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Perception in the absence of attention: Can optical illusions provide evidence for perceptual organisation under conditions of inattention?

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Abstract

Theories of visual perception posit that before attention is allocated within a scene, visual information is parsed according to Gestalt principles of organisation (Treisman, 1986). This assumption is challenged by theorists asserting that no parsing occurs in conditions of inattention (Mack & Rock, 1998). In this study, participants distinguished between lengths of two parallel lines, embedded within a dot matrix, forming the Müller-Lyer illusion in experimental trials, compared to no-illusion trials (control condition). It was hypothesised that participants would not be consciously aware of the illusion yet demonstrate decreased accuracy of length judgements. In line with the hypothesis, participants showed decreased accuracy in optical illusion trials, while explicitly being unaware of it. This suggests that participants grouped the dots through adherence to Gestalt principles of organisation, therefore confirming the notion that perceptual organisation occurs in conditions of inattention. This supports studies looking at perceptual organization as existing separate from attention.

Key words:	Perceptual organisation	Gestalt	Attention	Early visual processing	Optical illusions

Introduction

The present research is concerned with investigating the relationship between the consciously perceived visual world and the raw visual information that arises from external objects (Kimchi & Behrmann, 2003). More specifically, the overarching question is interested in answering whether perceptual organisation processes occur under conditions of inattention. Deciphering this relationship, with the utilization of geometric illusions, will demonstrate the autonomy of perceptual organisation from attention. This dichotomy will reveal the fundamental processes that govern early visual processing in human perception.

Visual attention is the process of how specific visual information in the environment is selected, whereas perceptual organization and grouping refer to the process of structuring visual information into coherent units. This is accomplished through detection of significant image relations from primitive image features in the environment (Palmer, 1999). By making our vision more resistant to minor changes in the retinal image, perceptual organization imparts robustness and computational efficiency to vision (Rock & Palmer, 1990). Both attentive and organisational processes are crucial for the perception of our visual environment in addition to our visuomotor behaviour (Kimchi, 2009). The principles that govern perceptual organization is acknowledged as one of the most enduring themes in research concerning human visual perception, with theorists such as the Gestalt psychologists having long acknowledged that it is imperative to find organization in sensory data (Braun, Ben-Av & Sagi, 1992).

The Gestalt psychologists are recognised as the first to study perceptual organization in human visual perception by suggesting that perceptual organisation is achieved by processes which group elements in the environment on the basis of similar properties (Koffka, 1935; Köhler, 1947). The renowned principles of grouping, proposed by Wertheimer (1923), suggested specific stimulus factors in the environment that determine perceptual organisation such as good continuation, common fate, proximity, closure and similarity. Gestalt theorists believed in the notion of structural simplicity and expressed this view in their famous principle of “Prägnanz”, meaning perception will be as “good” as the prevailing conditions allow. The prevailing conditions refer to stimulus constraints on the perceptual interpretation. In the case of vision, these constraints are provided by the structure of the retinal image. However, because retinal constraints are not generally sufficient to uniquely solve the problem of perceiving the environment, Gestalist’s proposed that additional constraints could be understood as arising from the maximisation of “goodness” or structural simplicity – or, alternately the minimization of complexity. The basic idea is that visual elements that are the same in colour, motion and size, are seen as grouped together because this organized perception is simpler than the alternative of seeing them as unorganized, independent elements. Gestaltists believed that to fully understand perceptual organization in vision, it is imperative to investigate which kinds of structure in the retinal image the visual system is most sensitive too. Despite the Gestalts work in perceptual organisation being widely recognised, only in the late 20^{th} century has any real attempt been made to provide further theoretical and empirical research on the topic (Kimchi & Behrmann, 2003).

The traditional view from attention research looks at a dichotomy between preattentive and attentive processes, whereby firstly preattentive processes, based on the Gestalt grouping principles, yield ‘proto-objects’ or ‘feature bundles’ in the visual field, which are subsequently attended to for further processing (Neisser, 1967; Treisman, 1986; Driver & Baylis, 1998). Palmer & Rock (1994) argued these two distinct processes are of logical necessity, stating, “logic dictates that some amount of visual organization must occur at an early stage in visual processing and that it must occur preattentively. As Neisser (1967) and Treisman (1986) have put it, discrete perceptual elements of some sort must be present to serve as candidates for further element-based processing. Only after such elements are present can we attend selectively to one or another" (1994, p.37). Although this view is encompassed in multiple recognised theories concerning vision attention, there are theorists that oppose it. The same year that Baylis and Driver (1992) argued, "Visual attention is directed to groups derived from a preattentive segmentation of the scene according to Gestalt Principles" (p.498), Mack, Rock, Linnett & Grant (1992) conversely stated that "no perception of either texture segregation of Gestalt grouping" takes place for unattended stimulus (1992, p.498).

For instance, a theory that highlights the importance of preattentive organisation is feature integration theory (Treisman & Gelade, 1980), which provides an influential model of visual perception. The theory discusses two autonomous processes in visual perception; the first is an early preattentive stage of global processes, which is followed by a second stage of analytic processing (Treisman, 1988). Within the preattentive level, sensory features such as orientation, colour and size are processed involuntarily at the same time without focused attention. This is considered to be an effortless process, which is not affected by factors such as arousal, mood or practise. This automatic coding of sensory features leads to the materialisation of “feature maps” that provide preliminary organisation of the visual field and prepare visual input for detailed serial processing. On the other hand, the next stage of processing is the “feature integration stage.” Within this stage focused attention allows consecutive scanning of the visual field, which conversely is an effortful and controlled process. Treisman & Gelade (1980) describe this process as “features that are registered within the same central ‘fixation’ can then be ‘conjoined’ and integrated into a single percept, the nature and relation of the feature conjunctions determining the identity of the object” (1980, pp. 98). Therefore, Treisman & Gelade (1980) provide a theory of visual perception that views the preattentive grouping as a process of preliminary perceptual segregation in the visual field, which enables effective processing subsequently through the direction of focused attention.

Within surrounding research, visual search studies have provided the most supportive evidence for theories emphasising preattentive organisation abilities of vision. For instance, Beck (1966, 1972) conducted one of the most extensive visual search tasks of grouping in human visual perception. Beck (1966) examined the role of orientation and overall shape of individual components in producing similarity groupings. All of Beck's stimuli were simple elements containing two lines placed at right angle to one another. He asked subjects to make ratings of similarity between various pairs of these items to which they rated pairs as very similar those that were identical except for orientation. However, other pairwise comparisons of the stimuli yielded low similarity ratings. The pattern of results changed markedly however, when subjects were shown whole groups of these stimuli rather than just two. In the second task subjects viewed an entire field divided into three noticeable, but contiguous sections. The task in this case was to divide the field into two regions by indicating a boundary where "the most natural break occurs". It was expected that subjects would group a "T" pattern segment with a "T" which is orientated slightly at a 45-degree angle due to being rated as "highly similar." However, almost all subjects placed the boundary so that the tilted "T's" were separated from the upright "T". This judgement appears to be based on the orientations of the line segments of the individual elements and not on pairwise similarity. For a series of such separation tasks, the only major exceptions to this rule occurred when the three elements had segments in the same orientations but differing in whether the segments crossed. Beck's (1966) findings that salient items and texture boundaries "pop out" with no effort indicates that grouping is governed by lower level mechanisms before attention is focused within the scene. Thus demonstrating that preattentive vision operates without attentional bottlenecks.

Despite traditionally being thought to tap into preattentive vision, studies that encompass a visual search task methodology have been criticised for not providing a true measure of inattention. They have instead been thought to involve diffuse attention with some intention by the participant to see particular visual properties (Mack et al., 1992). This was demonstrated in the visual search paradigm used by Treisman (1986) whereby participants were aware that all positions on the computer screen were task relevant and would regularly look for the specific target that was supposed to be a measure of inattention. Mack et al. (1992) asserted that to gain a true measure of whether grouping processes do exist autonomously without attention; an experiment must create a situation whereby the participant is consciously unaware of the grouping task. The participant must instead be engaged with another demanding visual task at a different location on the screen.

Based on this criticism, Rock (1975) developed a paradigm that he believed measured Gestalt grouping under true conditions of 'inattention'. Within this paradigm participants were presented with a demanding visual task whilst being consciously unaware of other separate visual stimulus, which are not task-relevant (Mack & Rock, 1998). The development of this paradigm was based on the hypothesis that the visual field will get grouped according to the question asked of an observer and therefore on what they are attending too. Mack (1975) found that asking participants to subsequently confirm what they have seen through surprise questioning in the experiment facilitates how visual stimuli are processed in perception. This method of surprise questioning has been a traditional way to measure unattended processing in vision research (Broadbent 1958; Cherry, 1953).
Mack et al. (1992) had participants view visual displays encompassing a cross fixed centrally in the screen. Participants were asked whether the horizontal or

vertical limb of the cross was longer. Embedded within the inattention trials was a Gestalt grouping display. Each participant was asked surprise retrospective questions concerning the background display of the task after several trials. Mack & Rock (1992) found across several experiments that participants tended to know nothing about the grouping of the background dot matrix when asked using surprise questioning. On the basis of this simple result, the experimenters reached their radical conclusion that Gestalt perceptual organisation is not autonomous from attentive processes. Mack & Rock's (1998) is widely acknowledged for coining the term 'inattentional blindness' on the basis of these results, which is characterised as a psychological lack of attention in vision.

Mack & Rock's (1998) results are in keeping with traditional views in vision research that use the methodology of surprise questioning (Broadbent, 1958) who conclude that participants are consciously unaware of the background stimuli and therefore are not exhibiting perceptual organisation. However, Mack & Rock's (1998) radical conclusion that no grouping can exist without attention is heavily criticised in contemporary literature. Moore & Egeth (1997) suggest that just because participants were unable to accurately report which grouping patterns were present in the background display of the inattention trials does not necessarily mean that the dots were not grouped. Rather than participants demonstrating an absence of processing of the unattended stimuli, it is instead suggested that participant's demonstrated poor explicit memory. This has lead to theorists such as Wolfe (1999) to suggest that participants instead were demonstrating signs of 'inattentional amnesia' and not 'inattentional blindness' – meaning they were simply forgetting the patterns. Mack & Rock (1998) denied this alternative explanation of their results, stressing how a valid measure of inattention would be jeopardised if surprise questions were asked throughout the experiment. They argued that these questions would cause the unattended stimuli to become relevant to the task and therefore become attended to by the participant.

Mainstream attentional research sought to find a way of measuring participant's preattentive grouping processes without causing the unattended background stimulus to become task-relevant and subsequently become attended too. The solution to this methodological problem was to develop an indirect measure of unattended processing at the time the stimuli was presented. This would not require participants to explicitly identify or judge the unattended stimulus, as previous studies had done. For instance, one way of encompassing an indirect measure of preattentive processing in attention research was to look at whether unattended stimuli can affect responses to attended information (Stroop, 1935). In addition, more recent work has focused on using indirect measures to decipher whether Gestalt grouping can occur under conditions of inattention. For instance, Moore & Egeth (1997) embedded a Ponzo and Müller-Lyer illusion within a background dot matrix of a line-discrimination task to investigate whether the background dots could be grouped. This grouping by common similarity would cause the illusion to be formed, which in turn would lead to biased line judgement of the two parallel lines. Results demonstrated that despite most participants being unable to explicitly identify the illusions, as shown in Mack & Rock's (1998) study, participant's line length judgement was affected. Participants appeared to be grouping the background dot matrix on the basis of its structural similarity, allowing the Müller-Lyer illusion to emerge. This seminal finding demonstrated that "some degree of the background grouping by similarity in contrast polarity can still take place, even when the background is task-irrelevant" (Driver et al, 2001).

However, Moore & Egeth's (1997) research does not necessarily establish that perceptual organisation does not require attention as participants became aware of the illusion throughout the experiment. Within the experiments 4th 'inattention' trial participants were asked three questions concerning the background of the task. Furthermore, within the 7th and 8th trials, participants were again asked three questions regarding the background display. This demonstrates a methodological problem as participants were being alerted to the presence of something worth paying attention to within the study. For instance, participants in this study were able to accurately recall what stimuli were present in the background display including features such as colour, location and number of stimulus dots (Rock et al., 1992). This was shown to affect performance in the line discrimination task as participant's line-length accuracy dropped to chance levels, suggesting that the illusion was no longer effective. Furthermore, the effectiveness of the optical illusions in this study is criticised as the background dots are argued to be too close to the target lines used in the line discrimination task. Therefore, the overall supposed effectiveness of the optical illusion may instead be due to the dots being attended too, along with the two parallel lines (Driver et al., 2001).

The present study was aimed at using the inattention paradigm, as according to Mack & Rock (1998) if processes really exist which are dedicated to organising the visual field and establishing units for subsequent attentional processing, it would seem necessary that they are independent from attentional resources. Therefore, any stimuli that are perceived under conditions of inattention are likely to be serious candidates for early visual processing. In light of this claim, it was predicted that perceptual organization should occur in the complete absence of attention. Furthermore, the present study aims to expand upon the methodologies used by previous literature, providing a reliable test of inattention that minimises error. This will be achieved through disallowing participants to become aware of the Müller-Lyer illusion. This will also be achieved through encompassing a control group and using number of accurate responses as the dependent measure of this experiment. Through providing an online indirect measure of inattention, this study aims to provide supportive evidence for the preattentive-attentive dichotomy. Based on the methodology used by Moore & Egeth (1997), participants were given a line-discrimination task where they were asked to indicate whether two parallel lines were of equal or different lengths. The two lines were embedded within a matrix of dots forming either a random pattern or the Müller-Lyer illusion.

H1: It was hypothesised that participants in the experimental condition would not be consciously aware of the Müller-Lyer illusion yet demonstrate decreased accuracy of length judgements. Participants in the control condition, who were not exposed to the illusion, would not misjudge the length of the lines.

Method:

Design

A between-groups design was employed. Participants took part in one of two conditions: (1) an experimental condition in which participants were exposed to the optical illusion and (2) the control condition, with no optical illusion.

The independent variable was “condition”, which was the group participants were in, consisting of two levels: one with A Müller-Lyer illusion, one without the illusion. The dependent variable was participant’s accuracy in regard to the line-discrimination task.

Participants

28 participants (14 females, 14 males) took part in this study with 14 participants in each condition. Participants’ ages ranged between 18-25 years, with an average age of 21 years (±2.00). The sample consisted predominately of undergraduate students with an exception of two postgraduate students. Furthermore, most participants indicated they were British. Each participant reported normal or corrected to normal visual acuity. Participants were recruited through random sampling and therefore, were assigned to conditions on a purely random basis. All participants prior to the study were naïve to the aims of the study. The researcher held no relationship to any of the participants. Participants were given the option to withdraw from the study and were given the opportunity to take a break. At the end of the study, participants had a final opportunity to withdraw the data they had provided. The study was carried out in accordance and with the approval of UWL Psychology department’s ethics committee (see Appendix B).

Apparatus/Materials

Stimuli were displayed using DMdX (Forster & Forster, 2003), run on a 15” Dell laptop computer with 640 x 480 screen resolution.
Responses were collected via the computer keyboard’s left and right shift key, which was accompanied by stickers to indicate this on the laptop.

Following completion of the experiment, participants were given a questionnaire to assess whether they had noticed the Müller-Lyer illusion within the background of the dot matrix. The questionnaire was based on that used in Mack & Rock’s (1992) experiment, and consisted of four questions (see Appendix A).

Stimuli

A fixation display was placed in the centre of grey background and took the shape of a black 0.60 x 0.60 plus sign (+).

All 54 dot matrixes with embedded horizontal lines were created by the experimenter, based on the dot matrixes employed by Moore & Egeth (1997).

Each matrix compromised of 48 white dots. This consisted of 25 columns x 23 rows in total. Each individual dot was 4mm x 4mm with 1mm between each dot. These white dots were placed on a grey background centered in the middle of the screen. This was consistent across every matrix. However, within the 54 dot matrixes black dots of the exact same size were embedded within the matrix to create scattered patterns. In total, there were in total 10 different random-matrix patterns, of varying levels of complexity, where each matrix had a completely random formulation of dots with no particular pattern. In addition, there were 6 critical trial pattern matrixes, each embedding the Müller-Lyer illusion within the matrix of dots, whilst also demonstrating random configurations of dots within the background of these illusions (see Appendix B).

Furthermore, embedded within these dot matrixes were two horizontally oriented black line segments. The line segments were centered from side to side within the matrix and were located on the 8th and 14th row, on top of the white dots.

Within random-different trials, there was an equal number of upper segments that were longer and bottom segments that were longer. The line segments fell into one of six available categories:

(1) Short lines (approximately 10cm) of the same length. (Number of how many for each)
(2) Short lines (approximately 10cm) with a longer top line.
(3) Short lines (approximately 10cm) with a longer bottom line.
(4) Medium lines (approximately 20cm) of the same length.
(5) Medium lines (approximately 20cm) with a longer top line.
(6) Medium lines (approximately 20cm) with a longer bottom line.

On each of the critical trial conditions, line segments formed shafts and the black dots in the matrix formed arrowheads (see Appendix X). The line segments and dots together form the Müller-Lyer illusion. The arrowheads are pointed in one of the shafts and pointed out on one of the other shafts. When the two parallel lines are the same length, the shaft of the wings-out display will look longer than the wings-in display. The same masking stimulus was used at the end of each trial. This stimulus consisted of a random matrix of dots with no line segments.

The three different types of stimulus were:

(1) Same-random: where the lines are the same length with a random dot matrix within the background.
(2) Different-random: where the lines are of different lengths with a random dot matrix within the background.
(3) Same critical: where the two lines are of the same length and are embedded within the Müller-Lyer illusion.

There was an equal number of trials where the lines were the same and different lengths, 24 same length trials and 24 different length trials. Within Block A & B there was 6 critical optical illusion trials. The control group had no critical stimulus trials and instead had 6 extra “same-random” trials in block A & B.

An example of the varying dot matrixes can be shown in the appendix. (Appendix B)

Procedure

Participants sat at a desk with a laptop in a well-lit, quiet room. They were then given a paper consent form including a rough guide of what they would be expected to do and the general aim of the study. These instructions were then reinforced in more detail on DMdX. Firstly, participants were asked to focus on the fixation point, which would then subsequently be replaced by two parallel lines.

Participants were asked to indicate as quickly and as accurately as possible, whether the two lines were the same or different lengths, by pressing the right of left shift keys, respectively. The right key was pressed if the two lines were the same length and the left key was pressed if the lines were of different lengths.

In both the control and experimental condition, participants were given 5 practise trials consisting of only same-random and different-random patterns. These were not included in the analysis. Participants were then asked to follow on to Block A consisting of 24 trials and then they would carry on to Block B, also consisting of 24 trials. Two blocks were used to allow participants to rest for a short period in between trials as they were allowed to continue on to block B within their own time. However, this was limited to less than two minutes.

Each trial began with a fixation point of a black cross, presented centrally in the screen for 1,000 milliseconds, which participants were asked to focus on when presented on the screen in each trial. This was replaced by one of the ten black and white dot matrixes with two black horizontally, orientated line segments embedded within it for 200 milliseconds. Participants had 4,000 milliseconds to complete this. Feedback of each trial’s accuracy was not provided. Immediately following this a masked stimulus would appear on the screen for 500 milliseconds. This sequence was repeated for every of the 48 trials.

Upon completion of the line discrimination part of the study, participants were asked to complete the questionnaire. Participants were then debriefed and thanked for participation. The overall study took approximately fifteen minutes to complete.

The procedure used in the control condition only differed by using 12 random-same stimuli trials rather than the 12 critical trials used in the experimental condition.

A pilot study, with the same procedure noted above, was conducted prior to the experiment. Eight participants were asked randomly to complete the experiment and subsequently provide feedback. This feedback allowed adjustments to be made to yield the current experiment.

Results:

Overall accuracy level was above chance with participants in the experimental group demonstrating decreased levels of accurate responses. Levene's test of homogeneity of variances was not significant, t (26) = -10.34, p> 0.05. The statistical significance of the observed patterns of accuracy was tested using an independent-samples t-test

As shown in Table 1, there was no difference in accuracy between the groups in the Different-Random, or in the Same-Random conditions, whereas in the Critical condition, the experimental group performed considerably worse:
t (26)= -10.3, *p* < .001

Table 1: Accuracy rates for each stimulus within both conditions

Stimulus	Group	Mean accuracy rate (± SD)	Mean percentage accuracy
No illusion – different lengths (24 trials)	Experimental	20.28±3	85%
	Control	20.21±3	84%
No illusion – Same lengths (12 trials)	Experimental	10.5±1	88%
	Control	10.42±1	87%
Illusion (12 trials)	Experimental	6.71±1	56%
	Control	10.3±1	86%

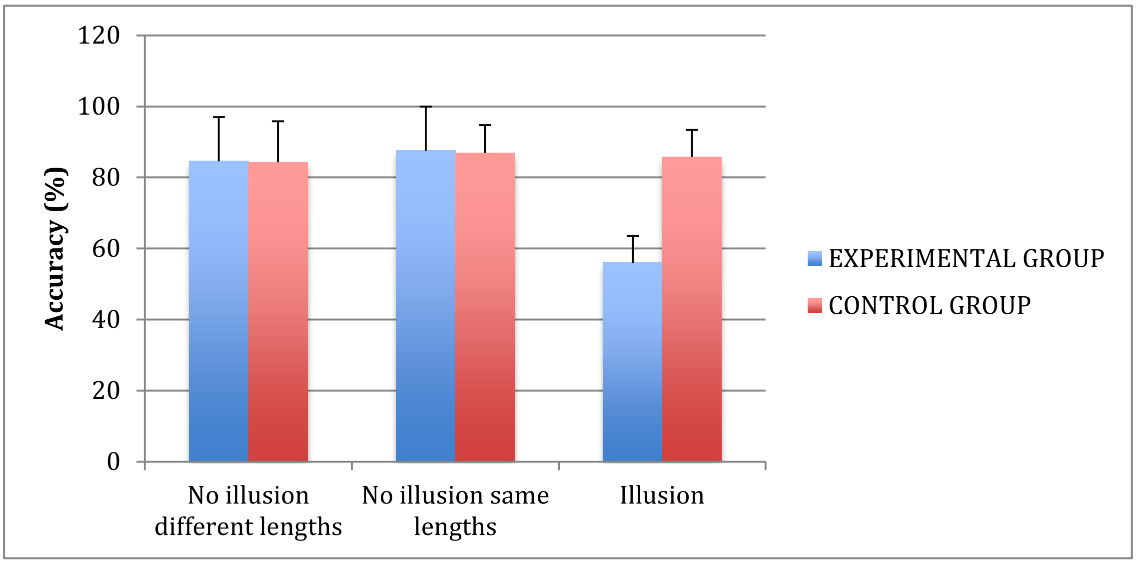

Figure 1: Experimental and Control participants' accuracy in the three conditions of the line discrimination task

Explicit measure of recognition

The following results demonstrate participant's answers from the three-part questionnaire presented after the line-discrimination task.

In the experimental condition, three participants out of 14 (21%) reported noticing "something unusual" in the background of the dot matrix. None of the three had identified correctly what was "unusual" within the dot matrix in the forced choice discrimination task or in the open question. One participant noted, "In block B the dots were spread out differently." All of these participants ticked that they were "not confident" with their decision on the forced choice and elaborative questions. Three other participants (21%) in the experimental condition (correctly identified the optical illusion in the forced choice discrimination task. These participants however did not report noticing anything unusual in block A or B. two out of the three participants noted that they were "not confident" with their answers. The remaining participant ticked that they were "neutral" in their decision.

In the control condition, one out of 14 participants (7%) reported noting something "unusual" in the background of the dot matrix. This participant did not correctly identify what was actually "unusual" in the background in the forced choice or open-ended question. This participant ticked that they were "neutral" with their decision. On the other hand, two other participants (14%) correctly identified the optical illusion in the forced choice discrimination task. Three participants indicated that they did not notice anything unusual in the background of the dot matrix. One of these participants ticked that they were "confident" with their decision. Two out of these three participants ticked that they were of "neutral" confidence with their answers.

Discussion:

The hypothesis that individuals in the experimental condition would demonstrate decreased accuracy in line length judgement, but not be able to explicitly report the illusion has been confirmed. It was hypothesised that individuals would group the dots on the basis of the Gestalt notion of structural simplicity, which would cause the optical illusion to emerge. Participants were given a line-discrimination task whereby they were asked to indicate whether two parallel lines were of equal or different lengths. The two lines were embedded within a matrix of dots forming either a random pattern or the Müller-Lyer illusion. Following completion of the experiment, participants were given a questionnaire to assess whether they had noticed the Müller-Lyer illusion within the background. Participants in the experimental condition had a significantly less number of accurate responses than participants in the control condition. Both the experimental and the control condition performed similarly well on other non-illusion trials. Furthermore, three participants identified the illusion in the forced choice task and three participants reported noticing “something unusual” in the background. However, none of the participants accurately reported the presence of the Müller-Lyer illusion in the background of the dot matrix.

The experimental group’s decreased accuracy in line-length demonstrates that they are successfully grouping the dots by similarity to give rise to the optical illusion. Additionally, participant’s inability to recognise the background illusion reinforces that they are not consciously aware of the grouping process. This demonstrates that there is a preattentive/attentive dichotomy in visual processing as participants are clearly being affected by the illusion at some level, which reinforces what is already known in surrounding literature. Therefore, the results of this present study are consistent with the view that perceptual organization functions at an autonomous, early preattentive level, in a bottom-up fashion, to generate units which then serve as candidate objects for subsequent and more developed processing, including object recognition and identification (Driver & Baylis, 1998; Treisman, 1986; Moore & Egeth, 1997). The result that participants are grouping the dots on the basis of their similar colour, size and shape is in keeping with the Gestalt notion of structural simplicity in vision (Wertheimer 1923). Participants appear to be organising the visual scene on the basis of similarities between the dots, instead of seeing the visual scene as an array of unorganised, independent elements. If participants were not grouping the dots on the basis of structural similarity then there would be no difference in line length judgement between the control and experimental condition.

As previously said, none of the participants accurately identified the optical illusion in the three-part questionnaire. Interestingly, this finding differs from Moore & Egeth (1997) whose participants were able to report the colour, location and approximate number of stimulus blobs that appeared in the background of the inattention trials (Rock, Linnet et al, 1992). It is arguable that this is the result Moore & Egeth (1997) using a greater amount of critical trials and increased number of surprise questions. This may be providing a more valid measure of the effectiveness of the optical illusion on accuracy scores with seventeen optical illusion trials compared to twelve used in this study being more substantial. The difference in results may be the consequence of Moore & Egeth (1997) demonstrating a more valid representation of preattentive processes in conditions of inattention. Although their research may provide a more valid measure of the optical illusion's affect on accuracy scores, it simultaneously demonstrates an invalid test of inattention, which is imperative to this paradigm. It can be argued that the higher frequency of trials and surprise questioning is causing participants to become aware of the background illusion. Therefore, the overall result of their experiment is the result of participant's conscious awareness of the Müller-Lyer and Ponzo illusion and is not evidence for grouping under conditions of inattention. The result in this present study that no participant was consciously aware of the optical illusion may be the result of fewer critical trials.

An alternative explanation of Moore & Egeth's (1997) findings may also be applicable to this present study concerning participant's inability to explicitly recall the optical illusion in the subsequent questionnaire. Moore & Egeth (1997) suggest two reasons for this: firstly, the patterns could have been simply forgotten once they were processed and secondly, the patterns were never successfully encoded in memory, but effected participants responses momentarily. This alternative explanation is plausible when looking at the result of 21% of participants in the experimental condition reporting seeing something "unusual" in the background that could be argued to demonstrate a vague remembrance of the critical stimulus. This could be evidence for the background display not being encoded successfully to ensure full retrieval. In addition, the other three participants who correctly identified the optical illusion in the forced choice task, but were uncertain in their decision, could be similarly demonstrating a lack of efficient encoding. In regard to the latter, it could be argued that the questionnaire, especially the forced-choice discrimination task, allowed them to retrieve the stored memory of the optical illusion. The other participants in the experimental condition who neither reported the correct illusion in the forced choice task, nor identified anything "unusual" in the background could simply be forgetting the patterns yet being affected immediately by the presence of the illusion, thus leading to reduced accuracy rates and lack of explicit recognition.

However, looking at evidence from the control group, which studies such as Moore & Egeth (1997) could not do, demonstrates that the failure to recognise the optical illusion, is not due to a simple memory lapse. For example, 7% of the participants in the control condition also reported seeing something "unusual" in the background of the dot matrix with 14% of these participants also correctly identifying the optical illusion in the forced choice task. If participants in the experimental group were processing the illusion and simply forgetting it, this would not be present in the control condition, as they were not exposed to the optical illusion. Participants in the study were instead exhibiting signs of random guessing rather than failure to encode or retrieve memories (Moore & Egeth, 1997). This is further demonstrated in the present studies results which indicate that both the experimental and control group answered that they were not confident with their decision in the subsequent questionnaire. It would appear, as suggested by Moore & Egeth (1997), attention is instead required for encoding the results of that memory, rather than attention being required for perceptual organisation.

Most importantly, the present results are not in accordance with those theories that maintain that very little perceptual processing occurs without attention (Mack et al., 1992; Palmer & Rock, 1994; Rock, et al., 1992). The results of this present study demonstrated that some form of perceptual processing is occurring without attention. This was shown through participants demonstrating biased line length judgement but not being able to explicitly identify the illusion. This finding contradicts Mack & Rock's (1998) radical claim that no Gestalt grouping takes place without attention. These differing results may have arose due to differing methodologies in measuring 'inattention' with Mack & Rock relying entirely on explicit measures of recognition, whereas this present study relied on both explicit and implicit measures of inattention. If this present study was only using an explicit measure to test inattention, it would be consistent with Mack & Rock's findings and the results could be said to demonstrate 'inattentional blindness.' On the basis of this it could be said that Gestalt grouping cannot take place under conditions of inattention. However, by providing an implicit measure of inattention through participant's accurate responses at the time the optical illusion is presented, these results allow Mack & Rock's (1998) theory to be refuted. Therefore, it can be argued that this present research provides an improved measure of inattention that considers both attentive and preattentive processes.

There are some study limitations which merit comment, such as the lack of construct validity within the questionnaire – meaning whether the questionnaire is really measuring the theoretical construct of inattention. The questionnaire was based on a similar one used within Mack & Rock's (1998). The question, "did you notice anything unusual about any of the patterns in block A or B?" can be criticised. The term "unusual" is ambiguous and vague and would often lead to participants asking the experimenter what was meant by "unusual." Therefore this uncertainty of what was being asked of them may have affected how recognition was being measured. A participant may have in fact been fully aware of the optical illusion, but felt as though it did not fall into the criteria for "unusual" so did not include it. On the other hand, this ambiguity could have also caused the participants to identify characteristics of the line discrimination task, which they would have not independently done, i.e. trying to find something unusual which they didn't actually find unusual – which might explain why 21% of participants in the experimental group and 7% in control condition incorrectly notified they saw "something unusual" but could not elaborate. Therefore, participants were demonstrating demand characteristics. Furthermore, this lack of clarity disallows replication in other studies, as the term "unusual" may vary from experimenter to experimenter, thus leading to inaccurate reporting of whether people are really consciously perceiving the stimuli. Therefore, future research needs to either replace this question with something more substantial or standardise what 'unusual' means so it can be used across various studies. The forced choice discrimination question on the questionnaire is more valid way of measuring explicitly participants conscious reporting of the illusion. In light of this, it can be said that the experiment was able to maintain some accurate measure of assessing explicit reporting. Future research should focus on this method as opposed to open-ended questions, which are misleading and unclear.

Driver et al. (2001) suggests a methodological problem with the Müller-Lyer illusion in Moore & Egeth's (1997) research – which may also be relevant to this present study. They suggest that the evidence of grouping proximal dots by common contrast polarity may have only occurred due to blurring in low spatial frequencies.

Therefore, this would only represent a very crude form of grouping at best. Indeed, it has also been suggested that the Müller-Lyer and Ponzo illusion can have a low spatial frequency basis (Rock, 1983). Therefore, the illusion in this experiment may not be a good measure of the effectiveness of grouping.

The ‘inattention’ methodology used in this present research can be practically applied to future research concerning perceptual and attention deficits following brain damage. If future research were to concern itself with these deficits it could start to unravel both the psychological and neural mechanisms involved in perceptual organisation. For instance, in integrative agnosia, individuals processes of binding individual features is compromised therefore a global form of a stimuli is not established – which appears to relate to the Gestalt principles of organisation. By using a methodology focusing on conditions of inattention, future research could assess specifically which grouping processes are impaired. On the other hand, future research could also look at individuals who have been diagnosed with neglect. Patients with neglect have impaired spatial attention and therefore should demonstrate preserved accuracy in feature search tasks, which do not require attention. This finding would yield further support for this present study and previous literature supporting the autonomy of early visual processing from attention.

Future research may find it of interest to focus on recent theoretical contributions that have differentiated between consciousness and attention, and, by extension between unconscious and inattentional processes (Dehaene & Changeux, 2011). Montoro et al. (2014) notes that to our knowledge, no previous study has examined the organisation of visual elements into global patterns by means of Gestalt principles of grouping in the absence of conscious perception. He proposes that present research should work towards investigating perceptual grouping processes by examining the possibility of a subliminal processing of Gestalt patterns generated by the action of grouping principles. This direction would extend this present research to a higher level of understanding by increasing our knowledge of early visual processing. Taken together, research concerning both subliminal and preattentive organisational tendencies can show the automatic and flexible nature of perceptual organisation operations in the human visual system.

Based on the results of this study and its consistency with surrounding research, it can be concluded that there exists a dichotomy between the consciously perceived world and the raw visual information that arises from external objects. The aim of this research was to answer the overarching question of whether perceptual organisation processes occur under conditions of inattention. The result that visual organisation is autonomous from attention has answered this question and provided further understanding of the underlying mechanisms of early visual processing. This is important for vision research as perceptual organisation imparts robustness and computational efficiency to our visual systems; therefore, it is crucial to understanding the underlying mechanisms governing it. In real world circumstances, this information is imperative considering attention and vision are important processes for human visuomotor behaviour and perception of our natural visual environments.

References:

Baylis, G. C., & Driver, J. (1992). Visual parsing and response competition: the effect of grouping factors. *Perception & Psychophysics, 51* (2), 145-162.

Beck, J. (1966). Perceptual grouping produced by changes in orientation and shape. *Science, 154*, 538-540.

Beck, J. (1972). Similarity grouping and peripheral discriminability under uncertainty. *Am. J. Psychology, 85*, 1-19.

Behrmann, M. & Kimchi, R. (2003). What Does Visual Agnosia Tell Us About Perceptual Organization and its Relationship to Object Perception. *Journal of Experimental Psychology: Human Perception and Performance, 19* (1), 19-42.

Braun, J., Ben-Av, M.B.& Sagi, D. (1992) Visual attention and perceptual grouping. *Perception & Psychophysics, 52* (3), 277-294.

Broadbent, D. E. (1958). *Perception and communication*. Oxford: Oxford University Press.

Cherry, E. C. (1953). Some experiments on the recognition of speech, with one and with two ears. *Journal of the Acoustical Society of America, 25*, 975-979.

Driver, J. & Baylis, G.C. (1998). *Attention and visual object segmentation: The Attentive Brain.* Cambridge, MA: MIT Press.

Driver, J., Davis, G., Russell, C., Turatto, M., & Freeman, E. (2001). Segmentation, attention and phenomenal visual objects. *Cognition, 80*, 61–95.

Forster, K. I. & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments, & Computers, 35* (1), 116- 124.

Kimchi, R. (2009). Perceptual organization and visual attention. *Prog Brain Res, 176*, 15-33.

Koffka, K. (1935). *Principles of Gestalt psychology*. New York: Harcourt. Brace Jovanovich.

Köhler, W. (1947). *Gestalt Psychology: An introduction to new concepts in modern psychology*. New York: Liveright Pub. Corp.

Mack, A., & Rock, I. (1998). *Inattentional blindness*. Cambridge, MA: MIT Press.

Moore, C. M., & Egeth, H. (1997). Perception without attention: evidence of grouping under conditions of inattention. *Journal of Experimental Psychology: Human Perception and Performance, 23* (2), 339- 352.

Neisser, U. (1967). *Cognitive psychology*. East Norwalk, CT: Appleton-Century-Crofts.

Palmer, S. E., & Rock, I. (1994). Rethinking perceptual organization: The role of uniform connectedness. *Psychonomic Bulletin & Review, 1*, 29–55.

Palmer, S. E. (1999). *Vision science. Photons to phenomenology*. Cambridge, MA: MIT Press.

Rock, I. (1975). *An Introduction to Perception*. New York: Macmillan.

Rock, I. & Palmer, S. (1990). The legacy of Gestalt psychology. *Scientific American,* 262, 84–90.
Rock, I., Linnett, C. M., Grant, P., & Mack, A. (1992). Perception without attention: Results of a new method. *Cognitive Psychology, 24*, 502–534.

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology, 18,* 643-662.

Treisman, A., & Gelade, G. (1980). A feature-integration theory of attention. *Cognitive Psychology, 12* (1), 97-136.

Treisman, A. (1982). Perceptual Grouping and Attention in Visual Search for Features and for Objects. *Journal Of Experimental Psychology: Human Perception and Performance, 8* (2), 194-214.

Treisman, A. (1986). Features and objects in visual processing, *Scientific American, 254* (11), 114-125.

Treisman, A. (1988). Features and objects: The fourteenth Bartlett Memorial Lecture*. Quarterly Journal of Experimental Psychology, 40*, 201–237.

Wertheimer, M. (1923). Untersuchungen zur Lehre von der Gestalt II. *Psycologische Forschung*, *4*, 301-350.

Wolfe, J. M. (1999). *Inattentional amnesia.* Cambridge, MA: MIT Press.