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A Framework for the Study and Treatment of Face Processing Deficits in Autism

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7.1 Introduction

From the moment of birth, newborns come into the world programmed with an innate preference for faces (Morton & Johnson, 1991). At the neurological level, distinct brain areas separately code information about the identity (Kanwisher, McDermott, & Chun, 1997) and emotional expression (Whalen et al., 1998) of a face. Beyond the simple recognition of its identity and emotion, what other purpose does the human face serve that would require such specialized neural machinery? In this chapter, we argue that faces provide an important channel for communicating personal information, such as private thoughts and feelings, to other people. We claim that this ability to understand and respond to facial cues is a fundamental skill that individuals must acquire in order to become full participants in a larger social environment. Given the importance of face processing abilities, it is therefore not surprising that this type of social expertise is achieved by most people at a relatively early age of development.

Although it is true that most people are social experts in their ability to decode facial information, an accumulating body of evidence indicates that individuals with autism and Asperger's Syndrome lack many of the rudimentary skills necessary for successful face communication. Autism is clinically diagnosed as impaired socialization and communicative abilities in the presence of restricted patterns of behavior and interests (DSM-IV; American Psychiatric Association, 1994). Children with Autism

Spectrum Disorder (ASD) frequently fail to respond differentially to faces over non-face objects, are impaired in their ability to recognize facial identity and expression, and are unable to interpret the social meaning of facial cues.

In this chapter, we propose a hierarchical model that describes three major domains of information processing involved in the perception, recognition, and communication of facial cues. We discuss the behavioral and neurological evidence to support the validity of these domains in normal populations and how they are adversely affected by autism and Asperger's syndrome. In the third section of the chapter, we describe a computer-based instructional program *Let's Face It!* which develops a child's face processing skills. In the *Let's Face It!* program, specific face processing skills (e.g., recognition of facial expression) are enhanced and strengthened in a game-like format. We discuss ways in which the program can be used as an intervention tool for teaching face recognition and communication skills to ASD children.

7.2 A Hierarchical Model for Face Processing

According to the Hierarchical Face Processing Model (shown in Figure 1), everyday face processing requires several stages of analysis or processing domains. Each processing domain in the model has its own functional characteristics, goals, and neural substrates. According to this model, face processing begins with the Domain I ability to abstract face stimuli from other stimuli in the visual environment. Domain II examines the separable processes required for the recognition of facial identity and emotion. Domain III describes the use of facial information as it is applied to the communication of thoughts and feelings within a social context. The face processing model is structured so that each domain builds on the processes of the previous domains. In the following chapter, we will describe the general characteristics of the individual processing domains and discuss how autism affects the operation and performance of these domain abilities.

7.2.1 DOMAIN I: Selective Processing of Faces

The first domain of face processing concerns a level so basic and fundamental that it is easily overlooked—simply attending to faces. When viewing a photograph or a painting, our eyes usually travel first and most frequently to the faces in the picture. Few people can recall from memory, for example, the landscape in the background behind the Mona Lisa or the cut of van Gogh's suit. Thus, from a very early age, humans regard faces as "special" or distinct from other kinds of objects in the environment. This early preference for faces can be demonstrated in experiments where 3- and 6-month-old infants look longer at face-like stimuli than non-face like stimuli (Fantz, 1963). These results, however, do not necessarily imply that face preference is biologically hardwired as a vast amount of learning takes place in the first few months of life. Stronger evidence for the biological position was provided by Morton and Johnson's study (1991) where neonates, a mere 30 minutes old, preferentially oriented to face stimuli over non-face stimuli. Given that 30 minutes is not enough time for significant learning to occur, these findings suggest that humans are born with an innate preference to attend to faces.

While faces command the attention of normally developing infants, they do not seem "special" to children with autism. A retrospective study (Osterling & Dawson, 1994) reviewed videotapes depicting the first birthday parties of children with ASD and control children. The experimenters blindly coded the child's interactions for social, affective, and communicative behaviors. The videotapes showed that children who were subsequently diagnosed with autism spent significantly less time looking at people's faces during the party than the control children. In fact, some authors report that infants who were later diagnosed with ASD exhibit "face avoidance" where they preferentially attend to non-face objects over faces (Swettenham et al., 1998). Thus, it appears that by the first year of life, children with autism and Asperger's syndrome are less engaged by faces than typically developing children.

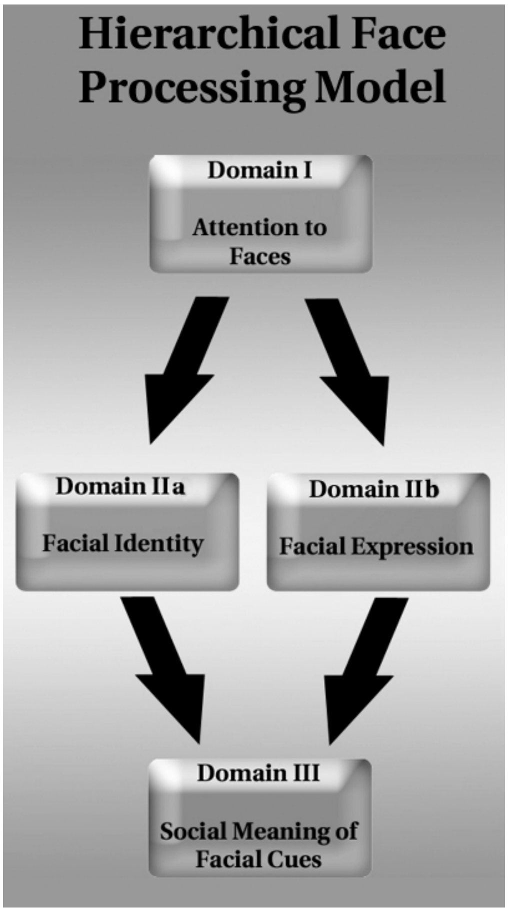

Figure 1. Diagram of Hierarchical Face Processing Model depicting the three domains of processing involving the perception of faces (Domain I), the recognition of facial identity (Domain IIa) and expression (Domain IIb), and the understanding of facial cues in a social setting (Domain III).

With regard to memory for face and non-face objects, individuals with autism do not differ from IQ-matched control participants in their ability to remember animate (e.g., horses, motorcycles) or inanimate objects (e.g., buildings). ASD individuals do, however, perform below control participants in their ability to remember faces (Blair, Frith, Smith, Abell, & Cipolotti, 2002). Thus, ASD children are not generally impaired in their memory for objects, but are specifically impaired in their memory for faces. In summary, whereas most children preferentially orient and recall faces over other types of objects, faces fail to achieve a privileged status in the perceptions or memories of children with autism.

The neurological evidence concerning face perception enriches our interpretation of the behavioral research and suggests a possible location for the processes of Domain I. In normal populations, brain imaging techniques have revealed the fusiform gyrus, a structure in the superior temporal area of the brain, to be significantly more activated by face stimuli relative to stimuli of other common objects (Kanwisher et al., 1997). Recently, Schultz and colleagues (Schultz et al., 2000) reported that when a group of adolescents with Asperger's Syndrome viewed pictures of faces, there was a *reduction* in fusiform gyrus activity relative to other non-face objects. Interestingly, when the Asperger's group viewed face stimuli, the inferior temporal gyrus was more activated than the fusiform area. In normal populations, this brain region is associated with object recognition, suggesting that faces may be perceived by people with autism not as entities of social agency, but as static non-social objects.

7.2.2 DOMAIN IIa: Recognition of Facial Identity

In Domain I, faces are differentiated from other competing objects in the visual environment. In Domain II, specific information about the face stimulus is derived regarding its identity (Domain IIa) and its expression (Domain IIb).

Within a few hours of birth, infants show a preference for their mother's face as compared to the face of strangers (Bushnell, Sai, & Mullin, 1989; Pascalis, de Schonen, Morton, Deruelle, & Fabre-Grenet, 1995). Thus, at a very early point in development, neonates can make within-category discriminations with respect to facial identity (i.e., this face belongs to a unique individual). By the age of six, normally developing children have extended their abilities to the recognition of faces which were unfamiliar before the testing situation and by the age of twelve, their face processing skills approach adult levels (Carey, Diamond, & Woods, 1980). Although the literature is not always consistent (Adolphs, Sears, & Piven, 2001), the prevailing view is that children with autism and Asperger's syndrome suffer specific deficits in their ability to distinguish facial identity (Boucher & Lewis, 1992; Hauck, Fein, & Maltby, 1999). In a carefully controlled study, Klin and colleagues (1999) tested the face recognition, Gestalt closure and spatial memory abilities of 102 young children with autism, pervasive developmental disorder (PDD), and mental retardation. On the visual tasks involving closure and spatial memory, the ASD children did not differ from either the verbally matched or non-verbally matched groups. On the face recognition task, however, the ASD group performed significantly below both control groups. These results indicate that, for children with autism, facial identity recognition is specifically impaired in the midst of a normally functioning visual system.

Inversion studies suggest ASD and normally developing populations have divergent strategies for facial identity recognition. While virtually all stimuli are more difficult to recognize upside-down than right-side-up, Yin (1969) showed that inversion disproportionately impairs the recognition of faces relative to the recognition of non-face objects (e.g., airplanes, houses). It was suggested that the inversion of a face challenges the specific strategy we use to process it, i.e., it challenges a *configural* strategy, where the processing of the spatial arrangement and relationship of the features is more important than that of the features themselves. Object recognition, on the other hand, employs a *featural* approach more concerned with the individual parts of an object. Featural processing is less vulnerable to inversion effects presumably because the isolated parts are more important for recognition whereas the entire configuration of features must be mentally reorganized before a face is recognized. Hobson, Ouston and Lee (1988) explored these strategic processing paths in adolescents with autism. They asked ASD and non-ASD adolescents to recognize expression and identity in upright and inverted photographed faces. Although the autism group, like the control group, had difficulty matching inverted faces according to facial expression, it was *superior* when matching the identity of the inverted faces. These findings suggest that individuals with autism do not adopt a configural strategy when recognizing faces, but rely on a more object-based, featural approach. Hence, the cognitive operations that distinguish faces from objects in normal populations may not be as clear-cut for individuals with autism.

Other evidence indicates that the facial features individuals with autism use to pinpoint an identity are different from the features used by the general population. Langdell (1978) asked children with autism and control participants to recognize the photographed faces of their peers presented in either full view or partially masked conditions. In the masked condition, the control children relied more on the eye features whereas children with autism recognized faces primarily by the mouth. In another study, both children with autism and control participants demonstrated evidence for holistic face recognition in that all of the children recognized a face part better when it was presented in the whole face than when it was presented in isolation (Joseph & Tanaka, 2001). However, normal children showed the largest holistic gains for eye features (i.e., eyes were better recognized in the whole face than in isolation) whereas the ASD children showed the greatest holistic gains for mouth features (i.e., mouths were better recognized in the whole face than in isolation). Finally, investigations of eye movements revealed that children with autism perform more visual saccades and spend longer fixation times looking at the mouth of a face as opposed to the eyes (Klin, Jones, Schultz, Volkmar, & Cohen, in press). Taken together, these results suggest that individuals with autism have modified or even contrasting strategies for facial identity recognition. From the features that command attention and facilitate recall to the manner in which the face is processed, ASD individuals exhibit different methods of face processing.

7.2.3 DOMAIN IIb: Recognition of Facial Expression

Domain IIb of the Hierarchical Face Processing Model focuses on the recognition of facial expression. There is a good deal of research concerning this section of the Hierarchical Face Processing Model, as expression recognition is relatively testable and an especially poignant feature in the disabilities of individuals with autism. It relates directly to communicative properties to be explained in Domain III as it is quite an unusual feeling to receive no response or acknowledgement when offering your warmest smile to a child with autism. Hobson, Ouston, and Lee (1988) tested the ability of children with autism to label schematic and photographic faces according to basic emotional expressions (e.g., happy, sad, disgusted). Compared to age- and IQ-matched normal children and retarded children, the ASD group demonstrated a marked impairment in their ability to select the correct emotion. This inability to grasp the emotional content of a face may not reflect an incapacity to process emotional information; it could instead be the result of a general inattentiveness to facial expression. As a test of this explanation, Weeks and Hobson (1987) asked ASD and non-ASD children to sort faces that varied by sex, emotional expression, and type of hat. Normal children sorted by sex first, followed by emotional expression, and then by type of hat. Children with autism, on the other hand, grouped the pictures by sex, then by type of hat, and finally by expression. Even when two pictures differed only in their facial expressions, many children with autism were reluctant to sort on the expression dimension, but did so if prompted by the experimenter. The diagnostic group presumably sorted the faces according to the categories which were most salient. The contrasting degrees of saliency could reflect the object bias in ASD individuals, a product of the previously noted face avoidance behavior. Or, perhaps, individuals with autism are unable to make discriminations between different facial expressions.

At the neuroanatomical level, the amygdala nuclei, a structure located in the medial temporal lobe, has been shown to play a key role in the processing of emotional stimuli (Whalen et al., 1998). Studies of brain-damaged patients demonstrate that bilateral amygdala lesions impair performance on tasks of emotion, such as the recognition of basic facial expressions, while leaving other cognitive abilities relatively intact (Adolphs et al., 2001). Some researchers hypothesize that the social and emotional deficits of autism are linked to amygdala processes (Baron-Cohen et al., 2000). Support for this view comes from neuroimaging studies where, unlike normal control participants, the amygdala was *not* activated for individuals with autism when viewing pictures of fearful faces (Critchley et al., 2000). The amygdala was similarly unengaged when ASD individuals interpreted an eye gaze stimulus with respect to its social information (Baron-Cohen, 1995). Thus, neuroimaging studies have identified possible connections between the behavioral deficits in facial expression processing to breakdowns of amygdala function.

7.2.4 DOMAIN III: Interpreting Social Cues

As discussed in the previous section, Domain I and II skills encompass the fundamental abilities of face processing, such as the detection of faces, identification of expression, and the recognition of identity. However, the pragmatics of everyday face processing demand that people go beyond the surface information of a face in an effort to understand the underlying message of its sender. For example, in the real world, we read a person's eye gaze to decipher what they might be thinking, or we evaluate a person's expression to deduce what they might be feeling. Thus, Domain III of the face processing framework focuses on the interpersonal dynamics of face processing. In other words, how people apply facial cues in their everyday lives to communicate ideas and emotions to others.

7.2.4.1 Eye Contact

The most basic Domain III skill involves the use of eye contact (i.e., the detection that one's eyes are in mutual contact with another's). As a nonverbal form of communication, eye contact has been shown to have a subtle, yet powerful effect on shaping the nature of social interactions. For adults, eye contact is used to emphasize information to an audience, regulate turn-taking in a conversation, convey intimacy, and exercise social control (Kleinke, 1986). Developmentally, it has been shown that 6-month-old babies will attend to a face looking at them for 2 to 3 times longer than a face that is looking in another direction (Papousek & Papousek, 1979). For the young infant, eye contact serves as an early form of prelinguistic communication with the mother (Ling & Ling, 1974) and is especially important for sharing affective states (Stern, 1985).

While most children begin to use eye contact at an early stage in development, this does not seem to be the case for children with autism. In one retrospective study, 90% of parents reported that their school-aged child with autism frequently avoided eye contact in social situations as an infant (Volkmar, Klin, Siegel, & Szatmari, 1986). Joseph and Tager-Flusberg (1997) found that ASD children attended to the face of their respective mothers for significantly less time than Down syndrome controls, and that mothers of ASD children had to use physical prompts or prodding to gain the attention of their child. Other studies suggest that children with autism do not differ from other children in the amount of time spent gazing at others, but do differ in the quality of their eye contact. Dawson, Hill, Spencer, Galpert, and Watson (1990) found that during unstructured play, young children with autism equaled controls in the amount of eye contact with their mothers. However, unlike the other children, the mutual gaze of children with autism was less likely to be combined with an appropriate facial expression. This result suggests that children with autism do not employ eye contact as a way to communicate emotion or affect to others.

7.2.4.2 Joint Attention

Sometime after the first six months of life, a child learns to use eye gaze for purposes of joint attention. In this triadic exchange, the child employs eye gaze or pointing cues to direct the caregiver's attention toward an external object or event that is of mutual interest. For example, a young infant will smile at her mother and look at a favorite stuffed animal in an attempt to enlist the mother's gaze and assumed attention to the toy. In a typically developing child, referential looking develops around 6 to 9 months of age (Walden & Ogan, 1988) and referential pointing occurs slightly later around 9 and 12 months (Hannan, 1987).

In contrast, spontaneous displays of joint attention occur later and are far less frequent in children with autism (Lewy & Dawson, 1992). Even when ASD children display behaviors of joint attention, their actions lack many of the qualities typically associated with this form of social communication. Similar to the previous findings on eye contact, the joint attention behaviors of children with autism are often devoid of affect, suggesting these actions do not carry any emotional content for the children (Kasari, Sigman, Mundy, & Yirimiya, 1990). Moreover, the joint behaviors of children with autism are more likely to be of the *protoimperative* type where the purpose of the eye gaze is to recruit the assistance of another to obtain a particular object or goal (Kasari et al., 1990). For example, a young child may look at her caregiver and a computer in order to gain her help in turning it on. The purpose of a *protodeclarative* display of joint attention, on the other hand, is to communicate a shared experience to another person (e.g., showing a caregiver that there is an interesting photograph in a magazine), and it is this type of joint attention that is much less frequently exhibited by ASD children. Thus, when joint attention is employed by children with autism, it is usually for instrumental purposes rather than for purposes of social affiliation.

7.2.4.3 Facial Cues in a Social Context

The final component of Domain III abilities concerns the understanding of facial cues in a social situation. This more advanced form of social cognition requires not only the recognition of the facial expression, but an understanding of the social context in which it occurs.

Not unexpectedly, children with autism are impaired in their ability to identify the appropriate emotion when it is embedded in a social context. In one study by Fein, Lucci, Braverman, and Waterhouse (1992), children diagnosed with PDD or autism were shown scenes with children portrayed in different affect-laden situations (e.g., a child eating an ice cream, a child holding a broken toy). The face of the child in the picture was obscured and participants were asked to identify the facial expression that matched the scene. Participants were also given a visual task in which they matched different views of the same object. Relative to verbal- and non-verbal-matched control participants, children with PDD performed significantly worse on the context-affect task than the visual task. This result suggests that these children may experience difficulties when trying to make sense of emotional situations in the real world.

Such real world events were enacted in an experiment by Sigman and colleagues (1992). In one situation, a child was seated at a small table with an experimenter who was showing the child how to use a wooden toy hammer. During the demonstration, the experimenter pretended to strike her finger with the hammer and displayed facial expressions indicating that she was in a great deal of pain and distress. It was found that the children with autism spent less time looking at the distressed experimenter than normal children or children with mental retardation. In fact, children from the ASD group ignored the distressed signals of the adult altogether and continued to play with the toy without interruption. Thus, even when children with autism experience emotionally-laden situations first-hand, they fail to display normal signs of emotional empathy and concern.

7.2.5 *Theoretical Accounts*

Two theoretical accounts have been given for the lack of interest that children with autism have for the emotions and feelings of others. According to a view originally described by Kanner (1943), children with autism "come into the world with an innate inability to form the usual, biologically provided affective contact with people" (p. 250). This approach proposes that impaired affective processing is the defining feature of autism and colors every social/emotional interaction of the child. In face processing, this deficit is manifested in the child's lack of reciprocal eye contact, impaired affective joint attention, and the inability to understand and respond appropriately to affective cues in the social environment. Given that these children have little motivation or desire to interact with people, they fail to encode and respond to the affective cues displayed by others. The affective position also assumes that autism is not due to environmental or social influences, but is caused by biological factors. In short, the affective view maintains that social/emotional dysfunction is the root cause of autism whose origins are innately biological.

An alternative view is that children with autism suffer from a cognitive deficit in the development of their "theory of mind." Theory of mind is the human ability to attribute beliefs and mental states to other people. Theory of mind allows a child to think, for example, that their friend Julie likes vanilla ice cream or to infer that their brother does not like his English teacher. While normally developing children acquire a basic understanding of theory of mind by age four, children with autism seem profoundly impaired in their ability to form mental representations for the contents of other people's minds (Volkmar, Carter, Grossman, & Klin, 1997). This deficit is shown by the absence of pretend play where the child must model the cognitions of an imaginary friend, or by failure on false belief tasks where the child must take the mental perspective of another person (Baron-Cohen, Leslie, & Frith, 1985).

An impaired theory of mind hampers these children in social interactions that require an understanding of other people's emotions. Hence, children with autism are less likely to use the protodeclarative form of joint attention because they fail to realize that their emotional state can be shared by others (e.g., being excited about seeing a rainbow is an experience that others will find enjoyable). In distressed situations, children with autism are less likely to demonstrate concern for others because they have little understanding of what a distressed person may be feeling or experiencing. The absence of an awareness of the thoughts and feelings of others would therefore negatively affect inter-personal relations that require social empathy. Thus, in contrast to the affective view, the theory of mind position claims that the social/emotional deficits of autism are not necessarily attributable to the failed understanding of an affective cue, but to the inability to connect one's emotional state to the emotional state of another person.

7.2.6 Summary

In this section, we claim that an important goal of the human face processing system is to facilitate the social communication conveyed through facial cues. To achieve this goal, we propose a face processing model with three functional stages or domains, each with its separate sub-processing goal (see Figure 1). Domain I abilities are responsible for filtering face stimuli from non-face stimuli. Domain II abilities extract information regarding the identity and expression of the face stimulus. Finally, Domain III abilities emphasize the use of facial information in everyday social communication.

The individual domains are hierarchically ordered such that the successful execution of one domain ability is contingent upon the successful completion of preceding domains. For example, accurate identification of a facial expression (Domain II ability) requires the capacity to selectively attend to faces over other types of non-face objects (Domain I). Similarly, interpretation of a facial expression in a social context (Domain III) requires the recognition of a facial expression in isolation (Domain II). The hierarchical nature of the model also predicts that impairment in one domain will have downstream effects on other processing domains. So, for example, damage to the face selective mechanisms in Domain I should hamper the Domain II ability to recognize facial identity or expression.

The model has important implications when applied to populations with face processing impairments, such as individuals with autism. As reviewed in the chapter, the neurological and behavioral evidence suggests that children with autism experience difficulties in all three processing domains. Domain I deficits are exhibited in ASD individuals behaviorally by face avoidance and neurologically by the failure of faces to activate the fusiform face area. Indicative of their Domain II deficits, individuals with autism also show selective impairment in their ability to recognize the identity and expression of faces. Finally, in their everyday social interactions, children with autism do not make appropriate use of eye gaze and facial cues indicating a deficit in Domain III abilities. Given that damage to earlier processes can have cascading effects on later processes, an important question is the extent to which the Domain I deficit of abnormal fusiform gyrus activity is responsible for the impaired facial recognition and communication found in Domains II and III (Schultz et al., 2000). Note that the converse is equally plausible where autism results in a general disinterest in people which, in turn, causes hypo-activation of the normally face-specific fusiform region. Currently, the causal link between fusiform activity and face perception is uncertain and warrants further investigation.

One advantage of the Hierarchical Face Processing Model is that it provides a framework for assessing the range of face processing deficits related to autism. Using the model, assessments can be developed that pinpoint deficits in the different domain levels thereby providing a clearer picture of what face processing abilities are compromised as a result of autism. As discussed in the next section, this model also suggests strategies for intervention.

7.3 *Let's Face It!*: A Computer-Based Intervention for Developing Face Expertise

7.3.1 Linking Face Recognition and Expert Object Recognition

The processes of face recognition bear a striking similarity to the processes associated with expert object recognition (Tanaka, 2001). Like "expert" face recognition, expert object recognition, such as bird watching or dog judging, requires the quick and accurate identification of objects at a specific level of abstraction (Tanaka & Taylor, 1991). For example, just as faces are individuated according to their proper names (e.g., "Bob", "Sue"), expert birdwatchers classify birds according to their specific taxonomic names (e.g., "chipping sparrow"). Moreover, object experts recognize objects in their domain of expertise in terms of a holistic configuration, the same strategy that is employed by the general population when recognizing faces (Gauthier & Tarr, 1997; Gauthier, Williams, Tarr, & Tanaka, 1998). Neurologically, it has been shown that for the expert, objects of expertise trigger that same electrical brain response (Tanaka & Curran, 2001) and engage the same neural substrates (i.e., fusiform gyrus) (Gauthier, Skudlarski, Gore, & Anderson, 2000) as faces. In light of their similarities, it has been suggested that face recognition may not be special in any biological sense, but a general form of perceptual expertise. According to the expertise position, people acquire face expertise as a natural consequence of their extensive exposure to faces and the need to individuate faces at specific levels of categorization.

Can expertise be trained in the laboratory? While it has been suggested that it takes several years to become an expert (Diamond & Carey, 1986), recent work (Gauthier, Tarr, Anderson, Skudlarksi, & Gore, 1999) has demonstrated that with proper instruction, normal adults can be trained to be object experts in a relatively brief period. Gauthier and associates (Gauthier & Tarr, 1997; Gauthier et al., 1998) trained participants to recognize artificial objects, known as Greebles. Greebles were constructed such that Greebles of the same category shared the same basic part features arranged in configuration. Participants learned to classify some Greebles as category members, while other Greebles were learned as individuals. After training, it was shown that for the Greebles learned as individuals, Greeble recognition, like face recognition, relied on configural processing. Brain imaging results also revealed that as participants became experts in Greeble recognition, they demonstrated increased activation in the fusiform face area. Therefore, the fusiform gyrus may not be a face area *per se*, but a brain area that is recruited to perform visual tasks related to perceptual expertise.

Laboratory training of expertise also appears to generalize to the learning of new objects in novel situations (Gauthier et al., 1998; Tanaka & Weiskopf, 2002). In a recent study, Tanaka & Weiskopf (2002) trained participants to individuate wading birds (or owls) at the species level and classify owls (or wading birds) at the family level. After training, it was found that participants were better at discriminating new exemplars of birds that were learned at the species level than new exemplars of birds learned at the family level which suggests that specific categorization is an important element of perceptual expertise. Moreover, the expertise advantage transferred to the discrimination of new species of owls (or wading birds) that were not included in the original training set. Hence, not only are familiar objects more easily recognized as a result of perceptual expertise, but new objects are more easily learned as well.

The studies on laboratory–trained experts make several important points. First, expertise entails the individuation of objects at specific levels of categorization. Second, using this approach, normal adult subjects can achieve expert levels of performance in a relatively short period of time. Third, similar brain areas and cognitive processes are engaged during expert object and face recognition. Finally, expert functioning is not limited to the privileged processing of a few objects found in the training set, but generalizes to the larger class of objects in the expert category.

7.3.2 *The* **Let's Face It!** *Program: Computer-Based Face Training for ASD Children*

Given that individuals with autism are selectively impaired in their ability to process facial information, an important question is whether face recognition abilities can be taught through direct instruction and training. That is, can the same strategies and principles that were used to teach Greeble and bird recognition to adults be applied to teach face recognition to children with autism? Toward that goal, we developed the *Let's Face It!* software program, a computer-based curriculum intended to teach children with ASD basic face processing skills.

It is important to stress that the *Let's Face It!* program is not meant to be a substitute for human interaction. However, for ASD populations, there are several advantages to a computer-based approach. First, children with autism may actually benefit more from computer-based instruction than traditional methods (Heimann et al., 1995). Moore and Calvert (2000) compared computer- versus teacher-based approaches in object naming skills. They found that children in the computer-based instruction learned significantly more new words and showed greater motivation for learning activity than children in the traditional teacher-based approach. The features, such as music, variable-tone intensity, character vocalizations, and dynamic animations, are particularly motivating and reinforcing for persons with ASD and can easily be incorporated into computer-based instruction (Ferrari & Harris, 1981; Gutierrez-Griep, 1984). Finally, a computer-based curriculum offers a way to provide cost-effective instruction to ASD children in either a home or school setting.

The *Let's Face It!* program is designed as a suite of interactive games with each game developed to teach a specific face processing skill. The program opens with a startup screen where the child types in his or her name which is used to store game logs and preference information. After the startup screen, the main menu appears displaying the game choices. The program follows the hierarchical stages described by the theoretical Hierarchical Face Processing Model (Figure 1). At the beginning level, the child learns to distinguish faces from non-face objects (Domain I). Once these skills are mastered, the child progresses to games involving the recognition of facial identity (Domain IIa) and facial emotion (Domain IIb). The more advanced games require the child to interpret the meaning of facial cues in a social context (Domain III). By playing the suite of games in the *Let's Face It!* program, the child will receive instruction and practice across a broad range of face processing skills. A representative game from each of the four processing domains is described below.

7.3.2.1 Example of Domain I Game: Find a Face

Domain I skills focus on the ability to differentiate faces from other non-face objects. Given that children with autism may have difficulty in selectively attending to faces over other types of objects (Swettenham et al., 1998), the *Find a Face* game encourages face attention abilities. In this game, as shown in Figure 2, faces are camouflaged in a realistic scene and the child's task is to locate the hidden faces with the mouse as quickly as possible. Points are awarded according to the speed with which the faces are located. For the advanced levels of the game, the child must differentiate between hidden faces and a contrast category of hidden objects (e.g., dogs, birds, chairs).

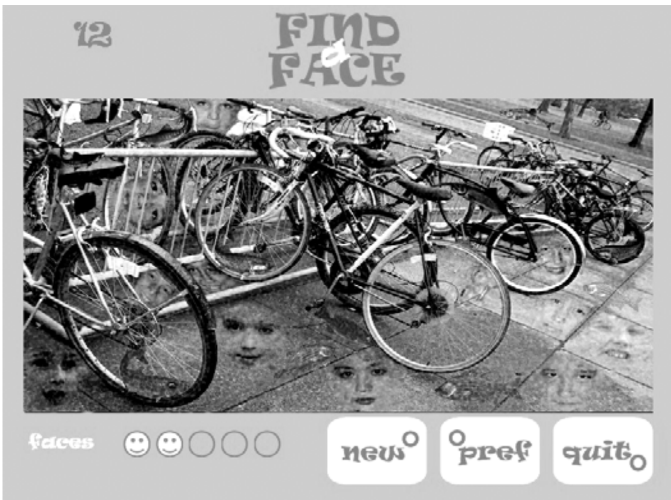

Figure 2. Screenshot of *Find a Face* game where the child finds faces and other target objects hidden in a scene.

7.3.2.2 Example of Domain IIa Game: Zap It!

Domain IIa games emphasize the ability to recognize facial identity – a skill that is often compromised in children with autism (Boucher & Lewis, 1992; Klin et al., 1999). In the game *Zap It!* (see Figure 3), the goal is to remove face tokens from the playing field by grouping them with other face tokens in groups of three's according to their identities. Scores accumulate by the number of face tokens that are removed from the playing field. The game ends when the player successfully clears the playing field or when the playing field is completely filled with face tokens. Advanced levels of *Zap It!* require that faces are grouped across changes in facial expression.

7.3.2.3 *Example of Domain IIb Game:* EmotionMaker

Games included in this domain emphasize the ability to recognize facial expressions. In *EmotionMaker*, the child is asked to recreate a target expression from a palette of eyes and mouth features conveying different facial expressions (see Figure 4). As the cursor is dragged over the feature, the child will hear the corresponding verbal label for the feature (e.g., when the cursor is over the sad eyes, he or she will hear the word "sad"). The expression is reconstructed by placing the cursor over the desired feature and clicking the mouse. The goal of *EmotionMaker* is to encourage the processing of facial expressions in terms of their features and configuration. In the advanced level, the child must reconstruct a target expression from its verbal label without the aid of auditory feedback from the features. In *EmotionMaker*, the child is required to attend to both the featural and configural aspects of facial expressions. Pertinent to expression recognition deficits found in children with ASD (Hobson et al., 1988), the game also emphasizes how subtle changes in eye information can alter the perception of the facial expression.

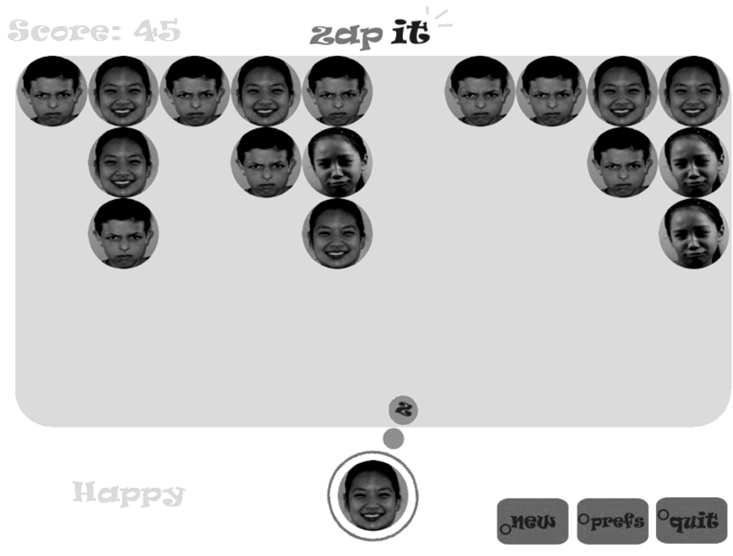

Figure 3. Screenshot of *Zap It!* game where the goal is to form a group of three faces that are similar in facial identity by shooting face tokens with a launcher.

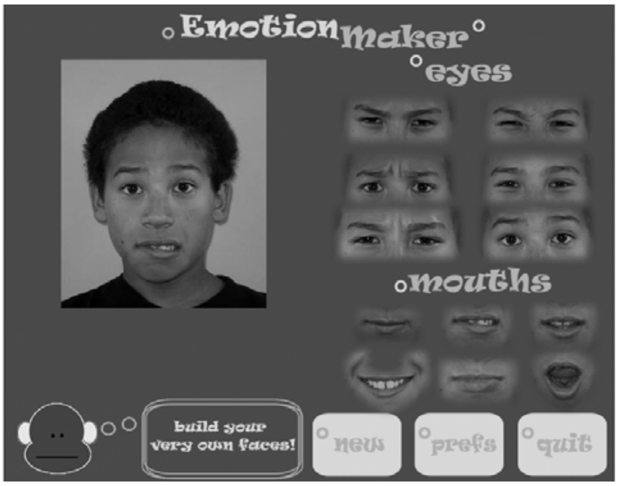

Figure 4. Screenshot of *EmotionMaker* game where the child reconstructs a target emotion from a selection of facial features.

7.3.2.4 Example of Domain III Game: The Eyes Have It

As discussed in a previous section, children with autism have problems interpreting a person's gaze to an external object or event (Kasari et al., 1990). As shown in Fig. 5, *The Eyes Have It* game provides the child with practice in this Domain III ability of joint attention. In this game, a central face is surrounded by a circular array of objects. The eyes of the face are gazing at one of the objects and the child is asked to indicate the object by clicking on it. If the child is correct, the corresponding object sound is played (e.g., a dog barks, a guitar is strummed). If the child is incorrect, a neutral feedback sound is played. Points are awarded depending on the speed and accuracy with which the child makes his or her responses. In the advanced level of the game, the child is asked to identify the object of joint attention in a complex scene.

Figure 5. Sample of *The Eyes Have It* game where the goal is to click on the object that is the focus of the child's eye gaze.

7.3.3 *Using* Let's Face It! *for Assessment and Intervention*

The *Let's Face It!* program has practical applications for the assessment and treatment of face processing deficits related to autism. As a diagnostic instrument, the program will help the clinician, teacher, or parent to identify areas where the child may have deficiencies in their face processing abilities; whether it is in their attention to faces (Domain I), recognition of facial identity (Domain IIa) or expression (Domain IIb), or in their interpretation of facial cues (Domain III). As an intervention tool, the hierarchical structure of *Let's Face It!* provides a practical curriculum for teaching face processing abilities across the different skill domains. Within a domain, the difficulty levels of the games are graded so that as the child becomes more proficient with a particular skill, his or her abilities are increasingly challenged. Because all game activities are logged by the program, the child's performance can be continually monitored and evaluated. In short, the *Let's Face It!* program should be useful for both the diagnosis and treatment of face processing deficits.

7.4 Chapter Summary

In this chapter, we claim that normal face processing requires four essential operations - attention to faces, recognition of facial identity, recognition of facial emotion, and interpretation of facial cues. In our model, these operations are hierarchically organized into separate processing domains through which different types of information are abstracted from the face stimulus. A large body of behavioral and neurobiological evidence affirms the importance of these domains for normal face processing, and the growing literature suggests that many of these processes are compromised in ASD individuals.

What is the best way to provide face processing skills to these individuals? If face recognition is a kind of expertise, it should be possible to develop a training program to teach face processing skills to children with autism. With this goal in mind, we designed the computer-based program *Let's Face It!* to improve face processing abilities. The ultimate goal of the *Let's Face It!* program is to enhance the social lives of children with autism by providing them with basic face processing skills.

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