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How Does Our Ability to Recognize Human Faces Develop with Age?

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ABSTRACT: Face recognition is a crucial cognitive skill in social interactions, ensuring individuals' safety and well-being. This paper examines how our proficiency in human face recognition evolves throughout various stages of development. A comprehensive literature review explores the changes and advancements in facial recognition abilities from infancy to adulthood. The findings reveal that newborns possess rudimentary face recognition capabilities, which subsequently undergo refinement and enhancement, leading to improved facial recognition skills. The paper highlights various cues such as inner vs. outer face cues, configural changes, movement, color, species discrimination, gender differentiation, race differentiation, age categorization, and holistic processing that contribute to this developmental progression.

KEYWORDS: Behavioral and Social Sciences; Clinical and Developmental Psychology; Neuroscience; Face Recognition; Cues; Abilities; Infant; Adolescent; Adult.

Introduction

Face recognition plays a pivotal role in the social interactions of both human and non-human species, serving various purposes such as recognizing kin, forming relationships, identifying emotions, and facilitating communication. This cognitive ability undergoes substantial changes, prompting an in-depth study of its developmental aspects. This paper examines the specific skills and cues related to face recognition that exhibit notable changes over time, excluding innate abilities and those that remain consistent. Instead, the focus will be on identifying transitional or emerging capabilities for facial recognition, providing age-specific details, supporting evidence, and other relevant information. To enhance clarity and organization, the paper follows a chronological structure aligned with the table in the "results" section, which serves as a comprehensive summary of the examined cues and abilities.

Humans are born with the innate ability to distinguish faces.[1,2] Neurologically, infants possess specialized brain regions involved in face recognition, including the inferotemporal cortex, fusiform face area, occipital face area, and superior temporal sulcus. Areas associated with face recognition grow in tissue mass, especially the fusiform gyrus.[3] By working with 22 children and 25 adults (in their 20s), researchers found that the more tissue an individual had, the better their ability was.[3] Infants are born with an innate ability to recognize and prefer face-like stimuli despite their limited eyesight. Studies have shown that they prefer an up-down symmetrical pattern, such as a symmetrical top-heavy element (Figure 1).[4]

Additionally, experiments that track newborns' head and eye movements have found that they will rotate their heads further when a schematic face is waved in front of them, compared to when there is nothing or a disoriented face.[4] This supports the idea that the location of features is vital for the mental algorithms used in face recognition. These findings suggest that the ability to recognize faces is present from birth and that newborns can process basic facial features, which will be refined and developed as they grow and experience more faces. Infants also pay attention to symmetry, the configuration of the eye, the configuration of the mouth, the shape of the mouth, and the shape of the face.[4] Adults do the same.[4] Contrast areas of the face, such as eyebrows, eyes, and shadows, play a role in facial recognition.[4] These regions work together to complete the four steps of face recognition: detection, encoding, comparison, and identification. Infants are also born with the ability to distinguish between a face representing the shape and an object.[4] This natural attraction to faces has been coined CONSPEC.

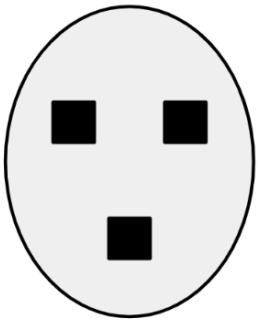

Figure 1 : An Up-Down symmetrical pattern.

Experience plays a crucial role in shaping and refining how humans perceive and recognize faces. As a human develops, faces are associated with various things such as names, personalities, emotions, etc. The brain learns how to process and interpret these associations. This learning process allows the brain to understand better and recognize faces, making the recognition process more efficient. Additionally, as we grow and experience more faces, we also learn to process and interpret emotions expressed by others, which further develops our abil-

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ty to recognize faces. Based on this, it can be hypothesized that the human mental algorithm for face recognition is innate, but with some developments and changes in the ability. Therefore, the essential ability to recognize faces is present at birth. Still, it is refined and developed as we experience more faces and associate them with different information. However, with age, some decline in the ability may occur, for example, due to age-related vision problems or cognitive decline. Therefore, future research should study how the ability to recognize faces changes throughout the lifespan.

Discussion

Method:

A literature review was conducted using keywords such as "face recognition," "infant," "adolescent," "adult," "cues," and "abilities." Articles were selected based on their relevance to the developmental aspects of face recognition in humans. Studies that provided age-specific details and empirical evidence were included, while those focusing on innate abilities or lacking relevance were excluded. The selected articles were analyzed, and relevant information on cues and abilities at different ages was extracted. A table was created to summarize the findings chronologically. Future research is needed to explore face recognition development in specific age groups.

Results

Cues:

Infants or newborns from 0 to 3 days old react differently to a full face, an outer face, and an inner face. An outer face is a face without features like the nose, eyes, and mouth. Exclusively, the hair and face shape are shown. The inner face is isolated to the person's eyes, nose, and mouth. The shape of the face is cut out. In 2006, Francesca Simion, Irene Leo, and others did a habituation experiment to determine the best cue. An infant's gaze was measured by showing pictures of the three types of faces. Conclusively, both the inner and outer face each gave infants (mean age hours, range 26 hours to 78 hours) the ability to recognize a face. However, the outer face was more advantageous in detection than the inner face because they were habituated to outer faces even when inverted. Despite their ability to utilize both inner and outer faces, infants could not encode them separately when shown a face with inner and outer features. This may suggest that infants only pay attention to one of the inner or outer faces when presented with both. Infants have specializations for detecting faces even with limited resources, such as missing facial features.

For significant configural changes or changes that occur unnaturally in adult faces, it takes three months of age, and for a standard change, it may take up to 5 months.[6] By age 4, every ability in adults to recognize faces is present.[7] Configural change accounts for the distance between the eyes, swapping of the eyes, splitting, mismatching of the face, etc. In these circumstances, configural change detection occurs during an infant's third month.[8]

Studies have shown that movement supports facial recognition. In B. Knight & A. Johnston's experiment, the study used a mixed design with one between-subjects factor of presentation (positive or negative images) and two within-subjects factors of movement (still or moving) and orientation (upright or inverted). Participants were scored on their ability to identify famous faces correctly; each presented with 80 faces in the same order and direction.[9] The average age of the participants was 24; there is no data below the lower end of the range. The results indicated that movement increased the accuracy of the subject's answers in the upright opposing faces. The additional views provided by motion sequences were found to be beneficial in recognizing opposing faces, which is thought to be due to the recovery of three-dimensional structures from motion.

It has long been thought that color had minimal effect on facial recognition because there were many other cues for face recognition.[10] Many researchers also thought that faces were solely perceived through the luminance-defined bounding-edge structure (BDS), the theory that faces are primarily encoded in terms of the edges or contours that define their shape, as determined by the image's luminance (brightness) information. Interestingly, however, color has been discovered to impact facial recognition significantly. Individuals tested in their ability to recognize a face in grayscale, full color, and pseudo-color conditioned face demonstrated that they had the highest accuracy with the pseudo-colored picture and the full-color picture.[11] At the age of 22, the ability to recognize faces with color does not fully mature but rather emerges as a rudimentary capacity (Table 1).

Abilities:

New categories for facial recognition appear and disappear from a very early age. At three months of age, infants can distinguish between species. They can form dog and cat face categories based on intact facial information, interfacial features, or external facial features.[12] They can also distinguish between the faces of each species, something human adults cannot do because of perceptual narrowing. Perceptual narrowing is the phenomenon where the ability to discriminate between faces decreases with age; humans start to specialize in humans and lose the ability to distinguish faces in other animals. This ability is available without any experience with animals; however, the experience with animals can help improve their categorization.[13] A neuropsychological study showed evidence that cortical specialization for faces appeared during 2-3 months of age (Table 1). Specifically, the ability to differentiate human faces from other animals emerged.

Because of the development in photography, the minimum age for opposite genders has decreased dramatically. With a realistic black-and-white photo of males and females, infants as young as five months could categorize between the two genders.[13] Interestingly, infants preferred the female gender, which has been speculated to be caused because the average caregiver in the U.S. is female.[14]

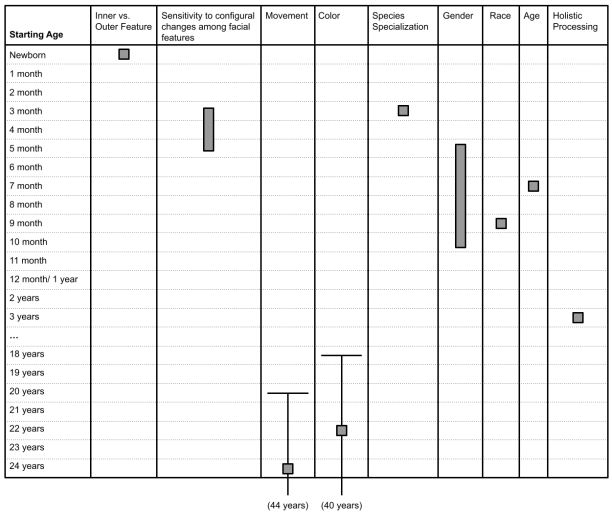
Infants can distinguish between races exceptionally well; however, this ability decreases with experience as the infant ages. More specifically, the infant can only distinguish between race and range by nine months and constantly falls. For example, a Caucasian infant at three months of age shows recognition memory for Caucasian, Middle Eastern, African, and

Chinese races; at six months, recognition was only present for Caucasian and Chinese faces; and finally, at nine months, the infant only distinguished their own race.[15] This phenomenon is not limited solely to Caucasian faces. In a similar experiment done on Chinese infants, the same phenomenon occurred, where at nine months, the infant had a recognition memory for its race.[15] The reason for this is speculated to be that the more an infant is exposed to its race, the stronger the neural circuits get.

In contrast, the less experienced an infant is with another race, the weaker this link gets. This phenomenon is called perceptual narrowing, where the ability depreciates with the lack of experience or exposure. The previous experiments suggest that parts of the mental algorithm for face recognition are nurtured and heavily depend on the environment.

Assessing an individual's actions toward different ages is a test for developing face-age differentiation. In an experiment, seven-month-old children showed other behaviors toward their peers and adults.[16] This was measured through looking/gaze aversion and facial expressions. Older children as young as two years old can verbally categorize.[17] At age 3, children could accurately rank modern photos of adults by age.

Table 1: Table of all abilities and cues listed in the paper, columns 1 to 4 are cues, and 5 to 9 are abilities.



Conclusion

This study discussed how a human's ability to recognize a human face develops with age through various literature and synthesis. This literature review ultimately charts human changes in face perception and tracks when they changed. To summarize the findings, when an infant is born, it uses inner and outer features to detect faces. Then, as the infant reaches its third to five months, they can be sensitive to the changes in the face. The experiment used the age range for color and movement from eighteen to forty and twenty to forty-four, respectively. It is essential to mention that this cue is not the lowest possible age at which it is used. For abilities, species specialization is the first to come online at three months of age. The ability to distinguish between race, age, and gender occurs between five to ten months, and holistic processing occurs at three years of age.

Experience also plays a significant role in developing these cues and abilities. Like language acquisition, a human must be exposed to various faces to learn abilities such as species specialization, gender, age, and race. Even physically, the amount of tissue in the brain processing region can affect the ability of an individual to recognize a face. Genetics may also affect the ability to recognize a face.

The importance of understanding the development of cognitive ability is demonstrated in this paper. These findings can be applied in many fields, such as psychology, neuropsychology, or social sciences. This knowledge can be used in interventions and educational strategies to optimize face recognition skills for various age groups. In addition, it may be helpful to understand the impact of experience and environmental factors on face recognition development to foster diversity, inclusion, and cultural sensitivity. This information will be a valuable basis for future research and operational applications that contribute to our understanding of human social interactions and boost the human experience relating to the face, which is also an essential part of everyday life.

Future Research:

This study has gaps that need to be filled. For example, this study only covers some of a human's cues and abilities because many have yet to be discovered. There is also much contradicting information that needs more evidence to support them. Recognition across view change and discrimination of individual identity has only been experimented with 2–3-month-olds, and their results had weak correlations. There were no studies on whether adults also showed habituation for faces; therefore, a comparison could not be made. This was the case for a few other studies.

Further, some aspects of face recognition need more research. Children and adolescents' face recognition is devoid primarily of study except for configural processing. Further research needs to be conducted on how their abilities change throughout childhood, puberty, etc.

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