THE FRAMEWORK FOR UNDERSTANDING ARRAY/GROUPING PRINCIPLES – Part 2

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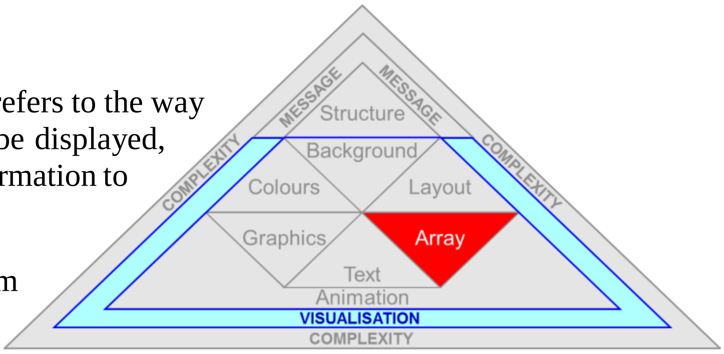
This handout follows on from the first part that is provided at this web location: http://www.seahorses-consulting.com/DownloadableFiles/ArrayHandout-Part1.pdf .

WHAT'S THE POINT?

This handout:

- ✓ is an excerpt from Chapter 2 of my thesis *(hence why it refers to other parts of the thesis in the text)*;
- ✓ gives practical insights into the best way to apply Gestalt principles to optimise the layout and grouping of information; and
- ✓ provides the first integrated model developed to cover these issues, so it is therefore provided to give you food for thought *(the more practical implications are provided in later issues).*

1.1. Introduction



As a short reminder, the term 'array' refers to the way in which groups of visual items can be displayed, to optimise the communication of information to viewers.

You have also probably heard the term Gestalt before, but most books covering the subject do not provide an integrated approach for using these principles effectively. This short paper shows you how to apply these Gestalt principles in a practical and innovative way, so you can readily work out the best way to group information in your presentations.

1.2. Applying the Gestalt Principles

Section 1.4.1 in the document provided in the layout handout[1] discusses the key Gestalt principles. Although these Gestalt principles are discussed independently, they appear to

1. This can be found at the following web location: http://www.seahorses-consulting.com/DownloadableFiles/LayoutHandout.pdf. Please note that if you can't remember all of this, it will be worth your while to quickly refresh your memory about the Gestalt principles, before reading the remainder of this document.

interact to support grouping through perceptual organisation (Palmer & Rock, 1994; Palmer, Brooks, & Nelson, 2003).

Identified interactions between the Gestalt principles are illustrated in Figure 1[(2)].

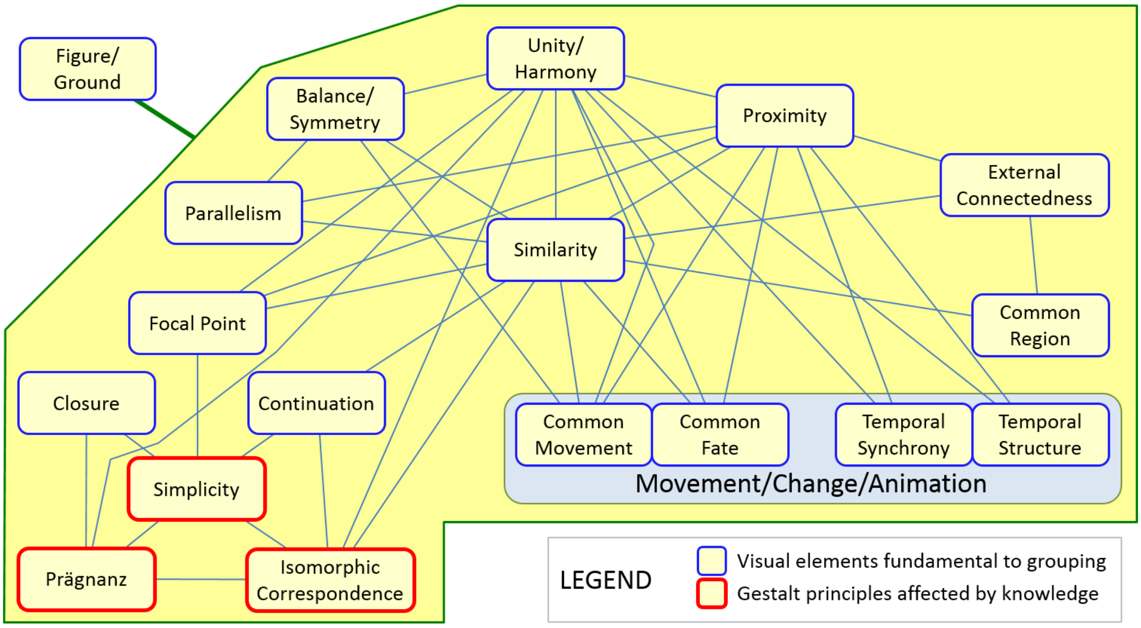


Figure 1: Interaction of the Gestalt Principles

Each Gestalt principle in Figure 1 is colour coded to demonstrate their likely application in the grouping of array elements. For example, those with a thick blue outline have been implicated in directly supporting the grouping of information (as discussed below).

Alternatively, those elements of the diagram shown with a red outline relate to the higher level cognitive processing that leverages the viewer's knowledge *(which aligns to the model described in Part 1 of the Array handout)*. According to Lehar (1998), principles such as isomorphism take primacy, because the other Gestalt related aspects of perception are modified

2. This model was developed by the author, by conjoining information provided in: Wagemans, Elder, et al. (2012), Grompone von Gioi, Delon, and Morel (2012), Chang, Dooley, and Tuovinen (2002), Kubovy and van den Berg (2008), Ehrenstein, Spillmann, and Sarris (2003), Sternberg (1998), Zakia (2002), Yang (2006), Graham (2008), Smith-Gratto and Fisher (1999), Palmer et al. (2003), Palmer and Rock (1994), Palmer and Beck (2007), Kim (2007), Sekuler and Bennett (2001), Lee and Blake (2001), Guttman, Gilroy, and Blake (2007), Fraher and Boyd-Brent (2010), Glicksohn and Cohen (2011), Yonggang et al. (2013), Peterson and Berryhill (2013), Kahan and Mathis (2002), Puustinen, Baker, and Lund (2006), Clarke (2010), Vickery and Jiang (2009), Moszkowicz (2011), Yee, Ling, Yee, and Zainon (2012), Lehar (1998), Lehar (2003), Van Kleeck and Kosslyn (1989), Zlatoff, Tellez, and Baskurt (2008), and Lamers and Roelofs (2007). None of these authors lists all of the interactions illustrated within Figure 1, but collectively they mention all of them directly or indirectly. For the purposes of brevity all of the interactions and their individual sources are not listed separately. Additionally, only interactions that could be identified in the publications have been included. It is possible (even likely) that other interactions may also be applicable. However, these other interactions have not been included, because the author could not find publications that support the premise for these. This shortcoming does not diminish the model, which is simply designed to demonstrate that the Gestalt principles interact, and not to demonstrate all of the interactions in detail.

subjectively by the viewer. This concept is also reflected by Ehrenstein et al. (2003), who linked the application of Prägnanz, simplicity and isomorphism to the viewer's memories. In other words, although each of the grouping principles (shown with the blue outline) are important, they do not work in isolation from what is already known by the viewer.

The figure-ground principle has also been separated, because:

- figure-ground analysis appears to be dependent on many other Gestalt aspects (Palmer et al., 2003); and
- the determination of which elements are figure or ground also shapes many other aspects of the perceptual organisation of the arrays (Wagemans, Elder, et al., 2012) (e.g. aspects identified as background are not grouped with foreground elements).

Finally, the light blue lines in Figure 1 demonstrate identified interactions between each of the Gestalt principles. For example, similarity appears to influence many other aspects of grouping (Wagemans, Elder, et al., 2012), because it is affected by, and affects so many other Gestalt principles. This concept is demonstrated by the examples provided in Figure 2.

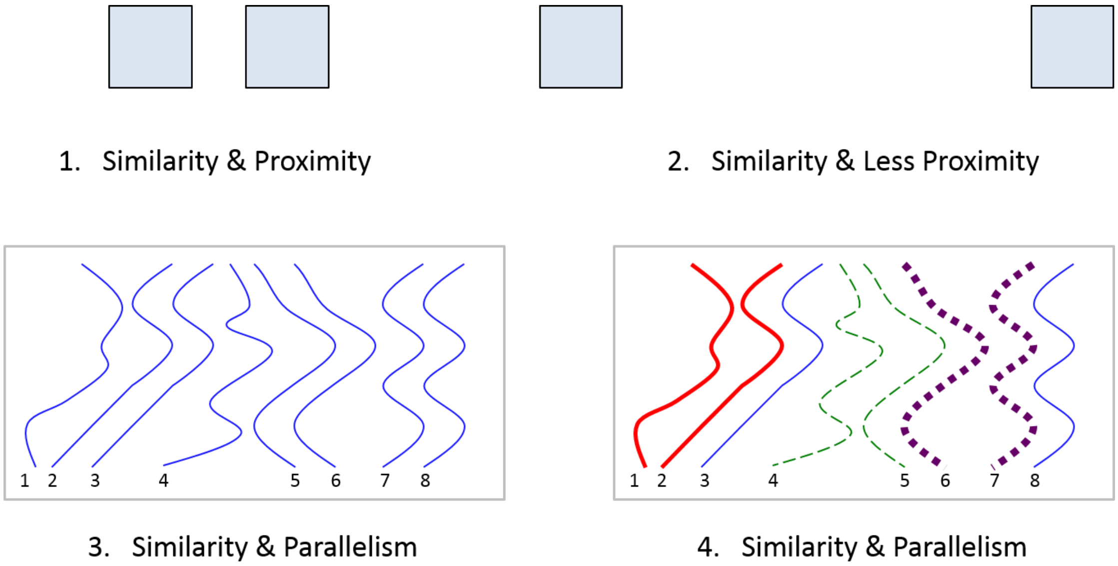


Figure 2: Examples of Interaction between the Gestalt Principles

As shown in Example 1 in Figure 2, the left two squares are highly similar and located close to each other. For this reason they are more likely to be grouped. On the other hand, the two squares in Example 2 are still highly similar, but they are less likely to be grouped, because of the distance between them (in fact the left hand square in this example may be more likely to be grouped with the squares in Example 1). Another exemplar of this Gestalt interaction concept is shown in Examples 3 and 4. In the left hand diagram similarity and parallelism are likely to lead a viewer to group lines 2 and 3, 5 and 6, and 7 and 8. This is because all of the pairs are similar as well as being parallel. However, by changing aspects of similarity (e.g. colour and line types) in Example 4, exactly the same line vectors are more likely to be grouped very differently.

Gestalt interactions should therefore be taken into account. The following subsections provide more information about the way in which key Gestalt principles affect grouping.

1.2.1. Similarity

Grouping through similarity can be generated by creating visual units that have comparable features (e.g. colour, luminance, orientation, size, shape, etc.) (Jansson, Marlow, & Bristow, 2004; Wang, Giesen, McDonnell, Zolliker, & Mueller, 2008). This does not mean that they have to be exactly the same to be grouped. For example, utilising monochromatic variations or analogous/related colours[3] for objects can also promote grouping through similarity (Wang et al., 2008). Additionally, similarity in animation and visual change aspects (e.g. common movement and common fate) can also cause groupings through perceptual organisation (Wagemans, Elder, et al., 2012).

1.2.2. Common Region/External Connectedness

For grouping purposes, the concept of common region can be 'viewed as similarity of containment' (Wagemans, Elder, et al., 2012, p. 10). Alternatively connectedness creates units that appear to be grouped (Palmer & Beck, 2007) very early in the array development process (Palmer & Rock, 1994). Such connections therefore appear to support grouping at a more fundamental level than just proximity (Wagemans, Elder, et al., 2012). The application of these common region and external connectedness principles can typically even generate grouping if the objects are very dissimilar (Humphreys & Riddoch, 1993).

1.2.3. Proximity

Proximity is a strong determinant for the grouping of array elements (Wagemans, Elder, et al., 2012). According to research conducted by Veksler (2011) grouping will typically take place when the angular separation of objects is relatively small, as shown in Figure 3 (overleaf)[4].

3. See Section 1.1.2.3 in the file provided at the following web address: http://www.seahorses-consulting.com/DownloadableFiles/ColourPsychology.pdf for more information on these colour harmony issues.

4. Figure 3 was developed from Figure 4 in Veksler (2011, p. 1098). The line data reflects the mean between the paper and web data provided in Veksler's (2011) graph (these data are highly correlated, so there is little variation between the two datasets). The approximate visual angle information has been added to the graph by the author, because Veksler (2011) only included pixels as the scale on the x-axis. The visual angles were deduced mathematically using the following formula: (DEGREES(ATAN2(0.5*Monitor Height in cm),Distance between Monitor and Viewer in centimetres)/(0.5*Vertical Resolution of the Screen))*(Size in Pixels/10). A range of average data options were then tested to determine the approximations illustrated in the graph. This deduction was also assessed against Veksler's (2011) statement that grouping typically took place within three degrees of separation for visual arc, which aligns fairly closely to about the 150 pixels position on the graph.

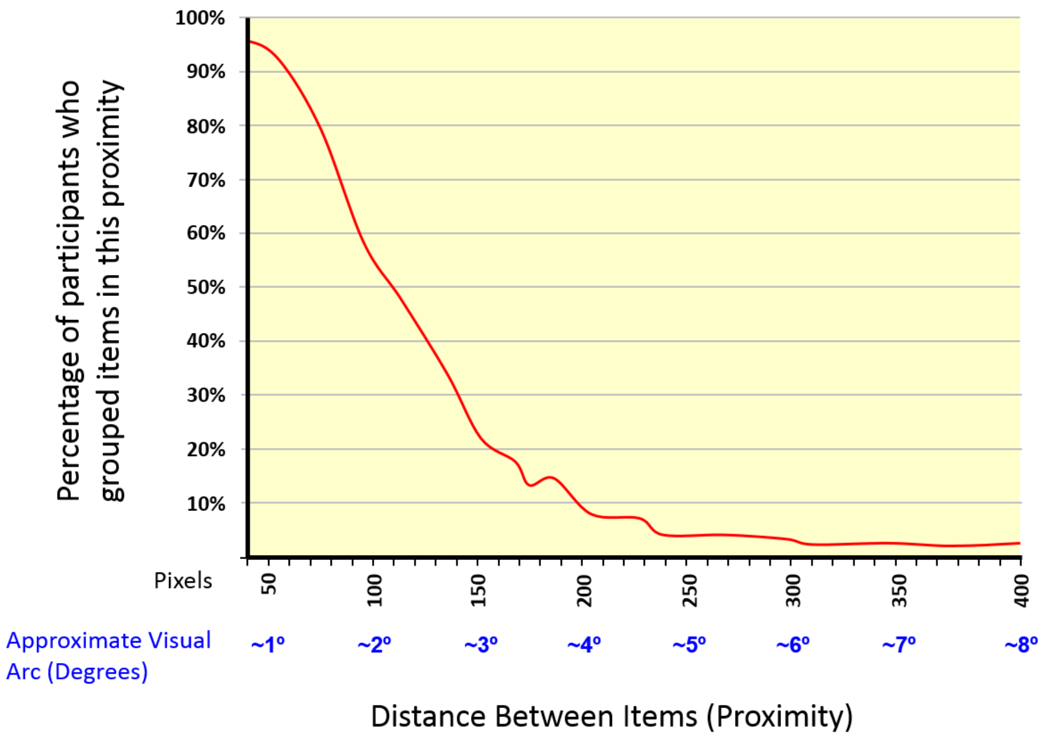


Figure 3: Visual Separation and Likelihood of Grouping

This graph reflects a key aspect of proximity within the Gestalt principles. There is a logarithmic relationship between the probability of grouping objects and their visual proximity (Wagemans, Elder, et al., 2012). In other words, if all other aspects of the visualisation are equal, the chance of grouping visual elements falls very rapidly as the angle of separation increases (Kubovy, Holcombe, & Wagemans, 1998). This concept is specifically supported by Veksler's (2011, p. 1098) experiments, which identified that 'participants felt items should be grouped if they fell roughly within …1-5° of visual angle', and they were most likely to link elements when there was less than three degrees of visual arc separating them. Veksler (2011) attributes this proximal grouping to the fact that the information was perceived concurrently through the foveal and parafoveal regions[(5)] of the retina[(6)].

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5. The fovea can be equated to a region of high definition vision that has a radius of about one degree of visual arc around the centre of vision within the retina. The parafovea is a region that surrounds the fovea on the retina and extends out to about 5 degrees from the centre of vision. See Section 1.3.1.2 in Appendix 1 for more information on the fovea and parafovea. See http://www.seahorses-consulting.com/DownloadableFiles/Appendix1.pdf for the Appendix 1 file.

6. Veksler's (2011) postulation is supported by Wandell, Brewer, and Dougherty (2005). They found that the central five degrees within the visual field (which aligns to the foveal and parafoveal areas) evokes more powerful stimuli responses than those generated from peripheral vision, because the visual system emphasises the processing of this central field of view, and particularly accentuates information passing through the fovea (Duncan & Boynton, 2003). The emphasis on central vision is explained in more detail in Section 1.3.5 in Appendix 1. Additionally, this weighting on the central five degrees within the field of view is reinforced by the fact that the average saccade amplitude is about five degrees (von Wartburg et al., 2007; Ware, 2013). The amplitude of these saccades can also extend beyond this (e.g. on average seven to eight degrees) in some circumstances, but they are seldom larger unless specific top-

However, other Gestalt principles can also additively affect the proximal grouping of objects (Wagemans, Elder, et al., 2012). For example, Kubovy and van den Berg (2008) identified that similarity can directly reinforce the probability that objects will be grouped, even if they are further apart than would normally lead to their conjunction. In other words, within limits, similar objects are more likely to be grouped even if they are somewhat further apart (Wagemans, Elder, et al., 2012).

There are also two other proximity related issues, which are associated with visual clutter. These visual clutter issues can be categorised as feature congestion (Rosenholtz, Li, & Nakano, 2007) and crowding (Strasburger, Rentschler, & Jüttner, 2011). This delineation is utilised to separate perception through the fovea and parafovea (related to feature congestion) and peripheral regions of the retina (which can cause crowding). Each of these categories of proximity related issue is discussed below.

Feature congestion refers to the presence of numerous competing visual elements (e.g. colours, textures, objects, etc.) that would need to be assimilated within central vision, to group or identify objects during visual search and perception (Rosenholtz et al., 2007)(7). This form of clutter increases the complexity of grouping, because target and distractor elements(8) must be separated by the viewer, to make sense of the visual content (Eckstein, 2011). This concept is illustrated in Figure 4.

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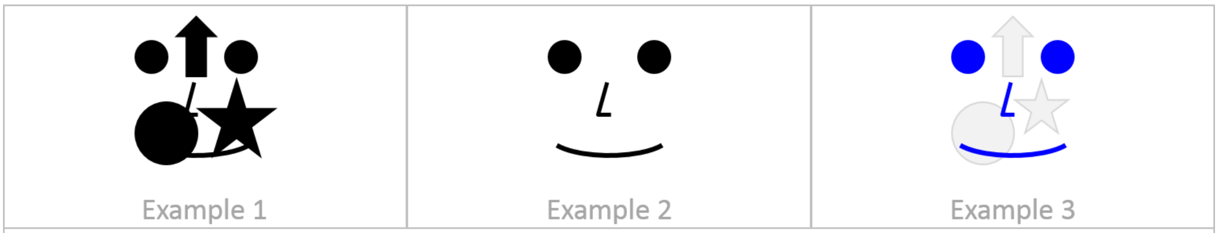
down drivers are employed (Dorr, Martinetz, Gegenfurtner, & Barth, 2010). The greater likelihood of grouping visual elements within the central eye field therefore makes sense for the following reasons: (1) The vast majority of the high definition cone cells are located in this region (see Figure 1.12 on Page 24 of Appendix 1), which means that this is the priority region for visual acuity (Larson & Loschky, 2009); (2) whilst providing overt attention to a region, the visual elements are being processed roughly concurrently (McPeek, Skavenski, & Nakayama, 2000), so there is more chance that they will be grouped in working memory (Demeyer, De Graef, Verfaillie, & Wagemans, 2011); (3) during the following saccade, some perceptual processing is suppressed (Ross, Morrone, Goldberg, & Burr, 2001), which may provide a natural break in the perceptual stream (and hence may affect grouping); (4) the next fixation will then either support the existing group, or if separated from the existing group a new group may then be formed (Demeyer et al., 2011); and (5) such grouping is also more likely if the object was already identified within peripheral vision (Demeyer et al., 2011) (e.g. flowing on from gist analysis, which identifies separate groups for more detailed analysis (Bar, 2004)).

7. Rosenholtz et al. (2007) do not specifically delineate feature congestion as being related to the fovea and parafovea. However, they refer to their approach in terms of visual search, and they are inferring this in terms of overt attention (and therefore foveal/parafoveal vision). Additionally, they have treated crowding (which relates more to peripheral vision) separately within their model. Rosenholtz, et al's (2007) formulas for assessing feature congestion have not been included within this thesis, because they would not be particularly practical for most PowerPoint® developers, but the general tenets of their formulae are applied within this model.

8. Visual distractors are objects, or other visual content, that are perceivable within the visible field, but are not important for attendance (Eckstein, 2011). Visual content that needs to be attended is typically referred to as a target (Eckstein, 2011). See Sections 2.2.4, 2.2.6 and 7 in the shaping attention handout (this is provided at http://www.seahorses-consulting.com/DownloadableFiles/ShapingAttentionHandout.pdf) for more information on the ramifications of distractors and targets.



EXPLANATION

In Example 1, the presence of distractors makes the object appear chaotic, and reduces the viewer's ability to integrate the important elements shown in Example 2. This problem can be resolved by minimising or eliminating distractors (as shown in Example 2), or utilising other Gestalt aspects such as similarity (Strasburger, 2011), as illustrated in Example 3. Please note that fundamental salience factors play an important part in such separation and de-cluttering (Schütz, et al. 2010)

Figure 4: Demonstrating the concept of Feature Congestion

The next aspect is crowding. Crowding is the 'phenomenon in which objects that can be recognised when viewed in isolation are rendered unrecognisable in clutter' within peripheral vision (Levi, 2011, p. R678). The concept is demonstrated in Figure 5[9].

AND	+	N
AND	+	A N D
AND	+	AND

EXPLANATION

Focus on the plus (+) sign in the top example. When doing this the isolated letter N to the right should be easy to identify and read, whereas the 'N' in the word 'AND' to the left is harder to read without shifting gaze. This is an illustration of crowding, because it is easier to perceive the single item on the right than the group on the left using peripheral vision. Crowding is also anisotropic (i.e. it is affected by the direction of the elements). Therefore if you focus on the plus sign in the second example, it is actually easier to recognise the letter 'N' to the right *(even though it has the letters A and D above and below)* than it is to separate the 'N' in the left hand example. Finally, the bottom example demonstrates that similarity affects crowding. In this case focus on the plus sign and the letter 'N' on the right appears to pop out and is easy to recognise, whereas the 'N' to the left is harder to differentiate from the other red text.

Figure 5: Demonstrating the concept of Crowding

9. The examples provided in Figure 5 are drawn from Figure 1 (on Page R679) in Levi (2011). Although the examples use text, crowding can also affect objects (including faces) and shapes (Levi, 2011).

As exhibited in Figure 5, crowding is triggered when cluttered groups are provided away from the focal point, so they are initially managed in peripheral vision (e.g. during initial gist analysis)[10]. This issue reflects a significant limitation in visual perception (Levi, 2011), because crowding can suppress awareness of the cluttered elements in the field of view, which means that attention may not be drawn to them (Wallis & Bex, 2011). Such suppression may then mean that visual elements are not identified or grouped appropriately (Gheri, Morgan, & Solomon, 2007; Whitney & Levi, 2011).

Therefore both local and global density of visual elements (i.e. proximity within arrays and across arrays) (Montoro, Luna, & Humphreys, 2011), and the saliency of the various groupings (Buzatu, 2013) must be taken into account within the design. To assist in achieving this objective 'white space (or "negative space" as it is called in the visual arts)' should be provided between visual elements that the designer wishes to separate (Lok, Feiner, & Ngai, 2004, p. 103).

According to Zdralek (2003) the minimum separation should be about 48 to 54 pixels[11] (which equates to about one degree of visual arc)[12] for direct viewing (e.g. through the fovea/parafovea). However, for peripheral viewing, the separation of the crowded outlying group should be approximately half the difference in angular separation between the focal point and the flanking elements[13]. Therefore if the visual separation of two sets of objects is five degrees, then the separation of the flanking objects (e.g. the A and D in the left hand 'AND' in the top example within Figure 5) should be at least about 2.5 degrees if the sub-elements need to be definable in peripheral vision.

However, the amount of separation is also affected by Gestalt principles such as the similarity of the objects and their salience (Gheri et al., 2007; Kennedy & Whitaker, 2010; Rosenholtz et al., 2007). Therefore, the more similar or salient the separated objects are, there more white space is required between them.

Finally, white space should be provided around the outer margins of the screen (Ngo, 2001). This requirement may not be as important if the presentation is going to projected, because the border white space is often not as noticeable (Alley & Neeley, 2005).

1.2.4. Balance/Symmetry/Parallelism/Unity/Harmony

Authors such as Parker (1976) treat aspects such as balance, symmetry, parallelism, unity and harmony as aspects of regularity, which are important in aesthetic judgement. Buffart, Leeuwenberg, and Restle (1981) also links these aspects of regularity as subset components within the Gestalt principle of Prägnanz, which is essentially an aesthetic concept related to content that generates the impression of good form (Moshagen & Thielsch, 2010).

10. A detailed analysis of crowding and its causation is beyond the scope of this thesis. A useful review is provided in Whitney and Levi (2011), should additional information be required.
11. According to Kropscot (2013) the term pixel refers to the smallest part of a digital image, which is adjusted for hue and luminance to provide a part of the displayed images and visual content.
12. As deduced utilising the formula defined in Footnote 4.
13. This separation applies Bouma's (1970) rule of thumb, which states that crowding may occur when the objects within the flanking group (viewed in peripheral vision) are within about half of the distance between the target (point of focus) and the peripheral group.

Such regularities are important, because a viewer's ability to identify them is fundamental to the creation of structured mental representations (van der Helm, 2012), and the discrimination of individual elements within a complex scene (Berlyne, 1963; Roberts, 2007). Additionally, aspects of regularity are strong determinants for grouping, and may actually be more influential than other Gestalt principles such as similarity (van den Berg, Kubovy, & Schirillo, 2011).

It is therefore important that good graphic design techniques should:

- 'group items into meaningful units to reduce cognitive effort' (Lohr & Gall, 2008, p. 93);
- align visual elements within groups to indicate relationships (Lohr & Gall, 2008);
- utilise factors such as size, colour, shape, orientation and repetition (i.e. aspects of similarity) to facilitate understanding of element status within the group (Lohr & Gall, 2008);
- utilise novelty (Allen, 2003)[14] and irregularity within groupings to draw attention to specific visual elements (Bradley, 2013);
- apply motion or change regularity and irregularity to shape meaning and draw attention to grouped elements (Kim, 2007); and
- apply recognisable regularity to create impressions and deeper understanding (Changeux, 2012) (e.g. invoking schemas due to the structure of the grouping).

1.2.5. Closure and Continuation

Closure and continuation of visual elements also plays an important role in grouping (Wagemans, Elder, et al., 2012). Key concepts related to closure and continuation, and their facilitation of grouping, are demonstrated in Figure 6[15].

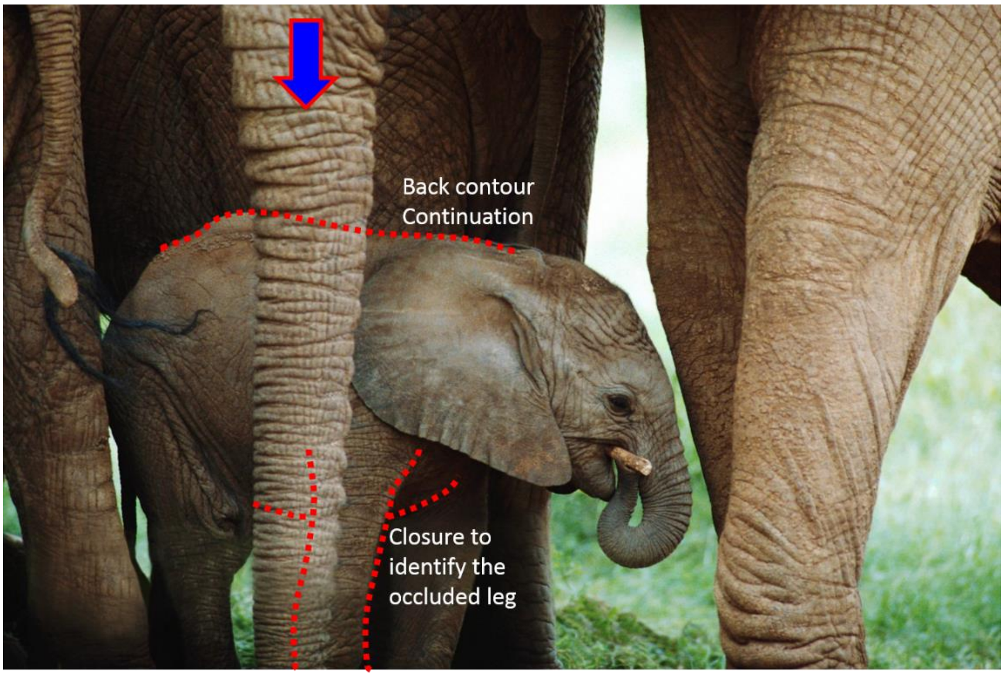


Figure 6: Demonstrating Closure and Continuation

14. See Section 1.2.2.1.2 (Factor 3) in Appendix 1 for more information on novel stimuli.
15. Figure 6 is a variation of Figure 10 on Page 17 of Wagemans, Elder, et al. (2012).

In this picture the elephant's trunk (which is highlighted by the blue arrow) is occluding the baby elephant. Rather than identifying the front and back of the elephant as two different groups, the viewer will utilise closure and continuation to discern an approximation of the edge contours of the baby elephant's shape (Wagemans, Elder, et al., 2012) (as illustrated by the top red dotted lines). Closure is also likely to be applied to identify the occluded front leg of the baby elephant (as shown by the bottom red dotted line) and generate meaning.

These types of grouping mechanisms appear to leverage prior knowledge to discern the grouping (Wagemans, Elder, et al., 2012) (e.g. the viewer is likely to recognise the elephant and expect that the front and back will be connected and it will have four legs). The cognitive elements related to Prägnanz, simplicity, and isomorphic correspondence are therefore important in this processing (as discussed below).

Additionally, this type of occlusion creates the impression of foreground-background positioning (Wagemans, Elder, et al., 2012).

1.2.6. Cognitive Aspects (Prägnanz, simplicity, and isomorphic correspondence)

The higher order processing of the Gestalt principles is affected by the context of the visual information (Wagemans, Elder, et al., 2012). These Gestalt principles can therefore be equated to contextualism (Gillespie, 1992), which cites that interpretations are inseparable from the perceived context of the situation and the knowledge of the individual (Fox, 2008). This concept is illustrated in the example provided in Figure 6 (above). A viewer is likely to have identified elephants quickly and used their knowledge to implement the continuation and closure. For instance, in these circumstances the simplest explanation of the visual information would be that there was something in front of (occluding) the baby elephant, and therefore the contours would be assumed based on available visual contours and prior knowledge of elephant physiology (e.g. what elephants normally look like).

However, it is possible, that a person who had never seen an elephant may not have joined the objects in the same way (Sternberg, 1998). It is therefore important to take into account the context generated by the material, and the likely knowledge of the viewer, when identifying optimal groupings (Lohr & Gall, 2008)

1.2.7. Figure-Ground

The last element within the grouping model relates to the separation of figure and ground elements. This is an important part of the perceptual organisation process (Palmer & Rock, 1994), because figure-ground separation is determined by, and helps to determine, the grouping of other objects and array elements (Wagemans, Elder, et al., 2012). According to Palmer et al. (2003) this takes place just before the entry level units are determined, so it happens relatively early in the process (but may be modified by later feed-back).

It is therefore important to make figure and ground distinctions as clear as possible (Lohr & Gall, 2008), and to apply salience and grouping issues appropriately to simplify the separation and allow the viewer to focus on the important figure elements (Wagemans, Elder, et al., 2012; Wagemans, Feldman, et al., 2012). In particular, salience appears to play an important role in the separation of figure-ground visual elements (Subirana, 1991). This importance is reinforced by Salvagio, Cacciamani, and Peterson (2012), who identified that the resolution of figures or ground is determined through a process of biased competition(16). Within this competitive framework, aspects of salience and Gestalt related grouping issues (e.g. proximity, symmetry, etc.)(17) play an important role in figure-ground selection (Salvagio et al., 2012).

1.3. Array - Summary

PowerPoint® design publications typically do not address array issues explicitly and the advice they provide is typically fragmentary. For example, none of the design publications found by the author address the important factors related to integrating Gestalt principles.

The information provided in Parts 1 and 2 of this Array information demonstrate that:

- salience issues play an integral part in the grouping of content within the arrays;
- Gestalt principles interact to assist the viewer to make sense of the visual information and effectively implement perceptual organisation; and
- Gestalt principles related to higher level cognitive (Prägnanz, simplicity, and isomorphic correspondence) leverage the viewer's knowledge to make sense of the visual content provided.

Optimised PowerPoint® design should therefore take these issues into account, when determining how visual content should be grouped within slides.

1.4. Further Information

Should you require further information, you can contact the author by email at: info@seahorses-consulting.com .

16. Biased competition is founded on the principle that percepts and representations generated within the visual system are analysed within a competitive framework (e.g. like a knockout competition) for attention at the higher levels of cognition (Mounts, 2005). Salvagio et al. (2012) utilise the term 'inhibitory competition' in their paper, but the term is analogous with biased competition, with the extension that the losing percepts or representations are directly inhibited. More information on biased competition is provided in Section 1 within the Shaping Attention handout.

17. Salvagio et al. (2012) don't actually utilise the Gestalt principle terms explicitly, but their experiments definitively apply them.

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