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Infant Facial Discrimination and Perceptual Narrowing

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INFANT FACE DISCRIMINATION AND PERCEPTUAL NARROWING

by

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This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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BRIGHAM YOUNG UNIVERSITY

As chair of the candidate's graduate committee, I have read the thesis of Joseph E. Fair in its final form and have found that (1) its format, citations, and bibliographical style are consistent and acceptable and fulfill university and department style requirements; (2) its illustrative materials including figures, tables, and charts are in place; and (3) the final manuscript is satisfactory to the graduate committee and is ready for submission to the university library.

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ABSTRACT

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During the early stages of infant development the capacity for perceptual (i.e., visual) discrimination is shaped by infants' perceptual experience. Perceptual narrowing is one process hypothesized to account for developmental change. Perceptual narrowing research often demonstrates that infants before 6 months of age are able to discriminate a wide variety of events whereas infants beyond 6 months of age seemingly "lose" some perceptual abilities. Two investigations are proposed to examine the claim that younger, but not older infants can discriminate faces across species. The purpose of Experiment 1 was to determine whether an increase in familiarization and trial times would result in cross-species facial (i.e. faces of macaques) discrimination in 12-month-olds. The hypothesis was supported, adding evidence that perceptual discrimination becomes more constricted, or less efficient with age, but does not decline. Experiment 2 examined whether reducing both the time of familiarization and comparison time by 50% would allow infants sufficient time to discriminate. Results were consistent with the hypothesis and previous studies were corroborated. These findings highlight the important role of perceptual experience in young infants' perceptual discrimination abilities and provide a greater degree of clarity regarding present use of the concept perceptual narrowing.

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Infant Perceptual Discrimination and Perceptual Narrowing

From the time infants enter the world, facial processing and discrimination is at the forefront of perceptual development. Within hours of birth newborns prefer their mothers face to other female strangers (Slater & Quinn, 2001), and can track a moving schematic face more accurately than a scrambled one (Morton & Johnson, 1991). By three days of life newborns show a visual preference for "attractive" compared to "unattractive" faces as rated by adults (Slater, Hayes, Brown, & Quinn, 2000) and visually prefer their mothers face compared to an unfamiliar woman's face even when controlling for similar hair color and length (Bushnell, 2001).

Assessing Infants' Discrimination

While infants tend to prefer *familiar* faces, they also, depending on the context of the "question" being asked of the infant, show a preference for a *novel* stimulus or event. Perhaps the two most widely used measures of infants' discrimination of stimuli involve some variation of procedures of habituation and visual paired comparison. In terms of habituation/dishabituation designs, a stimulus is repeatedly or continuously presented until the infant reaches a habituation criterion (i.e., typically a 50% decline in visual attention) whereupon a novel stimulus is presented. Critically, if the infant perceives the novel event as distinct from the event of habituation, visual attention will be renewed and the infant will look longer (dishabituate) at the novel event (Cohen & Cashon, 2006).

Another common test of infant discrimination and recognition is the visual preference method. In this procedure the infant is presented with two different stimuli simultaneously; whichever stimulus draws more visual attention is the "preferred", or in some paradigms, the more familiar stimulus. A variation of this method involves a visual

paired comparison task (VPC). The VPC involves presenting a stimulus for a set period of familiarization (e.g. 20s of cumulative looking time), and then pairing another stimulus with the original stimulus for a shorter period of discrimination (e.g. 5s). If the infant perceives the novel stimulus as distinct from the original, the infant will look longer at the novel stimulus than to the familiar stimulus (Fantz, 1964). Attention to novelty as well as to familiarity (depending on how stimuli are presented) in the preferential looking, VPC, and the habituation/dishabituation designs are at the heart of assessing infant discrimination.

Before focusing on infant facial discrimination more in depth, it will be useful to very briefly outline several important issues that relate to this research area: optimal (or critical) periods, neurobiological bases of face processing, and to what degree face discrimination and/or processing is a genetically- and experientially-based ability. Having these side topics in mind will help provide a better context and understanding while addressing the more central issue of this paper, that of facial discrimination.

Perceptual Learning and Optimal Periods

It has been argued that infants' preference for novelty provides it with a perceptual advantage by attending to, learning, and retaining a variety of information (Nelson, Thomas, & de Haan, 2006). Over time infants' perceptual ability improves (i.e., increases), and they become adept at discerning subtle differences between faces and many other stimuli. It is frequently assumed that infants' capacity for perceptual discrimination and learning is ever increasing and broadening; however, recent evidence described below suggests this may be too simplistic of a view. Specifically, some (e.g., Lewkowicz & Ghazanfar, 2006) suggest that there is a period in development when

infants have a broader perceptual discriminatory ability than adults. This brief period during the first eight months of life is considered an evolutionary advantage as infants can adapt to any perceptual environment by learning same-species or cross-species facial and vocal cues (Lewkowicz & Ghazanfar, 2006). This period of "wide" perceptual capability has been described as a possible critical or sensitive period with regard to early perceptual development.

A critical period, in its traditional definition, is one in which there is a relatively concrete onset and offset of time wherein a young infant is tuned to learn, acquire, or synthesize a characteristic critical for further development. The term sensitive period was coined in response to the realization that not all periods of development have truly fixed windows of opportunity. Werker and Tees (2005) selected the term optimal period to refer to a "window that is more variable in onset and offset than a classic critical period" (p. 234). The flexible optimal period is the term and definition used throughout this paper. An understanding of these developmental periods will be useful when considering their impact on experiential-based perceptual abilities.

Cursory Review of Neurological Underpinnings of Face Processing

During the course of early development, face processing mechanisms are "tuned" to learn and distinguish a variety of facial features. According to some, initial attention is drawn by the face-like arrangement of elements or "blobs" within a contour (Maurer, Le Grande, & Mondloch, 2002; Schwarzer, Zauner, & Jovanovic, 2007), and by 4 months of age infants process eyes and mouth separately by feature. By 10 months, infants process the face holistically as a type of "gestalt" similar to adults (Schwarzer et al., 2007).

Several neurological components are obviously necessary to accurately recognize and process various aspects of faces. These include and are in nowise limited to, shapes of facial features, the shape of the face, and spacing between facial features. Each of these seem to be relatively separate systems, working together to effectively process faces in the environment (Le Grand, Mondloch, Maurer, & Brent, 2003). One brain region commonly found to involve face processing in adults is that of the occipitotemporal cortex which includes the fusiform gyrus, or 'fusiform face area' (Farah, Rabinowitz, Quinn, & Liu, 2000; Le Grand et al., 2003). Expert face processing has a strong base in the occipitotemporal region of the right hemisphere even though activation is found bilaterally (Geldart, Mondloch, Maurer, de Schonen, & Brent, 2002; Haxby, Hoffman, & Gobbini, 2000). There has been some debate as to whether there is a specific face-processing structure in the brain present at birth or if facial recognition is wholly a function of experience (Johnson, 2001; Nelson, 2001a, 2001b). Regardless of whether it is best explained as innate or rapidly experiential, "from the beginning of life a sensitivity to [face-like arrangements] exists" (Schwarzer et al., 2007, p. 453).

To address this debate, Sugita (2008) performed an experiment that tested whether delayed exposure to faces would impact future facial processing. Monkeys were separated from their mothers within hours after birth, and raised in a visually rich environment with assorted colorful toys and flowers, but no exposure to monkey or human faces. Human caregivers who played with the monkeys two hours a day always wore face masks during every interaction. Ten monkeys were deprived from facial stimuli for a period ranging from 6 to 24 months.

Prior to exposure to faces following their period of facial deprivation, the monkeys were tested with preferential looking and VPC procedures to test for discrimination and preference. All monkeys preferred human and monkey faces equally over other non-face stimuli, and could distinguish between novel and familiar faces. Age-matched controls could only discriminate between monkey faces, but not human faces. These results are congruent with studies involving human infants, who after an optimal period are no longer able to distinguish faces across species (Pascalis et al., 2005).

For one month following the deprivation period, half of the monkeys were exposed to either human faces or monkey faces for the first time. At the end of this initial exposure period, the monkeys were placed in a normal environment that enabled them to interact with humans and monkeys daily. Even after a year of exposure to both human and monkey faces, those who were first exposed to human faces, still significantly preferred human faces, while those first exposed to monkey faces significantly preferred monkey faces. Critically, in a preferential looking paradigm the initial non-exposure species faces were viewed only as long as non-face objects, suggesting those faces were not interpreted as socially relevant.

Sugita (2008) states that face detection and discrimination can be delayed up to two years, during which time the facial processing system is kept “in an immature state” (p. 398). His results support the idea that infants are born with neurons that favor facial stimuli, but exposure to faces is necessary for their further specialization. Both a genetic predisposition for viewing faces and repeated exposure to facial stimuli are necessary for a proficient face processing system. Despite their deprivation, monkeys in this

experiment displayed a delayed optimal period for face perception, followed by rapid perceptual narrowing of visual discriminatory ability.

Human Infant Abilities and Perceptual Narrowing

As briefly reviewed above there is neurological and behavioral evidence documenting the developmentally flexible nature of early perceptual development – in particular for early face discrimination. Experience (e.g., including absence) leads to a modification of perceptual development in non-humans (both neurologically and behaviorally), and research with human infants has resulted in the use of a term called perceptual narrowing. There are at least two ways that perceptual narrowing can be defined. One definition is that perceptual abilities are temporarily restricted, or focused only on experiential-based stimuli, while still allowing for the reemergence of those same perceptional abilities with mild exposure or practice. This implies that abilities are not completely lost following the close of an optimal period, but become more constricted, or less efficient. Another interpretation is that narrowing becomes exclusive of stimuli not regularly encountered in the environment. Any previous abilities are consequently lost (the results of Sugita's 2008 experiment seems to fit under this definition), and can only be re-learned with heavy exposure and practice, perhaps using slightly different, though overlapping brain areas (see for example Werker & Tees, 2002, 2005). Because of these two possible definitions (and others), clarification of the refinement of perceptual discriminatory abilities called "narrowing" is therefore desirable.

There are many examples of perceptual narrowing with human infants which have been assessed using particular methodologies applied at two or more time-points. When infants are successful at Time A but not Time B it is common to say that "narrowing" has

occurred. Consider the following: On average, infants between 4-6 months of age are adept at discriminating between phonemes of their own language as well as that of foreign languages, whereas 8-9-month-olds (and adults) discriminate phonemes in their primary language, but no longer discriminate foreign language phonemes (Werker & Tees, 2002). In addition, infants as young as 3 months can associate voices with matching faces (Brookes et al., 2001) and at 4 and 6 months, but not at 8 months, infants can distinguish their native language phonemes from an unfamiliar language based on visual information alone (i.e. lip movement; Weikum et al., 2007). Three-month-old infants can also discriminate differences between their own and other-race faces (Sangrigoli & de Schonen, 2004). Finally, infants at 6 months, but not at 9 months, can discriminate monkey faces (Pascalis, de Haan, & Nelson 2002; Pascalis et al., 2005), match monkey calls with corresponding faces (Lewkowicz & Ghazanfar, 2006), and pair aggressive or non-aggressive dog barks with analogous static images (Flom, Whipple, & Hyde, 2008).

Of note is that each of these experiments involved a particular familiarization and looking criteria that was applied at both (or all) testing sessions. In other words, given *certain criteria* for discrimination, infants during the first year show a greater perceptual discriminatory and matching proficiency at a younger but not older age, and many of these perceptual abilities are seemingly "lost" before the end of the first year of life. Consequently, on tasks such as discriminating monkey faces and language phonemes, infants are no longer able to perform better than adults who typically perform at chance levels. It seems therefore that infants are born with a very broad perceptual discriminatory ability, and fine-tune their perception of the world through their every day experiences. As their ability to discriminate improves in one area (e.g., own-race faces),

there seemingly is a corresponding decline in other areas (e.g., other-race faces, other-species faces). In other words, several optimal periods figuratively open and close during the first year, and as Werker and Tees (2005) propose for language, there may even be overlapping or cascading optimal periods in other perceptual areas. Of particular interest for this paper however is the clarity of the term narrowing, and the accuracy of the previous can/can't or do/don't examples listed above. This topic will be further addressed in the Discussion section.

"Delaying" Narrowing

Werker and Tees (2005) state that although it may be less effective, changes effectuated outside an optimal period "is acknowledged as a real and testable possibility" (p. 234). The modifiability of optimal periods, particularly surrounding that of perceptual narrowing has been tested. One focus has been to ascertain to what degree perceptual narrowing can be postponed. Kuhl et al. (2003), for example, found that by exposing 9-month-old infants to approximately five hours of Mandarin Chinese, perceptual narrowing was postponed. One of four Mandarin speakers read children's books and spoke during play activities over the course of four weeks. The control group had English-only exposure for the same activities during the same time period. In a second experiment Kuhl et al. found that social interaction plays a critical role in language acquisition. Nine-month-olds were randomly assigned to exposure from either a unimodal (auditory only) or bimodal (auditory and visual) DVD of Mandarin Chinese. At the end of the four weeks, neither group showed differences between themselves or the English-only group. Those in the DVD learning group, just like the English-only

interaction group, showed no evidence of learning Mandarin or postponing perceptual narrowing.

This need for social interaction to obtain language and delay perceptual narrowing may also be necessary for cross-species facial perception. Pascalis et al. (2005) gave 6-month-old infants a folder of monkey faces each labeled with a name. Caregivers were instructed to show their child the pictures in a friendly way for 1-2 minutes a day for two weeks and then less frequently during the next 10 weeks. At the end of the training period, the now 9-month-old infants were compared with a control group of the same age. The trained infants were tested on their recognition of the familiar monkey faces from the folder, as well as discrimination of unfamiliar monkey faces. The infants looked significantly longer at the unfamiliar monkey faces than the familiar stimuli, demonstrating that they recognized the familiar, and did not recognize the novel stimuli. Control infants showed no looking preference for either pre-trial or test images, and perceptual narrowing was postponed for the exposure group.

Learning beyond Narrowing

If perceptual narrowing occurs, and an optimal period comes to a close, that does not mean that all potential for the development of a discriminatory ability is completely lost. Whether that ability is temporarily constricted/inefficient, or must be relearned is unclear from the present literature. What it does suggest perhaps is that a child (or adult) may be less adept at making subtle distinctions between unfamiliar stimuli. In alignment with this idea is an observation by Scott (1962) that what is learned at a particular point in development may limit or interfere with subsequent learning. If for example during an

optimal period an infant learns only to discriminate human faces, exposure to monkey faces beyond that period would likely present a completely new challenge.

During an optimal period a specific brain region may integrate information into one area, while information learned after an optimal period, although similar, is not specifically tied to that original region; such has been seen with language (see Werker & Tees, 2005). While it is not unusual for someone to learn to speak a second language, if acquired outside the optimal period for language in very early childhood their proficiency does not reach that of native speakers, even after years of practice and exposure (Pallier, Bosch, & Sebastian-Galles, 1997). Although a second language speaker may be fluent, the later the language is learned the less skilled in the language they will be (Werker & Tees, 2005). Language skill is better in those who learned the same second language during the optimal period in early childhood (Johnson & Newport, 1989). So while perceptual abilities can be retuned or relearned following the offset of an optimal period, those newly acquired skills are not incorporated as universally (at least for language) into the same specific brain structures as those learned during the optimal period (see Werker & Tees, 2005 for a review on this topic).

This second language acquisition is a partial reversal of perceptual narrowing in that language is acquired after the optimal period, and with sufficient practice, spoken fluently. This illustrates not only the optimal period of language, but the ambiguity of the term narrowing, as narrowing may be understood to allow for relearning when applied to second language acquisition, but constriction *or* relearning with regards to other perceptual discrimination.

Current Hypothesis and Proposal

During the first year of development, infants demonstrate the remarkable quality of fine-tuning their breadth of perception to match their environment. It has been shown that perceptual narrowing can be delayed in language (Kuhl et al., 2003) and facial discrimination (Pascalis et al., 2005). There is also evidence that language can be learned outside the optimal period and with sufficient exposure and practice, language can be learned well (Werker & Tees, 2005).

Few studies have determined whether the ability to discriminate unfamiliar stimuli can be reinstated after "perceptual narrowing" has putatively occurred. One purpose of this study was to determine if narrowing of cross-species facial discrimination demonstrates properties of a more malleable optimal period rather than a critical period. It was hypothesized that increased exposure to unfamiliar stimuli would result in a reemergence of cross-species perceptual discrimination after that ability has presumably been lost. By testing this hypothesis, it was hoped to further elucidate the degree of adaptability in the human infant, clarify if narrowing of facial discrimination shares similar characteristics with that of language, and determine to what extent cross-species facial discrimination is present following its optimal period of development.

Two experiments were performed. The aim of Experiment 1 examined whether 12-month-olds are able to discriminate unfamiliar monkey faces when they are given additional familiarization and time to compare the faces (i.e., four 10s test trials compared with two 5s test trials). Experiment 2 replicated, in part, the experiment of Pascalis et al. (2005) by testing cross-species facial perception in infants. In both experiments the same stimuli used by Pascalis et al. (2005) were used to examine 12-

month-olds' ability to discriminate monkey faces. The use of 12-month-olds was deliberate, as based on previous research, by that age it is expected that perceptual narrowing has fully occurred and infants are unsuccessful at cross-species discrimination.

General Methods

Participants

Participants were 48 healthy, normal, full-term infants weighing at least five pounds at birth, with Apgar scores of 7 or higher and with no visual impairments noted at birth. None of the infants had notable experience with monkeys or monkey faces as reported by either parent. Parents' names were obtained from Utah County public birth records and their phone numbers identified by using internet based public phone number directories (e.g., http://dexknows.whitepages.com). Parents of the participants were contacted via telephone and were asked if they would be interested in study involvement. Upon arriving, parents completed an informed consent form. There was no compensation for participation. Two criteria were required for inclusion of a participant's data: Infants were required to complete the familiarization phase and the 4 test-trials, and not demonstrate side bias (a preference for looking either to the left or the right regardless of stimulus presentation). Freedom from side bias was determined by looking at least 5% of the time at a less preferred stimulus (see Flom et al., 2008 for a related experiment using similar criteria). Data from infants that did not meet these criteria were excluded from the final analyses.

Stimuli and Apparatus

Stimuli were the same as those used in the study by Pascalis et al. (2005) with their consent. Stimuli consisted of 24 images of Barbary macaques cropped in an oval

shape with the ears removed- showing only a frontal view of each face. Cropped images were placed against a white background. Track and image labels were placed in the lower right corner of each image. Monkey faces are similar in emotional expression and facial orientation. See Figure 1 below for examples of 2 of the 24 faces.

Figure 1: Example of Barbary macaque face pairing stimuli used in each experiment.

Stimuli were edited and written to DVDs using Adobe Premier Elements and played using two Sony (DVP-NS57P/B) DVD players. Stimuli were presented on two 19 inch (48cm) color monitors (Sony KV-20M10) placed 15 centimeters apart from each other and approximately 50 centimeters from the seat where infants sat on their caregivers lap. Parents were instructed to look between and above the monitors in order to limit any infant looking bias due to gaze following. The lights in the room were turned off except for a small lamp directly behind the infant which illuminated the work area of the projectionist. The monitors were surrounded by black cloth with two small openings for observers to assess infant looking times. Observers were blind to the hypothesis and unable to see the presenting stimuli. Using a video game controller, observers depressed a button while the infant looked at an image and released it when the infant looked away. The same process occurred to measure looking times for the other image by using a separate button on the same controller. Acting as a stopwatch, these controllers relayed information to a computer that signaled the projectionist (who controlled the timing, presentation, and lateralization of stimuli) when familiarization had been reached. After a 5s delay following familiarization, the projectionist would then switch one of the faces, and the observer would measure looking times during the trial interval. Pairings of monkey faces were categorized as "very hard", “hard”, “moderate”, and “easy” based on degree of similarity. Study procedures were approved by the Institutional Review Board at Brigham Young University.

General Data Analyses

In order to assess whether infants showed a reliable preference for the novel or familiar face, infants’ proportion of total looking time (PTLT) to the novel face was

compared against the chance value of 50%, or equivalent looking to both faces. This was performed for each of the four trials in Experiment 1 and was averaged across the four trials. A Chi square analysis was used to evaluate potential looking time differences moderated by face similarity/dissimilarity (e.g. the very hard vs. easy faces), as well as to test for significance in the overall number of infants who looked longer at the novel stimulus to help control for any effect of outliers on the overall correlation. A second observer was present for at least 30% of participants. Interobserver reliability for the primary and secondary observers was based on their recording of infants' proportion of looking to the novel face using a Pearson correlation coefficient. The average level of agreement was $M = 0.92$ ($SD = .04$) across both Experiments 1 and 2 and no systematic difference was found across these two Experiments.

Experiment 1

Method

Participants, Stimuli, and Procedure

Experiment enrollment originally included 41 infants. Data from two infants were incomplete as a result of equipment malfunction, and 15 additional infants were excluded due to side bias. Thus final enrollment included 24 infants with a mean age of 359.33 days ($SD = 14.5$; 18 female). Using a visual paired comparison procedure infants were familiarized to one monkey face by viewing the same image/face on two side-by-side monitors until 40s of cumulative looking to either monitor was attained. Following the familiarization phase infants received two 10s test trials. On each test trial, one monitor conveyed the face of familiarization and the adjacent monitor presented the novel/unfamiliarized face for that pairing (see *Stimuli and Apparatus*). Following a 5s

intertrial interval, infants were familiarized to a second unfamiliar face for 40s of cumulative looking, which was again followed by a 5s delay, and then two 10s test trials. The face of familiarization, and its counterpart used as the test face, was randomly chosen for each infant from one of the 12 pairings. An equal number of infants (n = 2) received each pairing.

Results and Discussion

The primary dependent variable of Experiment 1 was looking to the novel face. Infants' looking behavior was recorded as a percentage of the total looking time (PTLT). Specifically, infants' proportion of looking to the novel face was calculated by dividing the amount of time spent looking toward the novel face by the sum of their looking to the novel and familiar face. Proportions of looking to the novel face were compared to the chance value of 50% (equivalent looking to the novel and familiar face) for each trial and were collapsed across all four test trials reaching significance M = .54, SD = .07; t (23) = 2.63, p = .02. Further analyses, revealed, however, this result was potentially "carried" by the first block, i.e., test trials 1 and 2, M = .58; SD = .07; t (23) = 2.63, p = .02, whereas infants' proportion of looking to the novel face did not reach significance in the second block, i.e., test trials 3 and 4, where p > .10. A Boxplot of infants' proportion of looking to the novel face for each trial in Experiment 1 is presented in Figure 2.

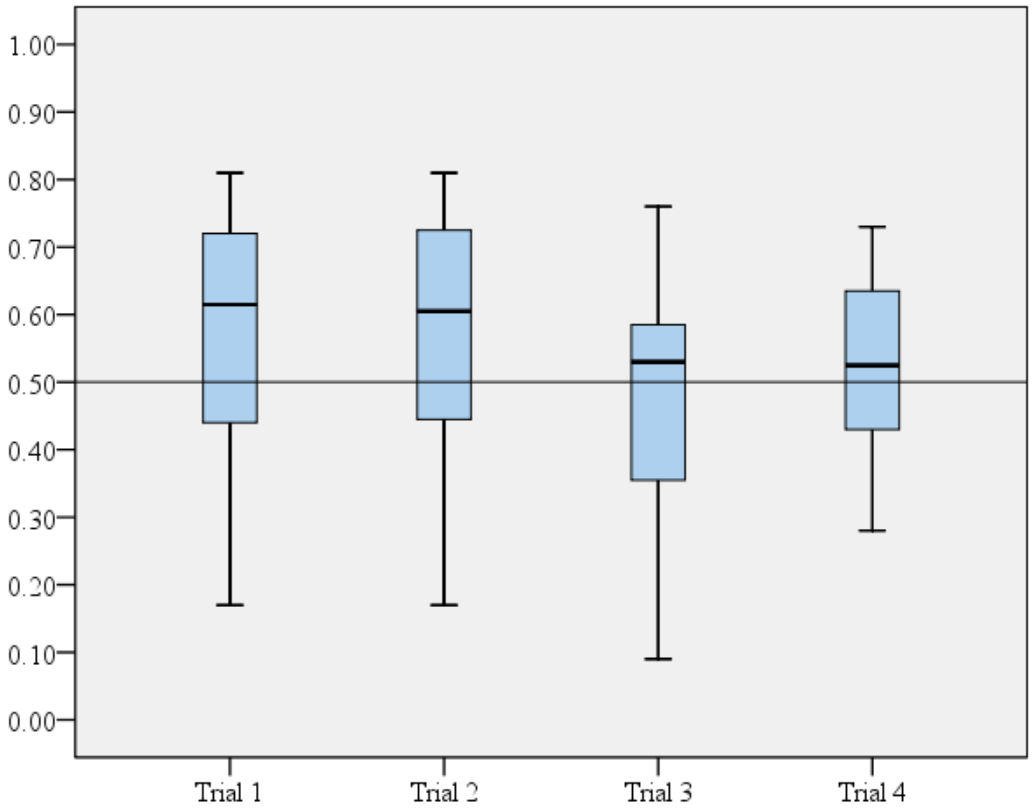

Figure 2: Proportion of total looking time (PTLT) for each trial of Experiment 1 compared with chance (50%).

While this result may be attributable to infant fatigue, time to familiarization for Block 1 compared to Block 2 (55.77s; 58.76s respectively) did not reach significance ($p > .10$). Moreover, infants' looking behavior, i.e., time spent looking during the test trials, did not reliably differ from Block 1 to Block 2 ($p > .10$). Thus it does not seem that infants became bored with the task as the experiment progressed. See Table 1 for the time to familiarization and PTLT results of Experiment 1.

Table 1: Proportion of total looking time (PTLT) for Experiment 1

Experiment 1: Block 1 (Trials 1 and 2)

	Time to	Mean Time		Mean PTLT	
	Fam	Novel	Fam	Novel	Fam
Mean	55.77	4.65	3.42	0.58*	0.43*
SD	10.69	1.70	1.51	0.17	0.17

Experiment 1: Block 2 (Trials 3 and 4)

	Time to	Mean Time		Mean PTLT	
	Fam	Novel	Fam	Novel	Fam
Mean	58.76	4.17	4.06	0.50	0.50
SD	12.65	1.60	1.48	0.15	0.15

Experiment 1: Block 1 and 2 Average

	Time to	Mean Time		Mean PTLT	
	Fam	Novel	Fam	Novel	Fam
Mean	57.26	4.41	3.74	0.54*	0.46*
SD	11.67	1.65	1.50	0.07	0.07

* = $p < .05$

At an individual subject level, within Block 1, 19 out of 24 infants looked greater than 50% of the time at the novel stimulus; $\chi^2(4, N = 24) = 8.17$, $p < .01$, and in Block 2, 11 of 24 preferred the novel; $\chi^2(4, N = 24) = .17$, $p = .68$. These results demonstrate that 12-month-olds are able to discriminate previously unfamiliar monkey faces when provided 40s of familiarization and two 10s visual paired comparison test trials. Historically, it has been shown that the ability to discriminate faces has "narrowed" by approximately 9 months of age (Pascalis et al., 2002; Pascalis et al., 2005). Our sample of 12-month-olds was selected with this assumption in mind. Recall in Pascalis et al. (2005) narrowing was "delayed" from 6 months until about 9 months of age whereupon infants were tested with a 20s familiarization period, followed by two 5s VPC test trials, and were given time to study the faces at home in the form of a picture book.

The purpose of Experiment 1 was to examine whether increasing the time of familiarization and time to compare or otherwise examine different faces promotes 12-month-olds' ability to discriminate unfamiliar monkey faces. As evidenced above, the results support the prediction and claim. Specifically, perceptual narrowing should not be taken to mean that a given perceptual ability is "lost", or otherwise declines (see Discussion section); rather, based on the results of Experiment 1 it may simply be "more difficult" for the infant to make such a discrimination. Thus the hypothesis that increased familiarization and time of comparison would reveal the continued ability of cross-species facial discrimination in infants was supported. Furthermore, the results of Experiment 1 support the *constricted* definition of narrowing provided earlier, suggesting that discrimination abilities were not "lost".

In order to bolster the claim that 12-month-olds' ability to discriminate the faces of Experiment 1 is due to the increased familiarization and/or comparison test-trial time, a logical extension would be that if the familiarization and test-trial time are reduced (i.e., decreased by 50%) then infants' discrimination should also decline. The purpose of Experiment 2, therefore, was to examine this claim by reducing both the time of familiarization and test-trial looking time by 50% and examine 12-month-olds' discrimination of unfamiliar monkey faces. A second purpose of Experiment 2 was to replicate Pascalis et al. (2002) as well as Pascalis et al. (2005) who found that younger (6-month-olds) but not older (9-month-olds) infants could discriminate unfamiliar monkey faces.

Experiment 2

Method

Participants, Stimuli, and Procedure

Experiment 2 included 48 infants. Data from two infants were incomplete as a result of experimenter error, one infant was excluded due to equipment malfunction, one for fussiness, and 21 infants were excluded due to side bias. Thus final enrollment included 24 infants with a mean age of 359.88 days (*SD* = 15.2; 13 female).

All stimuli, apparatus, and procedures were identical to Experiment 1 with the exception that infants received a cumulated 20s of familiarization and two 5s test trials. This procedure, as in Experiment 1, was replicated with a second unfamiliar face (i.e. Block 2). Thus Experiment 2 was a general replication of Pascalis et al. (2005). As in Experiment 1, the face of familiarization and its counterpart used as the test face, was

randomly chosen for each infant from one of the 12 pairings and an equal number of infants ($n = 2$) received each pairing.

Results and Discussion

The primary dependent variable of Experiment 2 was again, infants' PTLT to the novel face, and was again compared to chance (i.e., 50% or equivalent looking). Infants' proportion of looking to the novel face in Experiment 2 is presented in Figure 3.

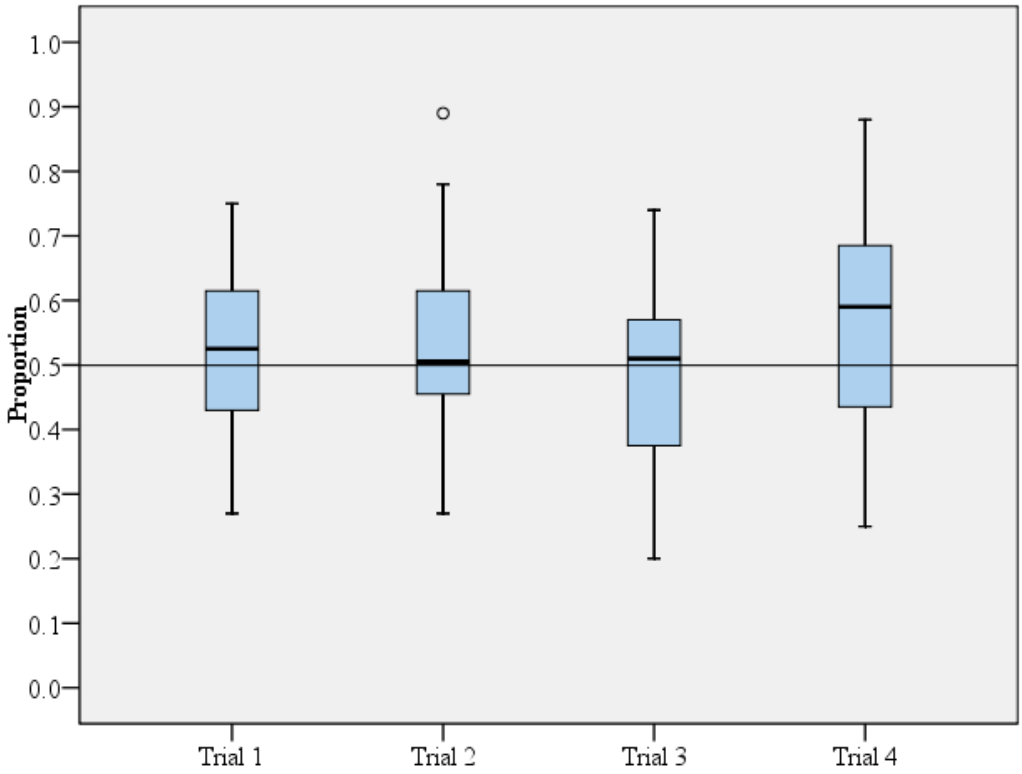

Figure 3: Proportion of total looking time (PTLT) for each trial of Experiment 2 compared with chance (50%).

Across all four trials infants' looking to the novel face (M = .53; SD = .06) failed to reach significance t (23) = 1.92, p > .05. Thus infants in Experiment 2, when provided shorter time of familiarization and time to compare the novel and familiar face, failed to show reliable evidence of discrimination, replicating the findings of Pascalis et al. (2002) and Pascalis et al. (2005). In addition, infants' looking to the novel face in Block 1 (test trials 1 & 2) and Block 2 (test trials 3 & 4) also failed to reach significance (both p's > .10). As in Experiment 1, infants' average duration to reach the 20s familiarization criterion did not differ across Block 1 and 2 (p > .10), nor did infants' looking during the test trials for Block 1 or Block 2 (p > .10). Finally, from an individual subjects perspective, across Blocks 1 and 2, 14 out of 24 infants preferred the novel face and this did not differ from chance $\chi^2(4, N = 24) = .67$, p = .41.

Taken together, these results replicate previous experiments, and are suggestive that the positive discrimination found in Experiment 1 is a result of the increased familiarization and test trial comparison time. See Table 2 for the time to familiarization and PTLT results of Experiment 2.

Table 2: Proportion of total looking time (PTLT) for Experiment 2

Experiment 2: Block 1 (Trials 1 and 2)

	Time to	Mean Time		Mean PTLT	
	Fam	Novel	Fam	Novel	Fam
Mean	26.22	2.42	2.19	0.52	0.48
SD	3.29	0.71	0.68	0.14	0.14

Experiment 2: Block 2 (Trials 3 and 4)

	Time to	Mean Time		Mean PTLT	
	Fam	Novel	Fam	Novel	Fam
Mean	26.40	2.37	2.14	0.53	0.47
SD	5.49	0.76	0.71	0.15	0.15

Experiment 2: Block 1 and 2 Average

	Time to	Mean Time		Mean PTLT	
	Fam	Novel	Fam	Novel	Fam
Mean	26.31	2.40	2.16	0.52	0.48
SD	4.39	0.74	0.69	0.14	0.14

General Discussion

To date very few studies have examined whether the ability to discriminate unfamiliar stimuli can be demonstrated after perceptual narrowing has putatively occurred. In the current study it was hypothesized that increased exposure to unfamiliar stimuli would result in 12-month-olds' ability to perform cross-species discrimination of unfamiliar faces. The present study clarifies that facial discrimination is not "narrowed" at 12 months, and demonstrates that infants can make such perceptual discrimination. Simply put, infants of this age require more familiarization and/or comparison time to show reliable discrimination. Whether familiarization or comparison time is more important or useful for discrimination cannot be determined from this study as both were proportionally (i.e., doubly) increased.

Two potential confounds arise when familiarization and/or comparison time are increased, such as occurred in Experiment 1. The first is the longer the trials (i.e. the overall length of the experiment) the more likely the infant will become bored or fatigued. The second issue is the potential for "on-line" learning, in other words, when a participant learns the faces due to repeated presentations and/or extended time to examine each face.

The fact that infants looking time to the novel stimulus in Experiment 1 reached significance in Block 1 but not in Block 2, supports the prediction that infants could distinguish the faces right away and did not "learn" them by mere exposure to the faces during the test trials. That is, if infants looking to the novel had improved across Block 1 and 2, that would be evidence for improving from "online" exposure, and not just from having more time initially to familiarize and compare. Moreover, infants did not become

more weary or fatigued as Experiment 1 progressed. If infants were becoming more fatigued or "bored", then time to reach familiarization from Block 1 and Block 2 would increase and the amount of time infants looked during the test trials would decrease from Block 1 to 2; critically neither of these outcomes occurred. It appears therefore by providing infants with a longer period of familiarization and time to compare side-by-side the novel and now familiar face, 12-month-olds' overall discrimination, and discrimination within the first block reached significance. The result of Experiment 1 is consistent with Scott et al. (2007) who state that infants at 9 months maintain the neural ERP component associated with facial discrimination, but lack the former proficiency to demonstrate behavioral manifestations such as significant differences in looking time.

Infants in Experiment 2 did not demonstrate significant discrimination given the outlined familiarization and comparison criteria. Experiment 2 used the same stimuli as Pascalis et al. (2005) and repeated the 20s familiarization and two 5s test trials a second time (Block 2), thereby thoroughly replicating and supporting Pascalis et al. This negative result is important in that it confirms a reduction in perceptual discrimination skill at that age when experience with monkey faces is lacking.

Side bias was controlled for in each experiment by excluding infants who looked less than 5% of the time at a less preferred stimulus. In other words, infants were required to at least look (even if for only as little as .5s in Experiment 2) at both stimuli on every trial, which as mentioned above, resulted in the exclusion of 36 infants across both experiments. Applying this side bias exclusion criteria insured that infants actually were (in theory) comparing stimuli on each trial. Of potential interest for Experiment 2 is that by Trial 4, infant looking began to approach significance at trend level ($p = .053$),

suggesting that infants might be benefiting from "online" learning which begins to be manifest by the end of the 2nd Block.

One-way analysis of variance revealed no significant differences between PTLTs and face difficulty (i.e., easy, medium, hard, or very hard) for either experiment; which, although surprising, suggests that infants' discriminatory ability is not moderated by face similarity/dissimilarity. Pascalis et al. (2005) state that their stimuli were paired by the authors "on the basis of pictures being similar but distinguishable" (p. 5298). At present it is unknown if the pairings made by the author and those done by Pascalis et al. are the same, and to the author's knowledge, other studies have not been conducted to directly determine if similarity or dissimilarity of faces has an impact on infants' discriminatory ability. Although the hypothesis needs to be corroborated, perhaps if infants were given slightly shorter timeframes such as 15s familiarization and 7s test trials, face difficulty might emerge as a significant factor influencing discrimination ability.

Although no significant differences between trials were found, in both experiments (for Block 1 and 2 respectively) infants tended to prefer the novel face more on the 2nd trial of each block (i.e. Trials 2 and 4). It is possible that by the 2nd trial infants might need less time to compare faces, and thus spend more time looking at what they recognize as the novel face. In this way, the first trial of each block could serve to help familiarize the infant to both faces and assist in decreased comparison time on the following trial. Following a new face of familiarization, this process would start over. If this observation is corroborated, it is suggestive of infants' working memory being applied to online discrimination (see Bauer, 2006; Nelson et al., 2006), resulting in less time required to distinguish faces the more they are viewed.

Taken together the results of Experiments 1 and 2 shed light on the phrase "perceptual narrowing" in terms of how it is currently used in the literature. In one sense, it is accurate to say narrowing in that with lack of experience the ability to discriminate is reduced (but not eliminated); but narrowing can also imply a diminishing of ability that results in an eventual end-point. Whether this end-point exists and if so, where, cannot be fully established given the current literature. However, it is safe to say that a hypothetical termination of discriminatory ability of monkey faces is not present at 12 months of age.

Although certainly unintentional, present research has perpetuated a philosophy that certain discriminatory abilities are "lost" by the end of the first year of life by stating that infants are unable to perform certain distinctions. Consider the following examples: "…*only* 6-month olds can also discriminate two monkey faces" (Pascalis et al., 2005, p. 5298; emphasis added). "…10- to 12-month-olds can *only* discriminate the phonetic variations used in their native language...[and] 9-month-old infants and adults show a marked advantage for recognizing *only* human faces" (Pascalis et al., 2002, p. 1321; emphasis added). "…the ability to individuate monkey faces is *absent* in 9-month-old infants and in adults" (Kelly et al., 2005, p. 1085; emphasis added). "…9-month-old infants *only* discriminate pictures of native faces… [and] older infants *only* discriminate same-race faces" (Lewkowicz, Sowinski, & Place, 2008, p. 292; emphasis added).

Uses of such words as "only" or "absent" while a convenient simplification or perhaps a simple semantic misuse, is nevertheless potentially misleading. However, it is unlikely that researchers would conclude or agree that various perceptual discriminations cannot happen beyond an optimal period. Prominent authors assert that the "lack of experience to monkey faces leads to neural disuse and inefficient processing…thus,

perceptual narrowing may not reflect the complete erasure of neural connections, making these systems flexible and ready to be reactivated at a later period in time" (Scott et al., 2007, p. 201).

The view that narrowing leads to a loss or absence of ability has most likely been perpetuated (ironically) by narrow methodological applications. In other words, several experiments examining perceptual narrowing have been based on certain familiarization and looking criteria (e.g. 20s familiarization with two 10s test trials) imposed by experimental conditions; not capturing the full (albeit less proficient) range of infant discrimination at later ages. If other more broad conditions or criteria are used (such as those applied in Experiment 1), continued perceptual discrimination is observed. Put simply, infants can be made to appear bright or dull simply by changing the durations that stimuli are presented. A more accurate description of whether infants can discriminate should include not only ages and stimuli, but timeframes for discrimination such as, "at 9 months of age, infants given 20s of familiarization, and 5s test trials are unable to discriminate monkey faces" and "12-month-old infants can discriminate monkey faces if given 40s of familiarization and 10s test trials, but not less."

It is far from the author's intent to be overly critical of the previous research, or to imply that the present study is somehow methodologically superior; rather to illustrate that Experiment 1 clarifies the potential meaning of "narrowing", and helps redirect some attention to investigate the degree and duration of perceptual narrowing in infants after the first year of life. Nearly all of the perceptual narrowing research articles cited thus far have the underlying theme that if infants do not have exposure to, or experience with, various stimuli their ability to discriminate is reduced over time. Therefore, a more

accurate description of the decline in infants' discriminatory abilities (perceptual narrowing) could be framed as experience-dependent perceptual learning. This emphasizes the importance of experience in the maintenance of skilled discrimination, rather than the idea that abilities simply fade and eventually disappear. Any reduction in proficiency should not be viewed as permanent; rather that further experience or training is required for that particular skill to be fully utilized.

Of possible future interest is how much and what kind of training could bring about a reversal of the reduction in experientially-based perceptual discrimination and allow infants older than 12 months to discriminate with only 20s of familiarization and 5s test trials. Reversals of "narrowing", or an increase in experience-based perceptual learning/discrimination have been demonstrated with the other race effect (ORE) in adults (e.g., Elliott, Wills, & Goldstein, 1973; Goldstein & Chance, 1985). Unfortunately, however, these results are not frequently cited in more recent articles examining perceptual narrowing. It seems more recently authors have described a "replacement" compared to a reversal. For example, Sangrigoli, Pallier, Argenti, Ventureyra, and de Schonen (2005) studied children adopted between 3-9 years of age into another country where faces of their native race were rare, if not absent. Now adults, these adoptees demonstrated similar ORE characteristics as those who were native, and did not discriminate faces of their own race any better than controls. As mentioned in a previous section, with continued experience, 9-month-old infants continue to discriminate monkey faces with 20s familiarization and 5s test trials (see Pascalis et al., 2005). It is likely that social relevance (e.g., parent interaction) would be valuable in exposure/training approaches with infants (see Kuhl et al., 2003).

The example of a training experience just mentioned involved sending children home with picture books of monkey faces to view several minutes a day for a period of weeks. Pascalis et al. (2005) used this approach to provide continued experience to infants, thereby allowing for perceptual discrimination at 9 months of age using the same criteria used at 6 months (see Introduction). Applying this same approach, if parents of 12-month-olds were instructed to show their infant the monkey pictures regularly, thereby providing visual experience with monkey faces, it would be expected that those infants would show an improvement in perceptual discrimination. This training approach hypothesis is presently underway as part of another research project, and will likely help answer the questions mentioned above.

Summary and Conclusion

The purpose of the present study was to determine whether an increase in familiarization and trial times would result in cross-species facial discrimination in 12-month-olds. The hypothesis was supported, and adds to the literature evidence that perceptual discrimination becomes more constricted, or less efficient with age, but does not decline. The purpose of Experiment 2 was to examine whether by reducing both the time of familiarization and comparison time by 50% would allow infants sufficient time to discriminate. A second purpose was to examine whether the results of Pascalis et al. (2002) and Pascalis et al. (2005) could be replicated. Results were consistent with the hypothesis and previous studies were corroborated. These findings highlight the important role of perceptual experience in young infants' perceptual discrimination abilities and provide a greater degree of clarity regarding present use of the concept perceptual narrowing.

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