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Affect Comprehension in Children With Autism Spectrum Disorder: A Visual Field Isolation Intervention

Erica L. Schmidt

South Dakota State University

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Author: Erica L. Schmidt
Faculty Sponsor: Dr. Debra Spear
Department: Psychology

ABSTRACT

Children diagnosed with Autism Spectrum Disorders (ASD) tend to show under-activation of the right fusiform face area of the ventral temporal cortex when viewing emotional faces, which may explain their affect comprehension deficits. This left hemisphere dominance, indicative of a piecemeal processing strategy, has been shown a less effective method of understanding true emotion. The present study aimed to condition the left-visual-field-to right-FFA pathway by allowing children with ASD to work through an emotion-matching computer program. One group completed the experiment with both eyes uncovered, while the other worked with only their left visual field open. Though no significant differences between improvement in accuracy, reaction time, and physiological response were found between the groups, almost all participants showed some improvement, and future investigations with larger sample sizes would be useful in puzzling out the benefit of visual field isolation in emotion comprehension interventions in children with ASD.

Keywords: autism, visual field isolation, emotional comprehension, intervention.

AFFECT COMPREHENSION IN CHILDREN WITH AUTISM SPECTRUM DISORDER: A VISUAL FIELD ISOLATION INTERVENTION

Often taken for granted, the ability to decode human facial expressions is not universal. Though two-month-old infants are able to recognize and reciprocate facial expressions, people with Autism Spectrum Disorders (ASD) show affect comprehension deficits (Grelotti, Gauthier, & Schultz, 2002; Silver & Oakes, 2001). And though individuals with autism have demonstrated the capacity to generate descriptive qualifiers, like gender, from photographs, they seem unable to extract emotional information (Clark, Winkielman, & McIntosh, 2008). Obviously such a deficit can make day-to-day social interactions intellectually taxing and can impede the formation of meaningful relationships.

Some mental health professionals postulate that the root of the social impairment is a lack of eye contact shown by individuals with ASD (Pierce, Muller, Ambrose, Allen, & Courchesne, 2001). Perhaps their lack of interest in faces and concomitant lack of experience with faces hinders emotional understanding. Others have suggested that a maladaptive emotional encoding system is at fault. In normal individuals, the fusiform face area (FFA), a region of the ventral temporal cortex, is dominantly activated when viewing facial expressions (Cox, Meyers, & Sinha, 2004; Kanwisher, Stanley, & Harris, 1999). In tests of affect recognition with autistic participants, on the other hand, FFA activity is markedly decreased in comparative responsiveness (Deeley et al., 2007; Grelotti et al., 2005; Pierce et al., 2001; Piggot et al., 2004).

Additionally, an imaging study conducted by Minnebusch (2009) revealed that the left FFA in normal participants was never activated in the absence of right hemisphere FFA activation. The right hemisphere FFA may act as a gateway into activation of other emotional processing regions and seems to be the center of emotional processing. Numerous other studies have confirmed this right hemisphere bias, a bias proven stable even across time and individuals. Yovel, Tambini, and Brandman (2008) reported that 16 out of 17 normal subjects in their study showed larger FFA activation in the right hemisphere, as compared to the left. Bourne (2008) similarly found that normal subjects asked to identify emotional expressions were fastest and most accurate when stimuli were presented in the left visual field; this corresponds to the right hemisphere FFA because of visual information crossover at the optic chiasm. Interestingly, numerous studies have revealed reduced right hemisphere FFA activation in individuals with ASD (Pierce et al., 2001; Schultz et al., 2003), and overtly slower and more error-filled responses on affect comprehension tasks (Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Celani, Battacchi, & Arcidiacono, 1999; Nijokiktjen et al., 2001; Piggot et al., 2004).

Autistic individuals do not show the severe recognition deficits of prospagnosiacs (Hadjikhani, et al., 2004). That is, they can recognize faces but are just not adept at reading the expressed emotion. A priori, an underdeveloped left-visual-field-to-right-hemisphere FFA pathway (rather than a lesion of the right FFA) may be to blame for emotional recognition deficits in ASD. In fact, Celani et al. (1999) and van Kooten et al. (2008) offer that autistic individuals may instead rely on a left hemisphere FFA pathway, characteristic of a more analytic processing approach. They maintain that holistic processing is a more preferred mode of decoding emotion, because it allows for a direct knowledge of another‘s emotion. The right hemisphere dominance shown in normal individuals corresponds to a more holistic processing strategy, but in autistic individuals, emotion is not as automatically inferred because the face is perceived as a mere collection of individual features (Gauthier & Tarr, 2002).

In support of a piecemeal processing theory in individuals with ASD, the present researcher‘s recent study demonstrated that children with autism spectrum disorders show a left hemisphere advantage (Brindley & Schmidt, 2009). When their right visual field was isolated, the autistic participants showed a slight increase in accuracy, significantly faster responses, and increased heart rate. Typically developing participants confirmed previous findings of left visual field bias in normal individuals.

Given all of the above, perhaps a method involving visual field isolation would be helpful in remediation of the emotional comprehension deficits faced by children with ASD. Studies of social and emotional skills interventions with autistic children are few, but those available have shown computer interventions to be most effective (Bö lte, Feineis-Matthews, & Poustka, 2008; Lopata, Thomeer, Volker, Nida, & Lee, 2008; Silver & Oakes, 2001). Computer programs work with the natural predispositions of autistic children, who tend to like structured and predictable environments. Silver and Oakes (2001) found that the traditional student-teacher format of social skills training can be problematic, as it intrinsically requires social interaction. Autistic children have shown increased motivation, attention, and enthusiasm with computer intervention programs; they have also reported satisfaction with programs that are predictable, allow them to make choices, and provide immediate feedback—especially auditory feedback (Lopata et al., 2008). Of course, the obvious caveat with a computer-facilitated face intervention is whether any progress will transfer reliably into real-life human face comprehension.

Expounding on the findings of typically developing individuals‘ left visual field/right hemisphere bias and superior emotional processing abilities, the present study aimed to implement a left visual field isolation intervention for children with ASD. It was hypothesized that autistic children, allowed to practice matching emotions with only their left eye, would show more improvement in affect comprehension –operationally defined as greater accuracy, faster reaction times, and higher BPM heart rate—than children with ASD who practiced matching emotions to their labels with both eyes uncovered. If the right hemisphere FFA pathway can be conditioned, the children in the experimental group should demonstrate more improvement.

METHOD

Participants

Participants were recruited from Hillcrest and Medary Elementary schools (grades K-3) and Camelot Intermediate School (grades 4-5). Permission to recruit from these schools was granted by the Brookings School District, and parent permission forms were returned by each student. Participants included a total of six boys between the ages of 5 and 11 years, who were randomly assigned to the experimental or control group. The experimental group participants were of the same mean age (M = 7.67 years, SD = 3.06) as the control group (M = 7.67 years, SD = 2.89). All participants had an Individual Education Plan based on the diagnosis of Autism Spectrum Disorder and had normal or corrected-to-normal vision.

Materials

The present experiment utilized SuperLab 4.0 software (Cedrus Corporation, 2008) installed on a MacG4, OS10.4 laptop computer. The software was programmed to randomly present affective pictures and then to prompt participants to choose the corresponding emoticon. SuperLab automatically recorded the accuracy of answers, as determined by placement of a left mouse click. Reaction time was also recorded as the latency between response screen appearance and a left mouse click on any trial.

Affective stimulus pictures were drawn from the experimenter‘s personal photographs and the public domain picture site Dreamstime Free Images (2009). Pictures were also drawn from an educational photo bank comprised of pictures of college-age students showing a variety of emotions. Students depicted in these pictures gave consent for the use of their images in the project. All photographs were subsequently categorized by affective label—happy, sad, or angry—by a panel of six undergraduate, non-psychology-major judges (4 women, 2 men). Judges were also given a “not sure” option in efforts to exclude any pictures which they judged as unrepresentative of any of the prescribed categories. Pictures were selected for inclusion in the study only if there was at least .80 inter-rater reliability for a certain emotion. Pictures were edited in Photoshop 4.0 (Adobe Systems, Inc., 2005) so that they included only head and shoulders against a white background (See Figure 1).

Biopac MP35 (Biopac Systems, Inc., 2007) was used to collect physiological data. A photoplethysmograph finger wrap, sensitive to changes in blood flow, was plugged into the acquisition unit via Channel 2. Pulse rate information was recorded from the non-dominant index finger and was converted into visual form on a Toshiba Intel Centrino laptop computer connected by USB to the Biopac acquisition unit. Pulse rate data was automatically saved and was then converted into beats per minute units.

To achieve visual field isolation, a pair of children‘s sunglasses was modified. Original lenses were taken out; the right eye was occluded using black construction paper to cover the entire lens, which was then reinserted. The lateral portion of the left eye of the glasses was covered with black construction paper, as well. Only the medial portion of the left eye was open for sight, achieving right hemisphere visual pathway isolation. A pair of identical children‘s sunglasses was modified for control group participants by removal of both lenses. No further adjustments were made to these glasses.

DESIGN AND PROCEDURE

The present study was a simple, between-group experiment. Experimental and control groups were equivalent, each including three elementary-school-aged boys diagnosed with Autism Spectrum Disorder. Participants who had returned parental permission forms were individually taken to a quiet area of their normal special education classroom. Teachers were present in the room during the course of the experiment, so as to make participants as comfortable as possible. The participants sat directly in front of the computer monitor and were greeted by a recorded message explaining the procedure. After they assented, participants were fitted with either the experimental or control glasses and the photoplethysmograph on their self-reported non-dominant index finger.

Day 1

Participants were led through practice block of the SuperLab program. They were asked to match a happy, sad, and angry photograph with their respective emoticons. For each of the three practice trials a stimulus picture appeared on screen for 2.5 seconds, followed automatically by a response choice screen. The left third of the screen featured a “happy” emoticon, the middle third a “sad” emoticon, and the right third a “mad” labeled emoticon. A left mouse click in any of these three areas would elicit auditory feedback (prerecorded message). If the participant made a successful match, he would hear “Correct.” If the participant answered incorrectly, he would hear “Oops. That‘s incorrect. Pick a different answer,” and then see the stimulus presented again before being allowed to correct the answer. SuperLab would not progress to the next trial until the participant selected the correct answer.

Next, participants completed the baseline block, consisting of 45 matching trials comparable to the ones they had done for practice. Fifteen pictures from each emotional category (happy, sad, or mad) were presented in random order. SuperLab recorded accuracy and reaction times of these baseline responses, while heart rate was recorded by Biopac.

Subsequently, participants completed the feedback block. This was the teaching portion of the intervention, where participants completed the same matching task with 30 new photographs. For each answer, participants heard “Correct” if they completed the trial correctly or “Incorrect. Pick a different answer” if they made an incorrect match. The computer program would show the trial stimulus again and progress to the next trial only after the correct answer had been selected.

Finally, participants completed the no feedback block. This teaching portion utilized the same 30 pictures used during the feedback block, except this time, participants were not told after each trial whether their match was correct. The purpose of withholding feedback here was to discourage the participants from becoming reliant on the feedback once they were asked to complete the final block at the conclusion of three days of the teaching intervention.

Day 2

Participants completed the feedback block in the same manner as Day 1. The no feedback block was also presented in the same manner as day one. Accuracy, reaction time, and pulse rate measurements were recorded but not saved.

Day 3

Day 3 also began with the teaching feedback and no feedback blocks. Then, participants were asked to again complete the 45 trials of the final block which was equivalent to the baseline block. In this way, changes in accuracy, reaction time, and physiological reactions from the start to conclusion of the intervention could be measured. A recorded debriefing message explained the purpose of the experiment, prompted participants to ask the experimenter questions if they had any, and thanked them for their participation. All participants received a small prize upon completion of each of the three sessions, including their choice of stickers, pencils, and pencil grippers. See Figure 2 for a complete diagram of each day‘s procedures.

RESULTS

Analysis of baseline block measures confirms that there were no significant pre-existing differences between groups in percent accuracy, $t(4) = -.47$, $p = 0.66$ (two-way).

Pre-intervention percent accuracy averaged across both experimental and control groups, was 70%. There were negligible differences between the groups‘ baseline reaction times, $t(4) = .60$, $p = .58$ (two-way), and baseline heart rates, $t(4) = 1.36$, $p = .25$ (two-way). An alpha level of .05 was designated for this experiment.

Table 1 shows the baseline and final percent accuracy scores, as well as total changes in percent accuracy for each participant. Participants in the experimental group showed an average decrease in percent accuracy (M = -2.00%, SD = 21.68%), while participants in the control group showed an average increase in percent accuracy (*M* = 7.41%, *SD* = 10%). The change in accuracy shown by the experimental group did not differ significant from that shown by the control group, $t(4) = -.68$, $p = .53$ (two-tailed). Notably, when the outlier (participant three of the experimental group) was excluded from analysis, the experimental group actually showed an average increase in percent accuracy (*M* = 10.33%, *SD* = 5.19%), slightly greater that of the control group, though still not significant.

There were no significant differences between groups on average change in reaction time, $t(4) = -.33$, $p = .76$ (two-tailed). The average improvement (decrease) in reaction time (*M* = 54.82 ms, *SD* = 3209.86) for members of the experimental group over the course of the intervention was less than average improvement shown by members of the control group (*M* = 670.73 ms, *SD* = 503.39). Again, if outlying data from participant three of the experimental group is excluded from analysis, the experimental group showed an average improvement in reaction time (*M* = 1680.39 ms, *SD* = 2179.82) greater than that of the control group, though not significantly so, $t(3) = .835$, $p = .465$, (two-tailed).

Figure 3 shows that the heart rates of members of the experimental group declined across trials (*M* = -3.67 BPM, *SD* = 15.05), whereas heart rates for the control group increased from baseline to final measurement (*M* = 47.06, *SD* = 45.64). There was no significant difference between the groups at the .05 level, $t(4) = -1.83$, $p = .14$ (two-tailed). If outlying data is excluded from examination (participants 3 and 4), there is, in fact, a significant difference between the mean change in heart rate shown by experimental participants (*M* = -11.70, *SD* = 8.16 and mean change in heart rate shown by control participants (*M* = 47.06, *SD* = 45.64), $t(2) = -10.73$, $p = .009$, (two-tailed). That is, the average heart rate of experimental participants dropped, while the average heart rate of control participants sped up.

DISCUSSION

In contrast to the hypothesis that the group with visual isolation would show significant improvement above that of the control group, no differences were found. In line with similar studies of facial affect recognition in autistic populations (Silver & Oakes, 2001), in the current study, the groups had a combined average of 70% accuracy at the beginning of the first day of intervention. However, contrary to the hypothesis that the visual field isolation group would demonstrate improvement in accuracy beyond the control group, the group‘s average accuracy actually decreased. A likely explanation for the decrease in average percent accuracy is the outlying data of one participant in the experimental group. This participant was particularly vulnerable to frustration and on the day of final measurements, became visibly irritated. When this data was excluded, the experimental group showed an improvement in accuracy greater than that of the control group. Previous studies of similar intervention programs have garnered mixed results. Lopata and colleagues (2008) also found no significant change in accuracy on children‘s‘ ability to identify emotion, whereas Silver and Oakes (2001) found modest improvements.

There are a few ways in which the present method could be improved to clarify changes in accuracy: In the present study, one participant in the control group achieved near-perfect accuracy on baseline and final measures, indicating a possible ceiling effect. Although some research has indicated children with ASD have the most trouble with emotions of negative valence such as anger and sadness included in the present study (Ashwin et al., 2006), others have found that the most trouble comes with more complex emotions like embarrassment, pride, and jealousy (Golan, Baron-Cohen, & Golan, 2008). Perhaps replacement of current stimulus pictures with those of more complex emotions would assist in discrimination of percent accuracy differences between groups. Additionally, although inter-rater reliability was .80 for all pictures, some pictures were consistently mislabeled by most participants. The mislabeled pictures were judged to be sad, but most children matched them to the mad emoticon. These pictures should be discarded and replaced in future studies.

Both experimental and control groups showed improvement in processing speed by decreasing their reaction times from baseline to final evaluation, though there were not significant differences present. Again, the emotional lability and inattention of participant 3 in the experimental group may misrepresent actual trends in reaction time. If this outlying data is excluded, the experimental group achieved demonstrably faster reaction times than the control group. While faster processing does not necessarily equate with better accuracy in processing emotional stimuli, it does indicate a greater level of stimulus salience, which is an improvement for children with autism, who tend to ignore faces (Krysko & Rutherford, 2009).

The findings of heart rate change in the present study are puzzling. Physiological measures are thought to be a particularly valid measure of arousal because they theoretically should not be affected by the communication impairments present in ASD and have been shown to change relatively quickly with changes in affective state (Liu, Conn, Sarkar, & Stone, 2008). According to Liu and colleagues, two minutes is the minimum amount of time needed to confidently identify these changes; participants in the current study worked on the baseline block and equivalent final block for more than two minutes. Therefore, physiological changes induced by the emotion-laden photographs should have been detected in the current study‘s participants.

Average heart rates, as measured by Biopac in the current experiment (M = 128.75 BPM, SD = 27.73) were very high— higher than the 70-80 BPM expected in typically developing individuals (Liu et al., 2008). Possible explanations for this discrepancy include evidence that autistic children have naturally-higher pulse rates than typically developing children (James & Barry, 1980). All of the participants in the present study demonstrated some anxious, repetitive hand activity while recording took place, which likely artificially inflated their heart rates. As this anxious activity took place on both the baseline block of trials and the final block of trials, its effects on the ―change in heart rate data of each participant are negligible.

According to the results of the present researcher‘s past study, ASD individuals showed significantly increased heart rate when viewing stimuli with their right visual field/left hemisphere (Brindley & Schmidt, 2009). If in the present study, left visual field isolation could condition the right hemisphere pathway, the experimental participants would have shown the most increase in arousal to stimuli after practice. The contrary was actually true. When outliers (Participants 3 and 4) were removed from their respective groups, the control group showed a significantly greater increase in heart rate than the experimental group. It is unclear why the control group improved more than the experimental group. Possibly, the experimental group stopped paying attention to the stimuli when they were not allowed to use their left hemisphere piecemeal strategy. This would fit well with hypothesis that autistic individuals do not pay attention to faces, because they just do not understand them.

Clearly, there were a number of limitations in the present study. Five of the six participants completed all three days of training, but due to illness, one of the children was able to complete only two of the days. Participants generally accepted the photoplethysmograph and glasses without irritation, although at times, participants would fidget with the glasses and move their fingers. Another possible source of error is that some children had to be periodically redirected back to the activity after they would get distracted or start to talk to the examiner.

Though significant differences between groups were not found, each student showed some level of improvement in accuracy and reaction time. It is important to interpret the present findings in light of the fact that the sample size of each group was very small. Additionally, there were severe time restrictions which allowed for only three days of the teaching intervention. Most interventions have occurred over the course of months, not days (Bryson, Rogers, & Fombonne, 2003; Lacava, Golan, Baron-Cohen, & Smith Myles, 2007; Lopata et al., 2008; Silver & Oakes, 2001). Future research should greatly expand the sample size. More time to teach would also allow for the most accurate understanding of visual field isolation and its potential utility in teaching emotional affect comprehension to children with ASD.

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Table 1:

Percent Accuracy by Participants Across Three Days of Affect-Learning Activity

Group	Participant	Baseline	Final	Percent Accuracy
Experimental	1	0.67	0.80	0.14
	2	0.62	0.69	0.07
	3	0.71	0.44	-0.27
Control	4	0.93	0.91	-0.02
	5	0.47	0.64	0.18
	6	0.80	0.87	0.07

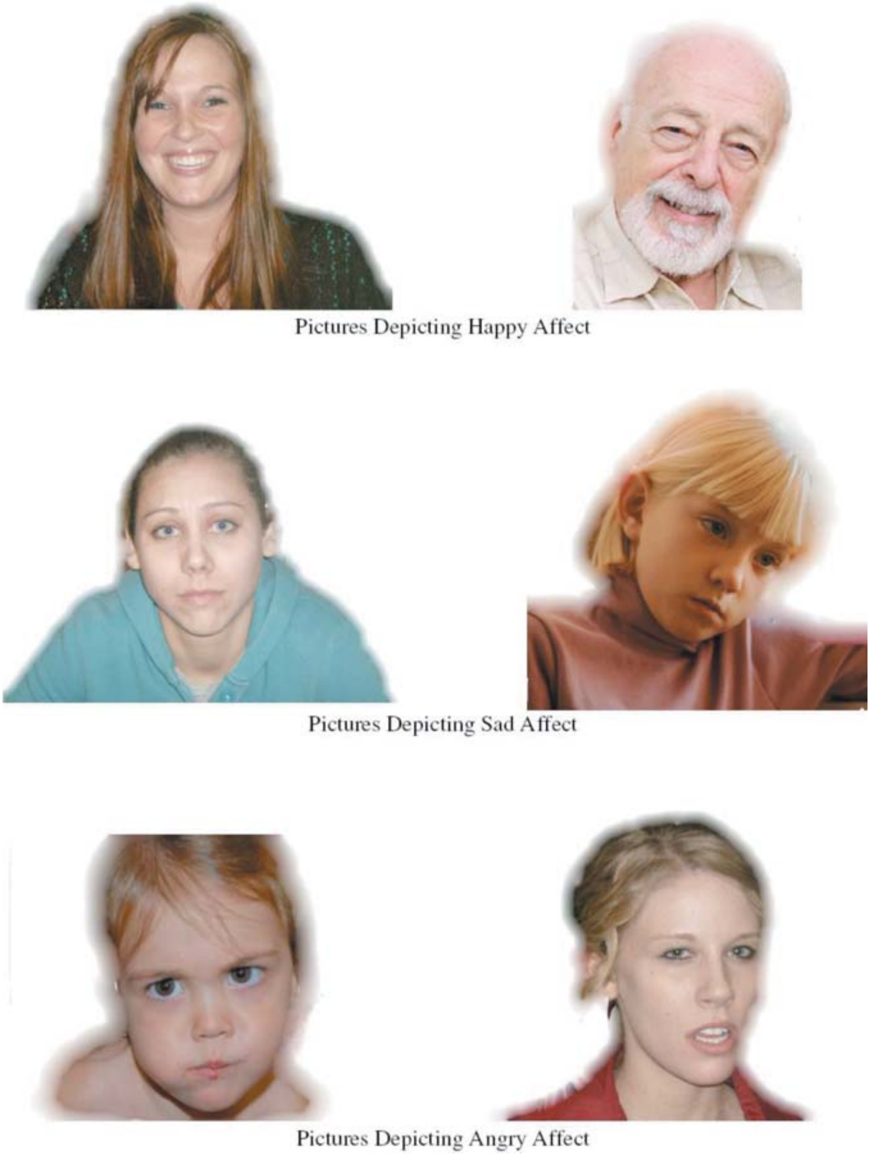

Figure 1. Examples of facial affect stimuli used in the intervention.

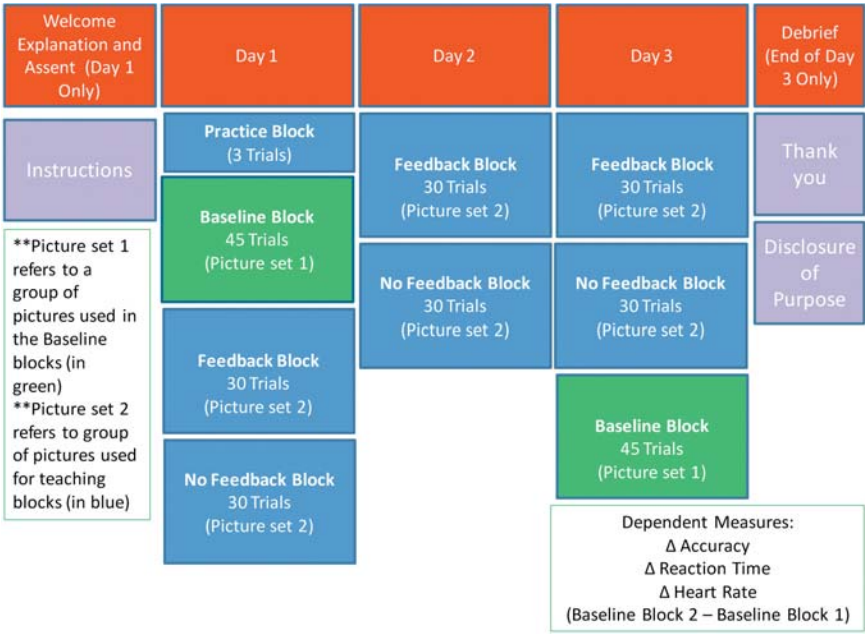

Figure 2. Three-day intervention design and measurements.

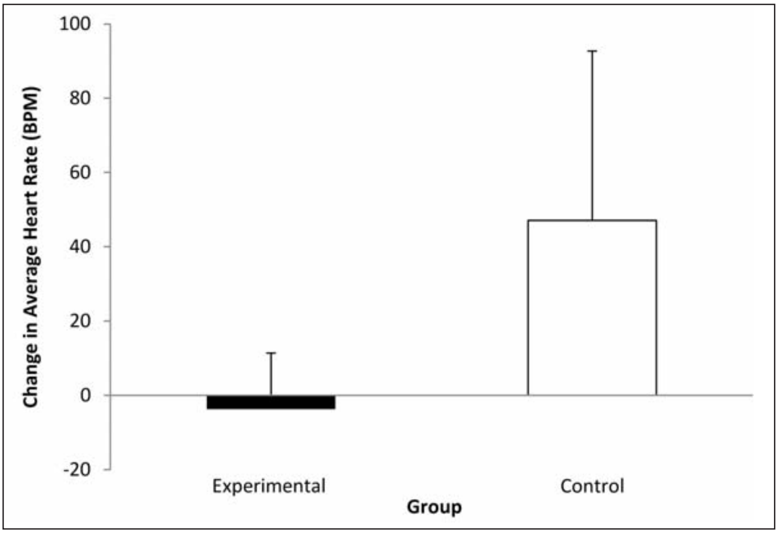

Figure 3. Mean (*SD*) change in heart rate (BPM) for the experimental group (n =3), and control group (n = 3) across three days of practice on a matching task of facial affective stimuli.