixed 10 seconds of display time began as soon as the infant looked at either face.

3. RESULTS OF STUDY 1

The primary dependent measure of interest was the percentage of looking time to novel faces during the test trials. A novelty preference score was calculated for each infant. Specifically, novelty preference scores were calculated by dividing the amount of looking time to the novel faces (total looking time to novel faces 1 and 2) by the total amount of looking time during the 4 test trials and multiplying by 100, thus a

$$\text{novelty preference score} = \left(\frac{N_1 + N_2}{(F_1 + F_2 + N_1 + N_2)} \right) \times 100$$

where *N* represents looking time to a novel face and F represents looking time to a familiar face.

3.1. Preliminary Analyses

An initial 3-Way ANOVA was conducted on the novelty preference scores. The between-subject variables were Distinctiveness (distinctive vs. typical face) and Infant Gender (male vs. female participant) and the within-subject variable was Memory Test (immediate vs. delayed memory test). Results indicated a significant 3-way interaction of Memory Test X Distinctiveness X Infant Gender, $F\ (1, 59) = 3.02$, $p < .01$. The novelty preference score means and standard deviations are presented in Table 1. There were no significant main effects of any variable or other reliable interactions.

Table 1: Infants' mean novelty preference percentages for typical versus distinctive faces in immediate and delayed test trials (standard deviations in parentheses).

	Immediate Memory		Delayed Memory	
Infant Gender	Typical Faces	Distinctive Faces	Typical Faces	Distinctive Faces
Male	57.9% +	51.0%	47.4%	54.5% ++
	(18.7%)	(12.2%)	(10.1%)	(14.0%)
Female	44.5%	53.0%	50.7%	55.8% *
	(14.9%)	(18.7%)	(15.6%)	(12.7%)

* *p* < .05 + *p* < .10 ++ *p* = .12

In order to understand this significant result, *t*-tests were conducted that compared each of the novelty preference score means to a hypothetical 50% novelty preference score. These *t*-tests revealed that both male, (*M* = 54.5%, *SD* = 14.0%), *t* (14) = 1.25, *p* = .12, and female infants, (*M* = 55.8%, *SD* = 12.7%), *t* (15) = 1.84, *p* = .01, remembered the distinctive faces after a delay, although the results for the male infants were only marginally significant. In contrast, the typical faces were not remembered after a delay.

The results of *t*-tests for immediate memory tests were less conclusive. With the exception of the male infants, who demonstrated marginally significant memory for the typical faces, (*M* = 57.9%, SD = 18.7), *t* (15) = 1.69, *p* = .06, there was no indication that infants had remembered the distinctive or typical faces during the immediate recognition memory test trials. (Possible explanations will be presented in the discussion section.)

Given these mixed findings, further analyses were conducted in order to better clarify the present results by looking at the infant memory for only the *most* and *least* distinctive faces. The face stimuli that were initially used in this study had been rated by adults for distinctiveness. From this initial set of rated stimuli, we selected the eight most distinctive faces and eight least distinctive faces. It could be, however, that while all sixteen faces are distinctive-looking or typical-looking to adults, these faces may not have been truly distinctive-looking or typical-looking to infants. Perhaps only the *most* distinctive or extreme faces would be distinctive to the infants. Therefore, it was decided to compare the results from infants who were tested with only the four most distinctive faces and four least distinctive faces. Recent research by Humphreys (2003) gives support to this approach. Her research suggests that sensitivity to face information increases with development. She has found that between four and seven months of age, infants become much more sensitive to the identities of similar-looking faces. With less sensitivity to face information than adults, infants may need more extreme (i.e. more obvious) examples of distinctive faces in order to show a memory advantage for distinctive faces over typical faces. Therefore, we decided to re-analyze the current data in light of these findings.

3.2. Most and Least Distinctive Analyses

The four *most distinctive* faces, defined as the faces closest to the end point of 7.00, based on the original ratings from adults on a seven point scale, and the four *least distinctive* faces, defined as the faces closest to the average rating of 1.00, were selected from the original set of stimuli. While the original set of eight distinctive faces had a mean rating of 4.47, the four most distinctive faces used in these analyses had a mean rating of 4.88[1] (see Figure 4).

---

[1] The group of adult raters was somewhat conservative with the use of the endpoint scores (i.e. 1 and 7); therefore, the highest mean rating for any given face was never greater than 5.50

Figure 4: Four most distinctive faces.

Similarly, while the original set of eight typical faces had a mean rating of 2.82, we analyzed the infants' memory to the four least distinctive faces which had a mean rating of 2.67 (see Figure 5).

Figure 5: Four least distinctive faces.

After isolating the test trials which contained the most and least distinctive faces, the sub-set of participants (*N* = 55) did not reflect a balanced design. There were a total of 23 infants who had been tested with the most distinctive faces. Of these, 11 infants (*N* = 5 male participants) were tested for *immediate* recognition memory and 12 infants (*N* = 7 male participants) were tested for *delayed* recognition memory. Similarly, there were 22 infants who had been tested with the least distinctive faces. Of these, 11 infants (*N* = 5 male participants) were tested for *immediate* recognition memory and 11 infants (*N* = 5 male participants) were tested for *delayed* recognition memory. (Means and standard deviations are presented in Table 2.)

Table 2: Infants' mean novelty preference percentages for most and least distinctive faces in immediate and delayed test trial (standard deviations in parentheses).

Immediate Memory Test Faces		Delayed Memory Test Faces	
Least Distinctive	Most Distinctive	Least Distinctive	Most Distinctive
52.6%	62.2%*	47.9%	54.4%*
(21.9%)	(17.1%)	(12.8%)	(12.1%)

* $p < .05$

The *t*-tests revealed that this sub-set of infants showed memory for the most distinctive faces in both immediate (*M* = 62.2%, *SD* = 17.1%), t (10) = 2.37, $p < .05$, and delayed (*M* = 54.4%, *SD* = 12.1%), t (11) = 1.25, $p < .05$, memory test trials. Additionally, the *t*-tests revealed no memory for the least distinctive faces in either immediate or delayed memory test trials. Thus, infants showed memory in both immediate and delayed test trials for the most distinctive faces but no memory for the least distinctive faces.

4. DISCUSSION OF STUDY 1

The preliminary results of the current study gave some indication that infants are able to remember distinctive faces better than typical faces. Infants did show better recognition memory for distinctive faces than typical faces in delayed recognition memory test trials, but not in immediate recognition memory test trials. The results also suggested that female infants may be better at remembering distinctive faces than male infants. This difference may be due to the female infants being more advanced or the result may be due to the fact that the girls were more responsive to the female faces.

While the preliminary results indicate memory for distinctive faces after a delay period, it is surprising that there was no memory for the distinctive faces in immediate test trials. One possibility is that the infants were heterogeneous in whether they showed a novelty or familiarity preference on the immediate test trial. Perhaps some infants showed a novelty preference while others showed a familiarity preference. Studies by several researchers (e.g. Cohen & Cashon, 2003; Houston-Price & Nakai, 2004) indicate that if during familiarization, infants have not completely processed or habituated to a stimulus, they often demonstrate a preference for the old, not the novel, stimulus. While habituation paradigms that require infants to reduce their looking to a criterion such as 50% can control for this, predicting familiarity periods as used in the current study can not. Cohen and Cashon (2003) have suggested that there are individual differences in the rate at which infants reach a point in which they have sufficiently processed a stimulus in order to demonstrate a novelty preference. While we assumed that our criterion of 15 seconds per face was sufficient, it may not have been for some participants. This possible preference for the familiar stimuli may have been stronger for distinctive faces versus typical faces. If the infants were more interested in the distinctive faces, it would take longer for them to habituate; hence, there would be a higher probability of their showing a familiarity preference during immediate test trials. This preference may have dissipated after a delay, allowing for the novelty preference that then emerged.

More importantly, the initial results of this study may have been affected by the assumptions of what faces infants would find distinctive. What may be considered a distinctive face to an adult is not necessarily a distinctive face to an infant because adults are much more sensitive to face information than infants. Evidence for the distinctiveness effect is present in 9- and 10-month-old infants when we examine memory of truly distinctive faces—faces that are extremely distinctive within the normal distribution of distinctive faces. Redesigning the current study with the use of truly distinctive and typical examples of faces will be helpful in understanding the memory abilities of infants that are suggested in these preliminary results.

5. STUDY 2: PRESCHOOL CHILDREN'S RECOGNITION MEMORY

Similar to the aim of Study 1, Study 2 explored a developmental question about when there is sufficient experience with faces to show a distinctiveness effect in young preschool children. An interactive story presented on a computer was used to test three-and four-year-olds' implicit recognition memory for unfamiliar faces. The preschoolers were familiarized to distinctive and typical female faces and then tested on their delayed recognition abilities.

5.1. Method

5.1.1. Participants

Study 2 tested 83 normally developing three-and four-year-old preschool. Data from seven children were not included in the analyses because they demonstrated a side bias. Data from two children were excluded for being inattentive during testing. Five participants' data were excluded because of experimenter bias. Finally, a total of 12 participants (8 three-year-olds and 4 four-year-olds) failed the practice test trial with the two suitcases, and their data were excluded from analyses. Thus, the data analyses included 57 (*N* = 28 boys, 29 girls) children (*M* = 3.6 months). Preschool children were recruited from the city of Pittsburgh, Pennsylvania and surrounding communities. Equal numbers of male and female participants were recruited. The racial, gender, and ethnic characteristics of the proposed participant population reflected the demographics of the area. Recruitment of participants was proportioned to these demographics. No one was excluded because of race, ethnicity, or gender. For both studies, participants were excluded if they are not generally healthy at the time of testing or if they were not developing normally.

5.1.2. Stimuli

Study 2 used the same set of distinctive, typical and neutral face stimuli as was used as in Study 1; however, each female face was inserted into a uniform cut-out of long hair to look more natural for the story format.

5.1.3. Design

The design for Study 2 was patterned after research by Brace, Hole, Kemp, Pike, Van Duuren, and Norgate (2001), in which they tested young children's face recognition abilities using a picture book and story format. As a result, an original story about a group of friends who are going on a field trip was created as the present design. This story was interactive and was presented on a computer screen. In addition, the preschoolers had the opportunity to advance the action of the story by using a magic wand at different points within the story. The goal of this interactive story was to create a paradigm that permitted testing of preschoolers' implicit memory of faces.

There were three main parts to the story. First, the participants were introduced to specific faces in the beginning of the story. Second, the story had a covert delay period in which there was no exposure to faces. Finally, a memory test occurred at the end of the story. Because the participants had no prior knowledge of the memory test, explicit strategy use on the part of the child during the familiarization to the faces was avoided.

5.1.4. Apparatus

The interactive story was created using Microsoft Power Point. The story included Power Point slides of colorful pictures and/or scenes with thematically related sound effects.

All preschoolers sat in a child-sized chair positioned in front of a 17-inch computer monitor. The caregiver was invited to sit in a chair in the same room as their child.

During testing, the primary experimenter sat next to the preschooler in order to interact with and keep the child focused during the testing paradigm. A second experimenter sat behind the preschooler and recorded the data from the forced-choice memory paradigm on a coding sheet.

5.1.5. Familiarization Period

During familiarization, the preschoolers were presented with six female faces (i.e., three faces rated as typical and three faces rated as distinctive), by being told a story about a group of friends going on a field trip. The preschoolers were also told that they would be helping to tell the story with the use of a magic wand. The story began with a scene depicting a yellow school bus to set up the theme of a field trip (see Figure 6).

Figure 6: Beginning slide for story.

The preschoolers then saw a picture of a red or blue suitcase (see Figure 7).

Figure 7: Introduction of suitcase with lunches inside.

The participants were told that this suitcase holds all of the friends' lunches for the field trip. Then they were asked to wave the magic wand over the suitcase to "magically" put the suitcase inside the bus. While waving their wand, the experimenter simultaneously advanced to the next slide which depicted the inside of the school bus with the suitcase sitting on one of the seats (see Figure 8).

Figure 8: Slide showing suitcase inside bus.

This same wand-waving procedure was used to "magically" load the bus with the friends. The preschoolers were told that these friends were best friends that like to dress alike and wear their hair alike, but they were actually different people if the preschooler looked closely at each friend's face. Each friend was shown one at a time on the computer screen (see Figure 9).

Figure 9: Slide showing one of the friends.

The preschooler was asked to wave the magic wand over each face to "magically" place the friend on the bus, whereupon the preschooler was asked to again point to that specific face to demonstrate that they were only paying attention to one face at a time (see Figure 10).

Figure 10: Slide showing friend on the bus.

5.1.6. Delay Period

In order to create a delay, the story continued with the friends traveling to several different locations (e.g. the ocean, a jungle, the moon). Each scene was shown without exposing the preschoolers to any of the friends' faces; instead the slides showed only the details of each location (see Figure 11.)

Figure 11: Example of a field trip location.

This series of stops on the field trip comprised the delay period. The duration of the delay period varied slightly from participant to participant in order to meet the needs of each preschooler (i.e. if the child asked questions about the location or wanted to talk about what he or she saw in the pictures), but was approximately 4 minutes long. At the end of the delay, the participants were asked to help the bus driver find all of the friends in order to return to school.

5.1.7. Test Trials

After the delay period, preschoolers were tested for their recognition memory for each of the 6 faces. At the last stop on the field trip, it was explained that the bus driver is ready to leave and needs to take the friends back to school (see Figure 12).

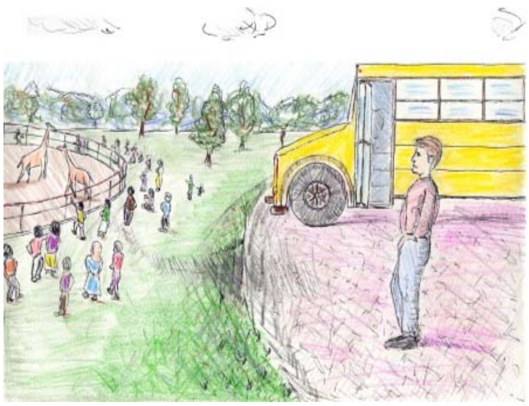

Figure 12: Slide showing bus drive that needs help.

The experimenter then enlisted the participant's help in finding all of the original friends and getting them back on the bus.

Recognition memory was tested in the form of a forced-choice paradigm. The three distinctive and three typical faces were each paired with a neutral novel face, such that there were two faces shown at one time, one old and one new (see Figure 13).

Figure 13: Example of forced-choice memory paradigm.

One face is old and the other face is new.

Participants were asked to use their magic wand to point to the face that they believed they put on the bus at the beginning of the story. An initial test trial with a picture of a new and old suitcase (red and blue) was also used to ensure that each preschooler understood the instructions for the forced-choice paradigm (see Figure 14). The basic outline of the story can be seen in more detail in the appendix.

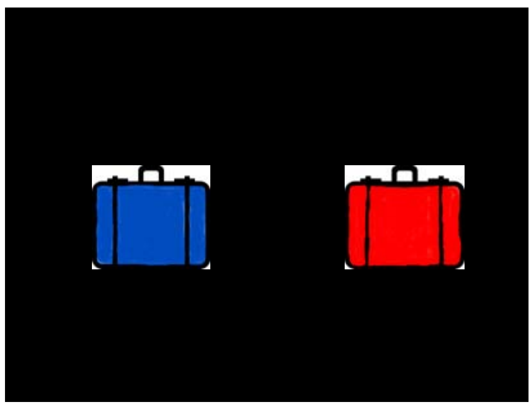

Figure 14: Slide showing forced-choice memory trial of new and old suitcases.

6. RESULTS OF STUDY 2

The primary dependent measure was number of correct choices in the forced-choice test trials. An accuracy score was calculated for each child by computing the percentage of correct choices.

An initial 3-Way ANOVA was conducted on accuracy scores that included the within variable of Distinctiveness (distinctive face vs. typical face) and the between variables of Child Gender (male vs. female participant) and Child Age (three- vs. four-year-old). Results revealed a significant 3-way interaction of Face Type X Child Gender X Child Age, F (1, 52) = 5.01, $p <$ .05. The accuracy means and standard deviations are presented in Table 3.

Table 3: Preschoolers' mean percentage correct for typical versus distinctive faces (standard deviations in parentheses)

	Three-Year-Olds		Four-Year-Olds	
Type of Face	Boys	Girls	Boys	Girls
Typical	45.2%	35.5%	58.9%	61.9%
	(28.2%)	(26.8%)	(31.1%)	(25.9%)
Distinctive	30.9%	53.3%	61.5%	52.4%
	(27.7%)	(27.8%)	(35.7%)	(36.4%)

There were no significant main effects or other significant interactions. Overall, four-year-old children remembered both the distinctive and typical faces, whereas, the three-year-old children showed limited memory and generally picked the most typical faces. Three-year-old girls, however, showed better memory performance than boys.

These initial results are deceptive, however, because there were individual differences in the children's overall memory performance. Some children had very limited memory abilities for this task, while other children performed significantly better on the task. Therefore, nonparametric analyses were conducted on individual children's responses.

Although there were only six faces used during the memory test, it was apparent that some children showed very limited memory. Therefore, we looked at the performance of only those children who showed above-chance memory on the forced-choice task. Specifically, we looked at children who remembered at least two or three out of three typical and/or three distinctive faces. Approximately 40 of the total 57 children fell into this category by demonstrating above chance memory. Table 4 displays the number of children performing above chance, those who correctly remembered more distinctive than typical faces, those who remembered distinctive faces equally as well as typical faces, and those who showed a reverse trend with better memory for typical faces than distinctive faces.

Table 4: Total number of preschool children with memory of 2 or 3 faces, distinctive versus typical (percentages of children in parentheses)

	Three-Year-Olds	
	Boys	Girls
D > T	2 (25 %)	6 (60%)
D = T	1 (12%)	2 (20%)
T > D	5 (63%)	2 (20%)
	Four-Year-Olds	
	Boys	Girls
D > T	4 (40%)	3 (25%)
D = T	3 (30%)	5 (42%)
T > D	3 (30%)	4 (33%)

Results for girls indicate that at three years of age, girls demonstrate better memory for distinctive faces. Sixty percent remembered the distinctive faces better than the typical faces, whereas 20% were equally good at both the distinctive and typical faces. In contrast only 20% of the girls showed better memory for typical than distinctive faces. Thus, the younger girls appear to be capitalizing on distinctiveness to aid in memory recognition.

The distinctiveness effect was slightly diminished in the four-year-old girls, with 42% showing equal memory for both the typical and distinctive faces. This diminished distinctiveness effect was the result of older girls showing better memory performance overall, such that 25% of the girls were actually at ceiling with memory for all six faces (3 distinctive, 3 typical).

In contrast, results for boys indicate that the majority of three-year-olds remembered the typical faces better than the distinctive faces (63%), whereas very few boys showed a distinctiveness effect (25%). This trend is reversed in the four-year-old boys, such that 40% have better memory for distinctive faces, and 30% have better memory for typical faces (see Table 4 above).

The patterns in the data suggest a gender difference in three-year-old children, but this gender difference does not occur in four-year-old children. A chi-square analysis revealed that the difference in memory for girls and boys is marginally significant for three-year-old children, χ^2 (1, N = 15) = 3.23, $p < .10$, and the difference between four-year-old boys and girls was not significant.

7. DISCUSSION OF STUDY 2

This task was difficult for preschool children in that only two-thirds of the preschool children performed above chance. However, by looking at those children who did perform above chance on the memory task, the results indicated that three-year-old girls showed a distinctiveness effect, and four-year-old boys and girls showed a distinctiveness effect. It is unclear why three-year-old boys remembered typical faces better than distinctive faces. One possibility is that although the three-year-old boys remembered certain faces, they were simply not remembering faces with respect to distinctiveness. In addition, with the limited number of three-year-old boys performing above chance ($N = 8$), the results also could have been spurious. More importantly, these results contradict the results of Johnston and Ellis (1995) who found that five-year-old children did not show a distinctiveness effect. The current results provide preliminary evidence of the distinctiveness advantage in children as young as three years of age.

By redesigning the current study, we can perhaps strengthen the distinctiveness effect that is suggested in the current data. Two major limitations with the current design are addressed in a follow up study already in progress. It is possible that displaying the faces within a uniform hair cutout may have made the task too difficult, and indeed, only two-thirds of the children performed above chance. In fact, many parents commented that the faces seemed very similar. Evidence from preschool children's ability to discriminate the gender of faces demonstrates that three- and four-year old children pay attention to hair cues (Newell, Strauss, Best, & Gastgeb, 2004a). Thus, the uniform hair surrounding each stimulus may have been a distraction in this memory task. The preschool children may have been paying less attention to the internal facial features because the hair was such a salient feature. We therefore redesigned the stimuli in the story to be presented in the same format as they were shown to the infants—a front view of a face with a baseball cap hiding the hair. This revised format for presenting the faces should hopefully make the faces easier to remember. Secondly, we increased the number of faces presented in the story from a total of six to eight faces. This will aid in analyses of accuracy rates such that chance performance will be more easily calculated due to a larger number of test trials.

8. GENERAL DISCUSSION

The present set of studies represented the first attempt to explore how infants and young children develop a memory advantage for distinctiveness in regard to faces. Because there was no existing literature on the distinctiveness effect in face recognition memory for infants and preschool-aged children, there were no previous studies from which to draw predictions, nor design appropriate testing paradigms. Therefore, in one sense, both experiments were pilot studies conducted to determine the basic parameters necessary to even begin to test for this memory effect. The designs for both studies were merely best guesses about parameters such as the number of stimuli that would avoid ceiling and floor effects for preschool children, and the amount of familiarization time required to demonstrate memory in infants.

Because the two studies used different paradigms and presented different face stimuli, they cannot be compared directly. However, they suggest that the distinctiveness effect begins in infancy and is a factor in the recognition memory abilities of preschool children. It is possible, however, that while the distinctiveness effect begins during infancy, it becomes a stronger effect as children's knowledge of facial features develops.

Previous research on the development of gender discrimination of faces in infants and preschool children suggests that beginning as early as six months of age infants have some knowledge of whether a face is male or female. However, infants are only able to discriminate faces that represent very typical examples of men and women. Gender discrimination abilities improve by three to four years of age, but do not reach adult-like abilities until approximately eight years of age (Newell, Strauss, Best, & Gastgeb, 2004b). In a similar fashion, infants may perceive as distinctive only those faces with very extreme featural values. Therefore, only faces that lie in the far parameter of the face space may be considered distinctive to infants. With development, infants may develop finer discriminations of facial features such that faces that were once perceived as similar-looking or typical, now may be perceived as distinctive. In other words, as infants and children develop greater expertise for discriminating facial features, their representation of distinctiveness may correspond to a region which is closer to the origin within the face space and farther from the outer parameters where extreme facial features values exist.

Subsequently, of interest is the question of why infants and children might be getting better at discriminating variations in facial features. One possibility is that with a greater sampling of faces, their face space gradually increases in density. During infancy, the face space may be fairly sparse with only few examples of features or faces. However, with increased exposure to more people, infants can gradually broaden the number of representations within their face space. In addition to the increased sampling, infants may need to develop better processing skills in order to discriminate the increasing number of representations in the face space. Thus, through experience, infants gain exposure to more people and are thus perceptually developing a better idea of what it means to be distinctive. Coupled with the perceptual development of face skills is an increased motivation to discriminate the range of faces within the face space. As the face space becomes denser, infants must develop a means to contend with the increased sample. See Figure 15 for a graphical explanation.

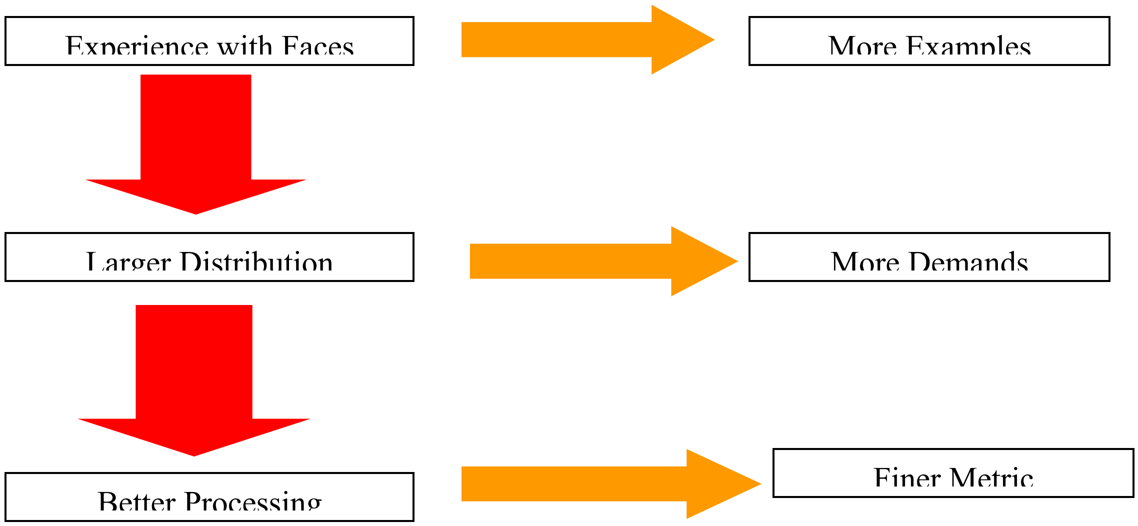

Figure 15: Graphical explanation of how the metric of distinctiveness may develop.

Featural values, as they are represented in the face space, have quantitative differences. To efficiently handle the distribution of faces and facial features within the face space, one must develop a metric for distinctiveness. This distinctiveness metric can help to coordinate the relative distances between featural values and thus allow for more efficient face recognition abilities. Perhaps with respect to the metric of distinctiveness, infants have a very limited notion of distinctiveness, one that is less finely tuned. With development, children's distinctiveness metric becomes more succinct and allows them to make finer distinctions among distinctive and typical faces. It follows then, that adult's distinctiveness metric would allow for very fine discriminations to be made among seemingly similar facial features. Thus adults' face recognition skills should be the most efficient. Each developmental age group should thus require less extreme examples of distinctiveness in order to show a distinctiveness advantage in face recognition memory. (See Figure 16 for a representation of the developmental picture of the face space with respect to distinctiveness.)

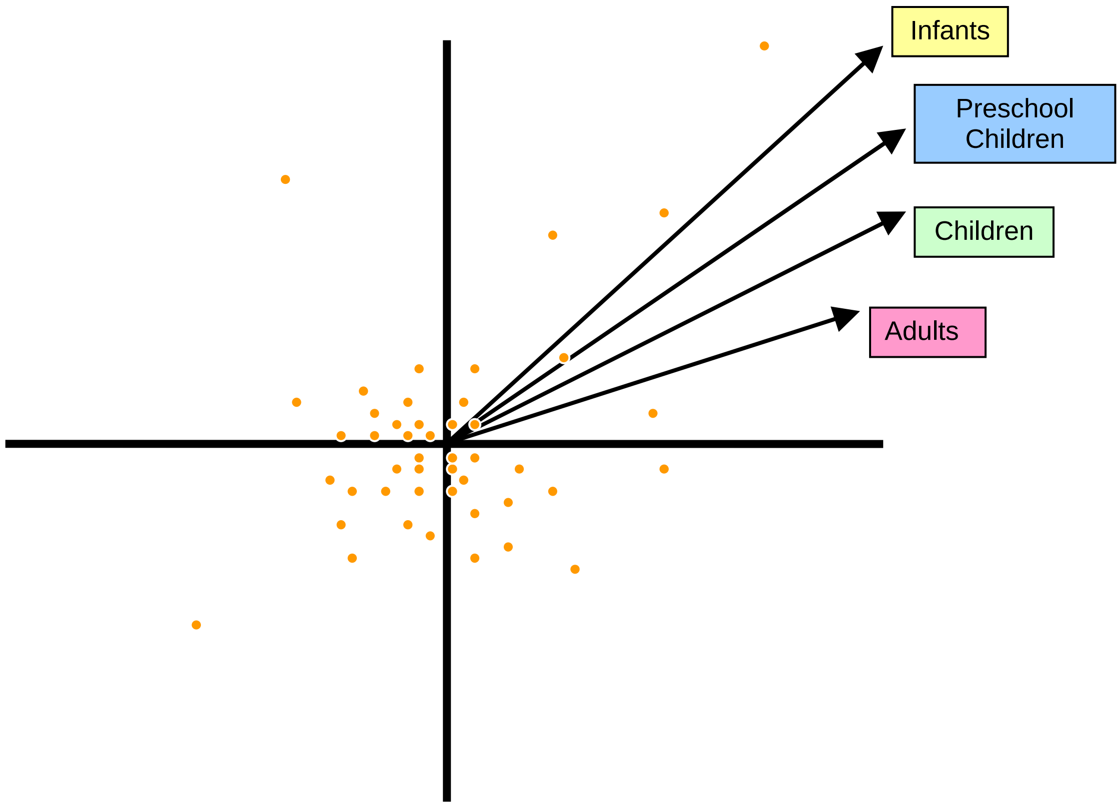

Figure 16: Possible developmental face space representation of distinctiveness by age group.

The point within the face space at which distinctiveness can be used to enhance memory recognition for specific faces is one that must emerge developmentally through experience with faces.

Traditional developmental theories (e.g., Carey, 1996) of face perception and recognition focus on processing strategies. Specifically, these theories posit a featural to configural "shift" as an explanation for how children develop face perception and recognition skills. Evidence for this processing change comes from recognition studies for inverted faces versus upright faces. Young children have been shown to process faces featurally, whereas older children (i.e. seven to ten years of age) use a more advanced strategy of configural processing. Thus, young children are equally good at recognizing inverted and upright faces, whereas, older children and adults are much worse with inverted faces. Evidence from the developmental literature on face recognition does not necessarily agree about this change in processing abilities since the results are discrepant for children and infants. There are several alternative possibilities. First, all of these previous studies used an explicit memory task. It could be that when children are specifically told to memorize faces, they rely on a featural processing strategy. Second, younger children may not be showing an inversion effect because they are equally poor at remembering both upright and inverted faces. Finally, Cashon and Cohen (2003) have shown that infants can process faces in a configural manner. Thus, there may be more than just a processing change involved in the development of face perception and recognition abilities.

These traditional theories do not taken in to account how the role of experience is also a critical developmental factor. The current set of studies strongly suggests that experience is a critical element in the development of face recognition abilities. The present view for developing a sufficient knowledge base for faces emphasizes the role of experience rather than the developmental change in how faces are processed. A change in processing strategies may be a plausible explanation for the development of expertise in face recognition. However, in light of the current findings in which experience seems to be a supporting factor, perhaps the most plausible explanation is that both processing strategies and experience drive children to become experts with faces. Infants' and children's underlying metric for distinctiveness may be refined as they develop better processing strategies to perceive important information from the faces of people they experience in their world.

Because we are still in the process of determining the optimal parameters for testing infants and preschoolers, follow up studies are currently in progress. It is important to establish reliable parameters in order to identify and understand the possible mechanisms behind the development of the face space. These further experiments are needed to better understand the level of sensitivity to information about the distinctiveness of faces and how knowledge of faces develops from infancy through early childhood such that it aids in memory and recognition of specific faces in the world.

APPENDIX

BASIC OUTLINE OF THE PRESCHOOL STORY SCRIPT FOR STUDY 2

(Feel free to ad lib depending on child's interests)

I'm going to tell you a story about a group of friends who are going on a field trip!

This is a special story because you get to use a magic wand as we watch the pictures on the computer.

Let's practice using your magic wand. Can you wave your magic wand over the bus?

Okay, I think we're ready to go on our field trip.

But before we can leave, I need you to help me load the bus.

Here is a suitcase filled with all of the lunches.

If you wave your magic wand over the suitcase, it will magically go on the bus!

Good job!

Now let's make sure we get all the people on the bus.

But I'll tell you something about these girls….They are all best friends, and that means that they like to wear the same clothes and have the same hair-do's, but they still look different if you look at them really closely.

Look, here is a girl. Do you see her? Wave your magic wand to put her on the bus.

There she is! Can you point to her with your magic wand?

Let's put the rest of her friends on the bus.

Now, can you wave your magic wand to put this girl on the bus? ETC……………

(Once all 6 are showing for last time….)

Look! You got all of the friends on the bus! See how they all look different. How many do we have….1…2….3… (Do this as a last chance to help the preschoolers encode the faces—make sure they don't cover the face when pointing with their wand.)

It's time for them to leave……Do you hear the bus driver starting the engine?

The first place they went to was the ocean! ETC……

The last place the friends stopped at was the zoo! They wanted to see the giraffes.

Look, here are all the people at the zoo watching the giraffes. Do you see all the people?

But look over here…..there is the bus driver….and he looks SAD!

Do you know why he is so sad?

It's time to leave. It's time for him to take all the girls back to school. But look! There are so many people at the zoo! He can't remember which girls we put on the bus! Do you think you can help him find all of the friends?? He really needs your help! Can you help the bus drive get each friend back on the bus?

Before we try to find all the girls, let's get the suitcase that had their lunches back on the bus.

Do you remember which suitcase we put on the bus? Can you point to it with your magic wand? Which suitcase did we put on the bus? Good!

Now I'm going to show you some of the people who were at the zoo, and I need you to tell me which one of the girls we need to put back on the bus. Which girl did we put on the bus before? Can you point to the girl that we put on the bus at the beginning of the story? ETC……

Great job!! You really helped out the bus driver. He's lucky you were along for the ride!

Now all the friends can make it back to school in time to go home to their families. There they go….. Goodbye! THE END! Thank you for being such a good helper today!

(If this is the second study and you are done, let them pick a toy for being a good helper today…..if this was the first study, give them a sticker and head back for a snack.)

REFERENCES

Bartlett, J. C., Hurry, S., & Thorley, W. (1984). Typicality and familiarity of faces. *Memory & Cognition, 12*, 219-228.

Benson, P. J. & Perrett, D. I. (1991). Perception and recognition of photographic quality facial caricatures: Implications for the recognition of natural images. *European Journal of Cognitive Psychology, 3,* 105-135.

Benson, P. J. & Perrett, D. I. (1994). Visual processing of facial distinctiveness. *Perception, 23,* 75-93

Brace, N. A., Hole, G. J., Kemp, R. I., Pike, G. E., Van Duuren, M., & Norgate, L. (2001). Developmental changes in the effect of inversion: Using a picture book to investigate face recognition. *Perception, 30*, 85-94.

Brigham, J. C., & Malpass, R. S. (1985). The role of experience and contact in the recognition of own- and other-race faces. *Journal of Social Issues, 14,* 139-155.

Bushnell, I. W. R. (2001). Mother's face recognition in newborn infants: Learning and memory. *Infant and Child Development, 10*, 67-74.

Bushnell, I. W., Sai, F., & Mullin, J. T. (1989). Neonatal recognition of the mother's face. *British Journal of Developmental Psychology, 7*, 3-15.

Calder, A. J., Young, A.W., Benson, P. J., & Perrett D. I. (1996). Self priming from distinctive and caricatured faces. *British Journal of Psychology, 87*, 141-162.

Carey, S. (1996). Perceptual Classification and Expertise. In R. Gelman & T. Kit-Fong Au (Eds.) *Perceptual and Cognitive Development* (pp. 49-69). San Diego, CA: Academic Press

Chance, J. E., Turner, A. L., & Goldstein, A. G. (1982). Development of differential recognition for own- and other-race faces. *The Journal of Psychology, 112,* 29-37.

Chang, P. P. W. (1997). Children's recognition of caricatures. *Dissertation Abstracts International, 58,* (UMI No. 9720026)

Chang, P. P. W., Levine, S. C., Benson, & Philip J. (2002). Children's recognition of caricatures. *Developmental Psychology, 38*, 1038-1051.

Chiroro, P., & Valentine, T. (1995). An investigation of the contact hypothesis of the own-race bias in face recognition. *The Quarterly Journal of Experimental Psychology, 48*, 879-894.

Cashon, C. H., & Cohen, L. B. (2003). The construction, deconstruction, and reconstruction of infant face perception. In A. Slater & O. Pascalis (Eds.), *The development of face processing in infancy and childhood*. Nova Science.

Cohen, L. B., & Cashon, C. H. (2003). Infant perception and cognition. In R. Lerner, A. Easterbrooks, and J. Mistry (Eds.), *Comprehensive handbook of psychology. Volume 6, Developmental Psychology. II. Infancy*. (pp 65-89). New York: Wiley and Sons.

DeCasper, A. J., & Fifer, W. P. (1980). Of human bonding: Newborns prefer their mothers' voices. *Science, 208,* 1174-1176.

de Haan, M., Humphreys, K., & Johnson, M. H. (2002). Developing a brain specialized for face perception: A converging methods approach. *Developmental Psychobiology, 40,* 200-212.

de Haan, M., Johnson, M. H., Maurer, D. & Perrett, D .I. (2001). Recognition of individual faces and average face prototypes by 1 and 3 month old infants. *Cognitive Development, 16*, 659-678.

Fagan, J. F. (1973). Infants' delayed recognition memory and forgetting. *Journal of Experimental Child Psychology, 16,* 424-450.

Fantz, R. L. (1965). Visual perception from birth as shown by pattern selectivity. *Annals of the New York Academy of Sciences, 118,* 793-814.

Furl N., Phillips P. J., & O'Toole A. J. (2002). Face recognition algorithms and the other-race effect: computational mechanisms for a developmental contact hypothesis. *Cognitive Science, 26,* 797-815.

Goren, C. C., Sarty, M., & Wu, P. Y. K. (1975). Visual following and pattern discrimination of face-like stimuli by newborn infants. *Pediatrics, 56,* 544-549.

Houston-Price, C., & Nakai, S. (2004). Distinguishing novelty and familiarity effects in infant preference procedures. *Infant and Child Development, 13*, 341-348.

Humphreys, K. (2003). *The development of face-space: An exploration.* Unpublished doctoral dissertation, University of London, London, England.

Johnson, M. H., Dziurawiec, S., Bartrip, J. & Morton, J. (1992). The effects of movement of internal features on infant's preferences for face-like stimuli. *Infant Behavior and Development, 15,* 129-136.

Johnston, R. A., & Ellis, H. D. (1995). Age effects in the processing of typical and distinctive faces. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 48*, 447-465.

Light, L. L., Kayra-Stuart, F., & Hollander, S. (1979). Recognition memory for typical and unusual faces. *Journal of Experimental Psychology: Human Learning and Memory, 5*, 212-228.

Malpass, R. S., & Kravitz, J. (1969). Recognition of faces of own and other race. *Journal of Personality and Social Psychology, 13,* 330-334.

MacLin, O. H., & Malpass, R. S. (2001). Racial categorization of faces: The ambiguous race face effect. *Psychology Public Policy and Law, 7*, 98-118.

Mondloch, C. J., Lewis, T. L., Budreau, D. R., Maurer, D., Dannemiller, J. L., Stephens, B. R., & Kleiner-Gathercoal, K. A. (1999). Face perception during early infancy. *American Psychological Society, 10*, 419-422.

Morton, J. (1993). Mechanisms in infant face processing. In B. de Boysson-Bardies (Ed.), *Developmental neurocognition: Speech and face processing in the first year of life* (pp. 93-102). Norwell, MA, US: Kluwer Academic Publishers.

Morton, J., & Johnson, M. H. (1991). Conspec and conlearn: A two process theory of infant face recognition. *Psychological Review, 98*, 164-181.

Newell, L. C., Strauss, M. S., Best, C. A., & Gastgeb, H. (2004a, May). Gender categorization abilities of preschoolers: The effects of typicality and hair. Poster session presented at the meeting of International Conference on Infant Studies, Chicago, IL.

Newell, L. C., Strauss, M. S., Best, C. A., & Gastgeb, H. (2004b, May). The role of gender categorization in face recognition. Poster session present at the meeting of International Conference on Infant Studies, Chicago, IL.

Newman, L. S. (1990). Intentional and unintentional memory in young children: Remembering vs. playing. *Journal of Experimental Child Psychology, 50,* 243-258.

Quinn, P. C., Yahr, J., Kuhn, A., Slater, A. M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. *Perception, 31*, 1109-1121.

Rhodes, G. Brennan, S. & Carey, S. (1987). Identification and ratings of caricatures: Implications for mental representations of faces. *Cognitive Psychology, 19,* 473-479.

Rhodes, G., & Tremewan, T. (1994). Understanding face recognition: Caricature effects, inversion, and the homogeneity problem. *Visual Cognition, 1,* 275-311.

Shepherd, J. W., Gibbling, F., & Ellis, H. (1991). The effects of distinctiveness, presentation time and delay on face recognition. *European Journal of Cognitive Psychology, 3,* 137-145.

Szur, R. (1981). Hospital care of the newborn: Some aspects of personal stress. *Journal of Child Psychotherapy, 7,* 137-140.

Valentine, T. (1991). A unified account of the early effects of distinctiveness, inversion, and race in face recognition. *The Quarterly Journal of Experimental Psychology, 43*, 161-204.

Valentine, T., & Bruce, V. (1986). The effects of distinctiveness in recognizing and classifying faces. *Perception, 15*, 525-535.

Valentine, T., & Endo, M. (1992). Towards an exemplar model of face processing: The effects of race and distinctiveness. *The Quarterly Journal of Experimental Psychology, 44*, 671-703.

Valenza, E., Simion, F., Cassia, V. M., & Umilta, C. (1996). Face preference at birth. *Journal of Experimental Psychology: Human Perception and Performance, 22*, 892-903.

Wilcox, B. M. (1969). Visual preferences of human infants for representations of the human face. *Journal of Experimental Child Psychology, 7,* 10-20.