Change Detection in Naturalistic Pictures among Children with Autism

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Abstract

Persons with autism often show strong reactions to changes in the environment, suggesting that they may detect changes more efficiently than typically developing (TD) persons. However, Fletcher-Watson, Leekam, Turner, and Moxon (2006) reported no differences between adults with autism and TD adults with a change-detection task. In this study, we also found no initial differences in change-detection between children with autism and NVMA-matched TD children, although differences emerged when detection failures were related to the developmental level of the participants. Whereas detection failures decreased with increasing developmental level for TD children, detection failures remained constant over the same developmental range for children with autism, pointing to an atypical developmental trajectory for change-detection among children with autism.

Key Words: change detection; attention; development

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Persons with autism are more successful than mental age matched typically developing persons on a variety of visual search tasks, including the embedded figures task (e.g. Joliffe & Baron-Cohen, 1997; Shah & Frith, 1983) and on visual search for targets defined by features (O'Riordan, 2004) or conjunctions (Plaisted, O'Riordan, & Baron-Cohen, 1998a). This enhanced visual search is thought to reflect superior ability in identifying subtle differences between stimuli (O'Riordan, 2004) and is consistent with the common clinical and anecdotal observations of intense reactions to changes in the environment, even to those that may not be observed or reported by persons without autism. If this increased sensitivity to change is pertinent to real-life functioning, it should translate to more effective search for changes in the environment by persons with autism. However, this hypothesis was not supported in a study in which adults with autism tried to detect changes to ecologically relevant images (Fletcher-Watson, Leekam, Turner, & Moxon, 2006). Here, we extend this study with a variant of the change detection paradigm and a focus on children with autism rather than on adults.

Change Detection

The detection of changes in the environment is typically dependent on attentional processes (Simons & Rensink, 2005), conceptualized by Enns and Trick (2006) as consisting of two interrelated dimensions of processing control – degree of conscious control (automatic versus conscious) and the origin of control (innate versus learned through experience). Enns and Trick (2006) proposed that four basic modes of visual selection could be identified by an orthogonal combination of these two dimensions that involves reflexive (automatic, innate), habitual (automatic, learned), explorative (conscious, innate), and deliberative (conscious, learned) processing. The change detection task was highlighted as a tool for understanding explorative attention, as it requires the conscious control of attention during the exploration of the environment, an activity that is governed by processes considered to be innate.

Change detection is typically measured with two different versions of a visual scene that are presented in alternation with an intervening blank screen (Rensink, O'Regan & Clark, 1997; Shore & Klein, 2000). The detection of scene differences is effortless and automatic if the interval between the presentations of the displays is less than approximately 80 ms (e.g., Aginsky & Tarr, 2000). In these cases, the change creates a spatially local flicker or motion signal that is registered by the sensory system as a salient luminance transient (Rensink, 2002). However, changes are not as easily detected if the blank interval between scenes is 100 ms or longer, since that exceeds the temporal limits of visible persistence, or iconic imagery (Aginsky & Tarr, 2000). Although performance on a change detection task is considered an index of the short-term memory of scenes, it also reflects several components of attention that function in synchrony or competition with each other. For example, the detection of change is more likely for objects of central rather than marginal focus (Rensink et al., 1997; Shore & Klein, 2000), when changes in objects and features are expected (Austen & Enns, 2003), when attention is drawn reflexively to the location of change (Scholl, 2000), and when fewer items are presented in a display (Rensink, 2002; Smilek, Eastwood, & Merikle, 2000). Thus, change detection is an index of where and to which objects and features attention is directed in the presentation of a visual scene.

Change Detection and Development

Using a variant of the flicker task (cf. Rensink et al., 1997), Shore, Burack, Miller, Joseph, and Enns (2006) examined the development of change detection from childhood through adolescence among typically developing persons. Their task, which was also used in the study reported here, involved the presentation of two images on both sides of a central fixation. These two images flickered with a blank interval of 50 ms or 250 ms. On each alteration, one image changed, whereas the other remained the same throughout the trial. The participants indicated their detection of change by a button press, corresponding to the side of the screen in which the changing images appeared. The differences in speed and accuracy of change detection between the shorter and longer durations were taken as indicators of change detection ability. This difference score showed a protracted development from 6 to 26 years, with clear improvements in detection response time (RT) and accuracy during the period from 10 year to 26 years of age. This trend differs considerably from those of traditional measures of attention on which performance becomes adult-like in infancy for reflexive attention (adult-like by 6 months within a specific visual field; Harman, Posner, Rothbart, & Thomas-Thrapp, 1994), but not until childhood for deliberative attention (adult by 7 years of age; Akhtar & Enns, 1989, Enns & Cameron, 1987). It strengthens the promise of change detection as an innovative context for addressing the “entry level” of attentional detail with which a scene is viewed and explored (Enns & Trick, 2006). The specific finding of larger age-related differences in the detection of deleted parts and color changes than of whole object orientation implies further that children are more sensitive to the relationship between the whole object and themselves than to its particular details (Shore et al., 2006).

Change Detection and Autism

Based on their superior performance in visual search (Plaisted, O’Riordan, & Baron-Cohen, 1998a, 1998b) and greater attention to local detail (Frith & Happé, 1994; Happé & Frith, 2006), persons with autism might be expected to show particularly efficient performance on a change detection task. However, in a study of change blindness among adults with autism, Fletcher-Watson et al. (2006) found no differences in the ability to detect semantically relevant or contextually relevant changes to meaningful scenes between adults with autism and typically developing adults matched on CA, verbal, performance, and full scale IQ. With both types of change, the participants were presented with images of a scene that alternated every 300ms in which a single inanimate object changed from one scene presentation to the next in one of three ways. Changes were made either to the color of an object, to its location (through vertical or horizontal movements) or to its presence or absence in a scene, and the participants responded verbally to the location of the changes.

In contrast to the Fletcher-Watson et al. (2006) study, the focus here was on children, since Shore et al. (2006) found improvements in change detection throughout childhood and group differences are most likely to be found at ages when the relevant skills are emerging (Burack, Iarocci, Bowler, & Mottron, 2002; Burack Iarocci, Flanagan, & Bowler, 2004). The experimental task was the same one used by Shore et al. (2006) in a study of typically developing children aged 6-12 years of age. The images consisted of both drawings and photos in which a change had been made to either the color of one of the objects, the deletion of a part, or a rotation of the global orientation of an object.

The Shore et al. (2006) task is appropriate for the study of participants who function at various levels of development, for at least two reasons. One, two continuously alternating images are presented side-by-side so that the participants merely have to indicate the side of the screen in which a change is detected. This minimizes the unwanted influence of any differences in linguistic ability or in the criterion used for a detection response. Two, change detection is indexed by a comparison of performances on two conditions that differ only in the blank interval that occurs between views of the each image (50 ms vs. 250 ms condition). This controls for any developmental differences in detecting and responding to a change of any kind or in executing a decision to respond with a motor action. Because 250 ms is longer than the duration of iconic memory, a correct response can be made in this condition only if the participants compare one image with the other in short term memory. With the 50 ms interval, change can be detected by a simple registration of the salient motion transient that occurs when images alternate.

The possible outcomes we considered were based on various theoretical perspectives of autism. According to Plaisted et al.'s (1998a) reduced generalization hypothesis, the children with autism were expected to show superior detection of all change types than the typically developing comparison children, even when the groups were matched on nonverbal visual-spatial measure of cognitive mental age. According to the view that children with autism display a local feature bias (Bertone, Mottron, Jelenic & Flaubert, 2005; Iarocci, Burack, Shore, Mottron, & Enns, 2006; Mottron et al., 2003; Plaisted et al., 1999), the children with autism were expected to show enhanced detection for changes involving features (colors) or parts of an object (deletions), but typical performance for global changes (rotations in object orientation). According to the view that children with autism display impairments in abstract reasoning (Minshew, Meyer, & Goldstein, 2002; Minshew, Siegel, Goldstein, & Weldy, 1994), and that the perception of drawings requires more abstract processing than photos, the children with autism were expected to show poorer change detection for drawings than photographs.

Method

Participants

The participants were 18 children (3 females) diagnosed with autism and 18 typically developing children (8 males) individually matched on nonverbal perceptual performance, ranging in chronological age from 4 years 4 months to 13 years (see Table 1).

[insert Table 1 about here]

These participants were placed into four groups in order to from a 2 x 2 design of Autism Diagnosis (autism, typically developing) and Age (7 years, 10 years). All the participants displayed normal or correct-to-normal vision and no co-morbid neurological or medical disorders. Participants classified as having autism met criteria for both current and retrospective diagnoses, based on the Autism Diagnostic Interview - Revised (ADI-R, 3rd Edition; Lord, Rutter, & Le Couteur, 1994). A trained clinician, with a .90 reliability concordance with a qualified ADI-R trainer, made this assessment.

Matching procedure. The Autism Diagnostic Interview was conducted at the experimenter's office or at the participant's school or home and during a separate meeting with the child's parents. The duration of each diagnostic interview was approximately 3 hours. Participant matching was based on nonverbal visual-spatial processing as measured by the Matrices subtest of the Kaufman Brief Intelligence Test (K-BIT; Kaufman & Kaufman, 1990). This 48-item subtest is used to measure nonverbal intelligence in individuals from 4 to 90 years of age and requires visual discrimination and nonverbal reasoning in problem-solving. Most items from the Matrices subtest involve geometric patterns and require that the individual either solve a 2x2 or 3x3 matrix or complete a pattern of dots, by pointing to the correct response among a set of choices. The raw scores of each child with autism were individually matched to a child in the comparison group. These scores were then converted to mental ages according to the procedures outlined in the manual.

Apparatus and stimuli. The displays were presented using VScope 1.2.7 software (Rensink & Enns, 1995) on a 333 MHz Macintosh PowerBook G3 with a 14.1” active screen. The screen measures approximately 29 cm horizontally (28.3° of a visual angle) and 22 cm vertically (21.1° of a visual angle) at an approximate viewing distance of 50 cm. Two keys on the keyboard were used to record the participants’ response. The “?” key on the right hand side of the keyboard and the “Z” key on the left-hand side were both covered with red stickers to facilitate responding.

Displays. The images were adapted from cards designed especially for children (Photo Language, manufactured by Nathan). The purpose of selecting images that were designed for children was to assure that the images were familiar to the participants. A color image of a stimulus object was printed on each card. The images that were used to create the experimental images were scanned with an HP DeskJet scanner and then modified with Adobe PhotoShop™ software. On screen, each drawing was approximately 12.5 cm by 8 cm and each photograph was 12.5 cm by 10 cm, at a resolution of 72 pixels per inch.

For the object change detection task, the displays consisted of 24 stimuli, which were presented randomly, in pairs, on a computer screen. The modifications to the images involved a change of color, deletion of a detail, or a rotation of the image. The images included 12 color photographs of commonly seen objects, and 12 color drawings of objects. Each pair that was presented included a changing target item and a non-changing distracter item that were presented side-by-side (see figure 1).

[insert figure 1 about here]

Thus, the 12 experimental pictures were modified each with four types of changes, totaling 48 items. In addition to the images that changed on each alternation, each trial also included an image that remained unchanged with each alternation. Unchanging images were randomly paired with changing images to ensure that all images were included in each testing block at least once. The changing image was shown randomly on the right or left on each trial.

Procedure. The participants were tested individually in two 30-40 minute sessions, on two separate days with 1 week between sessions. The participants were administered the K-BIT Matrices subtest and half of the change detection task (i.e., four blocks of 72 trials) in the first session, with the remainder of the task in the second session. A short break of 5-6 minutes occurred when shifting between the K-BIT and the computer task. Three short breaks of 1-2 minutes were also given between the testing blocks of the experimental task. Alternating displays were separated by 50 ms (the control condition that permitted change detection based on local luminance transients), or by 250 ms (the experimental condition requiring storage of the image in visual short-term memory). The participants were seated so that their eyes were approximately 50 centimeters from the screen.

On each trial, the participants watched two side-by-side flickering images. The images flickered until a response was recorded or until 15 seconds had elapsed. The participants were informed that only one picture would change on each trial and that their task was to indicate which picture changed by pressing the corresponding key as quickly as possible. The response time (RT) was recorded in milliseconds, measuring the time from the onset of the first changed image until the key was depressed. A response error occurred when the unchanging image was selected or when no response was recorded.

A total of 144 trials were presented in eight test blocks, with each block consisting of 18 trials. Two blocks of drawings (A and B) and two blocks of photos (A and B) were presented at 50 and 250 ms intervals, with a 1-week separation between blocks A and B so that the same image change was not presented more than once within a testing session. For example, during one testing session, half of the drawings were presented at 50 ms and the remaining half were presented at 250 ms. In the second session, the image-time interval relationship was reversed.

Prior to the testing, six practice trials were administered to the participants to test for comprehension of the task. If the participants made more than one error (less than 83% correct), they repeated the practice block. The stimuli in these practice trials were from both types of media (photos, drawings) and all three types of changes (color, deletion and rotation). The practice images were different than those included in the experimental task.

Results

Data cleaning procedures

Trial-by-trial data were screened to find mean correct RT and mean accuracy for each child in each experimental condition of Material (photograph, drawing), Time (250 ms, 50 ms), and Change type (deletion, color, rotation). The correct RT data were screened with a non-recursive outlier rejection algorithm (Van Selst & Jolicoeur, 1994) that removed from 3.4% to 3.9% of RT values for each participant. This resulted in the removal of 3.5% (166/4702) of correct RTs overall. For the group of typically developing participants, 4.0% (94/2346) of observations were removed, while for the group of children with autism, 3.1% (72/2356) of observations were removed. An ANOVA on the raw number of cut observations in each cell does not show any significant effects. There was a marginal effect of Time F(1,

17) = 3.21, p = 0.0911 such that more observations (93/2411 = 3.8%) were removed from 50 ms blank condition than from the 250 ms blank condition (73/2291=3.2%). Because each participant in a group was carefully matched on mental age with a participant in the other group, experimental factors were treated as repeated measures in all subsequent analyses of variance (ANOVA).

Error rates

Errors were considered the trials in which the incorrect picture was indicated as changing. The number of errors made was divided by the total number of observations in that cell. This error rate was multiplied by 100 to provide a percentage error rate for each cell, and for each participant. The error rates were entered into a 4 way repeated measures ANOVA with the factors of diagnosis, material, Change type, and Time. There were significant effects of Change type [$F(2, 34) = 21.28$, $p = 0.0000$], and of Time [$F(1, 17) = 25.47$, $p = 0.0001$]. The longer blank duration produced higher error rates [$F(1,17)$ 28.1, $p < .0001$] than the short blank duration, replicating previous research on change detection with these stimuli (cf. Shore et al., 2006).

Reaction time data

The remaining reaction times were entered into a 4 way repeated measures ANOVA with the factors of diagnosis, material, Change type, and Time (see figure 2). Main effects were found for the factors of time $F(1, 17) = 147.35$, $p = 0.00$, with the longer blank duration producing longer reaction times [$F(1,17) =155.2$, $p < .0001$] than the short blank duration (cf. Shore et al., 2006); change type $F(2, 34) = 110.75$, $p = 0.00$, with deletions being more difficult to detect than color changes, which were more difficult to detect than rotations; and material $F(1, 17) = 9.73$, $p = 0.0062$, with changes in photographs being detected faster than changes in drawings. Two-way interactions were found between material and change type $F(2, 34) = 21.73$, $p = 0.00$, and between change type and time $F(2, 34) = 32.01$, $p = 0.0000$, and a three-way interaction was found among diagnosis, change type, and time $F(2, 34) = 3.41$, $p = 0.0445$. An analysis of simple effects shows that this three way interaction was related to group differences between the 50ms and 250ms conditions for the deletion changes that resulted from a smaller difference between 50 ms and 250 ms for the children with autism than for the typically developing children.

[insert figure 2 about here]

Since no significant differences were found between the 50 and 250msec conditions, an index of change detection was computer by subtracting the difference between the 250 ms condition - the 50 ms condition for each cell in the factorial combination of material x change type, for both error rates and for mean RTs. Subsequent repeated measures ANOVA were done and demonstrated the same effects as above, namely an interaction between diagnosis and change type for the RTs $F(2, 32) = 3.41$, $p = 0.04$. Simple effects testing indicated that this resolves to a significant effect of diagnosis [$F(1, 17) = 4.58$, $p = 0.0471$] in the deletion condition (see figure 3).

[insert figure 3 about here]

Correlations between mental age and difference scores

Based on our earlier findings of a developmental trend (Shore et al., 2006), we wanted to investigate if a similar trend was evident with these children. For both RTs and error rates, we correlated the participants' mental age as measured by the Kaufman's matrices with the difference between the 250 and 50msec conditions for each of the combinations of materials and change types. For typically developing children, we found a negative relationship between error rates in the deletion condition for both the photographs (slope = -0.869 p = 0.005) and the drawings (slope = 0.707 p = 0.033), although this relationship was only significant for drawings only in the color condition (slope = -0.683, p = 0.009). These negative correlations imply that higher mental age resulted in lower error rates for typically developing children. In contrast, no relationship (positive or negative) was found for mental age and change detection ability in the children with autism across any of the change and material conditions (see figure 4), with none of the slopes in any of the conditions differing significantly from 0.

[insert figure 4 about here]

Discussion

The relatively superior ability of individuals with autism to find targets embedded in visual patterns (Joliffe & Baron-Cohen, 1997; Shah & Frith, 1983) and on visual search for targets defined by features (O'Riordan, 2004) or conjunctions (Plaisted, O'Riordan, & Baron-Cohen, 1998a) suggests that they should also show better performance than typically developing persons on measures of change detection. However, in a study of change detection in adults with autism, Fletcher-Watson et al., (2006) failed to find differences between persons with autism and matched typically developing persons on a change detection task. We extended those findings to the study of children with a change detection task with which age related changes in performance were found among typically developing persons (Shore et al., 2006). In order to further compare the developmental trajectories of change detection between the children with autism and the typically developing children, we correlated the error rates of the participants with their developmental levels as measured by a non-verbal visuo-spatial measure of intelligence.

In the present study, participants were asked to identify which of two images, presented side-by-side, changed during repeated presentations. The changes to the stimuli, which included both photographs and drawings of common objects, could be either the deletion of a local detail, a switch in the color of a part, or a global rotation that altered the object's orientation. Consistent with the strategy advocated by Shore et al. (2006), the intervals between flickers of changed and unchanged images were 250 ms in the test condition and 50 ms in the baseline condition. This strategy was successful, as all the participants displayed more errors and slower RTs across all changes and stimulus types when exposed to blank intervals of 250 ms as compared to those of 50 ms. Thus, the manipulation of 50 and 250 ms intervals was successful in producing both an effective control and a change blindness condition as demonstrated in similar paradigms (e.g., Aginsky & Tarr, 2000).

No group differences were found in RTs or error rates across different types of changes and materials during experimental displays of 250 ms intervals. Overall, both the children with autism and the typically developing children displayed comparable performances in RT and error rates for the two time intervals, and responded similarly to different types of changes. These findings are consistent with Fletcher-Watson et al.'s (2006) findings of similar performance on a change detection task between matched groups of adults with autism and typically developing adults, but inconsistent with the notion that individuals with autism display enhanced discrimination of unique features relative to typical individuals (Plaisted et al., 1998a).

Developmental Changes

The failure to support Plaisted et al.’s (1998a) theory of enhanced discrimination was qualified somewhat when a correlational analysis was conducted to assess the relationship between nonverbal mental age and error rates. For the typically developing children, a significant negative relationship emerged for both the deletions (photo and drawing types) and the color changes (only for the drawings) suggesting that performance improved with development in this group. The finding that change detection was less efficient in younger, typically developing children is consistent with developmental evidence that the ability to detect change on this type of flicker task improves from 6 to 26 years of age (Shore et al., 2006). The same correlational analysis revealed a difference in developmental trajectory between the groups. In contrast to the typically developing children who showed improved performance with age, no developmental gains were evident in the children with autism.

The discrepancies between the children with autism and the typically developing children on change detection suggest differences in the developmental trajectories associated with attention. One possibility is that change detection abilities develop earlier in autism than in typical development. A second possibility is that the differences in the developmental patterns of change detection are associated with the trajectories of enhanced discrimination abilities. In this interpretation of the data, the enhanced discrimination abilities of children with autism are manifested by more accurate performance in the detection of changes at earlier ages, before typically developing children are able to utilize other skills to perform this task. For the typically developing children, the presence of developmental effects may reflect a less stable perceptual representation in younger children following even a brief visual disruption (Shore et al., 2006). Alternatively, voluntary inhibition may be used more selectively in older than in younger children. Whereas younger children inhibit the processing of all attributes of an object that is not currently at the focus of attention, older children tend to selectively inhibit only the task relevant features of an object that is not currently the focus of attention (Enns & Akhtar, 1987).

Patterns of Change Detection across Types of Changes and Material

The pattern of performances in relation to the types of changes and the materials that were used is informative about the processing of visual information by persons with autism, and relevant theories. For example, the findings from this study do not support the notion that individuals with autism show enhanced discrimination of first order features (Bertone, Mottron, Jelenic, & Flaubert, 2005), as no difference in RTs were noted for color changes between younger and older children with autism and typically developing children across both experiments.

The consistent developmental patterns noted with regard to the difficulty in detecting the types of changes suggests that specific visual changes were likely processed similarly for children with autism and typically developing children. For both the children with autism and the typically developing children, most errors were noted in the deletion of changes. This was evident when deletion changes, as compared to other changes, produced the largest developmental difference in error rates and RT among the groups. One explanation for this finding may be that a deletion of a non essential detail was less critical in scene perception relative to configural properties. When viewing natural scenes or objects, the active allocation of attention seems necessary for observers to effectively encode information about nonessential details, whereas configural properties such as the position of an object appear to be better encoded without the need for active deployment of attention (Shore et al., 2006). Consistent with this interpretation, younger children who have less efficient attentional systems relative to older children may display impaired detection of deletion changes that require more active allocation of attention compared to other types of changes.

The finding that a change to the global orientation of an object was detected more readily than a change in a color or the presence of a part is consistent with evidence that changes in larger letters (i.e., at a global level) are detected more rapidly and accurately than changes in the smaller letters (i.e., at the local level) by typically developing adults (Austen & Enns, 2000). Both the present finding of efficient detection of changes in global orientation and the previous findings of efficient detection for changes to letters at the global level (Austen & Enns, 2000) is consistent with a “forest before trees” direction to visual perception more generally (Ahissar & Hochstein, 2000; Navon, 1977). The similarities in the patterns of detection of relatively global changes (i.e., object orientation) versus local changes (i.e., color and parts) between the groups is consistent with the notion of intact global processing among persons with autism (Mottron & Belleville, 1993; Mottron et al., 1999; 2003; Ozonoff et al., 1994; Plaisted et al., 1999) and broadens the finding to a wider range of tasks and displays.

With regard to the types of materials, expectations of differential performance between the groups for the drawing and photographic stimuli were not supported. Contrary to evidence of reduced generalization in autism (Minshew, Meyer, & Goldstein, 2002; Minshew, Siegal, Goldstein, & Weldy, 1994) that suggested that persons with autism would be less efficient in processing drawings as compared to photographs, the groups showed comparable change detection abilities to both drawings and photographs.

Conclusions

The primary finding in this study was that children with autism and typically developing children displayed similar patterns in the detection of changes to a visual display. This is consistent with Fletcher-Watson et al.'s (2006) finding with a different change detection task, but inconsistent with the notion of superior detection abilities among children with autism. The two groups of children displayed similar detection patterns at 250 ms blank intervals and similar styles of processing of local-global displays, with superior detection of global changes (i.e., rotation of a feature) as compared to local changes (i.e., the deletion of a detail). However, when the error rates of the groups were related to their developmental age, differences in developmental trajectories between the groups emerged. Although improvements in the performance of typically developing participants was related to age for 3 of the 6 conditions, no such relationship was found for the children with autism. This finding was unexpected and might suggest differences in the developmental trajectories of attentional abilities between the groups that could be explored by studying a larger range of both developmental ages in future studies.

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Table 1. Participants Characteristics

	Autism	SD	Typical (Nonverbal match)	SD
K-BIT	25.78 (10 years 1 month)	9.11	25.50 (10 years 1 month)	8.42
K-BIT range	13-43		13-40	
CA	8 years 9 months	25.26	8 years 4 months	35.46
CA range	6 years-13 years		4 years 4 months – 12 years 6 months	

Note. Approximate mental ages are in parentheses.

Figure Captions

Figure 1. Schematic illustration of a rotated object trial (on left) at a 50 ms blank interval.

Figure 2. Error rate and reaction time differences across time conditions, materials and change types for the two participant groups.

Figure 3. Error rate and reaction time differences between 50 and 250ms conditions across materials and change types for the two participant groups.

Figure 4. Correlations between error rates and non-verbal mental age for the two participant groups for each material and change type.

Figure 1 top

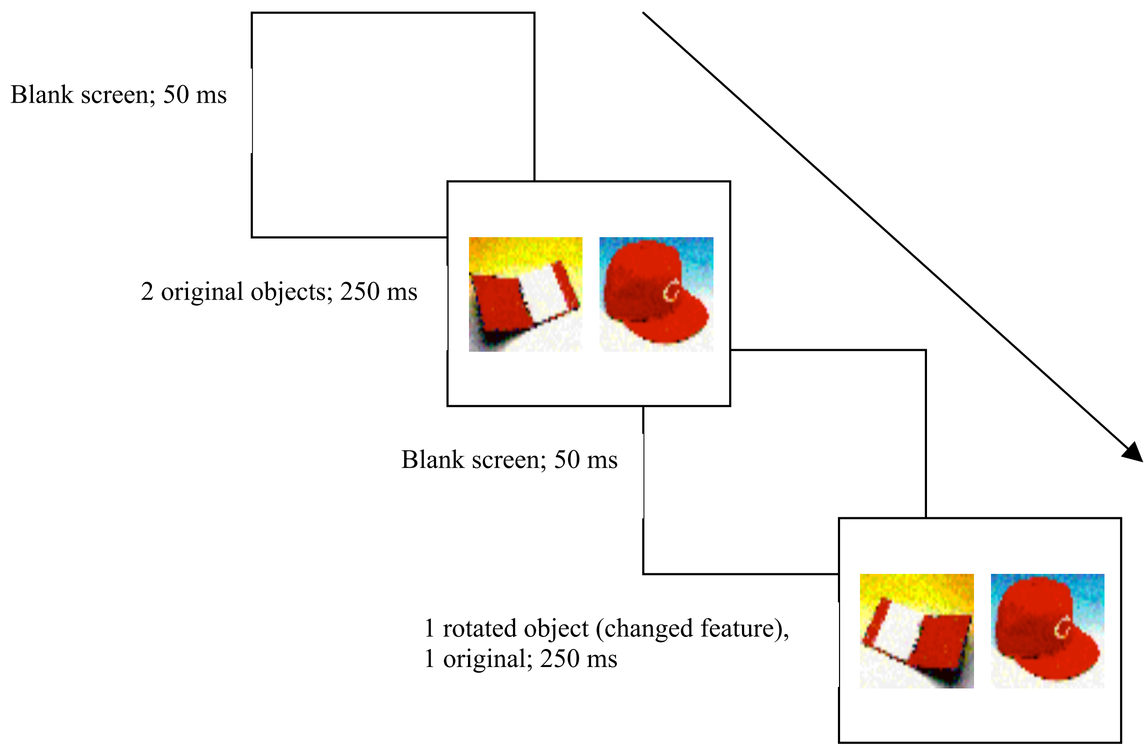
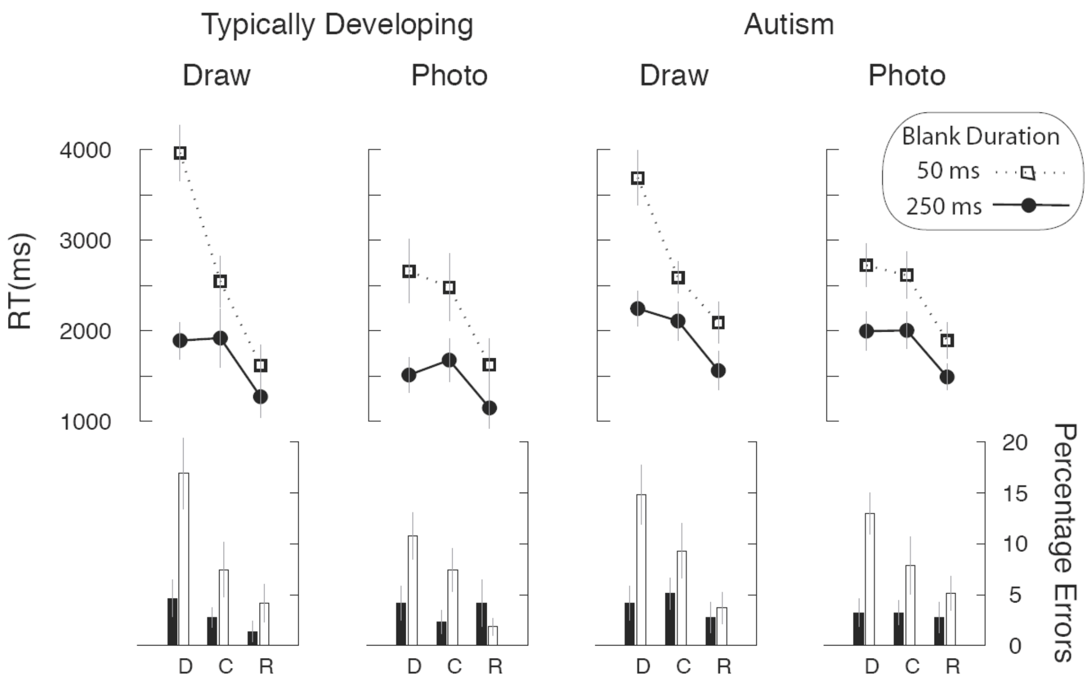

Blank screen; 50 ms
2 original objects; 250 ms
Blank screen; 50 ms
1 rotated object (changed feature),
1 original; 250 ms

Figure 2



Typically Developing
Autism
Draw
Photo
Draw
Photo
Blank Duration
50 ms
250 ms
RT(ms)
4000
3000
2000
1000
Percentage Errors
20
15
10
5
0
D C R
D C R
D C R
D C R

Figure 3

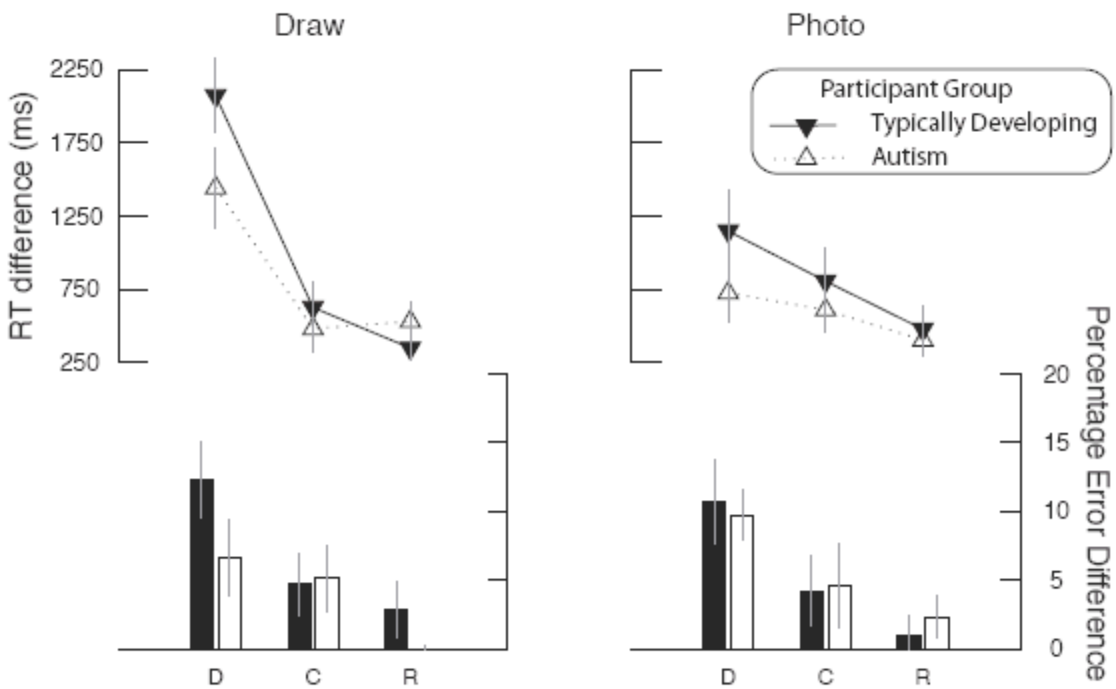

Draw
Photo
Participant Group
Typically Developing
Autism
RT difference (ms)
2250
1750
1250
750
250
Percentage Error Difference
20
15
10
5
0
D
C
R
D
C
R

Figure 4

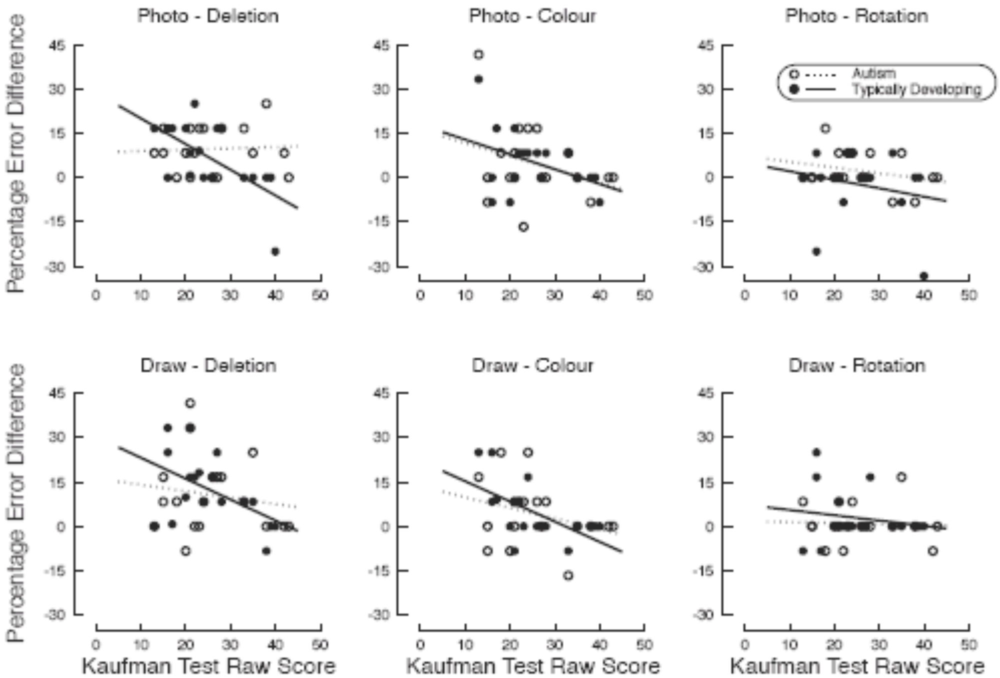


Photo - Deletion
Photo - Colour
Photo - Rotation
Draw - Deletion
Draw - Colour
Draw - Rotation
Autism
Typically Developing
Percentage Error Difference
Kaufman Test Raw Score
45
30
15
0
-15
-30
0
10
20
30
40
50