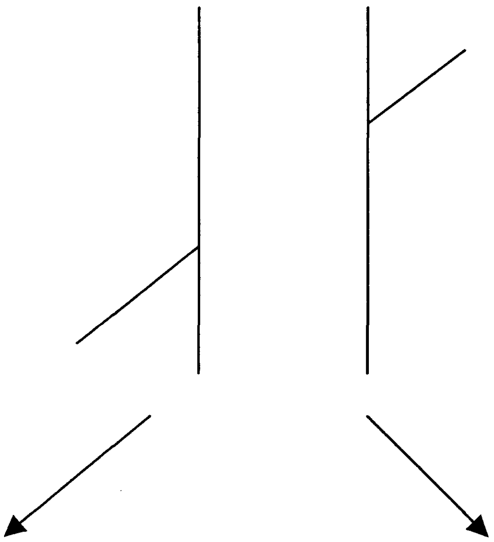
Chapter 2: The Illusions Experiment

This first experiment measured illusion effects using the Poggendorff, Muller-Lyer and Brentano displays (see Figure 1.6). As noted in Section 1.4.1, Happe (1996) found that an autism group was less susceptible than control groups to a number of illusions, including Poggendorff, but they showed equivalent susceptibility to Muller-Lyer. Although Frith (1989) had predicted that people with autism would have normal susceptibility to illusions, Happe (1996) claimed that the finding could still be reflecting weak central coherence. She suggested that central coherence integrates the inducing and induced parts of illusions and that, as such, a weakness in that function reduces susceptibility. She also suggested that the autism group was susceptible to the Muller-Lyer illusion because the explicit shafts physically connected the inducing and induced parts, thus compensating for weak integration.

The wings are the inducing parts and the shaft lengths are the induced parts of the Muller-Lyer illusion. Shaft length is overestimated when the diagonal lines point outwards (‘wings out’), relative to a shaft length without attached wings, but shaft length is underestimated when the diagonal lines point inwards (‘wing in’). Greist-Bousquet and Schiffman (1985) claimed that amputated ‘wings in’ and ‘wings out’ are embedded within the Poggendorff display, with an implicit shaft connecting the amputated wings. The gap between the vertical lines ends up being underestimated because there is a difference in the magnitude of the error that ‘wings in’ and ‘wings out’ each induce, with ‘wings in’ being stronger. The result is that the distance between the vertical lines is underestimated, which creates a perception where the right diagonal is seen as higher than the extension of the left diagonal (see Figure 2.1).

a) Poggendorff



b) Amputated wings, with implicit shafts

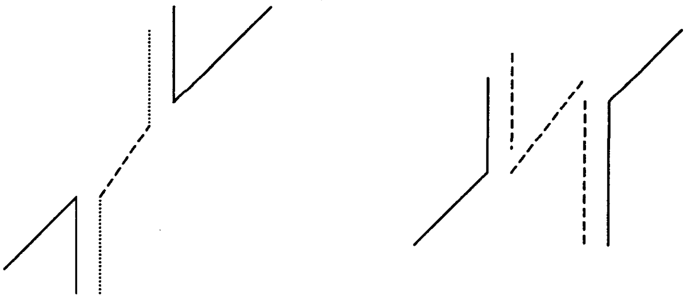


Figure 2.1: Amputated wings. Greist-Bousquet and Schiffman (1985) claimed that amputated wings on implicit shafts (dotted lines in b) are embedded

within the Poggendorff display. As a result, the gap between the vertical lines is underestimated and the illusion is perceived.

Following that reasoning, the Poggendorff illusion is a variation of Muller-Lyer, as it has the same inducing parts. According to Happe's (1996) theory, the difference in susceptibility between Muller-Lyer and Poggendorff in the autism group should be because the connecting shaft is implicit in Poggendorff, which will not be acted upon by the inducers due to weak integration. As the Brentano illusion has the same wings as Muller-Lyer but with an implicit shaft, Happe's (1996) theory predicts that the autism group in this experiment should not be susceptible to Brentano or Poggendorff.

Zucker (1980) claimed that 'wings effects' reflect local processes, as they can be detached from apparent motion effects (Section 1.4.2). As this thesis proposes that local processes are not impaired in autism, it predicts the autism group will be susceptible to wings effects. What makes Poggendorff more than just a wings illusion? Day, Jolly and Duffy (1987) showed that misalignment in the same direction as the Poggendorff illusion occurs with only dots instead of the diagonal lines; that is, when there are no embedded wings. As such, they argued that there is also a 'misalignment' factor in the Poggendorff illusion. Given Day et al's (1987) theory, the distinction between Poggendorff and Muller-Lyer in autism could be because reduced misalignment underlies reduced susceptibility to Poggendorff.

It could be said that 'wings effects' are local contexts acting over global processes (the length of explicit or implicit shafts), while misalignment is a global process acting over local contexts (the ends of the diagonals). As such, parvo processing should be dominant in wings effects, while magno processing should be dominant in misalignment. The distinction between Poggendorff and Muller-Lyer in the autism group of Happe (1996) may have been because reduced magno input reduces misalignment but not wing effects. Therefore, the current thesis predicts that the autism group in the current experiment will have a reduced illusion effect with Poggendorff but not Muller-Lyer or Brentano.

It could be argued that the central coherence model would distinguish between local and global processes in a similar manner. However, central coherence is a rather abstract concept and one can only be guided by what those who propose the model say and the predictions that are afforded to the model follow from Happe's (1996) weak integration theory.

As noted in Section 1.3, there is only limited information about perception in Asperger syndrome but what there is suggests that gestalt perception is weak but less pronounced than in autism. Given that, the autism group should have a smaller Poggendorff illusion effect than the Asperger syndrome group but there should be no difference between the groups in Muller-Lyer and Brentano illusion effects. There was insufficient information on which to base predictions about the Asperger syndrome group compared to the other groups.

Illusion and control displays (see Figure 1.6) were presented one at a time on a monitor. Each display was presented with one part offset from the position in Figure 1.6 and participants adjusted the offset part in a manner that allowed the key aspect of the given illusion to be measured. The score for each display was the distance from the veridical position that the line was placed. The illusion effect was the difference between the illusion and control display errors.

2.1 Method

Participants: There were 67 participants over 4 groups: Autism, Asperger syndrome (AS), Mild Intellectual Disability (MID) and Neuro-Typical (NT). All participants took part in all conditions with the exception that one AS participant did not undertake the Brentano condition. The Autism and AS groups were recruited through the help of the Autism Association of NSW or advertising, while the MID and NT groups were recruited through advertising. Participants in the disability groups were assigned to the respective groups on the basis of diagnostic information that was conveyed to the experimenter. The Token test from the Multilingual Aphasia Examination (1994) was administered to the disability groups before the sessions began to ensure that the participants had sufficient language development to follow the instructions. Token scores are out of 44. The normal performance expected is that 50% of subjects would score either 44 or 43, scores of 42, 41 or 40 are considered average and scores of 39 and 38 are considered low average or borderline. Group details are described in Table 2.1.

All participants in the Autism and AS groups were above the low average range, which suggests that they should have been able to follow the instructions for this experiment. The mean of the MID group was towards the low average range but only two subjects had borderline scores.

Table 2.1: Group details. Numbers, gender breakdown and means for age and token test, plus ranges (standard deviations in parentheses).

	N	male	female	age	token
Autism	11	8	3	21.5	43.1
range				14-54 (11.3)	41-44 (1.2)
AS	16	14	2	20.4	43.0
range				13-48 (8.1)	41-44 (1.1)
MID	14	10	4	17.0	40.9
range				15-23 (1.4)	38-44 (1.7)
NT	26	15	11	17.0	
range				14-19 (1.4)	

Apparatus: Displays were generated by a program in a Pentium II computer and presented on a 28 x 21cm monitor with white lines on a black background. The experimenter initiated each trial by pressing a footswitch, the participants adjusted displays with a response box and the computer program recorded the error (in mm) for each trial.

Displays:

Poggendorff (Figure 1.6a): The vertical lines were 80mm long and separated by 20mm, the diagonals were each 20mm long and at an angle of 45 degrees to the vertical lines. The control displays had the same dimensions but without the vertical lines. The position of the right diagonal only could be adjusted up or down by pressing one of two buttons on the response box. Zero offset was where the right and left diagonal were on the same co-linear plane. Starting offsets of the right diagonal line from below (positive, the expected direction of the illusion effect) to above (negative) the zero point were -10, -7.5, -5, 0, 5, 7.5, 10mm. Each offset was presented twice for both display types, making a total of 28 trials. The order of presentation was randomised but all participants received the same random order.

Muller-Lyer (Figure 1.6b): Each trial featured either 1) a 'wings out' figure above a 'wings in' figure, 2) a 'wings in' figure above a 'wings out' figure, or 3) one horizontal line above another horizontal line. The bottom shaft was always 50mm long and there was a gap of 15mm between the lines. For the winged displays, each wing was 10mm long at an angle of 45 degrees from the shaft. The control displays had the same dimensions but without the wings. The top line only could be lengthened or shortened by pressing one of the buttons on the response box, with both ends moving equally at the same time. Starting offsets for the top line were 10, 7.5, 5, 0, -5, -7.5, -10mm. If the starting offset was 10mm, the top line extended past the bottom line by 5mm at each end. Each offset was presented once each for 'wings in' as the top line and ‘wings out’ as the top line and twice for the control, making a total of 28 trials. All participants received the same random order but the order of offsets was different from the previous experiment.

Brentano (Figure 1.6c): The dimensions and the use of the response box were the same in the Muller-Lyer condition, except there were spaces instead of shafts, with the ends of the spaces for the control display indicated by dots (see Figure 2.1). All participants received the same random order, which was different from the previous experiments.

Procedure: Participants sat in front of the monitor at a distance where they were comfortable, while the experimenter sat alongside but slightly behind. The order of the conditions was always Poggendorff, followed by Muller-Lyer and then Brentano.

Poggendorff: The experimenter demonstrated that pressing one button on the response box moved the right diagonal up and pressing the other button moved it down. He explained that the task was to place the right diagonal on the same path as the left diagonal. The computer program recorded the distance in mm that the participant placed the right line from the position that the line would have been co-linear with the left line for each trial.

Muller-Lyer: The experimenter demonstrated that pressing one button on the response box made the top line longer and the other button made it shorter. He explained that the task was to adjust the top line to be the same length as the bottom line. The computer program recorded the distance in mm that the participant overestimated or underestimated the top line compared to the bottom line in mm for each trial.

Brentano: The experimenter demonstrated that pressing one button made the top space longer and pressing the other button made it shorter. He explained that the task was to adjust the top space, between the vortexes of the wings in the Brentano display and the dots in the control display, to be the same length as the bottom space. The computer program recorded the distance in mm that the participant overestimated or underestimated the top space compared to the bottom space for each trial.

The experimenter pointed out that the displays disappeared when a button had not been pressed for 2s, which was reinforced before the start of each condition. Participants had at least 2 practice trials with each display but the experiment did not begin until complete understanding of each procedure was demonstrated. The computer program recorded the error in mm from the veridical position that the participant placed the line for each trial.

2.2 Results

The Muller-Lyer and Brentano displays produced overestimation or underestimation, depending on whether the top line or space involved ‘wings in’ or ‘wings out’. Therefore, absolute error is reported for both illusion and control displays in those conditions. If real scores are calculated, the control display errors in those conditions were not significantly different from zero for any group. This shows that there was no bias towards either underestimating or overestimating the length of the top shaft that might have influenced the illusion effects.

There was a bias in error in lining up the two diagonals with the Poggendorff control display in the same direction as with the Poggendorff display. As such, real error is reported for that condition. A positive score indicates that the participant placed the right line below the extended diagonal plane of the left line, that is, in the expected direction of the Poggendorff illusion effect.

Two way (Display by Group) ANOVAs were generated for each illusion condition. Significant interaction would indicate that there was a difference between the groups in the magnitude of the given illusion effect, that is, the difference between the illusion and control display errors. There were no apparent effects of age or gender in any of the conditions.

2.2.1 Muller-Lyer

Participants were asked to adjust the top line of both the Muller-Lyer and control displays so that it looked like the top and bottom lines were the same length. Mean absolute error scores (in mm) were calculated for each individual and then for each group. Group scores for both displays are presented in Table 2.2. The illusion effect is the difference in error between the two displays.

Table 2.2: Results of the Muller-Lyer condition. Mean absolute error scores (in mm), plus ranges (standard deviations in parentheses), for the Muller-Lyer display and its control display.

	Autism n=11	AS N=16	MID n=14	NT n=26
Muller-Lyer **range**	1.1 .4 - 2.6 (0.7)	1.7 .5 – 3.9 (1.0)	1.6 .8 – 2.9 (0.6)	1.3 .5 – 3.4 (0.8)
Control **range**	0.3 .1 - .5 (0.1)	0.5 .2 – 1.1 (0.3)	0.4 .1 - .8 (0..2)	0.3 .1 -.8 (0..2)

A two way (Display by Group) ANOVA was generated to test for differences between the groups in the magnitude of the illusion effect. The Group by Display interaction was not significant, with F(3, 63)=.87, p=.46. This indicates that there were no differences between the groups in illusion effect. The main effect for Display was significant, with F(1, 63)=125.23, p<.001. This indicates that each group showed an illusion effect. The main effect of Group was not significant, with F(3, 63)=2.49, p=.068; there was a trend but any differences would only be reflecting error in matching the lengths of the shafts, with or without the wings. Therefore, all groups showed a Muller-Lyer illusion effect and there were no differences between the groups in the extent of the illusion effect, as expected from both Happe (1996) and the current thesis.

2.2.2 Brentano

Participants were asked to adjust the top space of both the Brentano and control displays so that it looked like the top and bottom spaces were the same length. Mean absolute error scores (in mm) were calculated for each individual and then for each group. Group scores for both displays are presented in Table 2.3. The illusion effect is the difference in error between the two displays.

Table 2.3: Results of the Brentano condition. Mean error scores (in mm), plus ranges (standard deviations in parentheses), for the Brentano display and its control display.

	Autism n=11	AS n=15	MID n=14	NT n=26
Brentano	1.4	1.6	1.9	1.3
range	.4 – 2.8	.3 – 3.2	.7 – 6.3	.6 – 2.5
	(0.75)	(0.86)	(1.26)	(0.58)
Control	0.3	0.5	0.6	0.3
range	.1 - .8	.1 – 2.5	.1 – 2.2	.1 - .6
	(0.2)	(0.6)	(0.6)	(0.1)

A two way (Display by Group) ANOVA was generated to test for any differences between the groups in the magnitude of the illusion effect. The Display by Group interaction was again not significant, with F(3, 62)=.39, p=.75. This indicates that there were no differences between the groups in illusion effect. The main effect for Display was significant, with F(1, 62)=69.82, p<.001. This indicates that all groups showed an illusion effect. The main effect for Group was significant, with F(3, 62)=2.89, p=.042. Orthogonal difference contrasts found that there was no difference between the MID and AS groups (p=.287), no difference between the combined MID/AS group and the Autism group (p=.087) and a difference between the combined MID/AS/Autism group and the NT group (p=.049). Therefore, all groups showed a reliable illusion effect, although the NT group was slightly more accurate than the clinical groups with both displays. Happe's (1996) theory predicted that the autism group should have shown reduced susceptibility to Brentano, as the shaft is implicit, which was not found. However, the result is consistent with the prediction from the current thesis that the Autism group would not show reduced susceptibility to either Muller-Lyer or Brentano.

2.2.3 Poggendorff

Participants were asked to adjust the right diagonal of both the Poggendorff and control displays so that it looked like the right diagonal was on the same collinear plane as the left diagonal. Mean real error scores (in mm) for each individual and then each group were calculated. The lack of a sign indicates a positive error; that is, placement of the right diagonal below the extension of the left diagonal. Group scores for both displays are presented in Table 2.4, along with the difference in error between the two displays (Error Diff).

Table 2.4: Results of the Poggendorff condition. Mean error scores for the Poggendorff display and its control display (in mm) and the difference between those scores (Error Diff), plus ranges (standard deviations in parentheses).

	Autism n=11	AS n=16	MID n=14	NT n=26
Poggendorff **range**	2.9 -1.2 – 6.5 (2.2)	6.6 3.8 – 10.0 (2.0)	6.6 3.8 – 9.5 (2.0)	5.3 2.5 – 8.6 (1.6)
Control **range**	0.4 -1.3 – 1.9 (1.0)	2.2 .7 – 4.5 (1.1)	1.7 .5 – 3.4 (0.9)	1.1 -.6 – 4.1 (1.3)
Error Diff **range**	2.5 -1.2 – 4.6 (1.7)	4.4 1.5 – 6.8 (1.6)	4.9 1.7 – 8.2 (1.9)	4.2 2.6 – 6.8 (1.1)

A two way (Display by Group) ANOVA was generated to test for differences between the groups in the magnitude of the illusion effect. The Display by Group interaction was significant, with F(3, 63)=5.67, p=.002. This indicates that there was a difference between the groups in illusion effect. All groups showed a significant difference between illusion and control error, with Toukey's HSD=1.21 (df=63, p=.05). This indicates that all groups showed an illusion effect. To interpret the interaction, that is to identify where the illusion effects differed, a one way ANOVA was generated for the variable, Error Diff in Table 2.4. As expected, this was significant, with F(3, 63)=5.59, p=.001, confirming that the illusion effect was not equal across the groups. Orthogonal repeated contrasts found that there was no difference between the MID and AS groups (t(63)=.80, p=.43) or between the AS group and the NT group (t(63)=.49, p=.63) but there was a significant difference between the NT group and the Autism group (t(63)=3.183), p=.002). Therefore, the illusion effect was significantly reduced in the Autism group, while the other groups showed equal illusion effects.

As noted above, that real errors are positive indicates placement of the right diagonal below the veridical position. This is expected with the Poggendorff display, if the illusion is perceived. If misalignment is a second factor in the illusion and is independent of the wing effects, as Day et al (1987) claimed, there should be a bias in the direction of the illusion with the control display (i.e., when there are no wings). The mean control display error was positive for all groups but it should be significantly greater than zero, if it reflects a genuine bias; that is, a misalignment effect. One sample t-tests showed that the control errors of the AS (t(15)=8.35, p<.001), MID (t(13)=6.76, p<.001) and NT (t(25)=4.37, p<.001) groups were all greater than zero but the control error of the Autism group was not significantly different from zero (t(10)=1.40, p=.19). Therefore, only the Autism group failed to produce a bias in control display error in the same direction as the Poggendorff display error. Also, Figure 2.2 shows the regression lines between the raw Poggendorff and control display error for the NT and Autism groups. The difference between the groups was most pronounced with low control error and only those in the Autism group with low control errors were out of the range of the NT group in Poggendorff error.

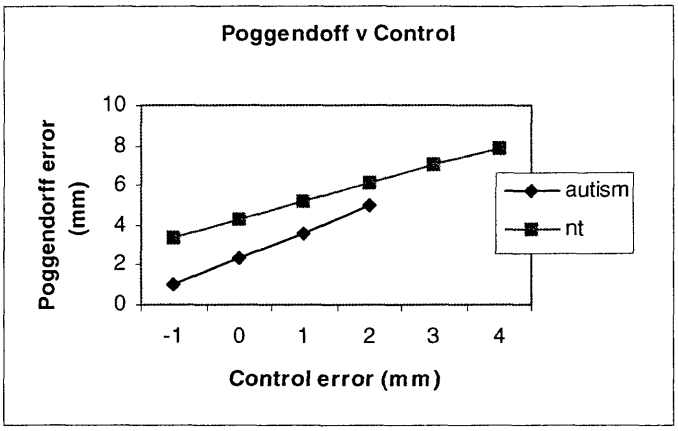


Figure 2.1: Poggendorff v control for the Autism and NT groups. The regression lines are not parallel. The participants from the Autism group with low error on the control display only had low error on the illusion display.

In Poggendorff condition, the NT, MID and AS groups all showed a bias with the control display in the same direction as the Poggendorff illusion effect, which supports the misalignment theory of Day et al (1987). The Autism group was the only group with a reduced illusion effect and the only group not to show a significant bias in the direction of the illusion with the control display. Moreover, the comparison between the regression lines of the Autism and NT groups suggests that the Autism group only had a threshold of misalignment before the full Poggendorff illusion was perceived. The Autism group showed normal wings effects in the Muller-Lyer and Brentano conditions, regardless of whether the shafts were explicit or implicit. Therefore, the data supports the prediction that reduced susceptibility to the Poggendorff illusion in autism is due to reduced misalignment, not weak integration of inducing and induced parts.

2.3 Discussion

This experiment measured the size of the illusion effects that are specific to the Muller-Lyer, Brentano and Poggendorff displays by comparing error scores from each illusion display against error scores from appropriate control displays. All four groups showed significant illusion effects in the three illusion conditions. However, while there were no between group differences in the Muller-Lyer and Brentano conditions, the Autism group showed a significantly smaller Poggendorff illusion effect than the AS, MID and NT groups, while there was no difference between those groups.

Happe (1996) found reduced susceptibility in an autism group to the Poggendorff illusion but no the Muller-Lyer illusion. The current research replicated that result but with a performance method, rather than the judgment method used in Happe (1996). This was important as Ropar and Mitchell (2000) did not replicate Happe's (1996) results with the Ponzo or Titchener illusions when they used a performance method. It was suggested in Section 1.3 that the method used in Ropar and Mitchell (2000) may have artificially deflated the illusion effect in the control groups, with the consequence that there were no differences between those groups and the autism group.

Two proposals were described earlier to generate predictions about the performance of the Autism group across three figure types that were tested in this experiment. Happe (1996) claimed that the reduced susceptibility of the autism group to most illusions reflected weak integration of inducing and induced parts. She suggested that the normal susceptibility to the Muller-Lyer illusion was because the physical connection between the inducing (wings) and induced (shafts) means that Muller-Lyer does not require integration and is not sensitive to an integration impairment. If this is correct, the Autism group here should have shown a reduced illusion effect with Brentano, which is a wings illusion but without explicit shafts. Also, Happe's (1996) theory predicted a reduced Poggendorff illusion effect, even though Greist-Bousquet and Schiffman (1985) provided evidence that Poggendorff may be another wings illusion in which, like Brentano, the connection between inducing and induced is implicit. Therefore, the normal Brentano illusion effect of the Autism group creates doubt that weak integration is the cause of the reduced Poggendorff illusion effect.

The dissociation between Poggendorff and Brentano in the Autism group also suggests that Poggendorff is not simply a variation of Brentano (i.e., a wings illusion with implicit shafts). Following Zucker (1980), the wings effects in all three illusions may be predominately reflecting local processing, regardless of whether the induced component is explicit or implicit. Given that the current thesis proposed that local processing would be unimpaired, it was predicted that the Autism group would show normal illusion effects in both the Muller-Lyer and Brentano conditions.

Day et al (1987) argued that misalignment is a second inducing aspect of the Poggendorff illusion. It was argued that misalignment reflects global processes and the current thesis proposes that only global input into gestalt perceptions is impaired in autism. Therefore, it was predicted that the Autism group would show a reduced Poggendorff illusion effect only, due to reduced misalignment. Whereas participants in the AS, MID and NT groups showed a significant bias in error on the Poggendorff control display in the same direction as on the Poggendorff display, the Autism group did not show any bias. Moreover, Figure 2.4 shows that the members of the Autism group with an illusion effect outside the range of the neuro-typical group produced low error on the control display. Therefore, the research found normal susceptibility to what are arguably illusions with local inducing parts (Muller-Lyer and Brentano) and reduced susceptibility to the Poggendorff illusion, which arguably has both local (wings) and global (misalignment) inducing aspects. Although the Illusion experiment is only an indirect test of the reduced magno input theory, the pattern of the Autism group was consistent with the predictions generated by the theory.

It seems odd that processes that 'link by co-linearity' are responsible for misalignment but, as De Yoe and Van Essen (1988) noted, global processes provide overall impressions, not accuracy. For example, Figure 2.3 presents a display that is borrowed from Livingstone and Hubel (1988). They claimed that the display is perceived as a jumble of lines under isoluminant conditions, not a coherent image. Most of the 'objects' in the display have some part occluded, so it is reasonable to suggest that the perception in normal conditions depends on linking by co-linearity. However, closer inspection shows that the links are quite inaccurate; in fact, the arrows indicate that a Poggendorff illusion is embedded within the display.

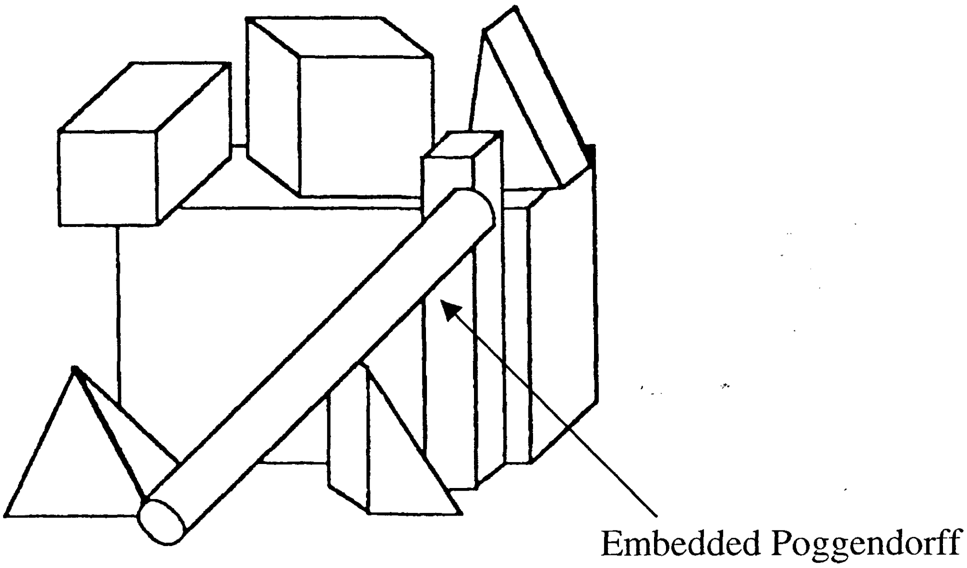


Figure2.3: Linking by co-linearity (from Livingstone and Hubel, 1988). Linking by co-linearity allows the display to be seen as a collection of objects with portions that are slightly occluded. Note that the linking is not very accurate and that the arrow indicates an embedded Poggendorff illusion. Livingstone and Hubel (1988) stated that this display becomes a jumble of lines in isoluminance.

Family studies suggest that there is a common genetic vulnerability for autism and Asperger syndrome (Happe and Frith, 1996). As noted in Section 1.4, there was not a lot of information available about perception in Asperger syndrome before this research began upon which to base confident predictions, although the available evidence suggested that gestalt perception is weak. BDT is a high score, at least among performance subtests, in the limited IQ profile research (Gilchrist et al, 2001), while Jolliffe and Baron-Cohen (1997) found superior performance in an Asperger group on EFT. This evidence also suggested that any weakness in Asperger syndrome is likely to be less pronounced than in autism. The most parsimonious explanation seemed to be that the disorders have a common underlying abnormality that weakens gestalt perception but that the abnormality is less profound in Asperger syndrome than in autism.

However, the performance of the AS group in the Poggendorff condition raises doubts that reduced magno input is a common abnormality. It was proposed that decreased misalignment in the Autism group was the reason for the group's reduced Poggendorff illusion effect; therefore, it seems that reduced error on the control display should be the marker of reduced magno input. An independent t-test between the AS and NT groups, used simply to highlight the problem, shows that the AS group not only produced a bias on the control display (2.2mm) but their bias was significantly greater than the NT group, where $t(40)=2.84$, $p=.01$.

Clearly, the reduced magno theory, as posited, does not accommodate the performance of the AS group. Should the theory be rejected outright? One possibility is that autism and Asperger syndrome arise from distinct abnormalities and the theory, which was based on evidence from autism groups, adequately accounted for the performance of the Autism group. However, there is growing evidence that weak gestalt perception reflects a genetic vulnerability that is common to autism and Asperger syndrome (Baron-Cohen and Hammer, 1997, Happe et al, 2001). What may be required is a more sophisticated model.

In the Navon task, described in Section 1.3.3, the global perception is of a large letter, which reflects the global structure, regardless of what small letters make up the large letter. However, gestalt perceptions are more than the sum of the parts and are not simply the global structure. Evidence of impaired global perception has been found in a number of other disorders, for example, dyslexia (Livingstone, 1993, Lovegrove, 1996), while the evidence described in Section 1.4.1 suggests that weak gestalt perception is unique to autism (and, perhaps, Asperger syndrome). There has been considerable debate over the years about whether illusions reflect the effect of impinging mental states or are limited cases that 'trick' the normally accurate bottom up processes. However, regardless of which position is correct, the visual system has to integrate the input into the perception. Section 1.3 proposed that weak gestalt perception reflects reduced magno input into that process of integration, not reduced magno input per se.

What the analysis overlooked though was the possibility that individual differences in subcortical input could also be a factor in the results. Any population will have a distribution of individual differences between subcortical parvo and magno input (or between high retinal acuity and low retinal acuity). The Autism and AS groups may be representative of single population with a normal distribution of subcortical processes that interact with an abnormality in higher level perceptual processes.

Some members in the NT group did not demonstrate a bias towards misalignment in their control error scores but each member demonstrated an illusion effect (the lowest Error Diff score in that group was 2.6mm). Therefore, it would seem that global processes effected their illusion perception, regardless of differences in subcortical input. The participants in the Autism group whose illusion effects were outside of the normal range had low scores on the control display, which suggested that reduced global processes effected their gestalt perception.

However, the members of the Autism group with relatively high, for their group, control error showed an illusion effect. Moreover, the Error Diff in the other groups was almost identical. This suggests that only a small amount of misalignment suffices to induce the illusion (allowing that there may be a second inducer) but that the underlying abnormality in autism created a higher threshold for misalignment. Most people placed the right diagonal below the veridical position with control display, which suggests that they would have seen the right line as being slightly higher than the extension of the path of the left line. It was suggested that misalignment is a global process acting over a local aspect, the end of the diagonals. A person with low retinal acuity might be see the right edge higher than the veridical position and reduced magno input at a cortical level is not going to rectify that error.

The members of the Autism group may be on the high acuity end of distribution for the autism/Asperger population. As a result, most of the group did not reach the threshold for misalignment. In contrast, the members of the AS group may have had low acuity, and high subcortical magno input, which meant that most of the group did reach the threshold and produced the normal Poggendorff illusion effects.

It is certainly not being suggested that the results support this conclusion. For example, it could be that the superior performances on BDT and EFT in Asperger syndrome simply reflect an ability to detach readily from gestalts, rather than weak phenomenal experience of gestalts. As noted in Section 1.3.1, the illusion strand of research is the most direct test of gestalt perception. The only two tests of illusion perception in Asperger syndrome groups, Ropar and Mitchell (2000) and this experiment, did not find reduced susceptibility to the illusions that were tested. However, a task that is based on the Kanizsa illusion, to which the autism group in Happe (1996) showed less susceptibility than Poggendorff and readily disappears in isoluminant conditions (Section 1.4.4), may be more sensitive to any weakness that may exist in gestalt perception in Asperger syndrome.

Whatever the reason for the difference between the Autism and AS groups on the Poggendorff control display, it would be interesting to see if the distinction between the Autism and As groups is reflected over the three parts of the research with the launching effect research, which are summarised in the next chapter.

Chapter 3: The Launching Effect

As noted in Section 1.4, Hume (1739) claimed that only two independent movements are seen in collisions between billiard balls and that mediating forces between cause and effect are not detectable. Therefore, we should be unable to see object A pushing object B. However, Michotte (1946) found that almost all subjects reported that they did see A *push* (or a similar term) B. As such, Michotte (1946) argued that the act of pushing is perceived in the launching effect.

Given that our perceptual system can detect forces themselves, how could even one causal relation be perceived? Michotte (1946) argued that two independent movements are not seen because of processes that the Gestaltists discovered. The finding that some gestalt perceptions are weak in autism raises the possibility that the launching effect is also weak. It was argued in Section 1.2.5 that the results of the theory of mind research are consistent with that possibility, although the same results led Leslie (1994) and Baron-Cohen (2000a) to the opposite conclusion.

In the previous experiment, the magnitude of an illusion effect was considered to be the extent of error that was specific to the given illusion display. Although Michotte (1946) claimed that the launching effect is a gestalt and Leslie (1994) claimed that it is an illusion, as it is not based on actual forces, it is not possible to measure the strength of the effect directly. Therefore, the relative strengths of launching in the groups will have to be inferred from indirect measures. In order to provide a basis for the research that was conducted, Michotte's (1946) theory, that was described Section 1.4, is briefly reviewed.

Michotte (1946) found that when a pause was introduced between the movements of A and B and increased over successive trials, the subjects changed reports from *pushing* to *delayed launching* with a pause of around 90ms and to *two independent movements* with a pause of around 150ms. When the speed of the objects was increased without any pause between the movements, the subjects' reports began to change at 40cm/s to that of *one continuous movement*; that is, they saw the movement of A tunnel through B.

Increasing the speed of both objects increases good continuation, with the result that a single movement is perceived. Good continuation can also be dominant at lower speeds, as tunnelling can be perceived when the event is viewed either peripherally or through semi-transparent paper (Michotte, 1946). As such, Michotte (1946) claimed that the event structure creates an anomaly between the gestalt laws of proximity and good continuation. The diagrammatic representation of the standard event that was presented in Section 1.4.3 is presented again in Figure 3.1 to understand this anomaly. Consider that object A is A before the point of impact and A1 after impact, likewise with B.

Before impact: **A→ B**

After impact: **A1 B1→**

Figure 3.1: Diagrammatic representation of the point of impact in the standard launching event.

Combining this representation with Michotte's (1946) theory, the standard event is processed as both 'A is A1, B is B1' (proximity) and 'A is B1' (good continuation), which presents an anomaly for the visual system. The Gestaltists had shown that anomalies between underlying gestalt laws with static displays are resolved in gestalt perceptions (Koffka, 1935). As such, Michotte (1946) argued that the perception of pushing is possible because the anomaly is resolved as a gestalt perception in which A's movement ampliates into B's movement. As 'A is A1' is expected from Hume's (1739) analysis of the event, continuity is the critical issue.

Peripheral vision increases the influence of rod reception, while viewing the event through semi-transparent paper decreased edge detection (Michotte, 1946), which is predominantly a parvo inter-blob stream function (Livingstone and Hubel, 1988). Therefore, intensity/magno processing could be the key to the continuity aspect. Livingstone and Hubel (1988) claimed that the magno stream is better equipped to link the movements, whereas the parvo stream is suited to detecting that A and B are distinct objects. Therefore, interaction between the streams and the event structure could create an anomaly that leads to a gestalt perception. As good continuation is the key to ampliation, the proposed gestalt aspect, reduced magno input into gestalt perception should weaken the launching effect.

3.1 Pause Thresholds for Launching

If magno input favours good continuation ('A is B1') in launching events, reduced magno input should result in lower thresholds when the standard event structure is changed to favour proximity. One way to increase the strength of proximity is by introducing a pause between the movements of A and B. Therefore, the first launching experiment measured the threshold of pause at which the participants changed their reports between *pushing* and not *pushing*. It was predicted that the Autism group would have a significantly lower threshold for the change in reports from *pushing* to *not pushing* than the other groups. Wilson (1991) found that the pause thresholds are lower with increasing speeds and the current experiment measured pause thresholds in both low (10cm/s) and high (40cm/s) speed conditions.

The criterion was simply *pushing* or *not pushing*. Participants were not trained to distinguish between launching, delayed launching and two independent movements, which expert subjects distinguished in Michotte (1946). It was felt that three-category responses may be too difficult for the relatively naïve participants in the current experiment.

Before the experiment could commence, participants had to describe the standard event using launching terms. It was possible that some participants in the disability groups would simply describe the parts of the event without using launching terms. It was also possible that they would perseverate on 'yes' answers during the experiment and, therefore, reports would not accurately reflect their perception. Training procedures and the method limits, with ascending and descending trials, were used to minimise these possibilities.

3.1.1 Method

Participants and Apparatus: As for the Illusion experiment.

Displays: The standard event for this experiment is described now and any variation will be noted at the relevant point. For example, the speeds used at any given point will be detailed when that point is described. In the standard event, a stationary square (B) appeared in the centre of the computer screen; after 500ms, another square (A) appeared 4cm from the left edge on the same horizontal plane as B and already moving in a straight line towards B. When A arrived beside B (there was no spatial gap between the squares at this instant), A stopped and B immediately began to move to the right at the same speed that A had been moving (there was no pause between the movements). B disappeared when it reached 4 cm from the right edge, then A disappeared after another 500ms. The squares had 1.5cm sides, A was green, B was red and the background was black. Participants sat 1.5m directly in front of the screen. The experimenter initiated each trial with a footswitch.

Procedure: Prior to the experimental trials, there was a training procedure. The experimenter placed a red marble and a blue marble separated by about 15cm in a groove on a block of wood. The red marble was pushed, so that it hit and displaced the blue marble. The participant was asked, "What made the blue marble move?" All participants answered, "The red marble pushed it" or something similar. This was a prompt for the use of launching terms with the less realistic events to follow on the screen.

The participant then sat in the chair in front of the monitor and the experimenter said "I am going to play an event three times. After the third time, please describe the event in your own words." The standard launching event was played three times with both objects moving at 10cm/s and all participants described it in launching terms (eg 'pushing' or 'bumping'). The experimenter then said, "I am going to play another event three times. Please describe the event in your own words." The same event was then played three times except that there was a 1500ms pause between the two movements. All participants described the event without using launching terms. The experimenter asked "Did it look like the green square pushed the red square in the first set of events but not in the second?" All subjects agreed. The purpose of this question was to emphasis the distinction that the participants had made themselves across the two previous questions. The experimenter then explained that the main task was to press a button with a green circle next to it when it looked like the green square pushed the red square and press a button with a red circle if not.

The response box was handed to the participant for practice. In the first practice trial, there was a temporal pause of 1000ms between the movements of A and B and the pause decreased 100ms per trial. No participant pressed the green ('yes') button when there was a pause of over 300ms and all changed responses from 'no' to 'yes' at some point. This procedure was used to limit perseveration effects by ensuring that participants had practice at pressing the 'no' button and also changing their responses.

The experiment then started. Firstly, there were two blocks of trials with speeds of 10cm/s. The first set began with a trial in which there was no pause between the movements of A and B and pause increased by 10ms per trial. The set ended when the participant pressed the red ('no') button on 3 consecutive trials, indicating a consistent change in reports from *pushing* to *not pushing*. In the second set, there was a pause of 250ms in the first trial, which decreased by 10ms per trial. The set ended when the participant pressed the green ('yes') button on 3 consecutive trials, indicating a consistent change in reports from *not pushing* to *pushing*. After the 10cm/s sets were completed, the procedure was repeated with events in which the objects moved at 40 cm/s. Therefore, there were four blocks of trials in total. The computer program recorded whether the 'pushing' or the 'not pushing' button had been presses and the level pause (in ms) between the movements of A and B in each trial.

3.1.2 Results

This experiment measured the temporal pause thresholds between the movements of objects A and B at which reports changed between *pushing* and *not pushing*. Scores were averaged over ascending and descending blocks of trials. There was one low (10cm/s) and one high (40cm/s) speed condition. Table 3.1 shows the mean pause thresholds for each group for the two speed conditions.

Table 3.1: Results of the pause threshold for launching experiment. Mean thresholds of pause (in ms) between the movements of A and B at which reports changed between 'pushing' and 'not pushing' in the 10cm/s and 40cm/sspeed conditions, plus ranges (standard deviations in parentheses).

	Autism **n=11**	AS n=16	**MID** **n=14**	**NT** **n=26**
Launch 10cm/s range	105 55-140 31	158 120 – 235 31	147 85 – 275 57	129 75 – 210 32
Launch 40cm/s range	83 55 - 120 22	154 75 – 240 46	131 85-205 31	115 60 – 200 38

A two way ANOVA (Speed by Group) revealed that the interaction between Speed and Group was not significant (F(3, 63)=.75, p=.41). The main effect of Speed was significant, where F(1, 63)=6.86, p=.019. This shows that the 10cm/s threshold was consistently greater than the 40cm/s threshold, as expected from Wilson (1991). The main effect of Group was also significant, where F(3, 63)=9.57, p<.001. Therefore, the thresholds were not equal between the groups. Simple orthogonal contrasts were generated to interpret this difference, with the NT group used as the baseline. There was no difference between the NT and MID groups (p=.106), a significantly reduced threshold for the NT group compared to the AS group (p=.001) and a significantly larger threshold for the NT group compared to the Autism group (p=.015). In summary, whereas the AS group had higher thresholds than the NT group, the Autism group had lower thresholds than the NT group.

Differences between the ascending and descending thresholds were calculated to estimate the degree of overlap between the two sets of trials. This was done to ascertain if there was any difference between the groups in their confidence in identifying the change between *pushing* and *not pushing*. Table 3.2 presents the mean scores for each group. Positive scores indicate that the ascending threshold was higher than the descending threshold with the reverse for negative scores. This difference is called the *range of uncertainty*.

Table 3.2 Range of uncertainty for launching. Mean 'range of uncertainty' for launching thresholds (in ms) for the two speed conditions, plus ranges (standard deviations in parentheses).

	Autism **n=11**	**AS** **n=16**	**MID** **n=14**	**NT** **n=26**
Launch 10cm/s	7	47	31	-10
range	-50 – 90	-70 – 280	-130 – 250	-50 – 60
	(41)	(73)	(90)	28
Launch 40cm/s	-6	23	31	-19
range	-80 – 100	-60 – 120	-100 – 240	-90 – 40
	(52)	(58)	(102)	(34)

A two way (Speed by Group) ANOVA for the range of uncertainty scores revealed that interaction was not significant (F(3, 63)=.46, p=.71), nor was the main effect of Speed significant (F(1, 63)=2.51, p=.12). The main effect Group was significant, with F(1, 63)=3.89, p=.013. A simple orthogonal contrast, with the NT group as the baseline, found that there was no difference between the NT and Autism groups (p=.42), while there were significant differences between the NT group and the MID group (p=.01) and the NT group and the AS group (p=.01). Therefore, it would appear that the Autism and NT groups were more certain with their reports than the AS and MID groups. If the pause thresholds for launching were re-examined with a two way (Speed by Group) ANCOVA with the range of uncertainty variables as co-variates, the main effect of Speed was not significant (F(1, 61)=3.36, p=.07) but the main effect of Group was significant (F(1, 61)=8.32, p<.001 and the results of the simple orthogonal contrast were virtually the same as those described above.

3.1.3 Discussion

It was argued that reduced magno input would weaken ampliation of movement in the launching effect. On that basis, it was predicted that the Autism group would have the lowest pause thresholds for the changes between *pushing* and *not pushing* reports, as measured with the method of limits. This prediction was supported by the research. Michotte (1946) claimed that the main component of the launching effect, ampliation of motion, is a gestalt that depends critically on the global processing. The previous experiment provided further evidence that gestalt perception is weak in autism. The results also suggested that the weakness reflects a reduced influence of global processes on gestalt perception. This might appear to be a reasonable basis on which to infer that the launching effect was weak in the Autism group.

However, the results from the AS group present a similar problem to the Illusions experiment. As noted, it seemed likely before the research commenced that gestalt perception is weak in Asperger syndrome, although this impairment would perhaps not be as pronounced as it is in autism. Given that weak gestalt perception in Asperger syndrome should also result from reduced magno input, the AS group should have had thresholds that were less than or, at most, equal to the NT group. However, the orthogonal contrasts showed that AS group had significantly higher thresholds than the NT group.

The AS group did show a much higher ascending threshold than descending threshold in the 10cm/s condition, which suggests that perseveration may have been a factor, despite the steps that were taken to minimise such an effect. However, when the range of uncertainty scores were co-varied against the launching thresholds, the pattern of between group differences was unchanged. Also, the pause threshold for the 40cm/s block of trials in the AS group is unusually high. While an influence of perseveration is a possibility, these results suggest that it would be insufficient to account for the difference between the AS and NT groups.

The previous experiment (Chapter 2) found that the Autism group had a reduced Poggendorff illusion effect, whereas the AS group did not. The evidence that gestalt perception is weak in Asperger syndrome is not compelling but, if it is assumed for the moment, then the likely reason that the AS group did not show a reduced Poggendorff illusion effect was reflected in their high control display error. It was argued in Chapter 2 that the difference in control error between the Autism and AS groups may be reflecting normal differences in subcortical magno input (or levels of retinal acuity) within a population and not discrete abnormalities. High subcortical magno input might also have been the determining factor in the high AS thresholds in this experiment.

However, if it is also assumed that the Autism and AS groups represent a single population of subcortical input, then, the low launching thresholds of the Autism group may simply be reflecting low subcortical magno input and not weak gestalt perception. As noted above, pause thresholds are not a direct measure of the strength of the launching effect but are a measurement that might have allowed an inference about launching strength, given that gestalt perception is weak in autism. However, the results of this experiment alone are an insufficient basis to infer that the launching effect is weak in autism and further investigation was conducted.

The most marked distinctions in both experiments thus far have been between the Autism and AS groups. Despite the problems in interpreting the pause thresholds, the difference is an interesting finding of itself, as it suggests that there may be two modes of causal attribution in the two disorders.

One possible reason for the different thresholds of the Autism and AS groups is simply that there are different levels of subcortical input within one population and launching is not weak. The fact that the combined mean of the groups is no different from the NT group supports this proposal. This would be consistent with Leslie's (1994) argument that the launching effect reflects imposed force representation onto the event structure by a theory of body module, rather than general gestalt processes.

A second possibility is that the thresholds of the Autism and AS groups reflect different abnormalities to processes that are specific to theory of mind and not differences in input processing. As shown in Section 1.2, the performance of autism groups on false belief tasks suggests they do not have access to processing that Leslie (1987) claimed is generated by a theory of mind module. One consequence is decreased imagination, as seen in the failure to initiate pretend play. This might lead to a rigid application of physical laws and, as such, members of the Autism group reported *not pushing* as soon as they detected a pause. Baron-Cohen and colleagues (eg Baron-Cohen et al, 1997a) have shown that adults with Asperger syndrome have difficulty in reading eye language, which is consistent with the lack of a shared attention module (Baron-Cohen, 1995). The lack of a shared attention module could result in a failure to inhibit output from the theory of body module, which may have lead the members of the AS group to over-attribute physical causality.

A third possibility is that the thresholds of the Autism and AS groups reflect interaction between subcortical magno input and an abnormality that reduces magno input to gestalt perception in the cortex. Where the NT group balanced decreasing strength of launching against increasing pause (i.e. they used ampliation as the basis of their responses), the Autism group used the detection of a pause only, while the AS group may have reported *pushing* until the separation of the movements was absolute. Therefore, ampliation may have been the dominant factor for the NT group only, which would suggest that ampliation in the Autism and AS groups was weak.

To summarise, the first proposal was that the pause thresholds in the Autism and AS groups reflect differences in subcortical input only. The second was that the thresholds are side effects of different abnormalities to specific theory of mind processing. The third was that the thresholds reflect subcortical input only, so ampliation is weak. The next experiment attempted to distinguish these proposals.

3.2 Pause Thresholds for Continuity

The first Launching experiment measured the thresholds of pause between the movements A and B in launching events for changes in reports between *pushing* and *not pushing*. The Autism group had lower thresholds than the NT group and the AS group had higher thresholds than the NT group. Although the current thesis predicted that the Autism group would have the lowest thresholds, the high thresholds of AS group prevented the inference that that the thresholds of the Autism group were reflecting weak launching perception, if it is assumed that gestalt perception is weak in Asperger syndrome.

Three proposals were presented for the pattern of results. Firstly, the different thresholds of the Autism and AS groups reflected differences in acuity and nothing more. Secondly, different abnormalities in autism and Asperger syndrome effect discrete processes for theory of mind, with a resultant side effect of distinct modes of relating to physical events. Thirdly, while the NT group based reports on ampliation of movement, the Autism and AS groups mainly reflected subcortical input processes, not ampliation.

It has been noted previously that there is no direct method to test launching strength. In the Illusions experiment, illusion effects were measured by deducting error made on control displays from error on illusion displays. Therefore, this experiment compared the pause thresholds of launching and of a control event.

It was argued in Section 1.4.3 that the appropriate control for continuity for launching events is an event where A moves towards the normal point of impact but without B being present. When it arrives, A disappears and B immediately appears moving in the same direction. Wilson (1991) found that subjects reported seeing A *flip over* into B with this event. As the event controls the level of spatial discontinuity in launching events, it is a control for good continuation and considerably reduces the proximity component ('A is A1, B is B1') of launching events. This experiment measured the pause threshold at which flipping was no longer perceived. It was argued that the magno stream favours 'A is B1' in launching events; given that, the Autism group should show the lowest pause threshold for the change in reports between *flipping* and *no flipping*.

If the different thresholds of the Autism and AS group in the previous experiment were side effects of different abnormalities that effect theory of mind processing, the launching thresholds of the groups should not have an obvious relationship with thresholds in this experiment. The other two possibilities both say that the difference between the groups reflected subcortical input, so a similar pattern of thresholds for the launching event and the continuity events does not distinguish them.

At high pause thresholds (eg 250ms), the perception of the continuity event is seen as one object with a single movement but as though the object disappears into a tunnel. As thresholds are lowered, an illusory movement becomes apparent across the space; that is, continuity is strong enough to influence form-detecting processes. Therefore, this perception reflects an integration of local and global processes into a gestalt perception. Following Michotte (1946), that integration should persist into the standard event; that is, when further information that says ‘A is A1, B is B1’ (i.e., proximity information) is added. If the pattern of the groups follow Michotte’s (1946) theory, the threshold of launching should be lower than the continuity event, due to the added proximity information. Also, while there will obviously be individual differences that reflect differences in discrete local and global processing, there should be a pattern of integration of those processes. It is expected that the NT group will have a lower pause threshold for launching than for the continuity event and a pattern of integration of discrete input processes. If these aspects are then not found in the Autism and Asperger groups, it would suggest that ampliation is weak in those groups.

Two points were important for the structure of the experiment. Continuation is so ‘good’ at high speeds that the perception is hard to distinguish from the normal perception of a single, uninterrupted movement (which may be the reason that tunnelling is perceivable at high speeds). Therefore, there was only one, 10cm/s, speed condition. Secondly, a flickering onto B persists at pauses where the flipping effect is no longer perceived, so there was a need to minimise confusion that might result. Therefore, the squares were the same colour, as this makes flickering less pronounced, while participants were instructed to concentrate only on flipping.

3.2.1 Method

Participants: There were 30 participants who were all involved in the Illusions and Pause Thresholds for Launching experiments and could be contacted again. The groups were Autism, AS and NT. As the launching threshold for the MID group in the previous experiment was not significantly different than the NT, it was decided that the NT group alone would be sufficient control here. As such, there was no MID group in this experiment. Table 3.3 presents the Illusion scores for the groups in this experiment.

Table 3.3: Group details for the continuity experiment. Mean Illusion scores (in mm), plus ranges (standard deviations in parentheses). Pogg is Poggendorff error, C-Pogg is the control display error, M-L is the Muller-Lyer error and Brent is the Brentano error.

	Age	Pogg	C-Pogg	M-L	Brent
Autism	20.9	3.0	0.55	1.1	1.45
range	14 – 54	-1.2 – 6.5	-1.3 – 1.9	0.4 – 2.6	0.4 – 2.8
	(12.5)	(2.4)	(1.1)	(0.7)	(0.8)
n=9					
AS	17.7	6.9	1.9	2.2	1.9
range	13 – 25	3.8 – 9.4	0.8 – 3.4	0.9 – 3.9	1.0 – 3.2
	(4.2)	(2.1)	(0.8)	(1.1)	(0.8)
n=7					
NT	17.2	5.3	1.15	1.3	1.1
range	15 –19	3.3 – 8.6	-.6 – 3.6	.6 – 3.0	.6 – 1.8
	(1.4)	(1.7)	1.3	(0.8)	(0.4)
n=14					

Apparatus: This was as in the previous experiments.

Displays: In the standard continuity event, A appeared 4cm from the left edge of the screen, moving at 10cm/sec. When A arrived at the normal point of impact for launching events, it disappeared and B immediately appeared in its normal position, moving in the same direction and speed as was A. B disappeared when it reached 4cm from the right edge. The squares had 1.5cm sides, both were green and the background was black. The only manipulation to this event throughout this experiment was the introduction of a pause between A disappearing and B appearing, which will be reported at the relevant points.

Procedure: Participants sat 1.5m directly in front of the monitor. The experimenter said, "I am going to play an event three times. After that, please describe the event in your own words." The standard event was played three times. All members of the NT group reported seeing an object move to the centre, where it flipped, jumped or skipped, to continue on its path. The experimenter played the event again and asked if they were seeing the square flip over and all agreed with this. However, over half of the AS and Autism groups reported after the third play that they had seen one object move across the screen but with a gap in the centre, as if they were seeing a continuous movement but without the illusory connection. The experimenter asked if they saw the object flip over, while playing the event several more times. All but two participants in the Autism group eventually reported seeing flipping but they clearly indicated that their perception of the event had changed (this is discussed later).

Participants were then shown an event with a 500ms pause between the disappearance of A and the appearance of B. All subjects reported seeing an object disappear then reappear. Although this means that the movement was still seen as continuous, all agreed that there was no perceivable connection across the gap. Subjects were asked to press one button when they saw the object flip or jump over and to press another button when they did not. The experimenter stressed that the only issue was whether or not they saw flipping.

The experiment then began. The method of limits was used to measure the magnitude of the pause between the disappearance of A and the appearance of B that coincided with the change in reports between *flipping* and *not flipping*. Thresholds were averaged over ascending and descending sets of trials. As in the launching experiment, the ascending set began with 0ms pause and pause increased 10ms per trial, while the descending set began with a 250ms pause and pause decreased 10ms per trial. As noted, two members of the Autism group reported at the end of the experiment that they had not seen flipping. However, they had pressed the 'yes' button on occasions, which they said they did when they saw flickering on to B. Although their scores should have been 0ms, their 'yes' responses were included.

3.2.2 Results

The experiment measured the pause thresholds that coincided with the change in reports between *flipping* and *not flipping*. Scores were averaged over ascending and descending blocks of trials. There was only one, 10cm/s, speed condition. Table 3.4 presents the pause thresholds for the continuity event, the pause thresholds for the launching 10cm/s condition from the launching experiment for these participants and the difference between the two thresholds. The difference in structure between the launching and continuity events is that 'A is A1, B is B1' is added for the launching event; as such, the threshold difference is called Add Proximity. The range of uncertainty (uncertainty) is the ascending threshold minus the descending threshold.

Table 3.4: Results of the continuity experiment. Pause thresholds (in ms), plus ranges (standard deviations in parentheses), for the continuity event, plus thresholds for the 10cm/s launching condition and the difference between the two thresholds (Add Proximity) and the 'range of uncertainty' scores.

	Autism n=9	AS n=7	NT n=14
Continuity	109	164	160
range	60 – 175	135 – 210	90 – 225
	(42)	(24)	(43)
Launching	112	165	125
range	60-140	120 – 235	75 – 160
	(28)	(35)	(24)
Add Proximity	3	1	-35
range	-75 - 65	-15 - 25	-90 - 25
	(50)	(14)	(36)
Uncertainty	-49	23	-23
range	-150 – 90	-110 – 40	-100 – 40
	(77)	(78)	(40)

A one way ANOVA for the continuity scores was significant, with F(2, 27)=5.65, p=.009. Orthogonal contrast analysis found that there was no difference between the AS and NT groups (t(27)=.26, p=.80) but there was a significant difference between the combined AS/NT group and the Autism group (t(27)=3.34, p=.002). A one way ANOVA that tested for differences in the range of uncertainty was not significant (F(2, 27)=2.64, p=.09).

If groups used ampliation to judge the change from *pushing* to *not pushing* in the launching experiment, then that threshold should have been lower than the continuity threshold, which would have been reflected in a negative Add Proximity value. A one way ANOVA for Add Proximity was significant, with F(2, 27)=3.67, p=.039). Orthogonal contrast analysis found that there was no difference between the AS and Autism groups (t(27)=.14, p=.89) but that there was a significant difference between the combined AS/Autism group and the NT group (t(27)=2.68, p=.012). Also, one sample t-tests for Add Proximity showed that the scores for the Autism (t(8)=-.20, p=.85) and AS (t(6)=-.13, p=.90) groups were not different from zero, while the scores for the NT group were significantly less than zero (t(13)=3.63, p=.003). Therefore, the Autism group had the lowest threshold for the continuity event with no difference between the AS and NT groups, while only the NT group showed a reduced threshold from the continuity event to the launching event. This suggests that ampliation of movement was an important influence in the launching thresholds of the NT group but it was not an influence in the Autism and AS groups. This suggests that ampliation was weak in the Autism and AS groups.

It is possible that the failure of the Autism and AS groups to show a reduced threshold with the launching effect (Add Proximity) simply reflected their different levels of threshold. To test this possibility, the NT group was broken into above mean (High) and below mean (Low) groups for launching thresholds (Table 3.5).

Table 3.5: High and Low threshold, NT groups. Scores for NT groups broken into those with launching thresholds above the overall mean (High) and below overall mean (Low), plus ranges (standard deviations in parentheses). Pogg Control is the error scores for the Poggendorff control display.

	Continuity	**Launch**	**Add Proximity**	**Pogg Control**
NT High n=8	176	141	-35	1.7
range	115 – 225 (41)	130 – 160 (11)	-80 – 15 (34)	-.6 – 3.6 (1.4)
NT Low n=6	138	102	-36	0.4
range	90 – 190 (38)	75 – 115 (18)	-90 – 25 (42)	-.6 – 1.3 (0.6)

An independent groups t-test found that there was no difference between the NT groups in Add Proximity (t(12)=.07, p=.94).). While the Autism (low launching threshold) and AS (high launching threshold) groups did not show a reduced threshold from the continuity event to the launching event, both of the comparable NT groups showed this reduction. Therefore, the failure of the Autism and AS groups to show any reduction in threshold for added proximity was not simply an artefact of having low and high launching thresholds. Also, comparison between the High and Low NT groups in their error scores on the Poggendorff control display was close to significant t(12)=2.02, p=.07), with small groups, which supports the proposal that differences between Autism and AS groups across the experiments are reflecting a difference in input processing.

Individual differences in launching pause thresholds should reflect individual differences in local and global processes, as the event evokes both proximity and continuation. Michotte's (1946) theory predicts that there should also be evidence that the processes integrated in the launching perception. There were significant correlations between continuity and launching thresholds for the AS (r=.96, p=.01) and the NT (r=.54, p=.05) groups in this experiment but there was no correlation for the Autism group (r=.02, p=.95). The whole Autism group in the previous experiments showed correlations between launching and Muller-Lyer (ML v Launch 10cm/s: r=-.58, p=.06; ML v Launch 40cm/s: r=-.67, p=.03), the whole NT group showed correlations between launching and Brentano (Brentano v Launch 10cm/s: r=-.40, p=.05; Brentano v Launch 40cm/s: r=-.44, p=.03), while the whole AS group did not show any correlation between launching and either Muller-Lyer (ML v Launch 10cm/s: r=.21, p=.43; ML v Launch 40cm/s: r=-.17, p=..53) or Brentano (Brentano v Launch 10cm/s: r=.47, p=.08, a trend but in the wrong direction; Brentano v Launch 40cm/s: r=-.03, p=.91). Therefore, while the NT group had correlations for launching thresholds with one measure of local processing and with the continuity event, the Autism group had a correlation with a measure of local processing only and AS group has a correlation with a measure of global processing only.

3.2.3 Discussion

Although the reduced magno input theory predicted the low pause thresholds for the Autism group in the launching experiment, the high pause thresholds of the AS group were not expected. As such, it could not be inferred with confidence that the launching effect is weak in autism. Perception of the continuity control event was then tested to see if this could help distinguish between three proposals.

One proposal was that the differences in launching thresholds were side effects of discrete abnormalities to processing in the theory of mind domain. The Autism group, who had the lowest thresholds in the launching experiment, also had the lowest threshold with the continuity event, while the AS group had a strong correlation between launching and continuity thresholds. These results suggest that input processing for the Autism and AS groups was a major factor in their launching thresholds, making this proposal unlikely.

The current thesis proposed that ampliation of movement, the gestalt aspect, was the dominant factor in the launching reports of the NT group, while the launching thresholds of the Autism and AS groups reflected early input processing only and that, therefore, ampliation was weak. Alternatively, it was suggested that the launching thresholds of the Autism and AS groups may have simply reflected low-level differences in a single population without any weakness in ampliation.

Michotte (1946) argued that the structure of launching events creates an anomaly between proximity and good continuation, which is resolved in a gestalt perception of ampliation. As participants were only asked to distinguish between *pushing* and *not pushing* in the launching experiment, launching thresholds should have distributed around the range of *delayed launching*. Launching thresholds should also have been lower than the continuity threshold, given the added information for proximity, and correlated with measures of proximity and continuity. The continuity event thresholds were the obvious measure of good continuation, as the event structure has the same spatial discontinuity as in launching events. However, there was no direct measure of proximity. It was proposed in Section 1.3 that 'wings effects' reflect local processing. As local processing should dominate proximity, the wings illusions, while indirect, are the best available measure of proximity. Table 3.6 compares each group on these criteria.

Table 3.6: Michotte criteria. Comparing launching thresholds to the criteria from Michotte (1946).

	In delayed launch range	**Add proximity reduction**	**Correlation with proximity**	**Correlation with continuity**
Autism	no	no	yes	no
AS	no	no	no	yes
NT	yes	yes	yes	yes

The NT group met all the criteria, which suggested that their perception of the launching events integrated proximity and continuation. This supports the proposal that ampliation was the dominant factor in their launching thresholds across individual differences in input processing. In contrast, the only criterion that the Autism or AS groups met was one correlation with their launching thresholds. This suggests that their launching thresholds did not reflect a strong integration of the input processes that underlie proximity and continuation. Also, while neither the Autism (low launching threshold) nor AS (high launching threshold) groups showed any reduction in threshold from continuity to launching, both the High NT and Low NT groups showed this reduction.

This evidence suggests that the critical gestalt aspect of launching perception, ampliation of movement, may have been weak in both the Autism and AS groups. This is not definitive evidence by any means but, hopefully, this research program will be the first step in resolving an important issue for understanding autism and Asperger syndrome.

As noted earlier, participants described the continuity event before the experiment. All NT members gave reports that were consistent with perceiving flipping and further questioning confirmed that they had perceived a connection between the movements. However, the initial reports of over half of the Autism and AS groups suggested that they did not perceive this connection, although the movement looked continuous. With further trials and the suggestion that flipping might be perceived, all but two reported seeing flipping. They also confirmed that their perception had changed and some made an unprompted comment after the next event, with a 500ms pause, that their perception was similar to their initial perception of the no pause event.

Section 1.3.4 presented variations of the Kanizsa triangle and the Necker cube to provide examples of weakened gestalts. In the standard conditions, the illusory perceptions are virtually unavoidable for the neuro-typical system but whether or not they are perceived in the variations depends on the focus of attention. It may have been that the perception of flipping was weak in the Autism and AS groups and the suggestion prompted a change in focus for those who did not initially perceive it. This was not systematically studied and the theory proposed here must be judged solely on results presented. However, it does suggest a promising avenue for further investigation.

It was suggested that weak launching in autism makes it difficult to develop the idea of force, which, in turn, makes it difficult to acquire a theory of mind, as measured by false belief tasks. The evidence suggests that children with Asperger syndrome have less difficulty than children with autism with false belief tasks (Ziatas et al, 1998). In order to account for this difference, it was initially proposed that the weakness to gestalt perception is milder in Asperger syndrome, which leaves the launching effect strong enough for the idea of force to develop more readily than in autism.

However, the results of the launching and continuity experiments suggest that the launching effect is not necessarily stronger in Asperger syndrome than in autism. There would have to be some compensation for weak ampliation in Asperger syndrome that is not available in autism. In order to acquire a theory of mind, children must develop a concept that mental states are forces that act over gaps in time and space. The high thresholds in the AS group suggests that they had extended their attribution, at least with physical events, over time. If they also extend physical state attribution across space more readily than the Autism group, it might be plausible that the increased early magno input compensates somewhat for weak ampliation. One way to test this possibility is with the tool effect, which Michotte (1951) discovered is perceived when there is a third object between A and B. The tool effect was the subject of the third experiment in the Launching research.

3.3 Spatial Thresholds for the Tool Effect

The launching experiment (section 3.1) found that the Autism group had low thresholds and the AS group had high thresholds for the pause between the movements of A and B at which reports changed between *pushing* and *not pushing*. The comparison between the pause thresholds of the launching and continuity events in the NT group suggested that they had based their reports of launching events on ampliation of movement. In contrast, the comparisons for the Autism and AS groups suggested that they had based their reports mainly on early input processing. Therefore, it was argued that the launching effect was weak in both the Autism and AS groups.

The thesis proposed that weak launching is a key factor in the difficulty that children with autism have on false belief tasks. The problem is that the results suggested that launching was weak in the AS group as well, yet children with Asperger syndrome have much less difficulty with false belief tasks than children with autism (Ziatas et al, 1998).

The neuro-typical perception of the launching effect can be weakened in two directions, either towards two independent movements (increased proximity, 'A is A1') or in the direction of one movement (increased continuity, 'A is B1'). The combination of weak ampliation and increased low level proximity, which Section 1.4 suggested is the case in autism, would lead to a perception of standard launching events that is closer to two independent movements than the neuro-typical system. This could necessitate the development of what Premack and Premack (1995) called a 'Humean' system of causal attribution; that is, a system that is primarily based on association. Section 1.2.5 argued that the pattern found in the theory of mind research into autism is what might be expected from such a system.

The results of the launching and continuity experiments suggests that there was s combination of weak ampliation and increased low level continuity in the AS group. This combination may result in a perception of standard launching events that is more like the neuro-typical perception of tunnelling; that is, closer to a single movement. There may be a reason why perception allows the development of system of causal attribution that is more suited to acquiring a theory of mind than is the case in autism.

A theory of mind attributes causal power to an agent's mental state across gaps in space and time. Therefore, a likely precursor to theory of mind is the ability to attribute causal power to an agent's physical state across gaps in space and time (Baron-Cohen et al, 2001). The high pause thresholds in the launching experiment suggest that the AS group showed increased attribution of causality across a gap in time. However, this finding has limited explanatory power the pause between the movements makes an unrealistic event.

Launching events are only about an immediate causal relation. For example, the launching effect could allow perception of the causal relation when an agent pushes ball Y. A more interesting event is when ball Y goes on to displace ball Z because the effect of the agent's force is extended across space and time (and objects). However, it does not necessarily follow that the perception of the agent's force will extend beyond the initial push of ball Y. If such events are perceived with two distinct launching effects, there would need to be an idea that 'only animate objects can initiate causal events' to inhibit the information from the perception that ball Y, not the agent, was the cause of ball Z moving.

Michotte (1946) suggested that a second factor of the launching effect, besides ampliation, is a *radius of action.* Subjects reported that B's movement is seen only as an extension of A's movement within the radius but, beyond it, B's movement becomes its own. Michotte (1951) demonstrated this phenomenon by introducing an intermediate object (I) between A and B. When I and B were close together, subjects reported seeing A's movement simply tunnel through I and then ampliate into B (Figure 3.2a). It was not until I and B were some distance apart, that subjects saw two distinct launches (Figure 3.2b). Therefore, if the point of impact of I and B is within A's radius of action, the event is perceived with only one launch and with I as a passive transport of A's force. Michotte (1951) called this perception the 'tool effect'.

A → I B

A I→B

A I B→

a: Spatial arrangement for 'A pushes' B (the 'tool effect').

A → I B

A I→ B

A I B→

b Spatial arrangement for 'I pushes' B.

Figure 3.2: The spatial arrangements for tool effect events.

Therefore, the tool effect suggests that an agent can be perceived as the final cause of the displacement of B, at least within a limited temporospatial range. The radius of action is temporospatial, as the spatial threshold of the tool effect increases with increasing speeds of the objects (Michotte, 1951). Also, as noted, the perception of the tool effect depends on the movement of A tunnelling through I. If their perception of standard launching events is more like tunnelling, it could allow children with Asperger syndrome to more readily perceive the causal force of an agent across greater distances than children with autism. If so, children with Asperger syndrome may be better equipped to make the leap in imagination to attribute causal power to mental states than children with autism. Therefore, it was predicted that the AS group would have the broadest spatial threshold for the tool effect, while the Autism group would have the narrowest spatial threshold.

As noted, Michotte (1951) claimed that the range of the tool effect broadens with increasing speeds. The speeds used here were chosen to balance the need for spatial thresholds that were broad enough to be sensitive to any differences between the groups against any problems that might arise from using speeds unsuitably high for participants who were still relatively inexperienced with launching experiments.

3.3.1 Method

Participants: This experiment used the same participants as the Continuity experiment.

Apparatus: As in previous experiments.

Displays: There were two standard events for this experiment. There were no temporal pauses in any event during this experiment. The standard *tool effect event* had the structure of Figure 3.2a. In initial positions, A was 4cm from the edge of the screen, I's left edge was 6cm from A's left edge and B's left edge was 8cm from A's left edge. In the standard *I pushes B event* (Figure 3.2b), B's left edge was 16cm from A's left edge. The sides of all the squares were 1.3cm, which was smaller than previously (which was 1.5 cm) so that the event would not look cluttered. A moved at 30cm/s, I moved at 25cm/s and B moved at 20cm/s. A was green, I was red, B was blue and the background was black.

Procedure: Participants sat 1.5m directly in front of the monitor. A launching event was played three times on the monitor to remind subjects of the perception of pushing. The *tool effect event*, described above, was then played three times. After the third play, the experimenter suggested that it looked like A dominated the event, while I passively conveyed A's force. The experimenter and the participant discussed the event, while it was played a few more times. The *I pushes B event*, described above, was then played three times. The experimenter suggested that it looked like I did its own pushing and the event was discussed while it was played a few more times.

The response box was then handed to the participant who was asked to press the green button if it looked like *A did all the pushing* and press the red button if looked like *I did its own pushing*. There were two sets of practice trials, one starting with the *tool effect event* with spatial separation between I and B increasing by 1.5cm per trial and the other starting with the *I pushes B event* with separation decreasing by 1.5cm per trial. After the 12 practice trials were completed, the experiment began.

The method of limits was used to measure the spatial threshold for the change in reports from *A did all the pushing* to *I did its own pushing*. Thresholds were averaged over one ascending and one decreasing set of trials. The ascending set began with the *standard tool effect event* and separation between I and B increased by 3mm per trial. The descending set began with the *standard I pushes B event* and separation decreased by 3mm per trial.

3.3.2 Results

This experiment measured the spatial threshold for the change in reports between *A did all the pushing* and *I did its own pushing.* Scores (in mm) were averaged over a ascending and a descending sets of trials and are presented in Table 3.7. Scores for two participants in the Autism group were the threshold on the ascending trial only, due to experimental error. It seems unlikely that this effected the overall results.

Table 3.7: Results of the tool effect experiment. Mean scores of the spatial threshold for the tool effect (in mm), the range of uncertainty, plus ranges (standard deviations in parentheses).

	Autism n=9	**AS n=7**	**NT n=13**
Tool Effect	109	137	115
range	80 – 129	116 – 149	99 – 137
	(15)	(13)	(10)
Uncertainty	-7.3	-4.6	-7.8
range	-3.2 – 1.0	-1.7 – 1.3	-.56 – 1.3
	(1.4)	(.9)	(1.9)

A one way ANOVA was significant, where F (2, 27)=11.37, p<.001. Orthogonal contrast analysis found that there was no difference between the NT and Autism groups (t(27)=1.20, p=.242) but that there was a significant difference between the combined NT/Autism group and the AS group (t(27)=4.72, p<.001) group. Therefore, the AS group showed a broader spatial threshold than the NT group, as predicted, but the predicted narrow spatial threshold for the Autism group was not apparent. A one way ANOVA for the range of uncertainty found that there were no differences between the groups (F(2, 25)=.1, p=.91).

The High NT group with launching thresholds (see section 3.2.3) had a mean spatial threshold in this experiment of 12.0 (range: 10.4 to 13.7, sd: 0.9), while the Low NT group had a mean spatial threshold of 10.9 (range: 9.9 to 11.6, sd: 0.8). The means of the two groups were significantly different (t(12)=2.6, p=.02). This suggests that there was a common factor across the three launching effect experiments. As such, it appears that the broad temporal pause threshold of the AS group with the launching effect converted to a broad spatial threshold with the tool effect.

3.3.3 Discussion

It was proposed that the combination of relatively low magno input at the subcortical level and weak ampliation could create a perception of launching events in autism that is more like two independent movements than what is perceived with the neuro-typical system. It was also proposed that the combination of relatively high magno input at a subcortical level and weak ampliation in Asperger syndrome could create a perception of launching events that is more like tunnelling. The perception that is more like two independent movements in autism could necessitate the development of a system of causal attribution that Section 1.2.4 argued would not be well equipped to rapidly acquire a theory of mind. In contrast, a perception that is more like tunnelling could allow children with Asperger syndrome to perceive the causal power of an agent acting across distances in space and time (albeit, it would still be weaker than the neuro-typical system if ampliation is weak). This possibility was tested with tool effect events.

It was predicted that the AS group would have the broadest spatial threshold for the changes in reports between *A did all the pushing* and *I did its own pushing*, which was supported by the results. It seems likely that this reflected increased continuity, given the high thresholds of the AS group in the previous experiments and the difference in spatial thresholds with the tool effect event between the High and Low NT groups.

However, it was also predicted that the Autism group would have the narrowest spatial threshold but no difference was found between the Autism and NT groups. Why did the Autism group not show a reduced spatial threshold compared to the NT group? Michotte (1951) used expert subjects and did not report what instructions were given. He did point out that there is an area of ambiguity between where the tool effect is perceived and two separate launches are perceived. Participants in this experiment were asked to base reports on whether it looked like A or I pushed B. These instructions may have led participants in the NT group to change reports to *I did its own pushing* as soon they as they saw I push B, rather than waiting until only two distinct launches could be perceived. A training procedure that concentrated more on the subtle change from a tunnel and a launch to two distinct launches may have been more sensitive to any differences between the NT and Autism groups in their radius of action.

Nonetheless, the AS group produced a significantly broader spatial threshold for the changes in reports between *A did all the pushing* and *I did its own pushing* than the other groups with the same instructions. This demonstrated an effect of their increased continuity with a realistic event. It also suggests that the perceptual system of people with Asperger syndrome may be more able to perceive an agent's causal power across distances than the system of people with autism. This could provide children with Asperger syndrome an important compensation for weak launching that is not available to children with autism and, hence, allow them to more readily acquire a theory of mind.

The experiments have examined perception in terms of local/global and proximity/continuity distinctions and it has been assumed that these reflect the partial segregation of perceptual streaming. The temporal integration task (Hogben and Di Lollo, 1974) is considered to be sensitive to this segregation and the next experiment applied this task.