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Using computerized games to teach face recognition skills to children with autism spectrum disorder: The *Let's Face It!* program

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Background: An emerging body of evidence indicates that relative to typically developing children, children with autism are selectively impaired in their ability to recognize facial identity. A critical question is whether face recognition skills can be enhanced through a direct training intervention. **Methods:** In a randomized clinical trial, children diagnosed with autism spectrum disorder were pre-screened with a battery of subtests (the *Let's Face It!* Skills battery) examining face and object processing abilities. Participants who were significantly impaired in their face processing abilities were assigned to either a treatment or a waitlist group. Children in the treatment group ($N = 42$) received 20 hours of face training with the *Let's Face It!* (*LFI!*) computer-based intervention. The *LFI!* program is comprised of seven interactive computer games that target the specific face impairments associated with autism, including the recognition of identity across image changes in expression, viewpoint and features, analytic and holistic face processing strategies and attention to information in the eye region. Time 1 and Time 2 performance for the treatment and waitlist groups was assessed with the *Let's Face It!* Skills battery. **Results:** The main finding was that relative to the control group ($N = 37$), children in the face training group demonstrated reliable improvements in their analytic recognition of mouth features and holistic recognition of a face based on its eyes features. **Conclusion:** These results indicate that a relatively short-term intervention program can produce measurable improvements in the face recognition skills of children with autism. As a treatment for face processing deficits, the *Let's Face It!* program has advantages of being cost-free, adaptable to the specific learning needs of the individual child and suitable for home and school applications. **Keywords:** Face recognition, autism, computer-based intervention, training, perceptual expertise. **Abbreviations:** *LFI!: Let's Face It!;* ASD: autism spectrum disorder; RCT: randomized clinical trial; PDD-NOS: pervasive developmental disorder, not otherwise specified; ADI-R: Autism Diagnostic Interview – Revised; ADOS-G: Diagnostic Observation Schedule – Generic; WASI: Wechsler Abbreviated Scale of Intelligence; WISC-III: Wechsler Intelligence Scale for Children; WAIS-III: Wechsler Adult Intelligence Scale; DAS: Differential Abilities Scales.

While it has been said that nearly everyone is an expert in face recognition (Carey, 1992), this claim might not be true for children with autism. An emerging literature suggests that many individuals with autism spectrum disorder (ASD) are less likely to attend to faces (Swettenham et al., 1998), are impaired in face discrimination tasks (Behrmann et al., 2006; Tantam, Monaghan, Nicholson, & Stirling, 1989; Wallace, Coleman, & Bailey, 2008) and have difficulty recognizing familiar faces (Blair, Frith, Smith, Abell, & Cipolotti, 2002; Boucher & Lewis, 1992; Gepner, de Gelder, & de Schonen, 1996; Hauck, Fein, Maltby, Waterhouse, & Feinstein, 1998; Klin et al., 1999). Difficulties in face processing are not attributable to deficits in basic visual or perceptual impairments because children with autism perform equally as well or better than age- and IQ-matched typically developing children on perceptual tasks involving non-face stimuli (e.g., houses) (Wallace et al., 2008; Wolf et al., 2008). The research suggests that a substantial proportion of individuals with ASD present significant and selective problems in their face recognition abilities. Indeed, recent neuro-cognitive theories of autism suggest that impaired face processing might lie at the root of the social dysfunction of the disorder (Dawson et al., 2005; Schultz, 2005).

An open question is whether the face recognition skills of individuals with autism can be enhanced through direct training. In other domains, perceptual expertise training has proved effective for enhancing the abilities of neurotypical individuals to recognize natural (Tanaka, Curran, & Sheinberg, 2005) and artificial objects, 'Greebles' (Gauthier & Tarr, 1997). The expert training protocol emphasizes

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the quick and accurate recognition of objects at specific, subordinate levels of abstraction. In face processing, expert training has also been shown to improve recognition of other-race faces where five days of intense practice at individuating other-race faces successfully ameliorates other-race face recognition (Tanaka & Pierce, 2009). Clinically, face training has been shown to remediate severe face recognition deficits (i.e., developmental prosopagnosia) in which performance is so compromised that the individual has difficulty recognizing familiar friends and relatives. In one study, 14 months of intensive face training improved a patient with developmental prosopagnosia's ability to discriminate configural differences in a face and to recognize famous people (DeGutis, Bentin, Robertson, & D'Esposito, 2007). Collectively, these studies demonstrate the efficacy of perceptual expertise training procedures for enhancing the object and face recognition abilities of healthy adults and patients with face processing disorders.

Despite the positive face training results obtained with neurotypical adults and patients, few studies have examined the effects of training to promote face expertise in children with autism. One exception is a recent study by Faja and colleagues (Faja, Aylward, Bernier, & Dawson, 2008) where five male young adults with ASD (mean age = 19.0 years, Full Scale IQ = 99.0) received training to identify Caucasian faces according to age, gender and identity. After a three-week training period, post-treatment results revealed that the training group showed greater sensitivity to configural information (i.e., distances between the eyes) compared to untrained control participants. The Faja et al. results provide 'proof of concept' that identity recognition skills can be improved through practice in face recognition. However, this approach has several limitations as a general intervention for treating face processing deficits in ASD. First, this was a relatively small intervention study and the individualized treatment is less practical for a large-scale intervention. Second, the protocol in Faja et al.'s paper does not include any object condition. So, it is unclear whether the improved configural processing that they find for faces is in fact specific to this class of stimuli. Third, the Faja et al. study focused on adult training which relied heavily on repeated presentations of the same learning trials and speeded reaction time responses. It is unlikely that this method would be appropriate for children with ASD's limited attention span and less reliable reaction times (Rinehart, Bradshaw, Brereton, & Tonge, 2001).

The *Let's Face It!* (*LFI!*) program comprises seven interactive computer games that address the specific face processing deficits in autism, including inattention to the eyes (Rutherford, Clements, & Sekuler, 2007; Wolf et al., 2008), impaired recognition of identity (Blair et al., 2002; Boucher & Lewis, 1992; Gepner et al., 1996; Hauck et al., 1998; Klin et al., 1999; Wolf et al., 2008) and failure to perceive faces holistically (Gauthier, Klaiman, & Schultz, 2009; Joseph & Tanaka, 2003; Teunisse & de Gelder, 2003)[1]. The *LFI!* games are organized into a theoretical hierarchy of face processing domains that reinforce the child's ability to attend to faces (Domain I), recognize facial identity and expression (Domain II) and interpret facial cues in a social context (Domain III) (Tanaka, Lincoln, & Hegg, 2003). Each game is designed with engaging graphics, an original music track, and at least 24 levels of game play that become progressively more challenging and complex (see Figure 2). For children with ASD, computer-based instruction has the benefit of providing a stable, consistent learning environment that can be customized to the instructional needs of the user (Moore, McGrath, & Thorpe, 2000). In other areas, computer training and multi-technology have been shown to be successful for teaching emotional skills to children with autism (Silver & Oakes, 2001; Golan & Baron-Cohen, 2006; Golan et al., in press).

In the *LFI!* intervention study, children were prescreened with *Let's Face It!* Skills Battery, a series of measures that have been shown to be sensitive to the face processing deficits in autism (Wolf et al., 2008). Children with ASD who were significantly impaired on these measures relative to their age-matched peers qualified for the intervention study (see Methods). Following the recommended guidelines for assessing treatment efficacy (Lord et al., 2005), eligible participants were randomly assigned to either an active treatment group (N = 42) or a waitlist control group (N = 37) in a randomized clinical trial (RCT). Children in the active treatment group played the *LFI!* games for an average of 20 hours in their home over a two- to four-month period. The child's game play was self-paced and not directly supervised by the parent or caregiver. Performance was logged on a file and sent on a weekly basis to the case managers to monitor treatment compliance. After 20 hours of treatment, the *LFI!* Skills Battery was re-administered to the treatment and waitlist participants. We hypothesized that children who received the 20 hours of training with the *LFI!* program would show larger gains in their face processing abilities relative to children in the waitlist group as measured by the *Let's Face It!* Skills Battery.

Method

This study was approved by the institutional review boards at both the Yale University School of Medicine and the University of Victoria. All participants (or parents of minor participants) gave written informed consent after study procedures were fully explained to them.

[1] The *Let's Face It!* program can be downloaded free-of-charge from the website: http://web.uvic.ca/~jtanaka/letsfaceit.

Participants

Participants of the present study included 79 children, adolescents, and young adults with autism spectrum disorders. Participants in the ASD group were recruited on the basis of previous diagnoses of autistic disorder, Asperger's disorder, or pervasive developmental disorder, not otherwise specified (PDD-NOS), through presentations at schools and parent organizations, and through existing relationships with families of children on the autism spectrum. Participants were excluded (a) if they had vision worse than 20–100 in both eyes, (b) if, in the judgment of an experienced clinician, they were unable to comprehend the instructions of the experimental tasks, or (c) if they did not have face processing deficits significant enough to warrant intervention (inclusion required impairments of 2 or more standard deviations below age-matched typically developing controls on at least 33% of variables, or 1 or more standard deviations below controls on at least 50% of variables).

Autism spectrum diagnoses were confirmed based on DSM-IV criteria through use of the Autism Diagnostic Interview – Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003) and the Autism Diagnostic Observation Schedule – Generic (ADOS-G; Lord, Rutter, DiLavore, & Risi, 1999) by a clinician trained in their administration, with at least five years of experience working with individuals with autism spectrum disorders. In some cases, data were missing (ADOS: 2 missing; ADI: 5 missing), or participants did not meet criteria for an autism spectrum disorder on one of these measures (ADOS: 11 did not meet; ADI: 8 did not meet; note that there is no overlap in these numbers; i.e., all participants met criteria on at least one of the two diagnostic measures). In these instances, a final diagnostic decision was made by consensus among two or more clinicians with at least five years of experience in the field of autism spectrum disorders, independent of any knowledge of how the child performed on the study's outcome measures.

IQ was obtained for all participants using either the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), the Wechsler Intelligence Scale for Children, 3rd edition (WISC-III; Wechsler, 1991), the Wechsler Adult Intelligence Scale, 3rd edition (WAIS-III; Wechsler, 1997), or the Differential Abilities Scales (DAS; Elliott, 1990). In cases in which a participant had an IQ test administered clinically within the last year, an IQ measure was not re-administered, and scores from the previous administration were utilized for the purposes of the present study.

Eligible participants were randomly assigned to either an active treatment group or a waitlist control group. Randomization was stratified by mental age (above or below 8 years) and diagnosis (autistic disorder vs. autism spectrum (i.e., Asperger's disorder or PDD-NOS). For purposes of stratification, mental age was calculated as (chronological age * Full Scale IQ / 100). The active treatment group consisted of 42 participants (34 males and 8 females) with a mean age of 10.5 (SD = 3.8) and a mean full scale IQ of 93.6 (SD = 22.1). The active treatment group comprised 27 individuals with autistic disorder, 6 with Asperger's disorder, and 9 with PDD-NOS. The waitlist control group was composed of 37 children (28 males and 9 females) with a mean age of 11.4 (SD = 3.7) years and a mean full scale IQ of 95.9 (SD = 23.4). The waitlist control group comprised 17 individuals with autistic disorder, 6 with Asperger's disorder, and 14 with PDD-NOS. The active treatment and waitlist control groups did not significantly differ with regard to age ($t(77) = 1.12$, n.s.) or IQ ($t(77) = .45$, n.s.). Mean ADOS and ADI algorithm totals for the two groups are presented in Table 1.

The Let's Face It! Skills Battery

The primary outcome measures for the present study were the facial identity and object processing subtests of the *Let's Face It! (LFI!)* Skills Battery. The *LFI!* Skills Battery is a comprehensive, computer-based battery that assesses perception of facial identity across a broad range of face processing tasks (for more details about the individual subtests, see Wolf et al., 2008). The subtests evaluate the child's ability to: 1) match faces across changes in expression and masked features, 2) discriminate featural and configural changes in faces, 3) recognize face features presented in isolation and in the whole face, and 4) identify faces in an old/new recognition task. The battery also includes two

Table 1 Mean ADOS and ADI algorithm scores for the active treatment and waitlist control groups. Note that 4 participants are excluded from the ADI averages, because they were administered an alternate version of the ADI (due to their recent prior participation in another study that utilized that version)

	ADOS Module 1	ADOS Module 2	ADOS Module 3	ADOS Module 4	ADI
Active treatment					
N	1	7	27	6	37
Communication total	7.00	6.14	5.22	4.67	17.24
Socialization total	9.00	9.71	9.78	9.00	25.08
Stereotyped Behaviors total	N/A	N/A	N/A	N/A	4.70
Waitlist control					
N	0	4	23	9	33
Communication total	N/A	6.25	4.74	4.56	15.70
Socialization total	N/A	12.00	8.57	8.89	22.73
Stereotyped Behaviors total	N/A	N/A	N/A	N/A	5.03
ASD cutoffs					
Communication	2	3	2	2	8
Socialization	4	4	4	4	10
Stereotyped Behaviors	N/A	N/A	N/A	N/A	3

control subtests with non-face stimuli that assess the child's ability to discriminate featural and configural changes in houses and their short-term recognition of cars.

Procedure

Participants came to the Yale Child Study Center for an initial, 2-day (Time 1) visit. During that visit, they were administered the *Let's Face It!* Skills Battery in addition to other neuropsychological and behavioral measures (e.g., IQ testing, diagnostic measures, and other experimental measures not reported in the present paper).

At the end of their Time 1 visit, upon confirmation of study eligibility (as described above), participants were randomly assigned to either the active treatment or waitlist control group. Participants assigned to the active treatment group underwent the *Let's Face It!* intervention (as described below) for an average of 20.2 (SD = 10.3) hours of intervention over an average period of 19.1 (SD = 7.3) weeks. Participants in the waitlist control group underwent treatment as usual for a comparable period of time. Following the intervention or waitlist period, participants returned to the Yale Child Study Center for a follow-up (Time 2) visit, at which time the *LFI!* Skills Battery was repeated to assess for intervention outcome. See Figure 1 for a diagram describing the progress of subjects through the enrollment, allocation, follow-up and analysis phases of the *Let's Face It!* intervention.

Active treatment. The *Let's Face It!* intervention is composed of 7 computer games targeting various face processing skills, as described in Appendix I. Screenshots from two of the games are presented in Figure 2. Players were able to select mode and level of play. Computer-animated graphics and high-score tables were included within each game as incentives to increase motivation to engage in the intervention.

Participants assigned to the active treatment group were provided with the *Let's Face It!* computer game intervention to take home with them, and were instructed to play the games for at least 100 minutes per week. Each week, parents sent the researchers log files (automatically generated by the software) that documented details about the participant's game play. Based on these log files, researchers were able to monitor participants' compliance with the intervention. An assigned case manager provided parents with feedback about their child's game play and suggested games for the participant.

All participants received monetary compensation for their game play. In addition, all families were provided with a set of plastic token reinforcers to use to increase motivation to comply with the intervention. The way in which these tokens were used was individualized for each participant and was implemented by parents in

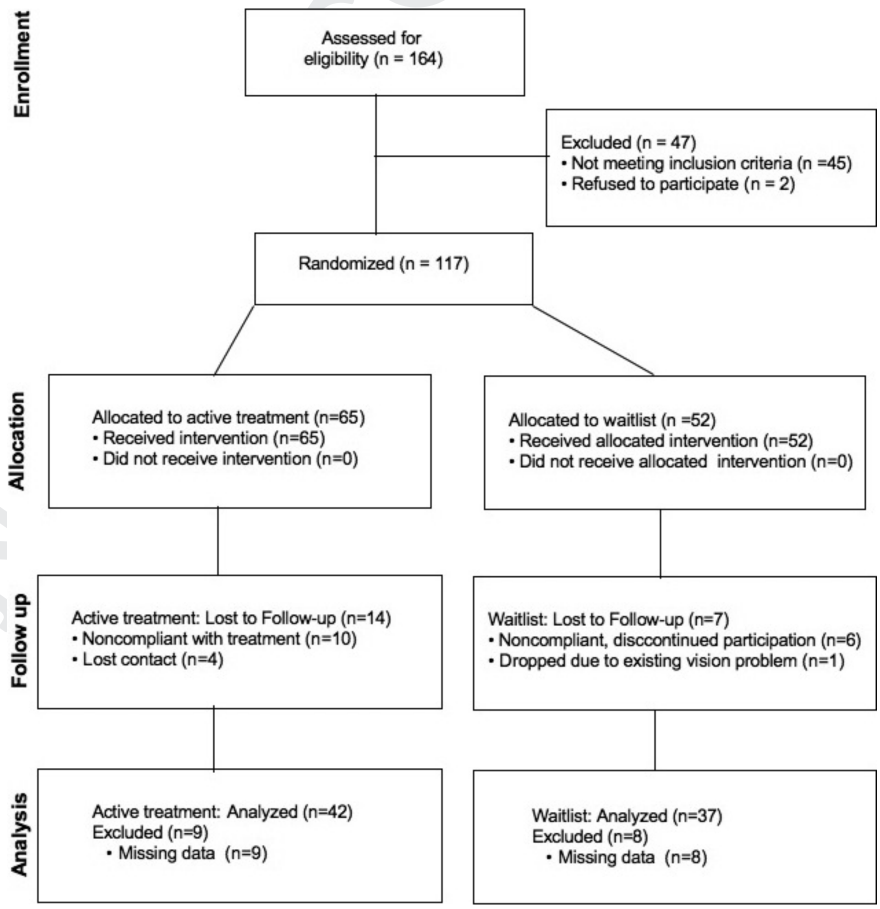

Figure 1 Diagram showing subjects' progress through the enrollment, allocation, follow-up and analysis phases of the *Let's Face It!* intervention study

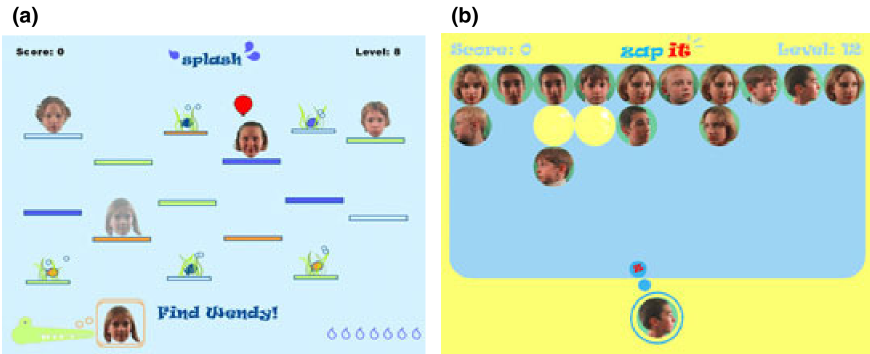

Figure 2 Sample screen shots from two of the *Let's Face It!* games. (a) In the game Splash, faces appear at random locations in the display and the child's task is to 'splash' the faces matching the identity of the target face (e.g., Wendy). (b) In ZapIt, the child uses a face 'launcher' to connect three faces of the same identity. As the difficulty level increases, faces can vary across multiple cues, such as viewing angle, expression and clothing

consultation with their case manager. Participants had the option of participating in a 'high-scores website' in which their high scores for the game were posted on a website (under a pseudonym to ensure confidentiality) so that participants could compete against one another, thus adding another incentive to increase and improve game play.

Participants continued in the intervention until their total intervention time reached 20 hours. Note that a small number of participants completed fewer than 20 hours of intervention, which is attributable to two causes: 1) Due to a technical error in the software's logging capability, some early study participants' logged time on game was inflated, so that at the time of their Time 2 visit (when the software logs indicated 20+ hours of game play), they had in fact played somewhat less than 20 hours (n = 3). Once this error was identified, total time on game for these participants was corrected, and these lower total game play times are reflected in the overall average time on game reported here. The technical glitch in the software was corrected so that it did not affect subsequent participants. 2) Some participants discontinued game play midway through the intervention period, but agreed to come back for a follow-up visit so as not to lose their data entirely.

Results

Separate mixed factorial ANOVAs were conducted for each of the *LFI!* Skills Battery's facial identity subtests. In each of these analyses, the independent variables were group (active treatment, waitlist control) and timepoint (Time 1, Time 2), and the dependent variable was total percentage accuracy on the given subtest. To assess for intervention outcome, the comparison of interest was the interaction between group and timepoint, in order to determine whether the active treatment group demonstrated significantly greater improvement from Time 1 to Time 2 than did the waitlist control group. Interaction effects for each of the LFI! Skills Battery identity subtests are depicted in Table 2. Eligible participants were randomly assigned to either an active treatment group or a waitlist control group. Randomization was stratified by mental age (above or below 8 years) and diagnosis (autistic disorder vs. autism spectrum (i.e., Asperger's disorder or PDD-NOS). For purposes of stratification, mental age was calculated as (chronological age * Full Scale IQ / 100). The active treatment group consisted of 42 participants (34 males and 8 females) with a mean age of 10.5 and a mean full scale IQ of 93.6. The active treatment group comprised 27 individuals with autistic disorder, 6 with Asperger's disorder, and 9 with PDD-NOS. The waitlist control group was composed of 37 children (28 males and 9 females) with a mean age of 11.4 years and a mean full scale IQ of 95.9. The waitlist control group comprised 17 individuals with autistic disorder, 6 with Asperger's disorder, and 14 with PDD-NOS. The Time 1 to Time 2 analyses were Bonferroni adjusted for the multiple comparisons to p < .05 (using a corrected alpha of .007).

One of the LFI! Skills Battery subtests, Parts/Whole Identity, demonstrated a significant interaction between group and timepoint (see Table 2). This subtest assesses the extent to which individuals use a featural or holistic face recognition strategy (Tanaka & Farah, 1993). In the Parts/Wholes task (see Figure 2), participants are presented with a whole study face and then, in a two-alternative forced choice paradigm, are asked to identify a face part presented either in isolation or in the whole face. On this subscale, recognition of an isolated eye or mouth part from a study face provides an index of analytic processing whereas recognition of the part when tested in the whole face stimulus is a measure of holistic processing. Results of the significant group × timepoint interaction for the Parts/Whole Identity task, $F(1, 71)$ = 9.15, p < .003, are depicted in Figure 3. For the active treatment group, direct comparisons between Time 1 and Time 2 showed reliable gains in the part mouth condition, $F(1, 38)$ = 5.35, p < .05, and whole eyes condition, $F(1, 38)$ = 7.69, p < .001 (Figure 4). There was a trend toward reliable improvements after training for recognition of the part eyes,

Table 2 Group × Timepoint interaction effects for each of the *Let's Face It!* Skills Battery subtest

	Time 1	Time 2	*F*	*p*
Face subtests				
Face dimensions	Active: 72.1%	Active: 79.8%	F (1, 75) = .20	n.s.
	Waitlist: 74.2%	Waitlist: 81.0%		
Immediate memory for faces	Active: 43.1%	Active: 43.0%	F (1, 71) = .47	n.s
	Waitlist: 46.3%	Waitlist: 49.2%		
Matching identity				
Masked features	Active: 52.1%	Active: 58.1%	F (1, 73) = .77	n.s.
	Waitlist: 54.6%	Waitlist: 58.5%		
Expression	Active: 49.1%	Active: 52.0%	F (1, 75) = .00	n.s.
	Waitlist: 56.4%	Waitlist: 59.2%		
Parts/Whole identity	Active: 58.3%	Active: 64.1%	F (1, 71) = 9.15	p = .003
	Waitlist: 63.3%	Waitlist: 63.1%		
Object subtests				
House dimensions	Active: 67.1%	Active: 72.8%	F (1, 68) = .53	n.s.
	Waitlist: 68.8%	Waitlist: 73.0%		
Immediate memory for cars	Active: 49.4%	Active: 54.0%	F (1, 43) = .33	n.s.
	Waitlist: 51.8%	Waitlist: 53.6%		

p = .06, and whole mouths, p = 07. Of note, the waitlist control group showed marginally higher accuracy at baseline than the active treatment group (t(72) = 1.95, p = .06). The reason for this baseline difference is unknown and likely reflects chance error, given that participants were randomly assigned to groups. In response to this baseline difference, a follow-up analysis was conducted using groups that were matched at baseline. These matched groups were created by eliminating from the analysis the waitlist participants who had the highest scores at baseline, resulting in an average accuracy for both groups of 58% at Time 1. Using these matched groups, the group × timepoint interaction remained significant, F(1, 63) = 7.33, p < .01, as shown in Figure 5. None of the group by timepoint interactions for the other face or object subscales were reliable, p < .05.

To investigate the relationship between improvement on the Parts/Whole Identity subtest and participant characteristics, correlations were conducted between the Time 2 minus Time 1 difference score (for the Parts/Whole Identity subtest total score) and each of the following participant characteristics: age, IQ, ADOS Social algorithm total, ADOS Communication algorithm total, ADOS Communication + Social algorithm total, ADI Social algorithm total, ADI Communication algorithm total, ADI Stereotyped Behaviors algorithm total, and total time on intervention (in minutes). Improvement from Time 1

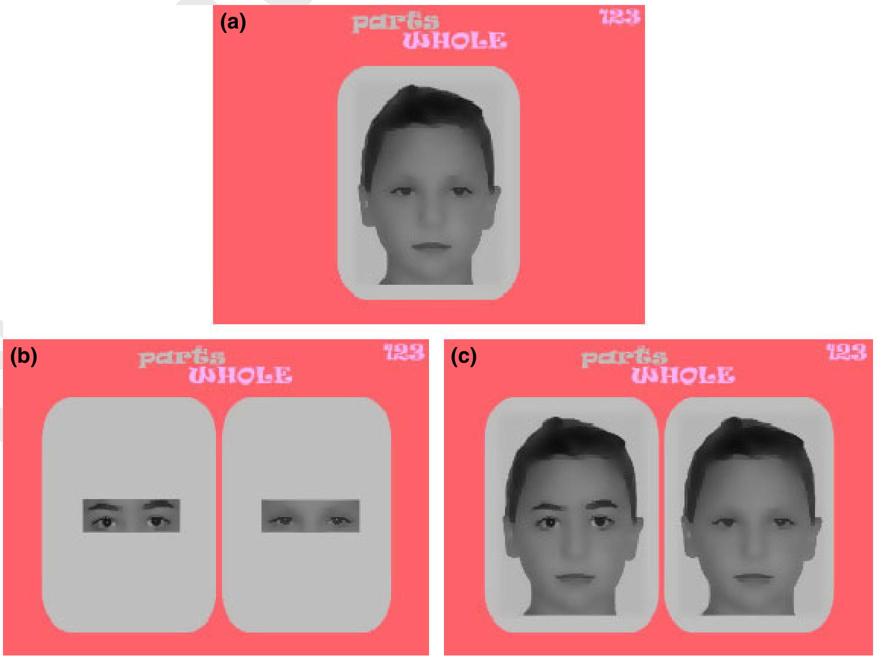

Figure 3 The Parts/Whole Test: (a) Study face, (b) 'Part' test condition and (c) 'Whole face' test condition. Note that in 'part' and 'whole face' test conditions, the target and foil items only differ with respect to the critical eye features. Analytic processing is measured by the correct recognition of the part in the isolated test condition. Holistic processing is measured by improved recognition in 'whole face' test condition relative to the isolated 'part' test condition

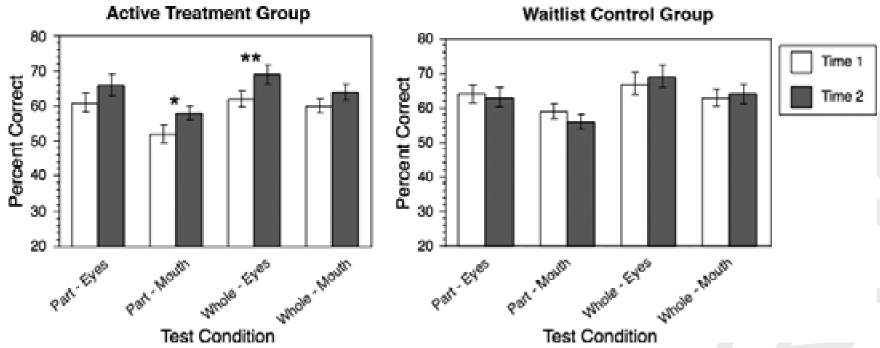

Figure 4 Significant (p = .003) group × timepoint interaction for the Parts /Whole Identity task. The active treatment group showed reliable gains in their ability to recognize mouths in isolation (*p < .05) and to process eyes holistically (**p < .01)

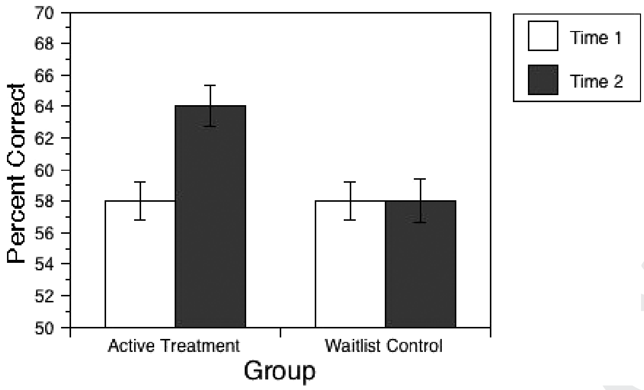

Figure 5 Group × timepoint interaction for the Parts/ Whole Identity subtest when groups were matched at baseline, $F(1,63) = 7.326$, $p < .01$. The active treatment group showed a significant increase in scores from Time 1 to Time 2 ($p < .001$), while the waitlist group showed no change

to Time 2 did not correlate significantly with any of these participant characteristics.

Discussion

In this study, it was found that 20 hours of face training with the *Let's Face It!* program was sufficient to improve the analytic and holistic face processing skills of children in the treatment group as assessed by the Parts/Wholes Identity Test. The post-treatment results revealed that *LFI!* training enhanced the recognition of both the eye and mouth face features. Interestingly, the largest improvements were found in analytic recognition when the face parts were tested in isolation. This finding is compatible with other results showing that individuals with autism are biased toward an analytic approach to face processing (Gauthier et al., 2009; Joseph & Tanaka, 2003). This result provides further evidence that as a general perceptual strategy, individuals with ASD focus more on the details of a stimulus rather than its global properties (Behrmann et al., 2006; Mottron, Dawson, Soulieres, Hubert, & Burack, 2006).

However, the local bias is not immutable to training and practice. Children who participated in the *Let's Face It!* face program improved in the holistic recognition of the eyes. The improvement in holistic eye recognition is notable because individuals with autism are more likely to ignore distinguishing information in the eye region in favor of the less informative region of the mouth (Rutherford et al., 2007; Wolf et al., 2008). Thus, as measured by the Parts/Whole test, the *Let's Face It!* intervention was successful in redirecting the participants' attention to the eyes and integrating eye information in the whole face.

The reliable improvements of the participants in the treatment group cannot be attributed to baseline differences. When participants in the treatment group and waitlist group were matched according to the Time 1 performance, individuals in the treatment group nevertheless showed appreciable gains compared to the control group. The results were specific to faces, indicating that the improvement was not a general training effect. To our knowledge, this is the first time that it has been shown in a large-scale, randomized clinical trial that face recognition abilities of children with autism can be improved through an unsupervised, computer-based intervention.

In contrast to the perceptual gains demonstrated on the Parts/Wholes measure, participants in the treatment group did not improve in their ability to detect featural and configural face changes (Dimensions test), to identify faces across changes in expression and orientation (Matching Identity tests) or to recognize faces over a short retention (Immediate Memory for Faces test) relative to the waitlist group. The absence of an interaction effect might reflect practice effects from Time 1 testing to Time 2 testing or overall, developmental improvements. The absence of training-specific effects on these other measures suggest that further modification and improvements of the program are required, such as providing children with explicit, rule-based strategies for aiding recognition (Faja et al., 2008). It is also possible that the treatment dosage of 20 hours was not sufficient to promote across-the-board improvements in face processing.

Despite its limitations, the *Let's Face It!* program shows promise as an effective intervention tool and treatment alternative. From a practical standpoint, the computer-based treatment is cost-free, can easily be implemented in a home, school or clinical environment and available on multiple operating systems (i.e., Mac OSX, Windows). The program does not require direct supervision and can be customized to the learning skills of the individual child. Although the extent to which gains on computer-based programs directly translate into improved socialization skills is unknown, it is believed that the *Let's Face It!* program provides an important bridge for children with ASD to the face processing skills that are critical in real-world face-to-face interactions. Indeed, the program is not intended to be a stand-alone treatment or a substitute for human interaction, but might best used in conjunction with human interventionists (Rogers, 2000) who can reinforce the principles introduced in the *Let's Face It!* software.

In summary, our results demonstrate that like other forms of perceptual expertise, face processes are amendable to the effects of training and practice. In this study, 20 hours of *Let's Face It!* training was sufficient to boost the face recognition skills of children with ASD. Although this is a non-trivial investment of time, it pales in comparison to the lifetime of experience that children have with faces. Yet, this relatively modest amount of face training was enough to bring about measurable gains in analytic and holistic face recognition skills of children with ASD. While encouraging, these results are only a first step toward developing a comprehensive curriculum in face processing. Further research is warranted to test the long-term benefits of face training and the degree to which training transfers to everyday social skills.

Supplementary material

The following supplementary material is available for this article:

Appendix 1. Description of the *Let's Face It!* games (Word document)

This material is available as part of the online article from:

http://www.blackwell-synergy.com/doi/abs/10.1111/j.1469-7610.2010.02258.x

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Author notes

Robert T. Schultz is now at the University of Pennsylvania, Cheryl Klaiman at the Children's Health Council, Mikle South at Brigham Young University and Martha D. Kaiser at Rutgers University.

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Online access to the *Let's Face It!* Skills Battery can be obtained by contacting James Tanaka at jtanaka@uvic.ca.

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Key points

- Children with autism have significant deficits in face recognition.
- As a form of perceptual expertise, it is hypothesized that face recognition skills can be improved through practice and training.
- In a randomized clinical trial, impaired face recognition was ameliorated through 20 hours of computer-based treatment with the *Let's Face It!* program.
- The *Let's Face It!* program is a practical intervention in face processing for children with ASD.
- The *Let's Face It!* program can be downloaded free of charge from the website: http://web.uvic.ca/~jtanaka/letsfaceit.

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