Harmonious Screen Interface Design Principles from Chinese Calligraphy

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A thesis submitted in partial fulfilment for the requirements for the degree of

DOCTOR OF PHILOSOPHY

October 2010

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Harmonious Screen Interface Design Principles from Chinese Calligraphy

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Abstract

Harmony is a major theme in Chinese culture. It is reflected in many forms, e.g. painting and garden design. However, calligraphy gives a straight forward insight into harmony in two dimensions. The main hypothesis was that the principles for building a harmonious calligraphic character could be converted from holistic to deductive and computable ones. These could then be applied to the design of harmonious screen interfaces, which would give visual pleasure. It is not claimed that harmony can be completely measured, but identifies some commonly shared aspects of harmony in Chinese calligraphy, that translate into measurable properties which produce harmonious screen interfaces.

The first aim was to investigate and discover the quantifiable features of harmony in Chinese regular script calligraphy. Calligraphy has been associated in China with harmony and elegance for over 1500 years. There are features that are commonly accepted to establish harmony which can be quantified. However, the principles of Chinese calligraphy are embedded within Chinese culture. Direct translation does not convey the meaning. An extensive study was made of the literature on Chinese calligraphy and a practical exploration of characters was made. This resulted in a small number of principles which were needed to be satisfied for the character to appear harmonious. These were tested on several groups of participants.

These principles were then converted into a mathematical form for Chinese regular script calligraphy, and for application to harmonious screen interface design. The mathematical forms were then tested on both Chinese regular script calligraphy and also on interface designs with groups of participants.

Finally, an application for comparing harmony in Chinese calligraphic characters and interface designs was created. The “Harmony” application can be used to calculate how a Chinese calligraphic character or an interface design satisfies the principles of harmony and it can give an indication of how harmonious they are.

Acknowledgements

This research started with a goal to find out how multimedia software could motivate minority ethnic children to learn their language and culture of origin. After two years, the project was taking more time than expected. Fortunately, part of the research, harmonious screen interface, had become an independent and fruitful project. It had a more promising outcome within the time limitation. Finally, the research changed its focus to harmonious screen interface and has been completed.

I would like to deeply and sincerely thank to my director of studies, Professor Mike Holmes for his valuable time and guidance. Without his wide knowledge, great experience and care, I would lose direction at the second stage of this project and it would be impossible to finish it.

I am truly grateful to my supervisor Dr Janet Read for her guidance on rigorous study organisation and writing. Many thanks to her for getting me a chance to complete my PhD.

I am very thankful to anther supervisor, Ms Feixia Yu. The research involved Chinese culture. With her endeavour, she helped me to get useful feedback from Chinese lecturers and artists. She also provided a lot of detailed and constructive comments on my work.

I am indebted to my previous director of studies, Dr Isobel Nicholson. Before her retirement, her advice, help and encouragement enabled me to develop from a novice to an independent and creative researcher.

I am also grateful to all participants in the studies. It was their feedback driving the studies up to so far.

Many thanks to Dr Isobel Nicholson, Ms Feixia Yu for finding the Chinese schools for my initial studies. Thanks to the Chinese schools for giving me access to children, parents and teachers.

Dedication

I would like to express my love to my parents, wife, son and daughter, and brother. Their supports in finance and emotion have been great encouragement during the studies. Many thanks to my friends and colleagues as well. The research life would not be so enjoyable and colourful without them.

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Chapter 1. Introduction

1.1 Classical Human-Computer Interaction (HCI)

In the past, computers were expensive and inaccessible to the public. Their intricacies made them operable only by computer scientists and engineers. Machine interface design concentrated on developing the physical hardware. Now, a personal computer (PC) is affordable for many people and software has been created for wide range of personal applications. The facilitation of communication between human beings and the computer has developed as a new field of study in the late 20th century (Preece, 1994). The human side of HCI involves cognitive psychology, vision, hearing, touch, movement and human memory. The computer side includes input, output devices and other devices to process data and generate reactions (Dix, 2004).

According to Dix (2004), the aspects of cognitive psychology include 'how human beings perceive the world around them, how they store and process information and solve problems and how they physically manipulate objects' (Dix, 2004: p.195); Human vision is the primary source of information collection for most people excluding the blind. It goes through roughly two stages: 'the physical reception of the stimulus from the outside world, and the processing and interpretation of that stimulus' (Dix, 2004: p.195). Hearing means the processing of sounds. Touch is another way for human beings to sense the surroundings. Movement includes the time taken by a human to react and respond to a stimulus (Dix, 2004).

The most common fault of novice designers is that their interfaces are only usable by themselves but are confusing to other people. The use of jargon, non-obvious design (for instance: a button that does not look like a button), confusing navigation, vague feedbacks and design inconsistency trouble users. Consequently, users will feel confused, panicked, bored, frustrated and be distracted from their original intention. (Galitz, 1993)

The user interface is the medium that enables the communication between human and computer. Since the 1970s, both system designers and researchers have recognised its importance. It was previously known as the Man-Machine Interface (MMI) (Preece, 1994). The concept of the user interface does not simply refer to screen interface design. It also includes physical machine interface design, which has an embedded system behind the interface, such as a fan, the buttons are the user interface and the system is made of the devices under the cover. The design of the user interface is complex. It combines at least two disciplines: psychology and computer science (Thimbleby, 1992). These days, more disciplines are involved in interface design, for example, art and culture.

Currently, the types of user screen interface comprise 2 dimensional (2D) interfaces, 2 and half dimensional (2½ D) interfaces and 3 dimensional (3D) interfaces. Two Dimensional interfaces are flat designs. They exist everywhere, such as websites and touchable screens, for instance, on the website of the University of Central Lancashire (Figure 1-1), no perspective effect is applied. The 2D interface concentrates on presenting information.

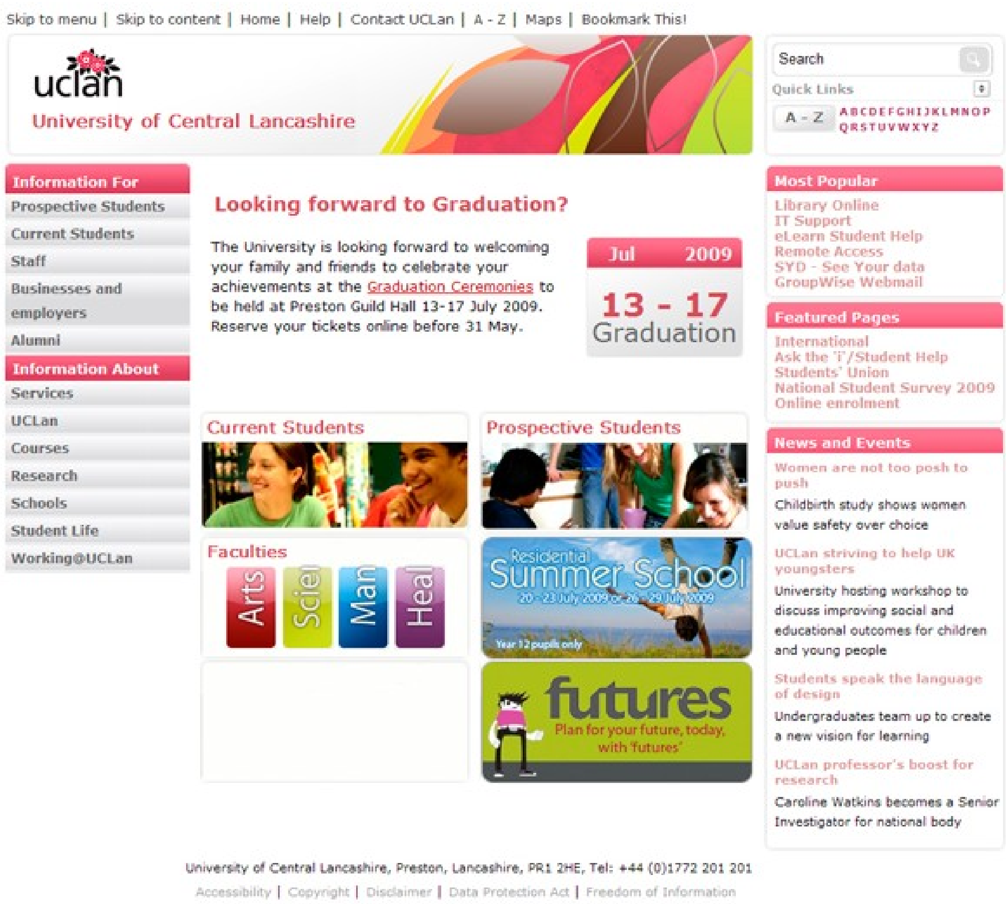


Figure 1-1 Website of the University of Central Lancashire (Screen shot in March 2009)

The 2½D interface simulates perspective in a static format. For example, buttons with shadow, or far objects are smaller. The Mac computer interface is a 2½D one (Figure 1-2). The Browsers drop shadow to give people a feeling of floating in the air. A trapezoidal stage is used to enhance the perspective effect of the iconic buttons.

Figure 1-2 The Mac computer interface

A 3D interface not only includes the visual effect of perspective. The user can also navigate through the interface to get close to a “distant” button, or rotate the interface so the “closer” interface components appear further and the “further” ones appear close. A 3D interface cannot be presumed to be better than lower dimensional interfaces. Cockburn and McKenzie (2002) conducted research in spatial memory, their experimental results show that their “subjects’ ability to quickly locate web page images deteriorated as their freedom to use the third dimension increased. Their subjective responses also indicated that they found the 3D interfaces more cluttered and less efficient (Cockburn 2002). 3D interfaces are used in a lot of modern games, for instance, the XBOX360 game “The Godfather II” (Figure 1-3).

Figure 1-3 The Godfather II Screenshot (Xbox 360)

The purpose of cognitive HCI is to solve the problems mentioned above. The functionality of the User Interface is important to HCI. It can be subdivided into the five measurable human factors as suggested by Shneiderman (1998):

1. *Time to learn*: the time for the user to learn how to use the interface
2. *Speed of performance*: the users' speed to complete a benchmark task.
3. *Rate of errors by users*: 'How many and what kinds of errors do people make in carrying out the benchmark task' (Shneiderman, 1998: p.15).
4. *Retention over time*: how well do the users retrieve the knowledge later?
5. *Subjective satisfaction*: was the user contented with the various aspects of the system?

A harmonious screen interface may have the potential to satisfy all these factors. This research concentrates on factor 5: Subjective (or Aesthetic) Satisfaction.

1.2 Aesthetics in HCI

Aesthetics was considered as a field outside HCI and was hardly mentioned by HCI textbooks (Lavie & Tractinsky, 2004). Norman (1988) as a representative critic on the issue of aesthetics disturbing usability, he published a booked titled "The design of everyday things” in 1988 which greatly influenced HCI researchers (Tractinsky, 1997). In his book, Norman (1988) claimed that “Designers Go Astray”. The reasons were:

> ‘First, the reward structure of the design community tends to put aesthetics first. Design collections feature prize-winning clocks that are unreadable, alarms that cannot easily be set, can openers that mystify. Second, designers are not typical users. Third, designers must please their clients, and the clients may not be the users’.
>
> (Norman, 1988: p.151)

This assertion has affected many designers, developers and researchers for a period of time. Kurosu and Kashimura (1995) discovered that there was a correlation coefficient of 0.59 between the apparent usability and aesthetics of layout pattern. That is to say, a lot of people expect an aesthetic layout to be more user-friendly. This result raised an argument about the traditional role of aesthetics in HCI. According to Leahey (1985), human memory processes information: from sensory memory to short-term memory, and finally to Long-Term Memory (Figure 1-4). When something is drawn to people’s attention, the first three parts of the information-processing system work immediately. Environmental input comes into sensory memory, which holds information for a very short time from around 0.5 to 1.0 seconds, just long enough for people to select what to attend to for further processing. Human’s sensory memory contains everything impinging on our senses, including not only the voices people can hear and the colours people can see, but also background noises, that people do not send on for further processing (Leahey 1985). If an interface fails to draw the users’ attention, the users will not stay with the applications, the well designed inherent usability will become useless, and the information conveyed by the applications will never reach the users’ short term memory.

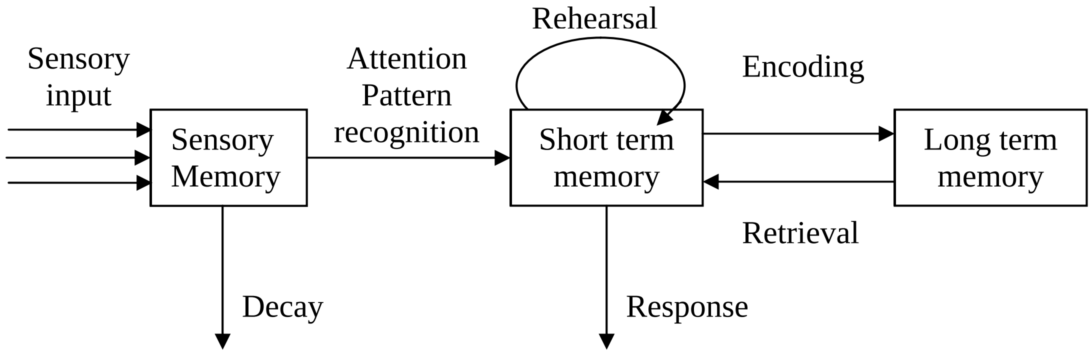


Figure 1-4 Overview of Information-Processing System Overview of Information-Processing System (Leahey & Harris, 1985: p.103)

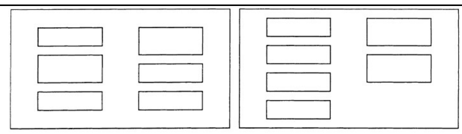
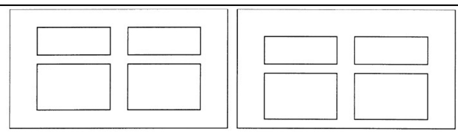
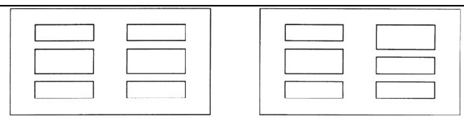
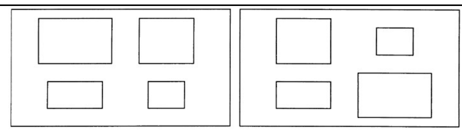
Norman (1988) states that aesthetics should give way to usability as the design should be user-centred. However, he omitted that aesthetics is one of the users' needs. More and more evidence has been discovered to support the importance of aesthetics in HCI. Schenkman & Jonsson (2000) organised 18 participants to compare 13 websites under the same conditions, such as the same monitor resolution, frequency and ambient brightness etc. One of their finding is that beauty is a determining factor for users' preference. Apparently aesthetics may elicit users' emotions and further affect embedded usability. Tractinsky (2000) conducted research to further explore the relationship between aesthetics and usability. He found out that people gave the same ranking to aesthetics and usability before and after the interaction with their automated teller machine, even if the actual usability was low. His research validates the idea that people associate aesthetics with other attributes such as usability for an application. For example, people tend to take it for granted that a good-looking person should be more reliable, and they are more tolerant to him/her (Nisbett, 1977). People transfer this habit to using computers. They believe that an aesthetic interface is commensurate with better usability, and users tolerate more design errors with an aesthetic interface. However, Chawda (2005) argued that systems with aesthetics may not work better than unattractive systems. The research on aesthetics in HCI has expanded from usability to other HCI attributes, such as credibility and accessibility. Robins and Holmes (2007) established the correlation between the aesthetics and credibility in web site design. They asserted that the more aesthetic a website is, the more the users would believe the website and continue reading. Twenty one websites were picked up by Robins and

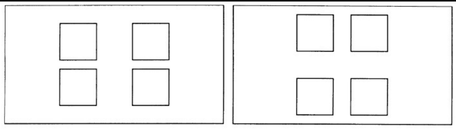
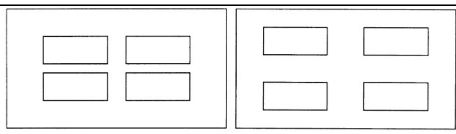
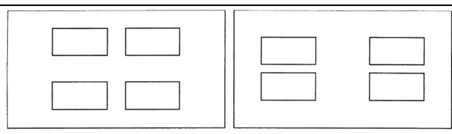
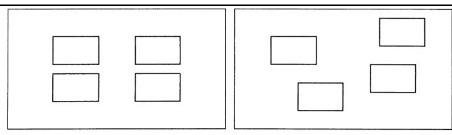
Holmes after searching Google for “web accessibility”. They stripped these websites of visual enhancements and presented them to 20 participants who were asked for their first impression on credibility. The idea was that the aesthetic ones should have better credibility than their counterparts. The result was analysed by a statistical t-test. Commonly, in statistical tests, if the possible difference is less than 95% ($P < 0.05$), it can be concluded that there is no difference between the two groups of data, as the difference is not significant enough. Among the 21 pairs, only 7 of them had significant difference between the original and its modified version. However, even the difference was not significant enough, which means less than 95% successful matches, the result showed that 19 out of the 21 cases (90%) match the assumption that the aesthetics brings credibility. The problem of this research was that the modification was done by the researcher without further evaluation, which may result in the modified version being more aesthetic than the original one. Additionally, Robins and Holmes also suspected that the cues implying a government website worked as credit indicators.

There is also a doctoral research project going on in the University of Manchester, England, UK, which is titled Empirical Investigation of Visual Aesthetics and Accessibility and conducted by Mbipom (2009). The aim was to bridge aesthetics and accessibility, also provide guidelines for aesthetic designs that are accessible. The term ‘accessibility’ here means making the application accessible to everyone, especially the people with aural, visual, or physical disabilities. In her study, five aesthetics terms have been used: “clean”, “clear”, “organised”, “beautiful”, and “interesting”. Thirty web pages were selected from Alexa7 UK Top 100 Websites on the 18th December, 2007. Fifty-five online participants rank the web pages on the five aesthetics terms. The accessibilities of the web pages were tested by an automatic evaluation tool named “Cynthia Says” (http://www.contentquality.com). The current finding is that the terms: “clean”, “clear”, “organised” are more clearly defined and those clean, clear, and organised web pages are more likely to be accessible as well. The terms: “beautiful” and “interesting” are more subjective, which means some people view the pages as beautiful or interesting while others may not. As the participants did not share the same definition of “beautiful” and “interesting”, it was difficult to clarify the relationship between “beautiful”, “interesting” and accessibility.

Aesthetics in HCI is important and belongs to the user experience, which can be greatly influenced by culture as well. When researchers such as Tranctinsky (2000) carried out their studies on aesthetics and usability and accessibility, some other researchers started to look at contributions from cultural aesthetics to HCI. Barber and Badre (1998) invented the term "Culturability" to express the importance of culture in usability. They analysed many websites from different cultures and identified the cultural markers, such as culturally preferred colours, icons, assignments etc. They argued that the cultural markers could impact user performance. Sheppard and Scholtz (1999) carried out an experiment to test Barber and Badre's hypothesis and concluded that the cultural markers did affect task performance. However, their experiment can only serve as an indication, as it was too small (ten participants), only employed simple cultural markers (fonts, colours and spatial arrangement), and just compared Northern American and Middle Eastern cultures. Marcus (2001) conducted research to prove that cross-culture interface design would be an important issue in the future as the Internet would be more available world-wide. He asserted that interface design would be culturally biased. His work supports Barber and Badre's hypothesis, as he found that the designs of the websites did reflect the preferences in the host culture. The study of the effect of cultural aesthetic preference on interface design has been carried into a step further. Shen et al (2006) no longer tried to identify cultural markers on websites and software. She produced an application which was full of cultural markers, and expected the users would be able to associate these markers with their usability. She claimed the result was inspiriting. Because Shen's work is culturally oriented, her work is described in Section 1.4.2.

Since aesthetics is now in demand in HCI, some researchers have put effort into providing guidelines and principles. Rivlin et al., (1990) published some guidelines for Screen Design. These principles cover layout, text, graphics and interaction. Layout is relevant to aesthetic interface design, which is part of this "Harmonious interface design" research. Rivlin only provides a few guidelines for layout design. The guidelines are *Grouping items* by colour, brightness, size, shape or type style, spacing, alignment, slope, direction and speed; *Figure/Ground* to separate different kinds of information; *Emphasising Items* with distinguishable size and colour etc.; *Use Colour* sparingly and meaningfully and display the right *Quantity of Information.* At the time when Rivlin's book was published, the display technology was not as good as today, which limited the creation and implementation of screen designs. About nine years later, Ngo, Teo and Byrne's were able to list fourteen aesthetic measures for screen layout design (Ngo, et al., 2000). These measures are based on Western perspectives. The following table (Table 1-1) contains the fourteen aesthetic measures and their explanations from Ngo (2000). In Table 1-1, sample As are better than sample Bs.

Num	Name	Explanation	Sample
1	Balance	Means balancing the optical weight on the screen. Large elements are heavier than small ones. It can be achieved by making the top half the same weight as the bottom half, the left half the same weight as the right half. The left column of the sample B obviously occupies more areas than the right column, so it is less balanced than the sample A.	 A B
2	Equilibrium	The visual centre should be the same as the screen centre. The visual centre of the sample B is below the screen centre as there is a big gap on the top.	 A B
3	Symmetry	Mirror effects on both sides of any centre line. The two columns on the sample B are different, so it is not symmetrical.	 A B
4	Sequence	Providing predictable changes to the eyes. The most popular reading pattern is left-to-right, top-to-right. It is predictable on the sample A that the shapes are increasingly smaller, but not on the sample B.	 A B

5	Cohesion	The ratio of the screen design should be close to the screen's ratio. Unlike the sample A, the screen design of sample B looks like a square but its screen is a rectangle, so it is not cohesive.	 A B
6	Unity	Can be achieved by using similar sizes and same internal spacing among the group of elements. The internal spacing should be different to the outside spacing. On the sample A, since the space between the two boxes in each column is different to the outside spacing, the two boxes appear to be a group. On the sample B, each box is standing alone.	 A B
7	Proportion	People share some common senses on proportional aesthetics. These are square (1:1), square root of two (1:1.414), golden ratio (1:1.618), square root of three (1:1.732), and double square (1:2). For example: a screen design's width is 16.18 cm and its height is 10 cm (golden ratio). The sample A is in golden ratio, and the ratio of the sample B is about 1:2.6	 A B
8	Simplicity	'Simplicity in screen design is achieved by optimising the number of elements on a screen and minimising the alignment points' (Ngo, et, al., 2000: p.6) There are more alignment points on the sample B than the sample A which makes the sample B too cluttered.	 A B

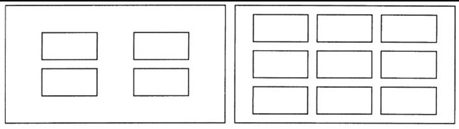
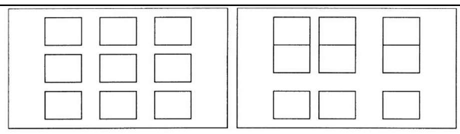
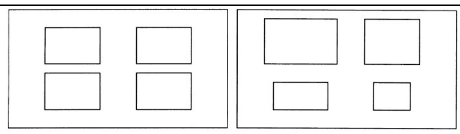
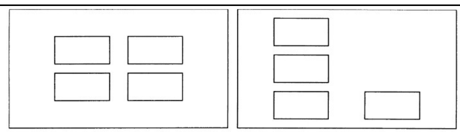
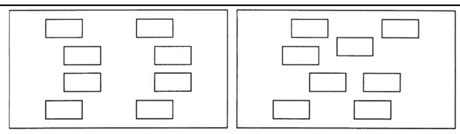
9	Density	The density of a screen design should be optimized. Too many items on the sample B, which may be too much to the eyes.	 A B
10	Regularity	Elements are uniform, based on some principles or plan. Consistent spacing and grouping of components plays the key role. This one is similar to Unity	 A B
11	Economy	Keep it simple. Using as few sizes as possible. There are four sizes on the sample B, but only one on the sample A, so the sample A is easy to read.	 A B
12	Homogeneit y	The screen design components should be evenly distributed among the four quadrants of the screen. This is close to Balance	 A B
13	Rhythm	Regular patterns of changes in the components. With rhythm, the sample A is more predictable than the sample B.	 A B
14	Order and complexity	The satisfaction of an aggregate of the above measures. If an interface can satisfy all the measurements above, it will be the most aesthetic.	

Table 1-1 Guidelines for the design of screen layouts (Ngo et al, 2000: pp.1-6)

As published, D.C.L. Ngo’s research at that moment excluded colours and shapes and only used rectangles. Two assumptions were made: ‘1. The interaction between the selected characteristics is linear; 2. All these characteristics are equally important’ (Ngo & Byrne, 2001: p.534). In their experiment, the aesthetic values of a set of real screens were calculated by the formulas of the measures and compared to the rating from the viewers. Based on the result, it was declared that the model was somewhat related to the viewers’ aesthetic perceptions.

Tractinsky (2004), together with Lavie carried out research into how people judge aesthetics on websites. They concluded from the adjectives used by the participants to describe aesthetics that the perception of aesthetics on websites consists of two dimensions: Classical Aesthetics and Expressive Aesthetics. Classical Aesthetics refers to the notions emphasising on orderly and clear design. Expressive Aesthetics is more relevant to designers' creativity and originality, e.g. sophisticated and fascinating. Lavie and Tractinsky's dimensions can be applied to all interface aesthetics. Ngo's list belongs to Classical Aesthetics. More and more aesthetics principles for layout are being added. Beaird (2007) in his book The Principles of Beautiful Web Design lists some Classical Aesthetics principles for layout. Some of them are not listed by Ngo:

- **Grid Theory** is to divide the screen into grids which will help designers to place the interface components. It is believed that the golden ratio is the most appealing division. The approximate way to achieve golden ratio is to divide a composition into thirds (Figure 1-5).

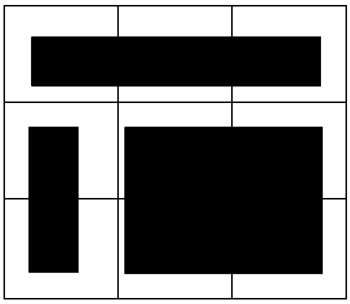


Figure 1-5 Grid Theory

- **The Rule of Thirds.** Usually Golden Ratio (1:1.62) is used as the best example of the rule of thirds. Basically, it means if two components in a row or column, one occupies one-third of the space, the other will take two-thirds.
- **Balance**
  - **Symmetrical Balance** is like mirror images on either side of the layout. This type of symmetry is named horizontal symmetry. Two other types of symmetry are available as well. Bilateral symmetry is about balancing a composition on more than one axis. Radial symmetry refers to cases "when elements are equally spaced around a central point". However, it can hardly achieve a well-balanced layout. Formal or symmetrical balance is almost always dull but it still necessary in some occasions

- **Asymmetrical Balance** contrasts with to symmetrical balance. It tends to be more visually interesting.

- **Unity** is mainly that associated items work better together when they have similar style interacting with one another, giving an impression of uniformity.
- **Proximity** refers to grouping some interface components by distinguishable spacing or layout.
- **Repetition** means if a feature such as the same background texture is carried by some interface components, these components will form a group, for example, bullet items or a menu. If a feature is repeated on each component, it will make the whole interface look united.
- **Emphasis** is making an interface component prominent.
- **Placement** is another way to deliver Emphasis by directing users' eyes with things such as an arrow:
- **Continuance** takes advantage of that fact that the eyes tend to move in the same direction once they have started, unless something dominant appears. The method of reading serves as an example.
- **Isolation** helps to create unity and emphasis. For instance, in an article, when a chuck of information indents on the left and right sides, the text and images inside the information will be regarded as serving the same purpose, whilst the breaking of the continuation lines will draw the readers' attentions.
- **Contrast** refers to elements carrying opposite attributes such as colours, sizes, shapes etc. It is a good method to deliver emphasis.
- **Proportion** is to adjust the sizes of components to attract attention.

(Beaird, 2007)

1.3 Summary of interface design

Interface Design Principles are used by designers to help them to decide what can be done to enable compatibility between designers' aims and users' aims. Universal Design Principles make an artefact/service available to a different type of person, not by adding a different version for their special needs, but by incorporating extra functionality that will make the artefact more useful for everyone. In other words, Universal Design Principles provide a resource that people can use to satisfy a wide range of user aims, such as Stone's (2005) principle of Simplicity: 'Simplicity is a design principle which emphasises the importance of keeping the UI as simple as possible' (Stone, 2005: p.170). It is not specified for any purposes like harmony in this thesis, just a general description. When Simplicity is combined with different principles, they can work as a set of principles for the purposes of improving aesthetics, readability, etc. The more goal-specified Interface Design Principles cover Accessibility, Usability and Engagement. Accessibility makes the usability and engagement as fully available as possible to the different types of people, for whom the software was designed. Usability enables people to do what the software is supposed to help them to do. Engagement makes the experience of using the software, such as a game, inspire an emotional reaction, e.g. fun or tension, learning software should bring achievement. This research focuses on engagement: covering the sense of harmony (Principles for harmonious interface).

The Interface Design principles start from a broad range (such as Stone, 2005) and narrow down to specific divisions: including usability, and accessibility etc (Such as Nielsen, 2000**;** Benyon et, al. 2005) (Appendix I), and then to more specific divisions: Layout, Font, and Colour (such as Rivlin, 1990, Cox, 1993 and Giles, 1996, Ngo, 1999 Beaird, 2007). Harmonious screen interface Design principles can be categorised to a sub-division of Layout. Figure 1-6 displays the hierarchical relationships among most User Interface Design principles.

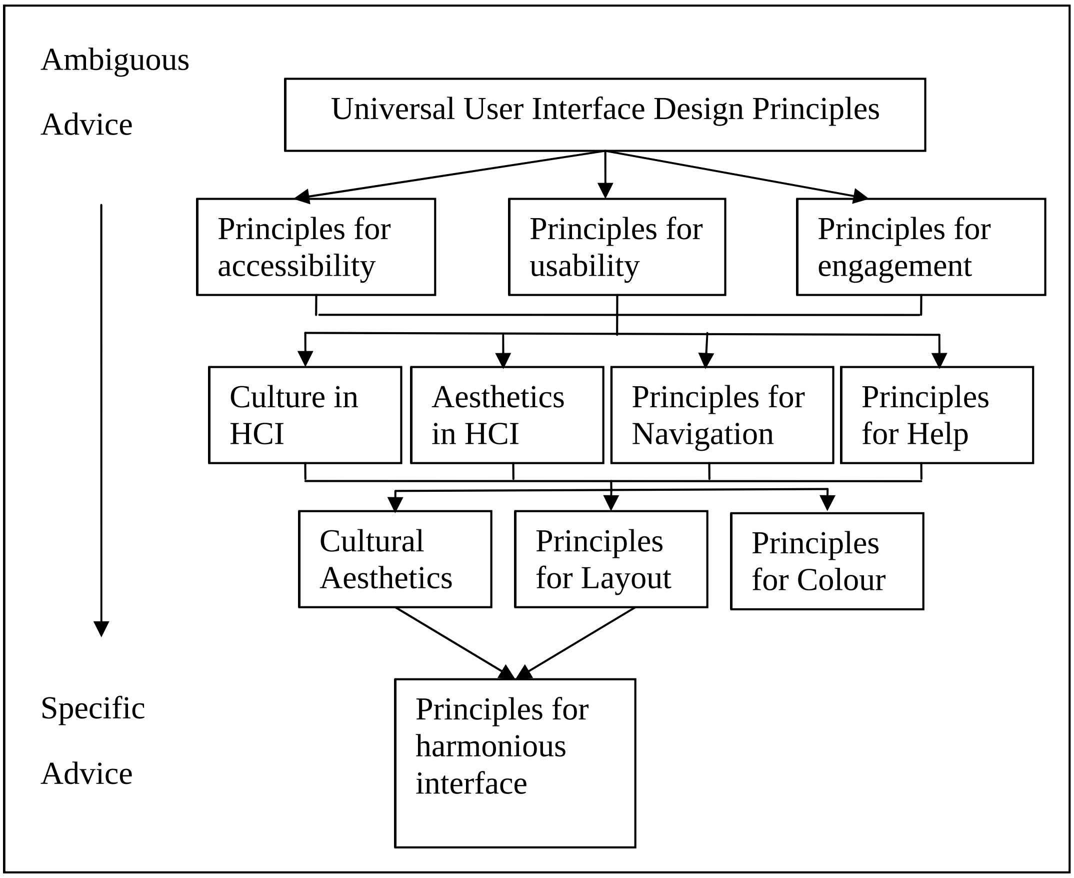


Figure 1-6 Categorising the Principles for Harmonious screen interface Design

The design principles provide designers with instructions and directions to produce good user interfaces. However, these instructions are usually not specific enough for the designer to decide exactly what to do. They are useful for experienced designers, but not for novices, since they are ambiguous. It is like asking for geographic directions: just knowing the heading is west or east is not enough for a new visitor to a city.

1.4 Recent relevant projects

1.4.1 Do Aesthetics Affect the Users' Perception of Virtual Learning Environments?

Based on the aesthetics design principles started by D.C.L Ngo et al. (2000), Parizotto-Ribeiro (2005) in his PhD research identified five of the aesthetics design principles which were more likely to work on the screen layout of a computer interface for Virtual Learning Environments. The five principles are Unity, Proportion, Homogeneity, Balance and Rhythm. In their earlier work, Parizotto-Ribeiro and Hammond (2004) applied these principles to screen layouts and produced five pairs of slides. Each pair reflected one principle. In each pair, one slide satisfied the principle and the other did not. 279 students and staff from a Higher Education Institution in Brazil (CEFET-PR) and Siemens-Brazil were divided into seven groups according to their backgrounds and participated in the evaluation. The participants were instructed to choose the one they preferred and were not allowed to change their choices. The result indicated that the screen layout designed according to the principles gained higher preference. The level of importance of each principle was in the following order: Unity = rhythm > proportion = homogeneity > balance (A>B means A is more important than B). In the later empirical study of this project, they intended to test the correlation between usability and aesthetics. Low usability (LU) was associated with delay and error messages and high usability (HU) was associated with rapid responses and a few error messages; low aesthetics (LA) meant complete violation of the five principles and high aesthetics (HA) meant full satisfaction of the five principles. The settings led to four conditions: LU-LA, LU-HA, HU-LA and HU-HA. 98 people participated in the experiment. Each participant only took part in one condition. The research environment was controlled to ensure that same facilities were provided to the participants and the participants could perform the tasks on their own. The Virtual Learning Environment prototype was a three page learning website. The website was modified to four versions according to the conditions. A questionnaire with a five levels Likert scale (an example of a five levels Likert scale: 1.Strongly disagree, 2. Disagree, 3. Neutral, 4. Agree, 5. Strongly agree) was used to collect the participants' views on usability and aesthetics. The statistical analysis indicated a positive correlation between usability and aesthetics (good layout).

1.4.2 Towards culture-centred design

Shen et al (2006) tested whether a culturally rich interface could affect the cultural group's interaction with the computer in her PhD project. She took the Chinese culture as a sample and employed some cultural markers to build an interface. These markers were from the design of Chinese gardens. Shen expected the participants could associate these markers with their usability easier than metaphor from other cultures such as those on Microsoft Windows (Figure 1-7).

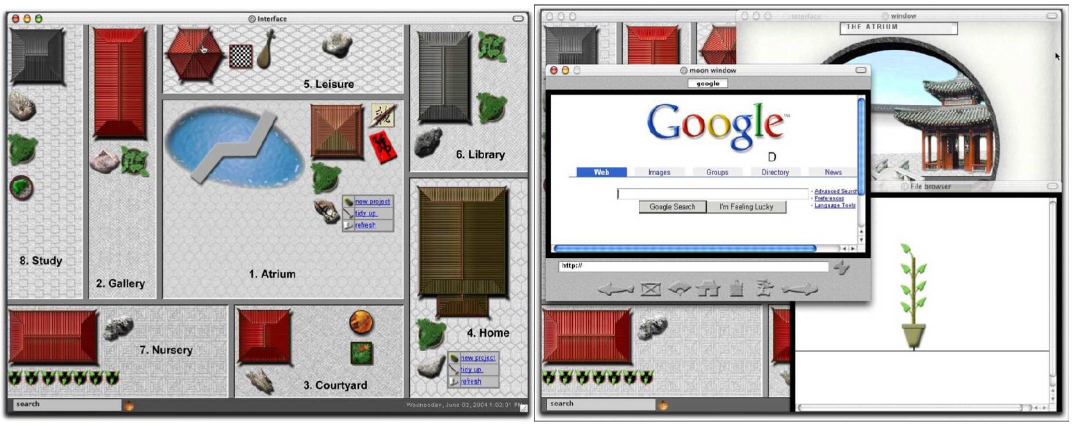


Figure 1-7 Towards culture-centred design, by (Shen et al, 2006: p.839, 842),

Shen picked the Chinese garden design as the source of cultural markers because: ‘

- The fact that the Chinese view the traditional garden as a reflection of the world around them.
- The garden and the computer could be used as a medium for relaxation and entertainment, inspiration and creation, knowledge and information, communication and socialising.
- Both the desktop and garden metaphors require spatial management and maintenance.
- The digital format has many similarities with organic cycles, with elements that grow, reduce, reproduce, die off, recycle, remain, move and relate.
- The garden metaphor applied opposites like ’natural’ versus ’artificial’ and ‘organic’ versus ‘geometric’ that can be relevant to different types of computing.
- A garden is often considered to be the doorway to a culture, so that garden design could offer insight into cultural specific design principles such as layout, styles, and aesthetics.
- The concept of a garden was highly transferable and adaptable to other cultural contexts, as the garden is present in some form or other in most cultures and periods.

’ (Shen 2006: p.833).

After selecting the cultural markers, coding the new interface in HTML, Heuristic evaluation (Nielsen, 1994) was applied, followed by user evaluation. The heuristic evaluation was to collect subjective feedback, and user evaluation was for gathering objective feedback. The initial evaluation was completed with three Chinese students from Taiwan. The modification after the initial evaluation was mainly to improve the elements that were not intuitively recognised by the users. Further study was conducted with six Chinese students from Taiwan to test the iconic recognition on the modified version. The result showed that most of the icons/cultural markers were recognisable except functions of the eight divided sectors. The user evaluation was completed with 3 user groups: 8 Chinese, 6 oriental (Japanese, Malaysian, Indonesian, Thai and South Korean) and 14 international (other cultural backgrounds). The procedure was contacting the participants by email and asking them to do the online evaluation and answer questionnaire. Additionally, 3 Chinese, 2 oriental and 3 international were invited to Shen's office to do the evaluation. According to Shen's analysis, 'the overall reaction to the user evaluation phase was remarkably positive, considering the variety of cultural backgrounds of the three groups of participants' (Shen, 2006: p.843).

Generally speaking, in Shen's experiments, the participants were satisfied with the visualisation, but it was not easy for them to identify the function behind each token. Together with other outcomes, Shen claimed that the culture-centred design did have an impact on interface usability and there was significant positive feedback for her to carry on further investigation.

1.4.3 Does the Aesthetics of the Web Page Interface Matter to Learning Mandarin?

Zain et al (2007) conducted research on the relationship between the aesthetics of Web Page Interfaces and Learning Mandarin. They developed an Aesthetics-Measurement Application (AMA) based on six aesthetic measures and formulae derived from the model created by Ngo, Teo, and Byrne (2003) and Ngo (2000). The six aesthetic measures were balance, equilibrium, symmetry, sequence, rhythm, also order and complexity. Table 1-2 shows the formulae they used to calculate these measures. The AMA implements these six formulae to compute the aesthetic value of a screen interface. The average result from the six formulas is the aesthetic value. They did the testing on a Mandarin learning website. Figure 1-8 lists the twelve (3 pages times 4 versions) web pages used in their research and the aesthetic values computed by AMA. The first group (first row) is the best and the fourth group (fourth row) is the worst. A questionnaire with 5 point Likert scales was offered to 56 students to rank the aesthetics of each group, and how the aesthetics affects learning. Their statistic test outcome indicated the AMA could be used to measure the aesthetics of web pages. However, in the students' feedback, the third group was actually rated as being more aesthetic than the second group, although the first group was still the best and the fourth group remained the worst. They interpreted this as the possibility of subjectivity and the Likert scale was too small to offer a clear distinction. Another negative outcome was that the statistical test result did not support their assumption that aesthetics could affect students' Mandarin learning. One problem in their research was that they used mean scores of the rankings from the students, but each student could assign different weight to the numbers, so using mean scores was not an accurate method.

1.Balance $Balance = 1 - \frac{\mid BalanceVer \mid + \mid BalanceHor \mid}{2} \in [0,1]$ Balance in screen design was achieved by providing an equal weight of screen elements, left and right, top, and bottom. Balance was computed as the difference between total weighting of components on each side of the horizontal and vertical axis.
2. Equilibrium $Equilibrium = 1 - \frac{\mid Equilibrium_x \mid + \mid Equilibrium_y \mid}{2} \in [0,1]$ Equilibrium on a screen was accomplished through centring the layout itself. Equilibrium was computed as the difference between the centre of mass of the displayed elements and the physical centre of the screen.
3. Symmetry $Symmetry = 1 - \frac{\mid SymmetryVer + \mid SymmetryHor \mid + \mid SymmetryRad \mid}{3} \in [0,1]$ Symmetry was axial duplication where a unit on one side of the centreline was exactly replicated on the other side. There were three types of symmetry, which were vertical symmetry, horizontal symmetry, and radial symmetry. Symmetry, by definition, was the extent to which the screen is symmetrical in three directions: vertical, horizontal, and diagonal.

4. Sequence $Sequence = 1 - \frac{\sum_{j-UL,UR,LL,LR} \lvert q_j - v_j \rvert}{8} \in [0,1]$ Sequence in design referred to the arrangement of objects in a layout in a way that facilitated the movement of the eye through the information displayed. Sequence, by definition, was a measure of how information in a display was ordered in relation to a reading pattern that was common.
5. Rhythm $Rhythm = 1 - \frac{\lvert Rhythm_x \rvert + \lvert Rhythm_r \rvert + \lvert Rhythm_{area} \rvert}{8} \in [0,1]$ Rhythm was accomplished through variation of arrangement, dimension, number, and form of the elements. The extent to which rhythm was introduced into a group a elements depends on the complexity. Rhythm, by definition, was the extent to which the objects are systematically ordered.
6. Order and Complexity $Order - Complexity = \frac{\sum_{i}^{5} Mi}{5} \in [0,1]$ The measure of order was written as the sum of the above measures for a layout. The opposite pole on the continuum was complexity. The scale created might also be considered as a scale of complexity, with extreme complexity at one end and minimal complexity (order) at the other.

Table 1-2 Six Aesthetic Measures (Zain et al, 2007: p.45)

Main Page (Group 1)

Balance	0.9445
Equilibrium	0.9991
Symmetry	0.9013
Sequence	1.0000
Rhythm	0.9085
Aesthetic value (av)	**0.9507**

Learning Page (Group 1)

Balance	0.6558
Equilibrium	0.9954
Symmetry	0.6062
Sequence	0.7500
Rhythm	0.6663
Aesthetic value (av)	**0.7347**

Exercise Page (Group 1)

Balance	0.8054
Equilibrium	0.9965
Symmetry	0.4402
Sequence	0.7500
Rhythm	0.5592
Aesthetic value (av)	**0.7103**

Main Page (Group 2)

Balance	0.9369
Equilibrium	0.9990
Symmetry	0.8234
Sequence	1.0000
Rhythm	0.8700
Aesthetic value (av)	**0.9259**

Learning Page (Group 2)

Balance	0.5784
Equilibrium	0.9945
Symmetry	0.4161
Sequence	0.7500
Rhythm	0.4917
Aesthetic value (av)	**0.6461**

Exercise Page (Group 2)

Balance	0.6911
Equilibrium	0.9932
Symmetry	0.3796
Sequence	0.7500
Rhythm	0.4331
Aesthetic value (av)	**0.6494**

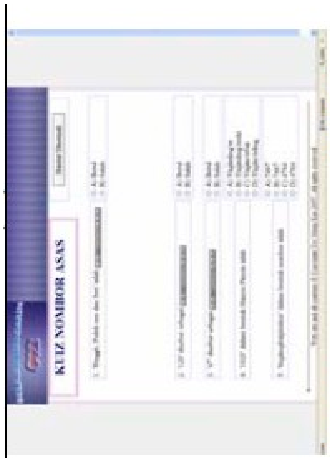
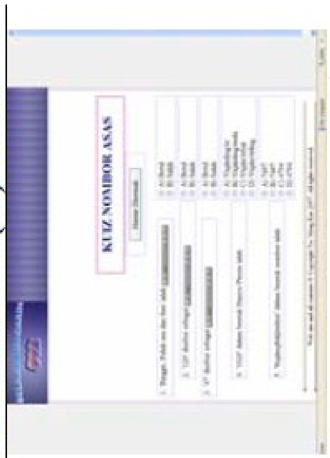
	Main Page	Learning Page	Exercise Page
Group 3			
	Balance 0.7656 Equilibrium 0.9960 Symmetry 0.4958 Sequence 0.6250 Rhythm 0.5324 **Aesthetic value (av) 0.6830**	Balance 0.5309 Equilibrium 0.9935 Symmetry 0.4555 Sequence 0.5000 Rhythm 0.4870 **Aesthetic value (av) 0.5934**	Balance 0.5944 Equilibrium 0.9913 Symmetry 0.4515 Sequence 0.5000 Rhythm 0.3459 **Aesthetic value (av) 0.5766**
Group 4			
	Balance 0.5674 Equilibrium 0.9918 Symmetry 0.2689 Sequence 0.3750 Rhythm 0.2258 **Aesthetic value (av) 0.4858**	Balance 0.5411 Equilibrium 0.9934 Symmetry 0.3399 Sequence 0.3750 Rhythm 0.3511 **Aesthetic value (av) 0.5201**	Balance 0.3296 Equilibrium 0.9859 Symmetry 0.3421 Sequence 0.5000 Rhythm 0.3134 **Aesthetic value (av) 0.4942**

Figure 1-8 Results of Aesthetic Values of Mandarin Learning Web pages (Zain et al, 2007: p.47)

1.4.4 Computing Chinese calligraphy

The research into automatically generating Chinese calligraphy started in the 1980s (Dong, 2008). It was mainly focused on image processing of calligraphic characters. ‘In most cases, the automatic generation of Chinese calligraphy can be divided into several phases: (1) shape decomposition, (2) model creation and (3) artwork generation’ (Dong, 2008: p.1277). When a user draws a line or character on the screen, the computer (model) find one from the database of the decomposed shapes, or generates the strokes based on the general features found from the stored Chinese characters. It may include the simulation of the effects of ink, paper and brush.

The method was extended to create new styles of calligraphy. Xu, et al. (2009) developed an Analogous Reasoning Process (ARP) system which can extract the strokes from some stored calligraphic characters and blend them to generate new style.

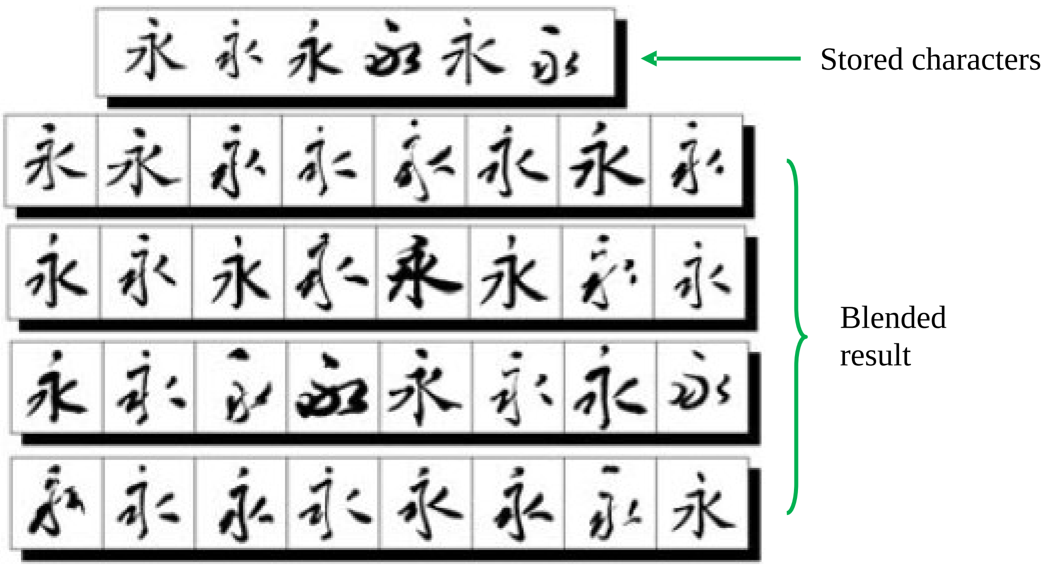


Figure 1-9 Analogous Reasoning Process by Xu, et al, (2009: p.216) – character blender

Figure 1-9 shows an example provided by Xu (2009: p.216). The six different styles of the same Chinese character 永 (forever) were inputted into the ARP. The ARP blended the styles and positions of the strokes, and then generated the character in new styles.

In contrast to Xu (2009), Dong (2008) focused on obtaining the critical features of characters and their controlling points. By manipulate the controlling points, the style of a character can be changed. Figure 1-10 and Figure 1-11 show an example from Dong (2008).

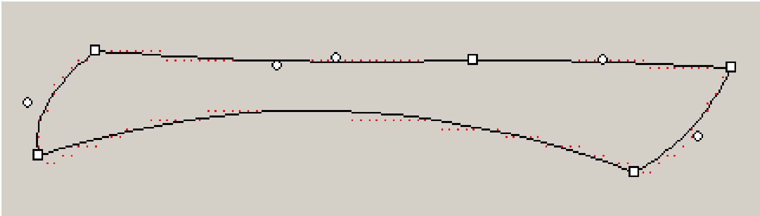


Figure 1-10 Featured and controlling points of the character 一 (one) by Dong (2008a: p.1279)

In Figure 1-10, the square dots are the featured point on the contour. The circular dots are the points that control the curve. By changing the parameters to manipulate the circular control points, the style of the character can be changed, as shown in Figure 1-11. In this example, the circled area was changed to a different shape with different parameters.

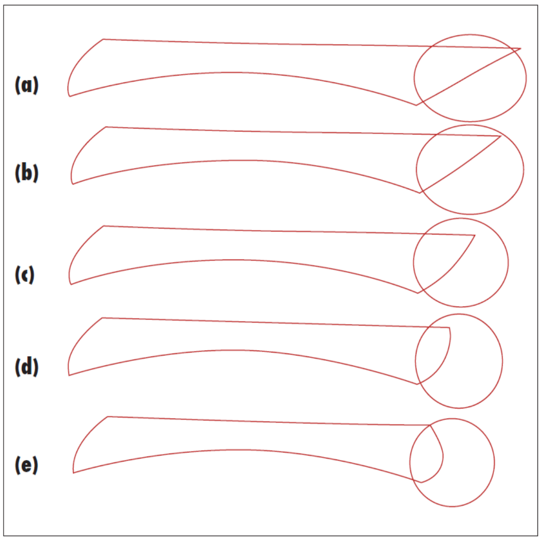


Figure 1-11 Changing the parameter to change the shape of the top-right corner of the character 一 by Dong (2008b: p.60)

So far, the research into computing Chinese characters is mainly about processing images and then re-generating images. Studies on computing the writing principles for Chinese calligraphy have not been established.

1.5 The aim of this project

The current practices for internationalisation are that designs for other cultures usually means adapting existing (Western) versions of the interface (Shen et al, 2006). The research of Harmonious Interface focuses on investigating guidelines/principles from

Chinese culture. It covers some aspects of Parizotto-Ribeiro, Shen, Zain, Dong and Xu's work. D.C.L. Ngo adapted existing guidelines which are from the West and developed mathematical measurements. Parizotto-Ribeiro and Zain were looking at aesthetics measures and computing on screen layouts based on Ngo's work. Shen transferred some cultural elements from Chinese culture to HCI, which is also one of the aims in this research. Dong Xu put effort into computing Chinese calligraphy which is the source of the principles developed in this project. However, although this research managed to develop design principles from the perspective of Chinese culture, since harmony is part of aesthetics and some aesthetic measures are universal, inevitably there will be some overlap of their projects, but harmonious Interface Design Principles have their outstanding traits.

Harmony is more likely to be abstract and subjective, nevertheless most Chinese people share a common sense of what constitutes a harmonious calligraphic character. This indicates that most Chinese regard harmony in calligraphic characters in the same way. This provides an opportunity to translate the subjective calligraphic principles into analytical and deductive ones. The new principles offer an approach to establishing screen interface harmony based on a Chinese perspective. If people from other ethnic groups perceive harmony in the same way, it may be possible to apply the principles to build harmonious screen interfaces. This was the main aim of this project.

1.6 Hypotheses

The main hypothesis was:

- Since both the main Chinese philosophies (Confucianism and Taoism) place an emphasis on harmony, the concept of harmony is embedded in Chinese artworks, such as Chinese calligraphy and painting. Although harmony is abstract, Chinese artists have summarised some principles to construct harmonious calligraphic characters and painting. These holistic Eastern design principles can be converted to Western analytical and deductive design methods.

1.7 Range of this research

HCI is a broad concept. Even Interface Design covers a large area including 2D interfaces, 3D interface (Cockburn, 2004) and colour balancing (Beaird, 2007) etc. This research focuses on 2D interfaces and on shape, space and size rather than colour.

The early part of this work was trying to identify which Chinese cultural artefacts demonstrate visual harmony. Generally a 2D interface consists of various components such as images, text blocks and menus etc. The target Chinese cultural artefact should be made up of components as well. Visual harmony carriers such as painting, calligraphy and garden design were considered. Chinese painting was excluded because the harmony in paintings involves so much intuition on the part of the painter and the observer. Garden design was also removed from the list as it is three dimensional.

There were many questions seeking answers for the reason of building a harmonious screen interface. For example: What are the benefits of a harmonious screen interface? Would a harmonious screen interface be easier to use? Would it improve the user performance? As stated above, the research mainly was to adapt holistic design principles from Chinese calligraphy and convert them into analytical and deductive principles. Therefore, most effort was put into isolating the quantifiable features in Chinese calligraphy. All the questions regarding usability will be answered in the further work.

1.8 Contributions

There are three main contributions in this research:

1. A set of fully deductive and computable principles for Chinese Regular Script Calligraphy was developed.

2. The new set of principles for Chinese Regular Script Calligraphy was converted into interface design principles for harmonious interface design, with the features of full deduction and computability.

3. An application was developed based on the principles. It can aid the development of skills on Chinese Regular Script Calligraphy and the construction of harmonious interface design.

Since Chinese Regular Script Calligraphy was created by Zhong, You (锺繇 151-230), many calligraphers put effect to summarise the features which lead to general acceptance of the elegance in Chinese Regular Script Calligraphy. Based on the features they found, many sets of principles were developed for calligraphic novices to master the features. The numbers of these principles range from a few, such as Guo's (1995) five principles, to nearly one hundred, such as Ziyuan's (1837-1918) ninety two principles (Zou, 2008). However, the features that these principles are going to achieve are difficult to measure. Words like "stable", "balanced" and "organise white space like strokes" are used to describe the features, or brief summaries of deferent structures of the characters are given, but no specific measurements provided for these features. That is to say, only those people who interpret these words in the same way as those calligraphy masters can benefit from the principles. The author of this thesis managed to mathematically discover some key concepts in Chinese Regular Script Calligraphy, which makes the measurements of the features possible. Based on the new discoveries, a set of fully deductive and computable principles for Chinese Regular Script Calligraphy was developed.

This research managed to bring benefit from Chinese culture to interface design as well. The translation of holistic Eastern calligraphic principles into Western analytical and deductive engineering design methods enables Western designers to arrive at harmonious screen interface design from the perspective of Chinese culture. It is easier to perceive a structured Layout (Stone, 2005). Harmonious screen interface design principles aim to building a well structured layout, but without the monotony of unity and balance which are the key words in the Western concept of harmony (Boyle 1997, Book 1987, Dissanayake 1995), by embedding the Chinese concept of harmony: "Harmonious yet different" (Hu, 1991) into the principles.

The developed application calculates how much a Chinese regular script calligraphic character satisfies each principle, how much an interface, both graphical and normal structure (consist of rectangle components), is harmonious. The application is expected to shorten the time spent on learning Chinese regular script calligraphy and constructing harmonious interfaces.

1.9 Thesis structure

Below is a brief introduction of each chapter:

Chapter 1. explains what area this project belongs to and what was expected. Literature reviews are included to justify the goal of this project.

Chapter 2. provides literature reviews to justify why Chinese calligraphy was chosen as the source for quantifying harmony. The harmonies in China and the West were compared as well.

Chapter 3. summarises the research methods applied in this project.

Chapter 4. justifies why the “Zheng” style (regular script) was selected from Chinese calligraphy and why Guo’s (2005) five principles were selected for translation. The first version of harmonious interface design principles was developed in this chapter and the clarified and ambiguous points were summarised

Chapter 5. presents four studies with participants. The first study provided feedback to analyse the clarified and ambiguous points from the first translation and then refine the principles. The second study tried to answer the questions left from the previous study and then refine the principles, same as the other two studies. The second version of the new principles was developed in this chapter.

Chapter 6. discusses the test of the second version with Chinese calligraphy. All ambiguous points were clarified in this chapter so a set of fully deductive and computable Chinese regular calligraphic principles was produced.

Chapter 7. discusses how the fully deductive and computable calligraphic principles can be adapted for the third version of harmonious interface design principle. Examples were given.

Chapter 8. discusses how the value of each principle and the Harmony Value are calculated, after developing the “Harmony” application.

Chapter 9. is about testing the third version of principles with the “Harmony” application.

Chapter 10. concludes the contributions and gives recommendations for further work.

Chapter 2. Harmony in China and the West

2.1 Harmony in Chinese culture

Confucianism is the dominant philosophy in Chinese culture. Confucius (551 – 479 BC) emphasized education and human relationships. The core of Confucianism is justice and humanity. He advocated the virtues of filial piety, kindness, loyalty etc and knowledge to build up a harmonious society (Yao, 2000, Pang, 2000). In the era of slavery, when education was only available to nobles, in the West, Aristotle (384 - 322 BC) claimed that the state should offer public education to the slaves. Confucius also put forward that everyone should have the right to receive education. Well-educated people should join the government to ensure justice and humanity in society. Among the educations, moral development was the most important one. He believed that society should focus on moral development rather than impose strict laws on citizens, and moral behaviours can be guided by a set of etiquettes. Confucianism encourages everyone to use their initiative and participate in building society. "Harmonious yet different" is one of Confucius' famous teachings. The initial idea of Confucius is that gentlemen respect each other, though holding different ideas and aims, never impose their beliefs on other people, finally they find a mutually beneficial solution; unlike the immoral people, who look like friends when there is a benefit to share, but secretly try to get as much as they can by all means. In the same era, another important philosopher who held different views from Confucius was *Hanfei Zi*. He was the main representative of the Legalist School. Different from modern law, Hanfei Zi's Legalist School beliefs aimed to protect authority rather than the citizen. Later, Confucianism split into two branches. These were led by *Meng Zi* (372 – 289 BC) and *Xun Zi* (313-230 BC). Meng Zi developed Confucius's idea on humanity. He asserts that human beings are born with humanity, but they can be misled and become immoral, and education is the most important method to ensure their humanity. One of Meng Zi's main claims was that citizens are the most important, then the country and finally the king. In contrast, Xun Zi claims that human beings are born as "devils". They should be guided by etiquettes and ruled by laws. Meng Zi's thoughts became the main stream since the Han dynasty (202BC – 220 AD). It has to be mentioned that Legalist School thoughts were employed as well behind Confucianism, in the service of the authorities. In the Shong dynasty (960 -

1279), established after a long period of chaos in China, the Confucians over stressed etiquettes in order to rebuild the order of the society. During that period, Cheng Ha, Cheng Yi and Zhu Xi absorbed some ideas from Taoism and Buddhism to ensure that the leading position of Confucianism would not be overtaken by Taoism and Buddhism. This is called Neo-Confucianism. Its emphasis on etiquettes and its dominant position resulted in Confucianism losing its creativeness and the etiquettes becoming doctrines. In the Qing dynasty (1636 - 1912), as China was controlled by an ethnic minority group, with the fear of being overthrown by the majority Han Chinese, they further removed the "harmony" aspects from Confucianism and promoted the hierarchical order of etiquette in Neo-Confucianism. In other words, the original Confucianism placed humanity before any etiquette, but in the Qing dynasty, the doctrines of etiquette were compulsory. For example, in the Confucian hierarchical order, the upper level and the lower level should be based on mutual respect: before the Qing dynasty, the Confucian ministers' jobs were to serve and criticize the emperor, although constrained by the fact that this freedom of criticism was given by the emperor. In the Qing dynasty, their priority was to obey the emperor's order.

Figure 2-1 "Life and works of Confucius" by Prospero Intorcetta 1687

The first person to introduced Confucianism to the Europe was Michele Ruggieri in 1588. Prospero Intorcetta also published a book about Confucianism in Latin in 1687 (Figure 2-1).

Throughout the Chinese history, Confucianism gradually failed to fulfil its original aims and became a tool of the ruling authorities. After the Qing dynasty, Confucianism was seriously attacked because of its etiquette doctrines and was treated as one of the causes of China's weakness. Confucianism also carried the blame for the Legalist School. This was because the feudal authorities filtered the etiquettes by selecting those that benefit their power and enforcing them by strict laws. The “Cultural Revolution” (1966-1976) nearly destroyed Confucianism, together with the traditional morality. Consequently, a lot of Chinese these days are improvident and money-oriented. As the demand for re-establishment of morality is becoming increasingly important, some Chinese people have started to redeem Confucianism based on its original aims. Although the future of Confucianism still remains unknown, its influence on Chinese art cannot be ignored. On the issue of harmony in art, the idea of “Harmonious yet different” has been clearly conveyed by Chinese paintings, gardens and calligraphy.

Taoism is another important Chinese philosophy. It was established by *Lao Zi* (571BC - Unknown). He was one of Confucius’ teachers. He put forward the concept of Tao. Tao means the 'Way' or 'Order of Nature'. It is the hidden rules of all existence. Therefore, it is a naturalist approach to human existence. The idea is that the human is part of nature, so all human activities should follow the Tao and merge into the nature. If Confucianism is an active view of life, then Taoism is a passive one. In other words, obeying the rules leads to prosperity; disobeying the rules leads to decline. Tao changes when the relevant attributes change. Taoism proposed the concept of 'Yin' and ‘Yang’. ‘Yin’ and ‘Yang’ are believed to be two fundamental forces in the universe. Their balance affects harmony everywhere, for instance, Man versus Woman; Hot versus Cold (Rawson & Legeza 1973). Lao Zi held the same opinion as Aristotle that the initial universe was a chaos, which was named as “Nothing” by Lao Zi. Following the Tao, the first object appeared, then split into two, and the two carried on with further splits under the Tao, finally arriving at today’s prosperity. The notion of “Nothing” has a great impact on Chinese people’s behaviours. In academic terms, it means the potential of everything. In social life, it is the source of calm and coolness. For instance, in Confucianism, respect is the key to minimize the conflicts in discussion and arrive at “Harmonious yet different”; in Taoism, all this discussion and conflict is actually not there (from “Nothing”), it is good if the discussion can solve problems, otherwise there is no point in raising anger because it is actually “Nothing”.

The Taoist perception of the real world differs essentially from the Western reductionist view. Western reductionism carefully divides everything into categories, (for example: being and not-being) assuming that the whole world is made up of solid building-bricks in many different unchangeable shapes and sizes. Taoism views this approach as problematical because it isolates components and loses sight of the relationships between them. There is a rule (Tao) guiding each interaction and change. The ideal Taoist should use all his senses and faculties to intuit the rule in order to completely harmonize himself / herself with the surroundings (Rawson & Legeza, 1973). ‘For in Taoist art, as in Taoist life with its yoga, the aim is harmony: harmony between the components of the dialectic situation, leading to harmony between each man and his turbulent universe, and an ultimate tranquillity’ (Rawson & Legeza, 1973: p.12).

In the Han dynasty (202BC – 220 AD), Taoism became the second philosophy to Confucianism. The Taoist thoughts were adapted by a Chinese religion created by *Zhang Ling* (34 – 156). After that, the Tao religion started to spread in China and people always mix up Taoism and Tao religion.

During the “Cultural Revolution” in China, Taoism was criticized because of its passive view of human activities and Tao religion’s superstition. Taoism faced the same fate as Confucianism. Nevertheless, Chinese culture is deeply embraced with Taoism.

Confucian and Taoist aesthetic concepts are both about balancing man-made art and natural beauty. The difference is the Confucian focus on man-made art and the Taoist places an emphasis on natural beauty. ‘However, Confucian aesthetic thought focused primarily on ethics and morals, while the philosophy of Lao Zi and Zhuang Zi had its major impact on beauty in art’ (Hu, 1991: p.12). Zhuang Zi was an important Taoist philosopher after Lao Zi.

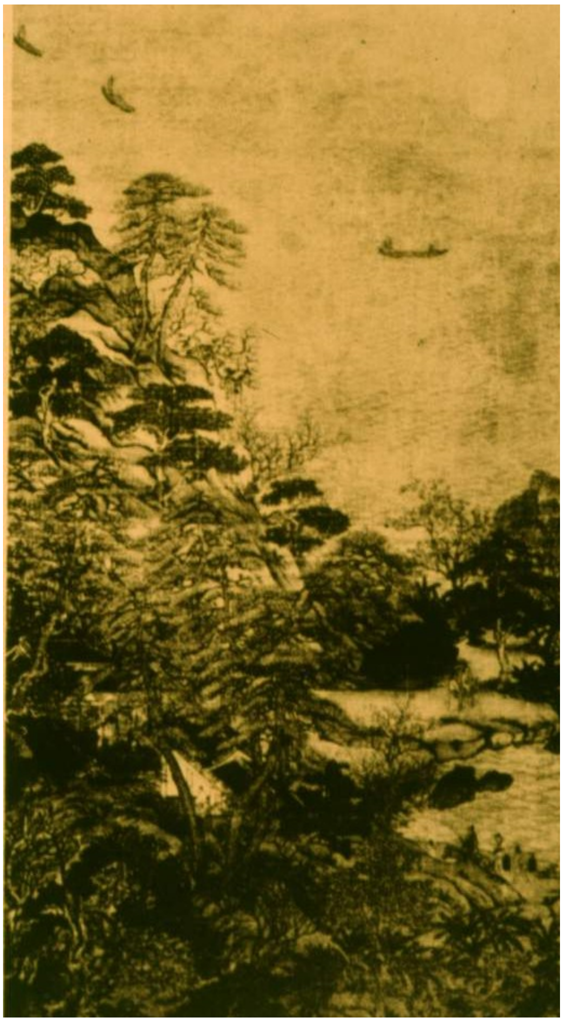
In summary, the harmony in Chinese culture does not mean ideological homogeneity or homogenization. It refers to the harmony within a person (such as the understanding and control of emotions), also in the relationships between two people, between people and the society and between the humanity and the cosmos (Jia, 2008).

2.2 Chinese art

Chinese art is a reflection of Chinese people’s perception of nature. Chinese artists will convert their holistic comprehension of their surroundings into their art and crafts. In

Chinese art history, the main subjects of art moved from one domain to another. For example, in Tang dynasty, human beings were the centre of the art creativities; in Song and Yuan dynasties, it was mountains and water; in Ming and Qing dynasties, flowers and plants were the domain. Although the focal points were different in different period and new art skills were developed, the styles were more stable than the Western. It is due to "Harmony", the major theme in Chinese philosophies, religions and aesthetics. (Rawson & Legeza, 1973; Yao, 2000). The styles were not changed dramatically in order to retain the harmony. On the other hand, some people argue that "Harmony" slows down the creativity in art (Zhang, 2005). Chinese painting, calligraphy and garden design all carry the idea of harmony.

2.2.1 Harmony in Chinese painting



He Xie, of the sixth century, lists six points to consider in painting: '

1. The circulation of the Ch'i (Breath, Spirit, Vital Force of Heaven) produces movement of life. (in Tregear's (1997) translation, this point is interpreted as Spirit Resonance, vitality - 'Spirit' here seems to denote symphony of the scene, which is to be transmitted from the artist through the brush into his work).

2. Brush creates structure.

3. According to the object draw its form.

4. According to the nature of the object apply colour.

Figure 2-2 A painting from Tang Dynasty, 1100 years ago

5. Organise composition with the elements in their proper places.

6. In copying, seek to pass on the essence of the master's brush and methods

' (Sze, 1956: p.19)

Among the six points, the first point is the most important one. Influenced by the culture of harmony, Chinese painters also try to embed the idea of harmony in spirit resonance. The harmony in painting is more subjective. Before producing a piece of art, Chinese artists have to meditate on the soul of their subject, erase their own delusions of the objects they are going to draw, to poetize, in order to produce a harmonious picture (Barnhill, 2004). Unlike Western oil painting, Chinese painters will not simply draw the subject as accurately as they could. On some aspects, it is similar with impressionism: Chinese painting is not just a picture of an immediate visual impression produced by scenes. However, the idea is usually delivered by organising the white space rather than using interlaced colours. The painters' task is to grasp the spirit of they have seen and present it on paper to the viewers (Wang, 1996). Therefore, not everything in a Chinese painting follows the natural perspective and dimensions. The purpose of this was to recreate the experience for the audience (Wang, 1996). The painting in Figure 2-2 does not follow the rule of perspective, as the boats should not be in the "sky" from this angle, but it gives people the overview of the scene and human activities. On the painting, the human activities are so subtle from a distance and follow the flow of the river, the shape of the mountain, which expresses the concept of harmony between mankind and surroundings.

“The six honourable gentlemen” By Ni, Zhang (倪瓒) 1301-1374

By Zhao, Wenyu 赵蕴玉 1916-2003

Figure 2-3 “The six honourable gentlemen” By Ni, Zhang (倪瓒) 1301-1374

Because painters embed a lot of subjective creativities into their paintings, the paintings are no longer simply presenting the scenery. It is more about sharing the spiritual and romantic experience between the painter and the audience. In some ways, it is like a poem. In this case, many Chinese paintings are not just a picture; they are usually accompanied with a poem (Wang, 1996). For example, on the paintings by Zhang Ni

(1301-1374) and Wenyu Zhao (1916-2003), the Chinese characters are some poems which describe the same spirit resonance of the paintings (Figure 2-3).

Personalities are associated with natural objects in Confucianism, which can be found in all Chinese art. In “The six honourable gentlemen” by Ni (1301-1374) (Figure 2-3), the six straight trees standing in the endless desolation reflect honest and fearless personalities.

An important philosophical thought in Taoism is the Yin-Yang (negative-positive) dualism. It is believed in Taoism that all attributes are in pairs and they are both contradictory and complementary, for example, darkness vs brightness, life vs death and stillness vs motion. They are against each other while depending on one another, for example, darkness is opposite to brightness, but without darkness, brightness means nothing. The most harmonious painting should present the two sides of each attribute at the same time. This dualism is embodied on the three paintings in Figure 2-2 and

Figure 2-3 Figure 2-3. On the painting from the Tang Dynasty (Figure 2-2), cluster vs emptiness, still vs motion, order vs disorder, highness vs lowness and simplicity vs complexity. In “The six honourable gentlemen” by Ni, it is mainly Life vs death and Hope vs Desperateness. In the painting by Zhao, it is Still vs Motion, Object vs Emptiness and Cold colours vs Warm colours (Figure 2-3).

No matter the spirit, personalities or dualism in Chinese painting, all these rules are either too various or too difficult to measure, which makes it difficult to quantify them into useful screen interface design principles.

2.2.2 Harmony in the Chinese garden

As the two basic philosophies in Chinese culture, Confucianism and Taoism exert their influence on Chinese garden design as well.

> ‘Over time, Taoism and Confucianism blended to form China’s traditional aesthetic view of natural beauty which became the basis for the design and construction of Chinese gardens. A major principle used in creating a traditional Chinese garden was that it should harmonize

with nature, that the man-made and natural scenes should blend together'.

(Hu, 1991: p.9)

In a Chinese garden, the designer will try to use objects with the most natural forms as much as they possibly can. All man-made arts should be elaborately hidden in the scenery (Figure 2-4).

Taoist Yin-Yang dualism can be found in Chinese gardens as well. In Chinese garden, strong, hard and rough rocks are usually placed with weak, soft and beautiful flowers; tall, solid, monochrome stone crafts are put next to a pond which carries the opposite attributes to the stone crafts, and so on.

Figure 2-4 Examples of Chinese Gardens

'Taoists believed that all sizes were relative…[so] the comparative nature of size is also an important principle in the construction of Chinese gardens' (Hu 1991: p.16). For instance, a lake is big, but small when compared to a sea. A well-designed Chinese garden should not only offer people elegant scenery from a distance, but there should be more to discover when you walk through the garden. 'Upon entering the garden, the viewer sees the scenery continually unfolding before him instead of taking in everything at a glance' (Hu 1991: p.16).

Hu (1991) also points out the Confucian values "harmonious yet different" and "etiquette and order" are practiced in garden design. The phrase "harmonious yet different" initially means that in human society, although everyone's behaviours and perspectives are different, as long as people respect each other, social harmony can be achieved. Confucianists believe that proper “etiquette and order” can reduce people’s friction and conflicts and so facilitate social harmony. A concert is a good example of this thought. In a concert, each musical instrument has a chance to generate its unique sound. Ordered by the composition, they produce beautiful rhythm and form a great symphony. It will be just a piece of noise if every instrument is played freely. In garden design, Chinese gardens contain various objects which are carefully arranged according to an order, so each element can show its traits but does not dominate the scenery. Whatever you pick up in the garden, it will gradually lead you to another scenic object as the hidden order is guiding you (Figure 2-5).

Figure 2-5 An Example of Chinese garden

The garden objects are also associated with personalities. For instance, bamboos together with rocks are usual used to deliver the meaning of strong, fearless and justice.

Figure 2-6 Examples of Western Gardens

General speaking, traditional Western designs tend to be more extrinsic, well-designed with clear layout, offering the whole scenery at a glance. Usually there is a prominent feature placed at the middle (Figure 2-6). The man-made art is apparent in Western gardens. A Chinese garden looks like a part of nature at first glance. The closer you look at the garden, the more artist creativities you can find. The principle behind was ‘though built by man, it appears to come from nature’ (Hu, 1991: p.10), which derives from the Taoist philosophy: all human creativities should follow the rule of nature. In contrast, Western classical garden designers will clip trees and bushes into various shapes to create green sculpture (Hu, 1991).

Same as the Chinese painting, the rules for the Chinese garden design are difficult to quantify for screen interface design.

2.2.3 Harmony in Chinese calligraphy

Chinese calligraphy is at the top of the hierarchy in Chinese art. In Chinese tradition, many Chinese political leaders are also calligraphers (King, 1999). First of all, there are many scripts in Chinese calligraphy, but there is only one basic script that each novice calligrapher has to practice first: the Regular Script (Zheng style). Zheng in Chinese means the model of calligraphy. The Regular Script is enriched to convey the Chinese concept of harmony.

The ancient Chinese believed that the sky/universe was round, the earth was square, and human activities took place under the sky and on the earth (Wu, 2006). The pattern used in Chinese calligraphy practice represents the Chinese ancient interpretation of the universe. The pattern in Figure 2-7 contains the square as the “earth” and the circle as the “sky/universe”. This pattern has been used in some cases for calligraphy novices in China to position the characters, and guide writing strokes.

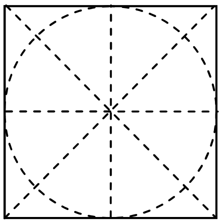


Figure 2-7 The pattern used in Chinese calligraphy.

Based on the Chinese philosophies, as human beings are a part of nature, a harmonious human activity should not break the constraints of nature. Reflected in Chinese calligraphy, all the strokes should be elaborated to follow the constraints of the “sky” and the “earth”. Table 2-1 displays some examples of Chinese characters in regular script within the pattern.

一	二	三	四	五	六	七
One	Two	Three	Four	Five	Six	Seven
八	九	十	百	千	萬	億
Eight	Nine	Ten	Hundred	Thousand	10,000	10,000,000
兆	我	你	她	他		
10,000,000,000,000	I	You	She	He		

Table 2-1 Some example of Chinese regular script calligraphy

Confucius’s idea of “Harmonious yet different” is also reflected in the Calligraphy. Each character consists of a few strokes. Each stroke has different size and shape and its position can be anywhere. There is no need to make each stroke the same size and shape, or produce a symmetrical effect to achieve harmony. An appropriate arrangement of the strokes will produce an elegant character.

As the pattern  is used to guide novice calligraphers practicing calligraphy, and adapted in this research to judge the satisfaction of the principles, it is named Judgement Lines in this thesis. A more detailed introduction to Chinese calligraphy is available in Chapter 3.

Compared to Chinese painting and garden design, it is easier to translate the Chinese calligraphic principles into screen design principles, as screen design and Chinese calligraphy share some common features, for instance, most screen design are two dimensional, which is the same as the Chinese characters; a screen design consists of many components and a Chinese characters is built with many strokes.

2.3 Harmony in Western culture

In Western visual art, harmony is primarily conceptualized ‘as an aesthetic state with an ideal form from a rational and mathematical point of view’ (Jia, 2008: p.25). Based on the The English Dictionary for Advanced Learners, ‘harmony of something is the way in which its parts are combined, so that when you look at the whole arrangement you feel that it is elegant’ (Sinclair, 2001: p.716). This is a general definition and not specified enough. The question is: what are the elements in the Western concept of harmony? Boyle (1997) gives another definition of harmony in terms of multimedia design, ‘harmony refers to how all the parts of the system fit together. Harmony is closely tied in with building and maintaining expectancies. The basic layout of the main components should be consistent across screens. The deeper basis for this consistency is conceptual design’ (Boyle, 1997: p.125). Boyle’s definition of “harmony” is a kind of explanation of “unity”. Stout (2000) believes unity and harmony are alike. She declares that ‘When things look right together, you have created unity or harmony’ (Stout, 2000: p.3) In Beaird’s (2007) explanation of unity, unity is mainly that the associated items are better to have similar style interacting with one another, so they give people an impression of working as a whole (Beaird, 2007). Boyle’s definition of harmony can be interpreted as all the parts of the system fit together in a style, and the style should be consistent. Actually, when Western scholars mention harmony, usually it comes with two other words “balance” and “unity”. For instance: Boyle states that ‘an aesthetic effect of balancing the screen and keeping the sequence of screens in visual harmony’ (Boyle, 1997: p.125). Book (1987), when introducing headings and lines of text to various shapes, expresses that ‘at this stage you may wish to run the text around the contours of your shape or shapes, merging them with harmonious unity’ (Book, 1987: p.42). Dissanayake (1995) asserts that the evolution of art is similar to human evolution, ‘the development of behavioral means to promote cooperation, harmony, and unity between and among individual members of a group has been every bit as important as the development of aggression and competitiveness' (Dissanayake, 1995: p.12). That is to say, balance and unity are the elements in Western harmony. This harmony can be easily identified in the arts from the medieval period.

2.4 Summary

Harmony exists in both Western and Chinese cultures. In Western art, harmony is mainly an aesthetic state. It is a combination of balance, unity and consistency. Harmony is a major theme in Chinese philosophies, religions and aesthetics (Rawson & Legeza, 1973; Yao, 2000). The harmony concept fostered by Chinese culture contains more values. The Chinese harmony covers the relationships between human beings and the universe, human beings and human societies, human beings and human beings, and within the mind of each human being. Every natural, man-made object can be a metaphor of a human character (Jia, 2008). This is reflected in the research result (Section 6.5). Although the concept of harmony in both cultures is not exactly the same, at least the idea of avoiding conflicts is shared.

In Chinese culture, Chinese painting, calligraphy and garden design all carry the idea of harmony. Chinese painting and garden design are both varied, multi-dimensional and complex. So it is more difficult to identify and translate their hidden design principles than for Chinese calligraphy. For Chinese calligraphy, the only need is to focus on the harmony between a series of strokes. Also, like a screen interface, all calligraphic strokes are arranged in a square/rectangle to make up a character. Therefore, Chinese calligraphy was chosen as the best source of information on creating harmony on the screen interface design.

Chapter 3. Methodology

HCI is a multidisciplinary field which borrows techniques from many domains. Mackay (1997) produced a diagram (Figure 3-1) to illustrate the phenomenon of multidisciplinarity in HCI.

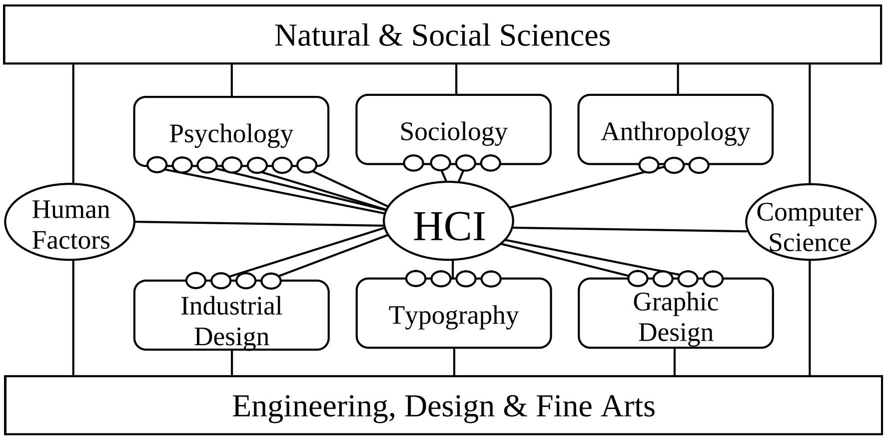


Figure 3-1 HCI is a multidisciplinary field that draws from both scientific and design disciplines (Mackay 1997: p.225)

This diagram is not exhaustive as denoted by Mackay, 'but rather to illustrate why HCI is neither a scientific nor a design discipline, but actively incorporates aspects of both' (Mackay 1997: p.225). In the same way that Mackay described, the research of this thesis also involves several research frames, which are positivist empirical research in the physical sciences, interpretative research in the human sciences (social sciences and humanities), and exploratory design research by cyclic prototyping.

3.1 Positivist empirical research

3.1.1 What is positivist empirical research

Positivism is a traditional research method in physical sciences. The core is 'mathematical logic contains enough power and precision to allow us to capture and express in a useful and understandable way the most important causal and explanatory relationships that occur out in the real world' (Klee, 1997: p.30). In positivist empirical research, knowledge is gained by using scientific methods. Statistical and mathematical methods are commonly applied to gather (usually) quantitative data, which are used to prove or disprove a hypothesis generated at the beginning of a research. It is a rigorous, objective and deductive method to discover the causes and effects of a phenomenon (Kane, 2001).

According to Mackay (1997), the cycle of deductive method will go through the following procedures:

1. A specific prediction about the behaviour of a phenomenon is generated in the form of a hypothesis.
2. Experiments, usually in a laboratory, are conducted to test the hypothesis by manipulating a set of independent variables, whilst eliminated or systematically varying other factors through control conditions.
3. Measures and analyse the results to revise the hypothesis
4. More precise and controlled experiments are conducted to test the revised hypothesis.

If the result of the deductive research does not support the hypothesis, the hypothesis may be either discarded or modified (Martella et al, 1999).

3.1.2 Where positivist empirical research is used in HCI

In HCI, empirical research is one of the most powerful methods of evaluating a design hypothesis. In terms of the selection of participants, they should be closely matched to the expected user population (Dix et al, 2004). However, doing experiments in HCI is not easy, as the data from the humans is often quantitative. Therefore, experiments in HCI usually address specific aspects of design. Two basic approaches are used in HCI experiments: compare the performance between a new system and an existing one (comparative experiments), or a new system is tested alone (absolute experiments) (Faulkner, 1998). ‘The important feature of experimental studies is that the investigator can manipulate a number of factors associated with the design and study the effect on various aspects of user performance’ (Preece et al, 1994: p.642). As with other empirical researches, those in HCI require testable hypotheses and statistical analysis.

3.2 Interpretative research

3.2.1 What is interpretative research

Interpretative research is commonly used in psychology and social sciences in which it is defined as follows: ‘Interpretive research does not predefine dependent or independent variables, does not set out to test hypotheses, but aims to produce an understanding of the social context of the phenomenon and the process whereby the phenomenon influences and is influenced by the social context’ (Rowlands, 2005: p.82). That is to say, the role of a researcher in interpretive research is to interpret and (re)construct the reality by accessing the meanings which participants assign to the phenomenon (Breakwell et al, 2006). ‘Interpretive research is inductive, leading to constructs, hypotheses, and theory’ (Miller 2004: p.117).

Mackay (1997) also lists the procedures for doing inductive research:

1. Phenomena in the real world are observed without a preconceived target.
2. Attempts will be made to describe the phenomenon in a framework or model.
3. Based on the emerged questions, further specific observations are made to evaluate the validation of the original framework
4. Based on the result, a modified framework is developed.

New theories are developed after supporting data have been collected systematically (Martella et al, 1999). Inductive research can be applied to construct theories and hypotheses from data. However, it has the disadvantage of constructing the theories and hypotheses from limited data. Once a hypothesis is available, empirical research can be carried out to validate it (Martella et al, 1999). In contrast to positivist research, interpretative research is a way to discover new knowledge.

3.2.2 Where interpretative research is used in HCI

In general, interpretative research in HCI is established based on the same concept but especially for understanding the users’ activities with a system. Interpretative research is particularly useful for feasibility studies, designing feedback and post-implementation reviews (Preece et al, 1994). Preece (1994) lists three evaluation methods for interpretative research in HCI:

1. Contextual inquiry: a system is run by users or collaboratively with researchers in the normal working environment of the user. Interviews and discussions are recorded for later re-examination.
2. Cooperative and participative evaluation: users and researchers work together to develop a prototype/product. During the development, evaluation tasks are identified by researchers, and comments and suggestions will be given by the users.
3. Ethnography: researchers are immersed in the culture of a research target to gain insight about what to investigate. For example, to develop an online shopping system, a researcher will become a sophisticated online buyer first. Otherwise, intensive observation and in-depth interviewing is needed.

3.3 Exploratory design research

Exploratory research is useful to clarify ambiguities in a project. It is 'an iterative and flexible one that seeks new information and ideas' (Dawson, 2009: p.24). Prototyping is an effective iterative development method to explore the requirements of a system with users and the technical feasibility of a system (Dawson, 2009). Dawson (2009) lists two approaches of prototyping: throw-away prototyping and evolutionary prototyping. Throw-away prototyping is a way that some aspects of a system are simulated by convenient applications. For example, quick screen design using a drawing package, and a simple version of a website to demonstrate and evaluate the functions. The advantage of it is that a tangible product that can be used to test, demonstrate, evaluate, and compare with other products. Its disadvantages include the unsophisticated "look and feel", and limited or no technical capability. Evolutionary prototyping starts with an initial specification for a system. Process is systemically and logically designed and followed, as the work is not planned to be "thrown away". The changes help the system to evolve into a better one. The evolutionary prototyping has the same advantages and disadvantages as throw-away prototyping, especially at the start, except that most efforts can be saved.

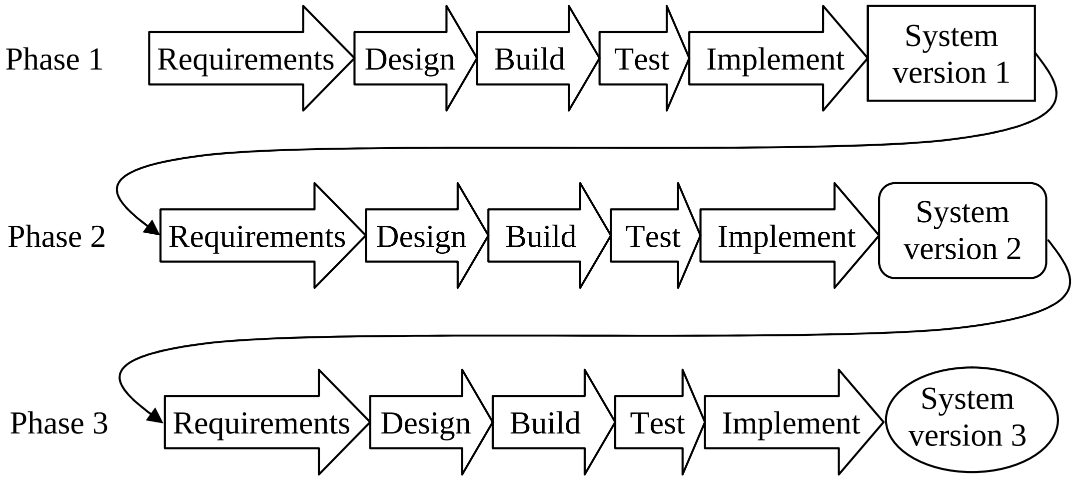


Figure 3-2 The evolutionary prototyping model (Dawson, 2009:127)

The cycle of the evolutionary process is illustrated in Figure 3-2. As Dawson (2009) explains, after the first prototype is developed, feedback is gathered in each phase to readdress and adjust the requirements, which leads to the improvement of the prototype each time. Finally, a satisfying system can be developed. The problem of evolutionary prototyping is that it 'tends to encourage designers to "fix" on a particular solution too soon rather than exploring the alternative more fully' (Preece et al, 1994: p.540).

3.3.1 Exploratory design research in HCI

There are a many models in HCI. Preece (et al, 2002) illustrates a simple lifecycle like Dawson's for interaction design rooted in software engineering and a few HCI lifecycle models (Figure 3-3).

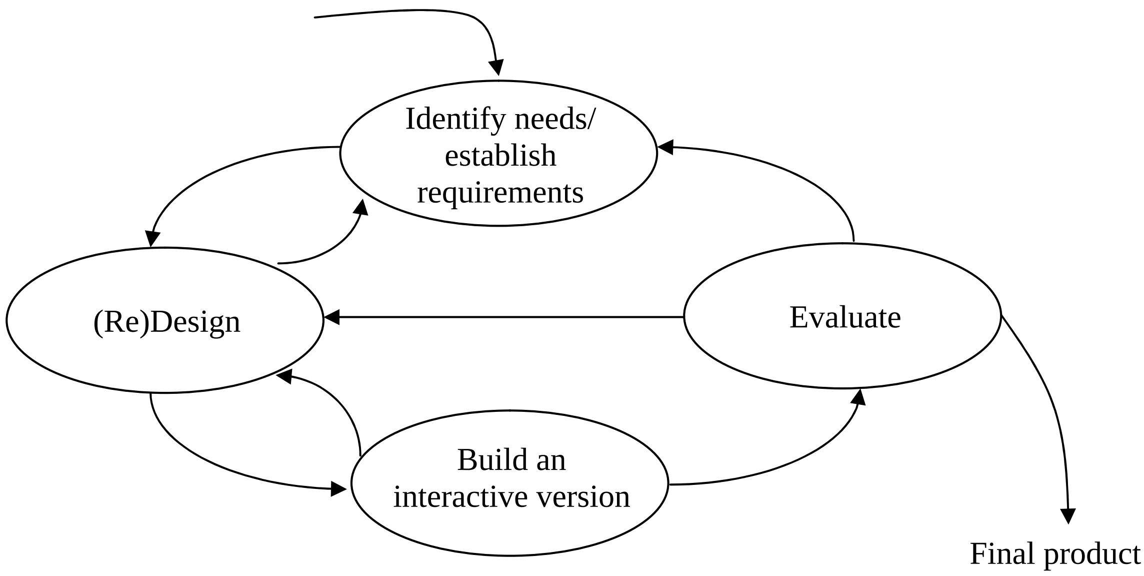


Figure 3-3 A simple interaction design model (Preece, 2002: p.186)

In Preece's lifecycle for interaction design, the stages are a more intertwined; but in general, the first step is also about requirements, followed by (re)designing and building an interactive version, and then evaluation. Based on feedback, new requirements may be identified and re-design will take place. Eventually the final product will be completed. 'For users to effectively evaluate the design of an interactive product, designers must produce an interactive version of their ideas' (Preece et al, 2002: p.239). This interactive version is a prototype, and the two development models, evolutionary prototyping and throw-away prototyping are also applied in HCI. (Preece et al, 2002). The throw-away prototyping is usually called rapid prototyping in HCI. Also, more prototyping models are introduced into HCI, such as incremental prototyping which means a system is built in sections based on an overall design (Preece et al, 1994). In summary, exploratory design research with prototyping is adapted in HCI as well for interaction design.

3.4 The research philosophy of this thesis

3.4.1 Cyclic exploratory prototyping approach

The principles of Guo (1995) were translated and refined to simplify and clarify so that they could be understood more clearly by a novice calligrapher or by a interface designer. This was the "phase 1" in the research (Figure 3-2). Unfortunately, at this phase, some points were too vague. Therefore an exploratory prototyping approach was considered to identify useful information for clarifying these points. Because the principles were elaborately reformulated and the aim was to clarify the ambiguous points to complete the reformulation, so throw-away prototyping was not appropriate and evolutionary prototyping was chosen. Thus a cycle for developing the principles was planned (Figure 3-4). The requirements, ambiguous and clarified points, came from the reformulated principles in each round. Studies with prototypes were designed based on the requirements and then tested on groups of participants. From the results, changes were made to the principles to develop them further. In total there were three versions and three periods of study.

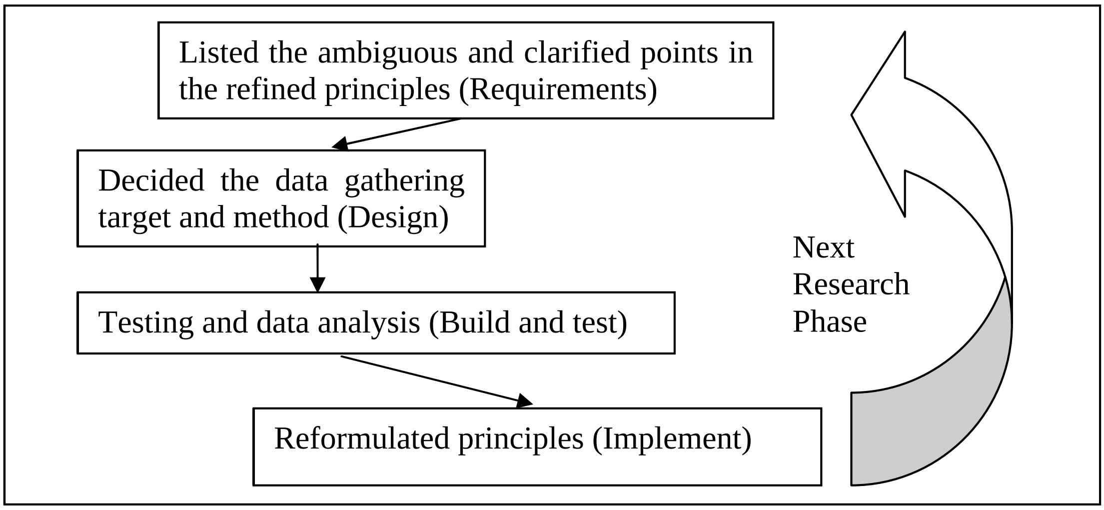


Figure 3-4 The routine of research activity design

3.4.2 Combined interpretative and positivist evaluations

The concept of harmony in this research belongs to the area of aesthetics. Aesthetic appreciation is more subjective and was measured by asking people to compare things. Traditionally, aesthetics cannot be measured by positivist empirical research methods. The challenge in this research is to reformate the principles for Chinese regular script calligraphy into deductive and analytical engineering design methods and apply them to screen interface design. There is an argument about whether aesthetics are subjective or objective. Some scholars argue that people judge an object’s aesthetics by its objective functionality; other scholars advocate that aesthetic feeling is intrinsic and stems from the subjective appreciation of an object’s properties (Tractinsky, 2004). The aesthetics of an object should be seen as whole rather than isolated elements (Arnheim, 1992)

Take a big pearl as an example, some people regard it as beautiful because it is valuable and serves as a sign of loftiness (objective functionality). Some people are attracted because of its size, polish and colour (subjective appreciation). Objective aesthetics leads to associating aesthetics with measurement. It applies a scientific deductive approach to analyse aesthetics and produce some standards which are measurable and believed to be commonly preferred by human beings, e.g. the golden ratio, symmetry, rhythm etc (Ngo, et.al, 2003). On the other hand, the research on subjective aesthetics attempts to connect aesthetics and emotions (Osborne, 1968). However, it is difficult to distinguish the subjective and objective aesthetic attitudes, it could be a mixture of both (Tractinsky, 2004), such as the pearl, it could be its size, polish and colour that make it valuable. This situation can be applied to harmony as well. As part of aesthetics, harmony may be considered to be subjective. However, since the harmony in Chinese regular script calligraphy has been broadly accepted among Chinese people for around two thousand years, some elements of harmony embedded in Chinese calligraphy may be objective and can be used to develop a tool to measure harmony. This suggests that neither positivist empirical research nor interpretative research can be solely applied in this research. In fact, these two research method can be combined. 'When one engages in deductive logic, the source of the original formulation of the theory comes from induction……Once the theory is constructed, the researcher can make hypothesis statements or predictions about expected results in future investigations of the phenomenon. This hypothesis testing is deductive' (Martella et al, 1999: p.13).

The existing calligraphic principles actually did not provide a precise scoring system for harmony. Therefore, interpretative research is needed to find potentially objective rules for the harmony embedded within Chinese calligraphy. Based on the interpretation, some hypotheses can be constructed, and tested by positivist empirical research. In practise, the principles for harmonious Chinese characters could not be fully reformulated into deductive ones by one study. In each phase of the research (Figure 3-4), those principles that could be mathematically described were treated as hypotheses and the positivist research method was adopted. For those ambiguous principles, the interpretative research method was used to make inductive postulates leading to the construction of new hypotheses. Deductive methods were then applied to test the principles as a whole (Figure 3-5).

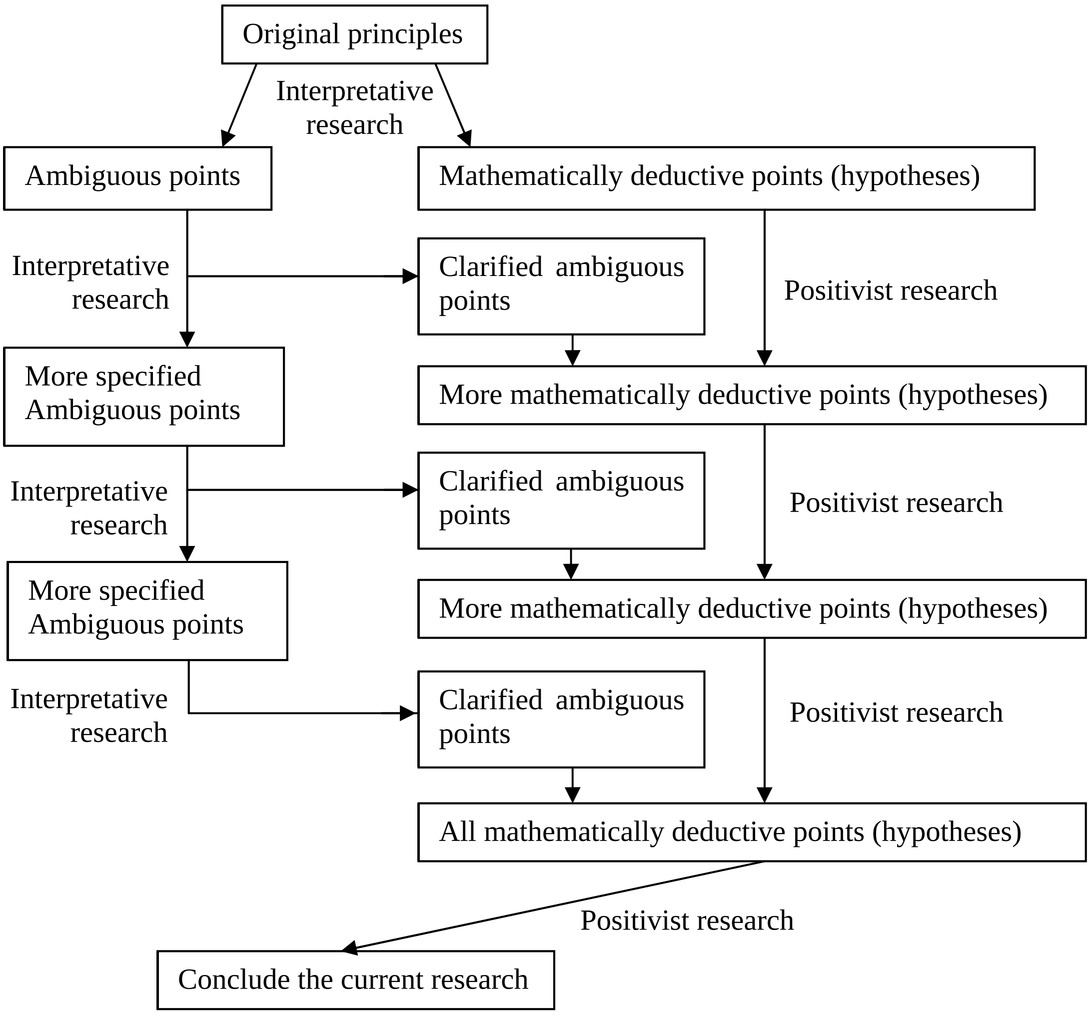


Figure 3-5 Combining interpretative and positivist methods in this research

3.5 Specific methods

3.5.1 Diagnostic evaluation

In HCI, diagnostic evaluation is a user based evaluation of a working system to find out usability problems. It is adapted here to identify problem with principles. The benefits of this evaluation method are, that, it can give insight into why the users have difficulties in using the principles. Second, users' effectiveness, efficiency and satisfaction can be collected as well. The participants must be a user group, and they need to be instructed in what to do (Nigel Bevan, 2006). In this thesis, diagnostic evaluation is used in Section 5.1, Section 5.3 for identifying how well the participants applied the principles, also in Section 5.4 for finding out the accuracy of how people identify the centre of gravity for shapes.

3.5.2 Experiments

The development of the principles into mathematical methods for defining and measuring harmony was achieved by using experimental methods. The experiments are discussed in Chapter 6.

3.5.3 Focus group

A focus group allows a researcher to gather ideas, feelings, attitudes etc from a group of stakeholders about a specific subject (Nigel Bevan, 2006). A group of lecturers was chosen to obtain confirmation and suggestions for the method of translation of the principle, which is presented in Section 5.2.

3.5.4 Interpretative phenomenological analysis (IPA)

IPA is a method used in psychology. It explicitly acknowledges the necessary of the researcher's interpretation of a phenomenon. 'IPA means that the researcher adopts a probing stance towards the meaningful worlds offered by the participants' (Breakwell et al, 2006: p.330). This method was adapted because gathering useful information from the users' designs depends on the researcher's subjective interpretation.

Two trials were carried out to see how users handled the translated principles. Users' designs were studied after they had applied the principles. This method was used for the first and second versions of the translated principles (Section 5.1, Section 5.3).

3.5.5 Preference evaluation

Preference evaluation enables researchers to find out which one is preferred between two objects or standards. In this research, two groups of four screen interface designs were presented to participants and they were asked to sort them in order of harmony, and then compared with the order sorted by the "Harmony" application built on the third version of the principles, which is discussed in Chapter 9.

3.5.6 Surveys

Surveys are usually conducted with questionnaires or interviews to collect a large amount of data (Dawson, 2009). A group of computing students were asked to provide keywords for “attractiveness”, “pleasing” and “harmony” and to select the top three attractive and unattractive designs from fifteen interfaces (Appendix 3). The purpose of this survey was to validate the variables from the reformulated principles in harmony.

3.6 Statistical test

Statistical test is a research evaluation method for making decisions from research data. There are a Null Hypothesis (H_0) and an Alternative Hypothesis (H_a or H_1) in each test. Null Hypothesis is an equation, for example: there is no difference before and after applying the principles. The Alternative Hypothesis is the opposite of The Null Hypothesis, for example: there is difference, including better and worse, before and after applying the principles (two-tails); it will be either better or worse after the application of the principles (one-tail). Statistical significance is the probability (*p* value) to reject the null hypothesis. Commonly if the *p* value is less than 0.05 (0.1 and 0.01 are also optional), the null hypothesis is rejected (Argyrous, 2005). A *p* value of 0.05 means an event occurring by chance alone is less than 5%. At this level, people can confidently believe that something is influencing the event. However, a statistical test will not give a clear answer about what is influencing the event. The researcher has to justify that the variables identified were the only possible source of influence (Black 1999). In practice, even the test result which achieves a significant level at 0.01, it still means that there is 1% probability that the event happened by chance. It has been argued that experiments will never actually prove hypotheses, as a counter-example is always theoretically possible (Mackay 1997). Nevertheless, a statistical result will provide confidence for researchers draw conclusions about their results (Martella et al, 1999).

There are many statistical tests. The only statistical test used in this research is Page’s L Trend test, for testing whether outcomes of the principles matched people’s choices (Chapter 9).

3.7 Summary

The chapter discusses the methodology used in this project. Two research approaches: positivist empirical research and interpretative research were discussed. Positivist empirical research is mainly for testing hypotheses for new relationships in existing knowledge. Interpretative research was mainly for constructing theories or hypotheses for new knowledge. The research of the harmony from Chinese calligraphy required both approaches. Therefore, the interpretative approach was applied to study users' feedback on ambiguous points in the reformulated principles and the positivist empirical approach was used to test hypotheses. A cyclic prototyping approach using a mix of interpretative and positivist evaluation in each phase was planned. That is to say, a new research activity was designed based on the outcomes from the previous one. The methods used were listed as well. Since HCI is a multidisciplinary field, there are many research methods available to be adapted in this research. Only those that were appropriate and feasible were applied to this research.

Chapter 4. Chinese Calligraphic Principles into Analytical and Deductive Principles (Version 1)

4.1 Chinese calligraphy

Pablo Picasso expressed his appreciation of Chinese calligraphy, saying ‘Had I been born Chinese, I would have been a calligrapher, not a painter’ (Beijing Times, 2002). Chinese calligraphy has been fostered by Chinese culture for over three thousand years and has become rich in conveying a sense of harmony (Chuang, 2004). Three thousand years ago, a Chinese general, Tian Meng, improved the writing brush and Chinese brush calligraphy developed into a unique art form in the Far East (Yue, 2004). It has been adopted by Japan and Korea. Each Chinese character consists of different strokes of various shapes and sizes, whilst the general appearances of the shapes are permanent and unchangeable, some flexibility is still allowed. For instance, the shape of a stroke does not need to be even or uniform from the beginning to the end. It can have a big head and slim tail or the other way round. Carefully keeping a two-dimensional framework in mind to balance the space and weight in an invisible square or circle, a calligrapher can use his/her imagination to construct a character. The existence of flexibility has led to vague principles for calligraphy. To master the skills, one has to devote considerable time to practice. Eventually, each calligrapher will develop their own written style. That is why calligraphy is regarded as a powerful tool to reveal one’s personality. For example, an impatient person will not have good calligraphy skills, as he/she is eager to finish writing rather than produce aesthetic calligraphy. Sophisticated calligraphers can demonstrate grandeur, freedom and happiness in their calligraphy.

There are many types in Chinese calligraphy, such as Zhuan 篆，Di 隶，Zheng 正，Hang 行，and Cao 草 (Figure 4-1). Zheng is the regular script.

Zheng Di Hang Cao Zhuan

Figure 4-1 Example of the five styles of Chinese calligraphy (Wen, et, al. 1987: p20)

The regular script (Zheng) was developed from the type of Di. The creator was You Zhong (锺繇 151-230). The regular script calligraphers were aiming to achieve a style which was elegant, clear, stable, regular and had decorum. After many generations of calligraphers' elaboration, a calligrapher, Zhenqing Yan (颜真卿 709-785) finally developed a style of regular script which was widely acknowledged as one of the most elegant. (There are another three styles but not as famous as his.) After maturity, the regular script has been the standard style of Chinese characters for the last thousand years,

4.2 Chinese regular script calligraphy principles

Many calligraphers have summarised some principles so people can master the skill of writing good regular script calligraphy. For example, Xun Ouyang (欧阳询 557-641) created "The thirty six principles". Chun Li (李淳 Around 1400-1500) wrote "The eighty four principles" and Ziyuan Huang (黄自元 1837-1918) summarised "The ninety two principles" (Zou, 2008). Modern calligraphers have also joined the research. For instance, Liu published "The twelve principles" in 1981 (Liu, 1981). These sets of principles may have a couple of different features, besides the common features with different levels of details in the explanations, but unfortunately they are all abstractive descriptions like Guo's (1995) principles listed in the Section 4.3. In practice, even with a guide to the principles, the path to become a calligrapher still consists of three stages: 1. Copy the character one after another from some famous calligraphers' work, such as, Zhenqing Yan's, to develop the sense of the structure; 2. Practice without looking at the master calligrapher's work; 3. Develop personal style (Zou, 2008). These three stages can take years, which discourages a lot of people. Thus it can be asked:

> In the regular script calligraphy, was there something consistent, deductive and globally accepted as the key factor to construct a harmonious character. In other words, when these key factors are achieved in a character, people will regard it as a well-written character. Whilst, these keys were flexible so each calligrapher can develop his or her personal style.

4.3 A set of Chinese regular script calligraphic principles

Guo (1995) published five principles for writing Regular Script, the standard font of Chinese calligraphy. Unlike other principles, his principles were the simplest set and focused on achieving the overall harmonious feeling, rather than trying to categories the characters' structures and describe the features in each category, such as Xun Ouyang (欧阳询 557-641) and Chun Li's (李淳 Around 1400-1500) principles. Therefore, Guo's principles were chosen for the translation. His five principles are: Pingzheng, Yunchen, Rangjiu, Xietiao and Bianhua.

1. Pingzheng (平正) emphasizes that a character should look balanced and stable, not as if it would topple over. This principle also requires that the down stroke must be exactly vertical. Guo introduced the concept C*entre of Gravity* in this principle. In Guo's (1995) description, the centre of gravity of each character is determined by the central vertical stroke. The characters Ping and Zheng themselves can serve as an example (Figure 4-2). Their central vertical strokes are exactly vertical to enhance the stability of the whole character.

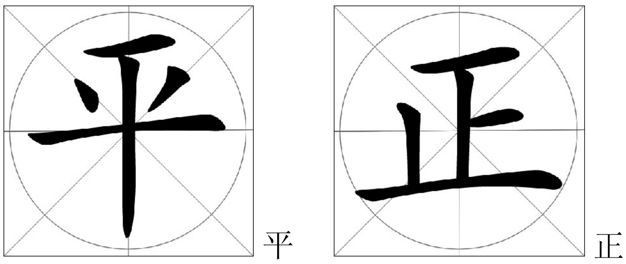


Figure 4-2 Chinese character: Ping (Balance) and Zheng (Stable)

If there is no vertical stroke, it will be the invisible Y axis at the centre. In other words, the visual weight should be balanced on the left and the right. In Figure 4-3, there are no vertical strokes in the Characters Duo (多: many) and Can (参: join, refer), but the visual weight is balanced based on the central Y axis, so the characters are stable.

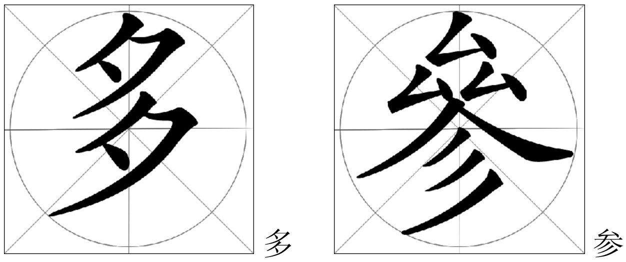


Figure 4-3 Chinese character: Duo (Many) and Can (Join, Refer)

Pingzheng is the basic principle in Guo’s view.

2. Yunchen (匀称) ‘The Chinese term yunchen means well proportioned. The arrangement of long and short or large and small strokes gives the viewer a sense of harmony. This calls for a suitable arrangement of fat and lean strokes. The complicated and simple strokes must be well proportioned’ Guo (1995: p.27). This is the second important principle. For instance, in Figure 4-4, Fei (非: No) contains a moderate number of strokes. Ding (丁: fourth, man) only consists of two strokes and Lu (辘: tackle) has nineteen strokes. Ding’s strokes are fatter compared to Fei. Lu’s strokes sizes are slender compared to Fei. What determines the gauge of the stroke sizes? This question is answered in the later principle Rangju.

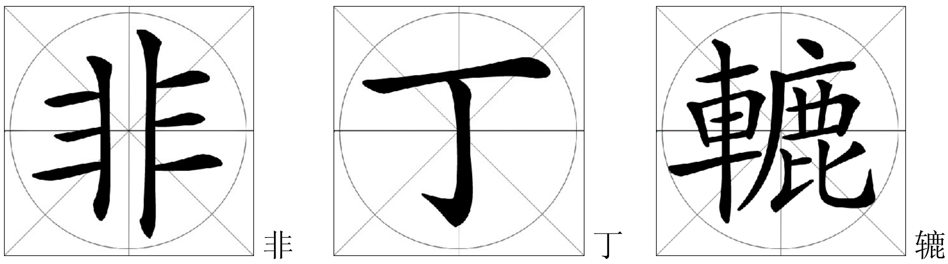


Figure 4-4 Chinese character: Ding (fourth, man) and Lu (tackle)

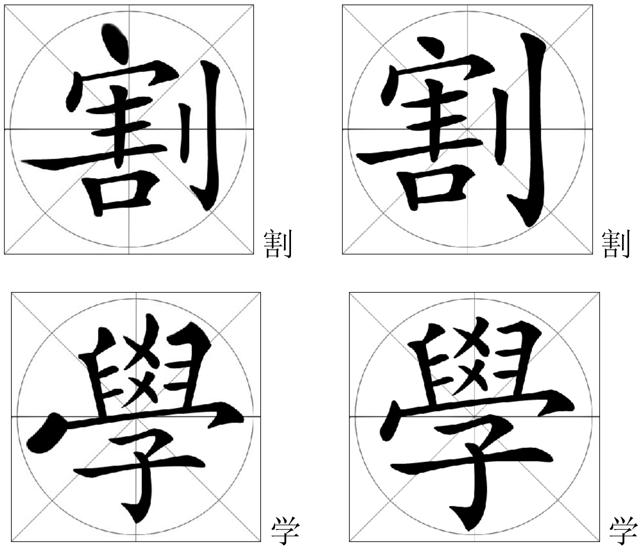
The character Yun (匀) means average. In a Chinese character, if a space is divided by a few parallel strokes, ‘The distance between strokes is more or less the same’ (Guo, 1995: p.27), as illustrated by the character Lu (辘) (Figure 4-5)

Figure 4-5 Distance between parallel strokes.

3. Rangjiu (让局) concerns the structural arrangement of the character.

> 'When you find an incongruity between left and right, top and bottom, large and small, tall and short, etc., you must try to make the part that is out of place with the rest less incongruous, draw a distinction between the principal stroke and the subordinate stroke and harmonize them'.
>
> (Guo, 1995: p.27)

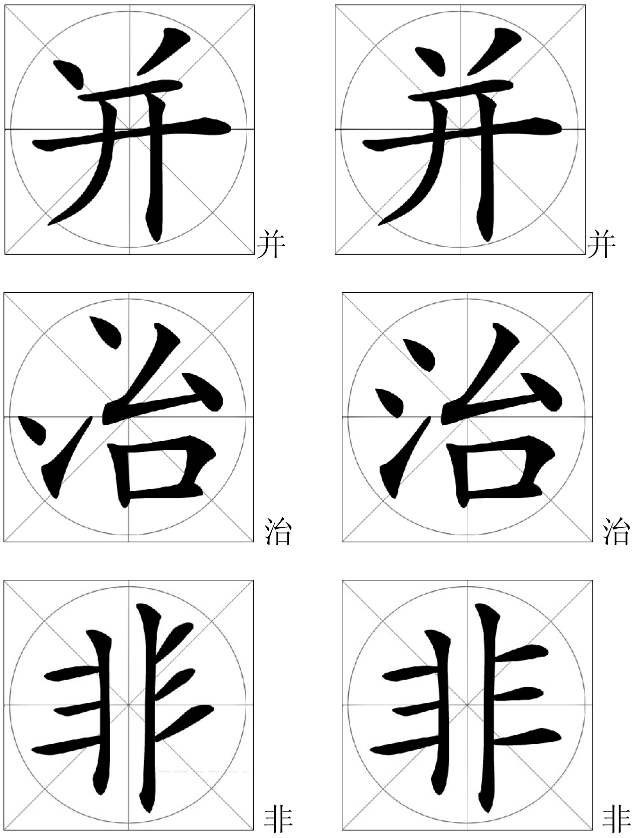
This is about making the heavy part of the character less prominent. For example, when a character consists of two sub-characters, one is complex and the other one is simple. A sub-character is a group of strokes that conveys a meaning. The size of the strokes of the simple sub-character should be enlarged and give more space to it. The complex sub-character will occupy less space than usual. For example (Figure 4-6), the character Ge (割: cut) has a left-right structure. There are only two strokes on the right part. Without Rangjiu, by making it bigger and the left side smaller, the left side is too dominant and gives people a feeling that the left side is forcing the right side to the corner, which is breaking the harmony of the character. The character Xue (学: study) has a top-bottom structure. The bottom only consists of three strokes. Keeping the strokes the same size as those on the top part makes it look like it is oppressed by the top part, which is not beneficial to harmony.



Before Rangju After Rangju

Figure 4-6 Examples of Rangju

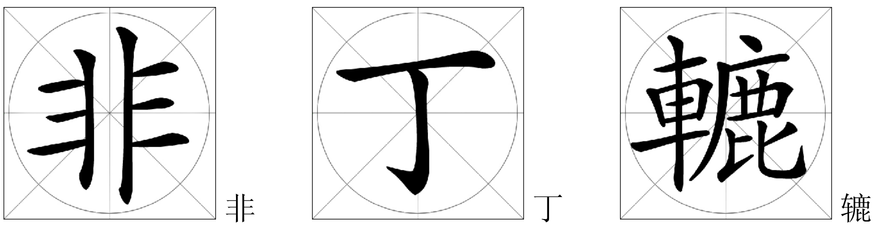
4. Xietiao (协调) refers to the cooperation between the strokes. It requires people to consider harmonious relationship between thick and thin strokes, long or short strokes, fat or slender strokes, complicated or simple parts, tall or short parts, left or right parts and top or bottom parts in the same character. In other words, you must have a harmonious layout of the character you are writing. Guo (1995) provides some example characters to express the idea of Xietiao. For instance, the dots on the characters, 并 (merge), and 治 (cure), the way they are positioned implies a relationship between them, which groups them together. The styles of horizontal strokes on the left and right of the character 非 (No) should be consistent, which suggests keeping the same structure for both parts, enhancing the feeling that these two parts belonging to one character. The relationships between the strokes should be expressed when writing a Chinese character. ‘If we pay attention to [the] structure and to the relationship of one stroke to another, we [will] produce a harmonious atmosphere among the characters’ (Guo, 1995: p.28). If they are moved to other places, the relationship will be broken (Figure 4-7 left column). Unfortunately, Guo does not explain what the relationship is and why it should be positioned like that.



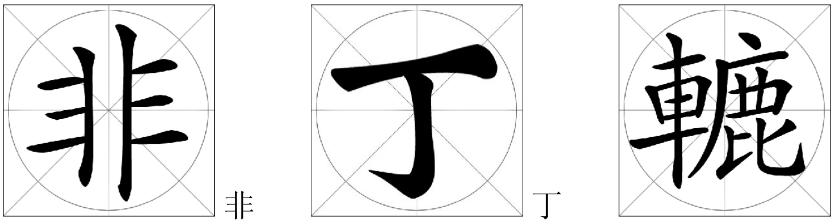
Without Xietiao With Xietiao

Figure 4-7 Examples of Xietiao on single characters

Xietiao not only takes place among the strokes on a character, but also between the characters. Harmony in Chinese culture requires that any changes should not be so distinguishable as to cause surprise. When it is necessary to increase the sizes of the strokes on a simple character, even if there is still a lot of space available, the sizes of the strokes must not be too different to those of other characters. This answers the question in Yunchen: What determines the gauge of the stroke sizes? For instance, if the sizes of the strokes of the character Ding (丁) are further increased, it breaks the harmony among the characters (Figure 4-8).



Decently increase the sizes of the strokes of Ding 丁


非 丁 辘

Indecently increase the sizes of the strokes of Ding 丁

Figure 4-8 Examples of Xietiao among characters

This also reflects Chinese culture, ‘Taoists believed that all sizes are relative’ (Hu 1991: p.16): Although the stroke sizes of Ding (丁) are increased, but the plentiful amount of space makes the strokes relatively small, so the increase is not distracting.

5. Bianhua (变化) refers to flexibility in following the rules of calligraphy. In order to retain the characters’ harmonious appearance, the sub-characters have to change their original form. Otherwise, they will break the rules of writing Chinese calligraphy and affect the character’s harmonious structure. Consequently, flexibility has been added to the principles. Guo uses the character 林 as an example. The character 林 which means trees consists of two characters 木 indicating wood (Figure 4-9). In the character for trees, if both characters of wood kept their original form, it would break the principles of balanced space and proportion and circular Layout, which results in a less harmonious appearance. Therefore, the right-falling stroke has to be changed into a dot in order to satisfy the conditions:

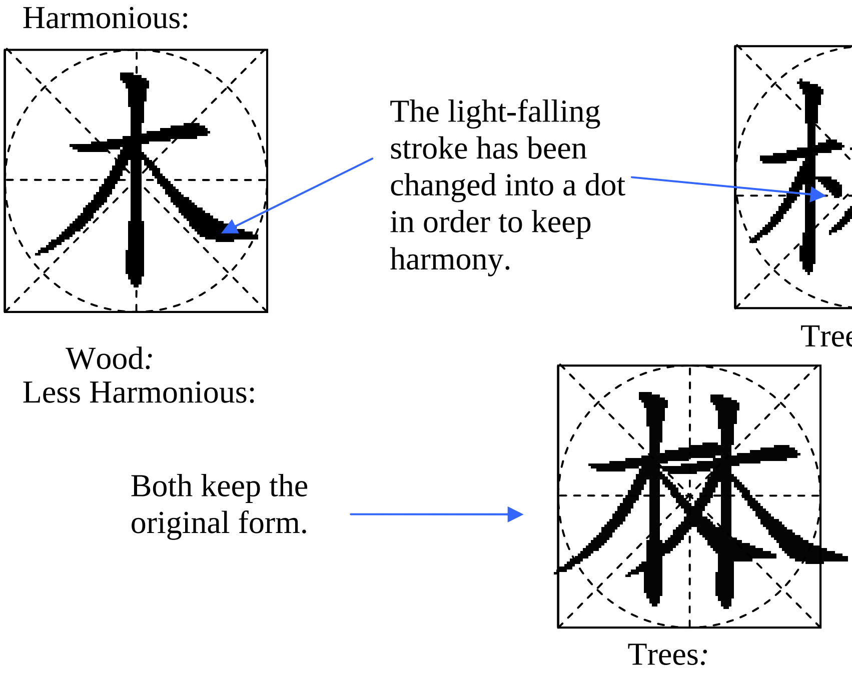


Figure 4-9 Flexibility on the Chinese character "Trees"

4.4 First version of the new principles

There are both some clear and ambiguous points in the principles.

The clear points are:

1. The centre of gravity is mainly determined by the central Y axis or the principle down stroke which must be exactly vertical.
2. The visual weight should be balanced on the left and right sides.
3. When a character consists of a few or too many strokes, the sizes of the strokes should be made bigger or more slender, but the changes should not be noticeable at a glance.
4. When a character consists of a few parts, none of the parts should look superior to others.
5. If a space is split by some parallel strokes, the distance between the strokes should be more or less the same.

6. If the structures of two parts on a character are similar, their style should be the same.

The ambiguous points are

1. Is it enough that the centre of gravity is only measured by the central Y axis? What happens if a character satisfies this point by only occupying the upper part, such as the character in Figure 4-10.

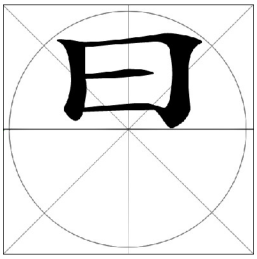


Figure 4-10 A character that only occupies the upper part

2. If some strokes appear to be a group, their positions should imply the relationship, but what determines the positions?

3. Flexibility is allowed if a sub-character breaks the harmony of the whole character, but what form should the sub-character be changed to?

The thesis author was taught by calligraphers in China and has practiced Chinese calligraphy for many years. With his experience and the insight of Chinese calligraphy, the author has re-defined the five principles but kept and developed the useful ideas presented by Guo (1995), and provide detailed explanation of how these principles can help to construct a harmonious screen interface. The set of principles was presented in a seminar to 26 scholars in Chinese studies. None of them criticised that the translation strayed away from the original principles.

Based on the existing calligraphic principles, five new principles were created. These principles were refined after each stage of the research. At the start, they were:

1. Balanced Weight (BW)

2. Balanced space and proportion (BSP)

3. Avoiding Proportional Prominence (APP)

4. Circular Layout (CL)
5. Flexibility (F)

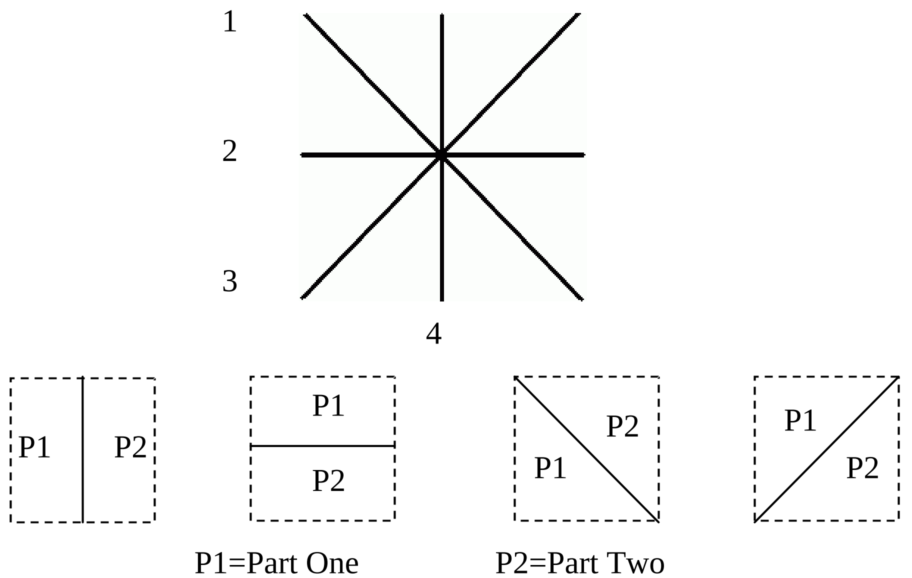
In this thesis, simple patterns, together with Chinese characters, are used as examples to explain the principles. To test a screen interface for harmony, the interface might be ‘converted’ into its most basic components as follows:

- Ignore colour (change the various colours into monochrome)
- Convert each significant component into a black block that represents its size, and shape.
- Convert chunks of text into a black block.
- For simplicity at this stage, “movement” is not considered.

The Chinese font used to analyze in the research is created by the Founder Group which is a Chinese technology company. The company developed the font based on the regular script Chinese calligraphy standard. However, the standard is an art standard but not a measureable standard, which means each calligrapher can have their own style on their regular script calligraphy. Therefore, not only has this research developed the principles for harmonious interface design, but also created a measurable standard for the regular script Chinese calligraphy, which is a milestone in Chinese calligraphy.

4.4.1 Balanced Weight

This new principle is developed from Guo’s (1995) first principle “Pingzheng” which requires the stability of the characters. The basic idea of Guo’s for constructing Chinese regular calligraphy requires the identification of the centre of gravity of a character, which is based on principle down-stroke or the central Y axis if there is no down strokes. To identify the centre of gravity inevitably involves the concept of weight. Since each calligraphic character is in monochrome (usually black), people will intuitively perceive all strokes to have the same specific gravity, that is to say, thicker strokes feel heavier than thin strokes. However, Guo (1995) only looks at the left and right sides. By combining the Judgement Lines (Figure 4-11) for calligraphic practice, the author extended the idea of “Pingzheng” to all the sides divided by the vertical, horizontal and diagonal lines. If the weight on each side is balanced, the centre of gravity of a character will be at the middle of the square (Figure 4-11). This should sort out the first ambiguous point that it may not be enough if the centre of gravity is only measured by the central Y axis (Example in Figure 4-10). At this stage, the weight of the strokes was not computed, because the shapes of the strokes are so different and it was difficult to work out how much area each stroke occupies. This has been fixed in the later research (Section 6.3.2). At this stage, based on the visual estimates of many Chinese characters, the weight on each side was more or less the same the same. Influenced by Guo's idea that the weight on both sides of the central Y axis has to be more or less the same, it was concluded that when each line divided the character into two parts, it was difficult to make all Part Ones as "heavy" as Part Twos, but the more Part Ones' weight are equal to their corresponding Part Twos', the more harmonious it will be (Figure 4-11). For instance, in Figure 4-12, when applying each line to divide the character Zhi 紫 (purple) into two parts, the weight of part one is roughly equal to that of the part two. The central point should be the centre of the gravity.



The Judgement lines consist of four lines crossing one point and a circle. Each line divides a character into two parts. If the strokes in both parts can convey the same sense of weight, the central point will be the centre of gravity.

Figure 4-11 How to use the Judgement lines pattern to judge weight

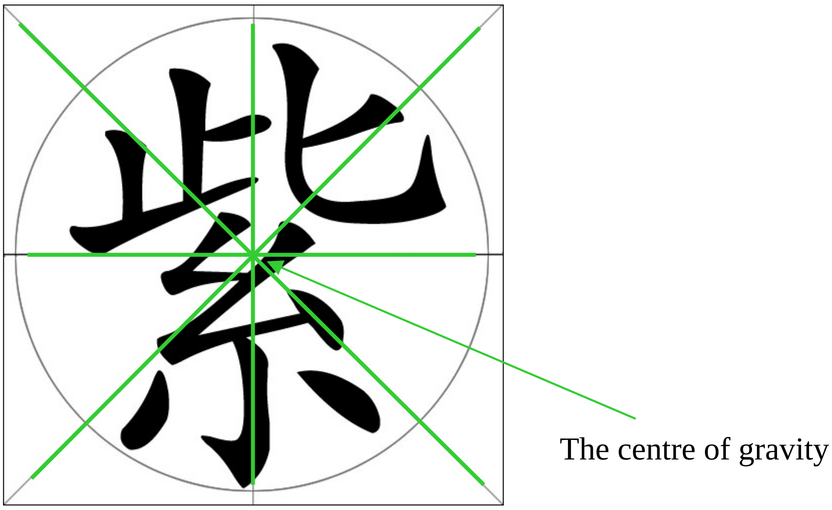
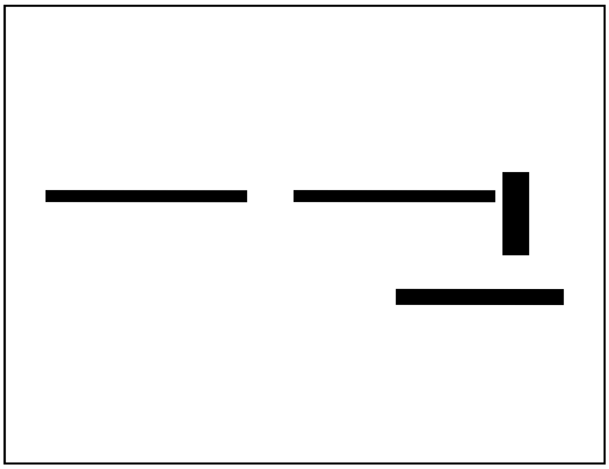


Figure 4-12 Applying the lines to the "Purple" character

As the Chinese characters already exist, calligraphers' only job is to find a reasonable point on a character and then decide the size and shape of each stroke to balance the feeling of weight. Interface designers have an extra job to do, which is to construct their own "characters". For example: suppose there is an interface comprising four components. Three of them look like horizontal lines and the fourth one appears to be vertical: Figure 4-13.

Do the positions of the four components in Figure 4-13 make up a harmonious screen interface viewed on a computer monitor? Different people may look at it from different perspectives. The application of the Judgement Lines can help to reposition these four components and create a more harmonious screen interface.

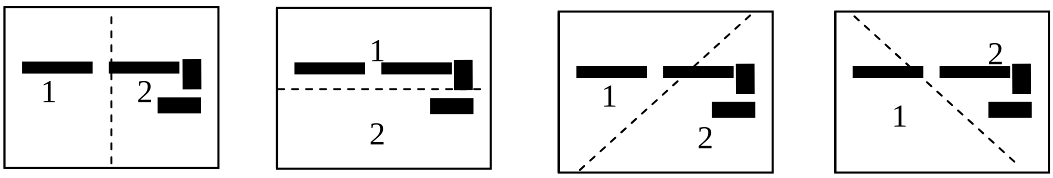


The areas of the black rectangles are the same.

Width: Height = 4:3 (regular interface's dimensional proportion)

Figure 4-13 A simple interface without harmony

In Figure 4-14, intuitively, the two parts with the same size divided by any one of the four lines does not give people the same feeling of weight. Physically, they do not contain the same physical area of components. That is to say, the centre of gravity is not at the middle.



Width : Height = 4:3 (regular interface's dimensional proportion)

Figure 4-14 Apply the Judgement Lines to analyse the simple interface for Balanced Weight 1

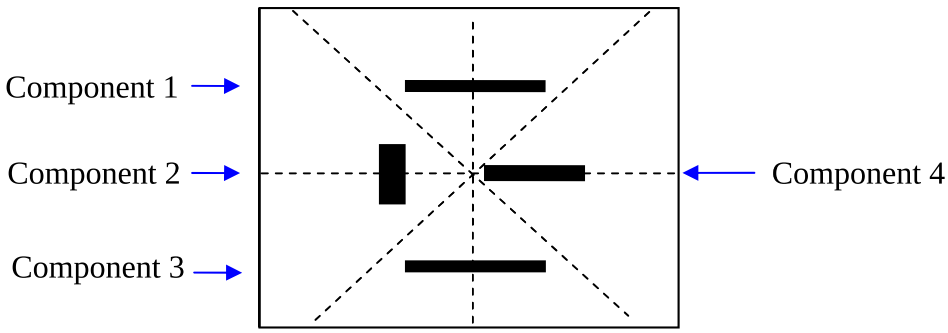


Figure 4-15 A simple harmonious interface

After adjusting the positions of the four components, the interface looks like the one in Figure 4-15. Visually, this interface is more harmonious than the previous one. The Judgement Lines are applied to analyse the differences. As illustrated in Table 4-1, the area of Component 1 is equal to the Component 3's and the Component 2's area is the same as Component 4's.

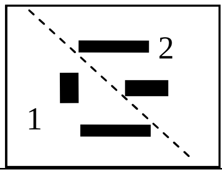
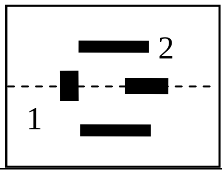
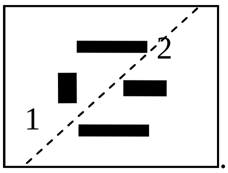
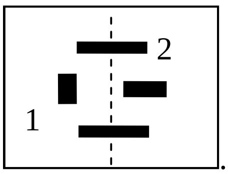
Line	Area
when the Line 1 divides the new interface into two parts 	Component 1 + Component 4 = Component 2 + Component 3
when the Line 2 divides the new interface into two parts 	Component 1 + half Component 2 + half component 4 = half Component 2 + Component 3 + half component 4
when the Line 3 divides the new interface into two parts 	Component 1 + Component 2 =Component 3 + half component 4
when the Line 1 divides the new interface into two parts 	Half Component 1 + Component 2 + half component 3 = half Component 1 + half Component 3 + component 4

Table 4-1 Apply the Judgement Lines to analyse the simple interface for Balanced Weight

Any changes of the place of a component require corresponding repositioning of other components to rebuild the harmony. Otherwise, the established harmony will be broken down. For instance: (Figure 4-16)

Harmony

Less harmonious

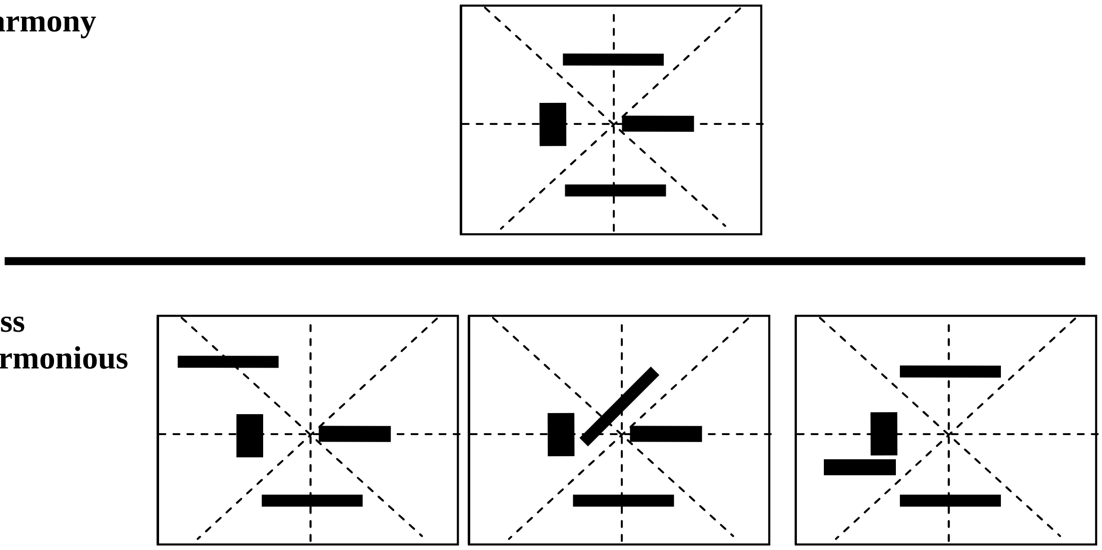
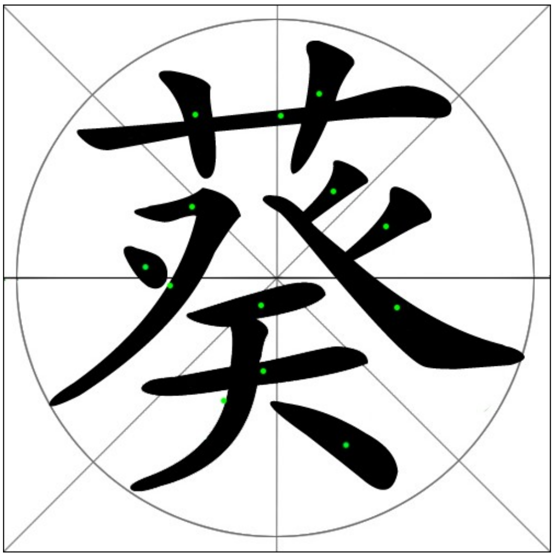


Figure 4-16 Breaching the principle Balanced Weight to break harmony

The new principle aims to delineate the first ambiguous point. However, at this stage, the weight of the strokes was only estimated, because the shapes of the strokes are so different and it was difficult to work out how much area each stroke occupies.

4.4.2 Balanced Space and Proportion

The second important feature of Chinese calligraphy is balanced space and proportion. Guo’s (1995) second and third principles, “Yunchen” and “Xietiao” cover this feature. This idea suggests that Harmonious screen interface design requires attention to the distance between each component. It implies that even if an interface is constructed under the principle of Balanced Weight, unbalanced space and proportion may still cause problem to the sense of harmony. However, Guo’s principle only clearly states that if a space is divided by some parallel strokes (components in terms of screen interface), the distance between the strokes (components) should be the same. His description of positioning the other strokes is ambiguous, which is the second ambiguous point. By analysing many Chinese characters, it was found that the distance between the centres of gravity of neighbouring part strokes is more or less the same. Figure 4-17 shows the character 葵 (sun flower) in which the centres of gravity of the strokes (a) and of the part strokes (b) (Section 4.4.2.1) are marked (Calculated by the software Autodesk AutoCAD v14). The distances between the neighbouring centres of gravity (Section 4.4.2.2) of the strokes was more variable (in size of 500px by 500px, there are 15 distances, mean is 86.47px, standard deviation is 33.39px) than the distances between the part strokes (in size of 500px by 500px, there are 40 distances, mean is 77.43px, standard deviation is 26.66px). In addition, when drawing a new stroke the calligrapher positions the near stroke by reference to the neighbouring parts of strokes. Thus in achieving Balanced Space and Proportion emphasis was placed on the part strokes.


(a) Centres of gravity on the whole strokes

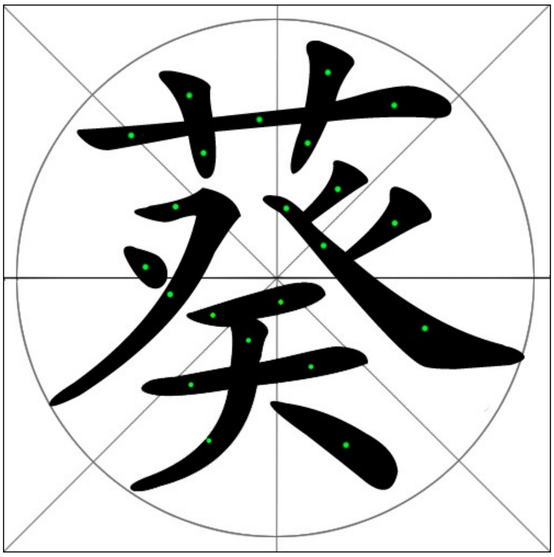

(b) Centres of gravity on the part strokes

Figure 4-17 Centres of gravity on wholes strokes and part strokes

In order to use this discovery, two things were need to be clarified:

4.4.2.1 Part strokes

If a stroke crosses another stroke, the shared area was not taken into account. For instance, on the character Kui (葵: sunflower), the shared areas are crossed out and omitted (Figure 4-18).

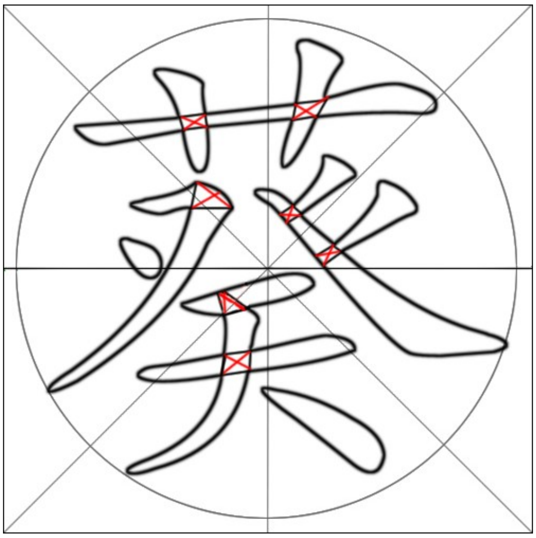


Figure 4-18 Omit the shared areas between strokes

The reasons are that: first, it is difficult to tell a shared area belongs to which stroke; second, if a shared area is part of any sectors that connect to it, some sectors of the divided strokes may be smaller than the shared area. If the shared area is not omitted, the centres of gravity will be on the shared area, which will result in more than one centre of gravity on one sector. For instance, this happens in the character 夏. The circled sectors are smaller than the shared areas connected to them (Figure 4-19).

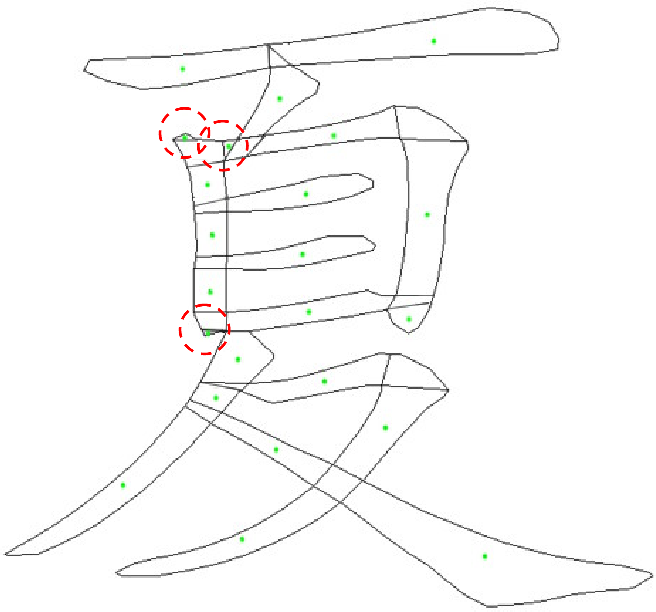


Figure 4-19 Sectors of some divided strokes are smaller than the shared areas

4.4.2.2 The first definition of neighbouring strokes

The definition of neighbouring strokes (redefined in Section 6.3.10.2) was: if a straight line could be drawn between two centres of gravity without any blocks, then the two strokes were neighbours. For instance, in Figure 4-20, in the character for purple (紫), the centres of gravity of stroke 1 and 3 are blocked by a stroke, so they are not neighbours, but the centres of gravity of stroke 1 and 2, the centres of gravity of stroke 2 and 3 are neighbours.

Figure 4-20 What are neighbouring strokes – no stroke block at the middle of two centres of gravity

Similar distances from the centre of gravity of a stroke to the centres of gravity of its neighbouring strokes.

Figure 4-21 Similar distances between strokes' centre of gravity

In Figure 4-21, because there was no suitable software found to calculate the centre of gravity at this stage, all the centres of gravity and the distance between the centres were estimated. The distances between the centres of gravity of the neighbouring strokes were more or less the same. Perhaps a simple mathematical example will make this point clear: suppose there is a 12cm long space and five components. In terms of harmony, the space has to be evenly divided by the five components' centres of gravity (Figure 4-22):

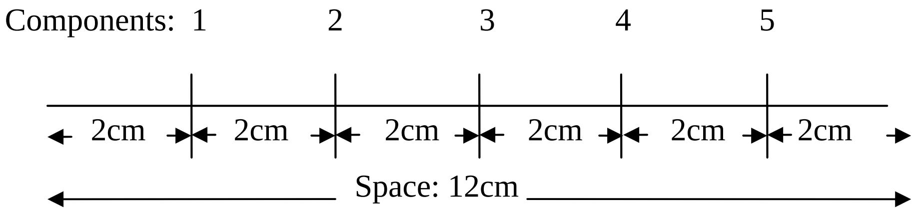


Figure 4-22 Equal spaces between the centres of gravity

Harmonious screen interface design will be more complicated. On the interface in Figure 4-23, the distances between any centres of neighbouring components are nearly the same.

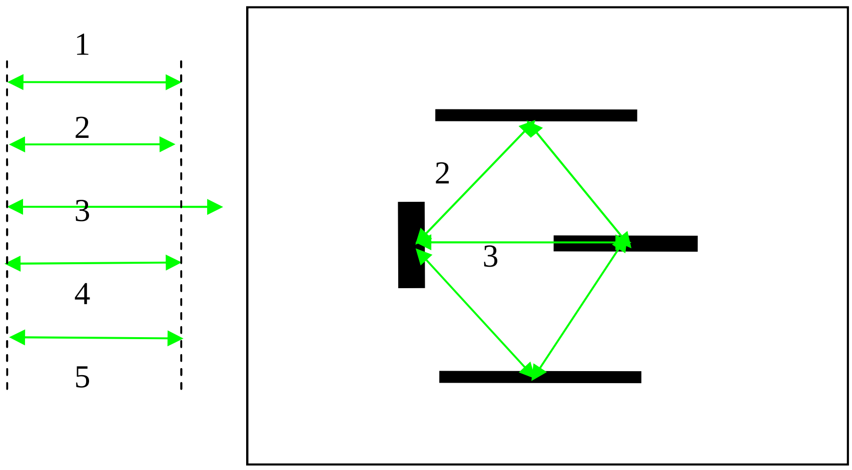


Figure 4-23 Similar distances between any centres of neighbouring components

The pattern in Figure 4-24 was created on basis of the principles.

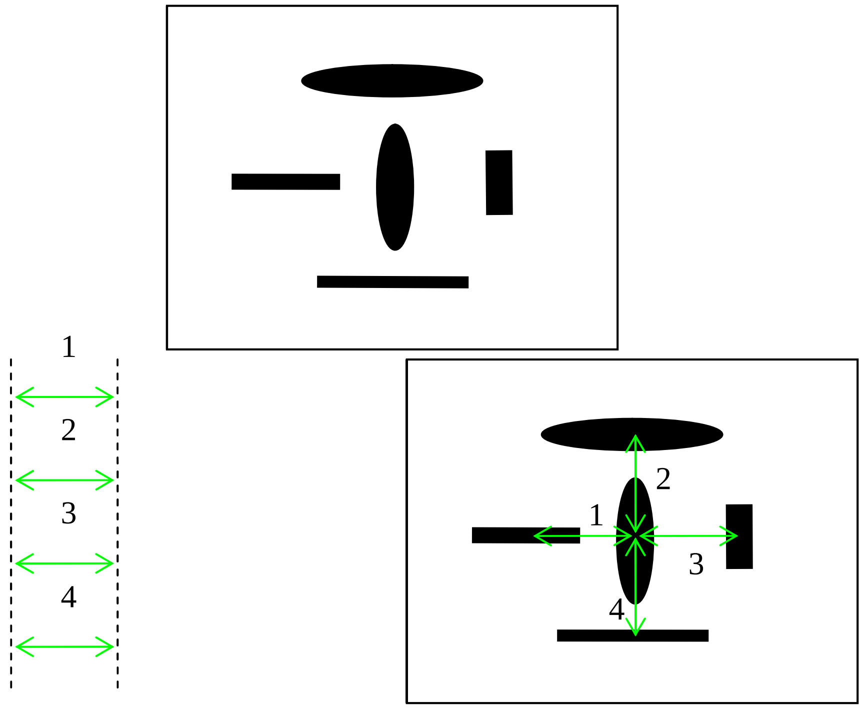


Figure 4-24 The pattern satisfies all the principles

According to the second principle, the distances between centres of neighbouring strokes are more or less the same. Repositioning the components whilst retaining the centre of gravity can make the interface less harmonious. (Figure 4-25)

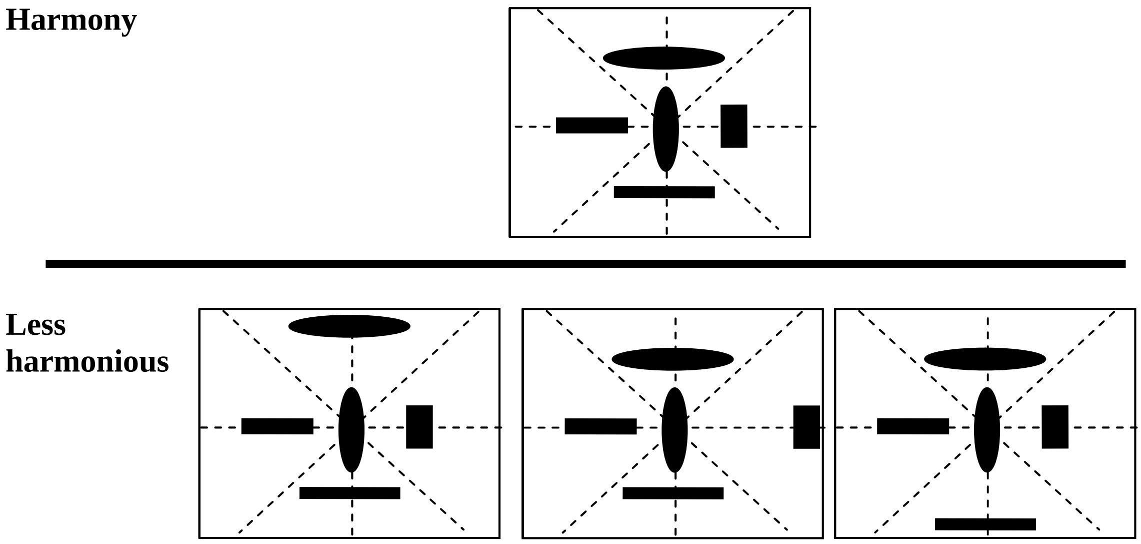


Figure 4-25 Repositioning the components whilst retaining the balanced weight can make the interface less harmonious

The above two ideas above were based on the thesis author's personal experience in practising Chinese regular script calligraphy. They were discussed and improved again in Section 6.3.10.

4.4.3 Avoiding Proportional Prominence

This principle comes from Guo's (1995) third principle "Rangjiu". In Chinese calligraphy, consider a character that consists of two parts, the first part consists of a few strokes and the second part is made up of many strokes. In this case, the second part has to be less conspicuous. Otherwise it will dominate most of the space and ruin the harmony. This feature is seen indicates that in harmonious screen interface design, if one component occupies too much space, then something has to be done to reduce the size of it and enlarge others. For example: (Figure 4-26)

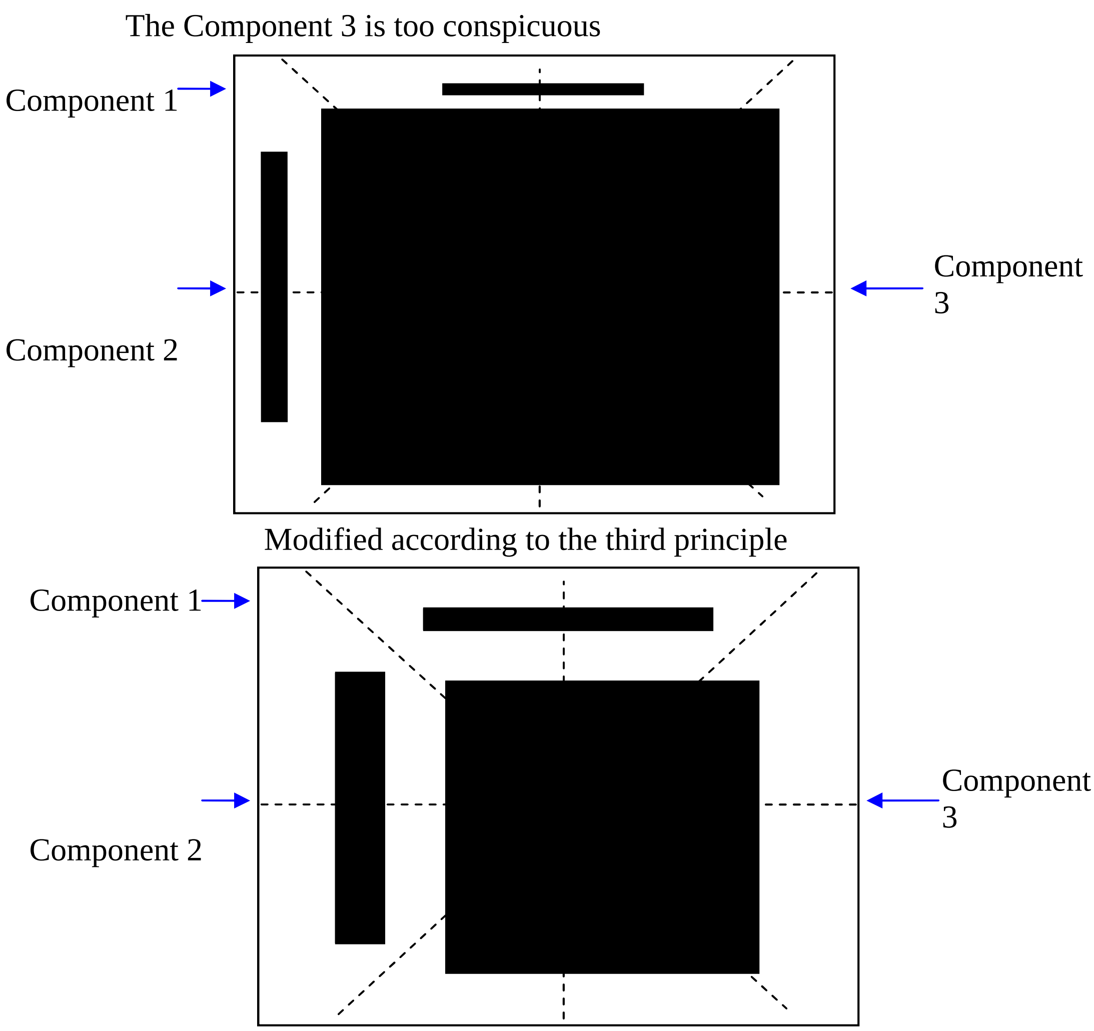


Figure 4-26 An example of Avoiding Proportional Prominence

4.4.4 Circular Layout

Circular Layout is not mentioned by Guo (1995). The researcher concluded it from his calligraphic experience. It is also supported by another Chinese calligrapher, Fu (2003). Traditionally, people regard the layout of a Chinese character as a square. Actually, the layout should be circular. If a circle is drawn outside a regular Chinese calligraphic character, it can be found that usually none of the strokes extends outside the circle. They elongate or shrink under the constraint of the curve, whilst the ends of the strokes have been elaborately located to convey a sense that there is a circle (Fu, 2003). This matches the Chinese concept that the harmonious human activities should follow the constraints of nature/the universe which was believed to be a circle outside the square earth (Wu, 2006). Most people do feel that a circle is the most harmonious of all shapes. Also, according to Interposition Cue Theory, when people see part of a circle, the human brain will insert the missing parts, so that the person is aware of the entire circle (Eysenck, 2000). Therefore, it suggests that an interface with a Circular Layout can achieve a more harmonious visual effect. For example, in Figure 4-27, the bottom pattern is more harmonious than the upper one, since the outline of the components lie on or within a circle.

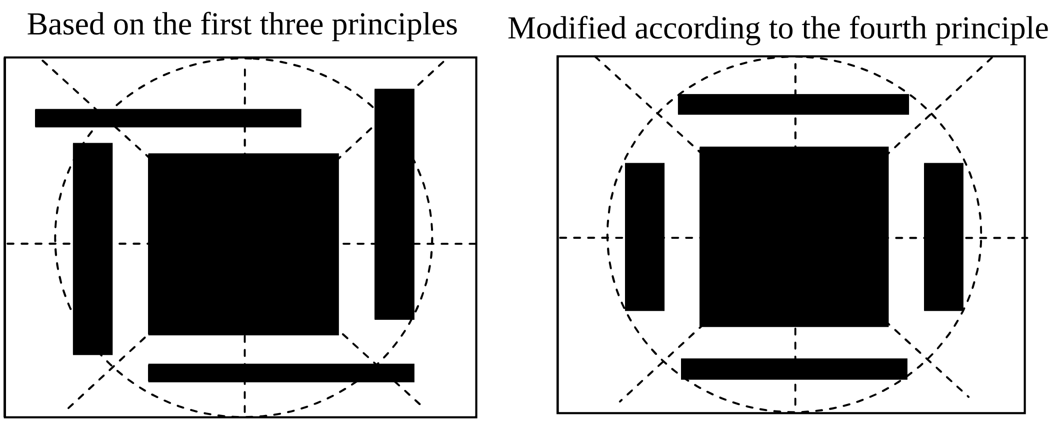


Figure 4-27 A comparison between circular and not circular layout

The circle or ellipse does not necessarily only inside the screen area. For instance, the circle in Figure 4-27 can be enlarged as in Figure 4-28.

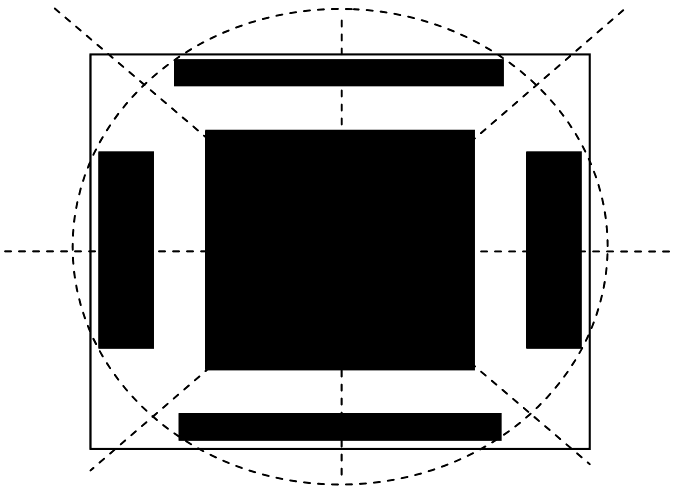


Figure 4-28 Enlarge the circle to the outside of the screen

4.4.5 Flexibility

The principle of Flexibility is equivalent to "Bianhua" which is Guo's (1995) final principle. In terms of harmonious screen interface design, the application of this principle changes the shape of certain components to generate a better sense of harmony. For example, in Figure 4-29, the left component includes a vertical component and a horizontal one at its middle. The horizontal one looks aggressive in the pattern. Therefore, its shape should be modified to make it more harmonious, such as rounding its corners and producing a parallel effect. According to the principles of Yunchen, the space between the vertical components will be more or less the same.

Based on the first four principles   Modified according to the fifth principle

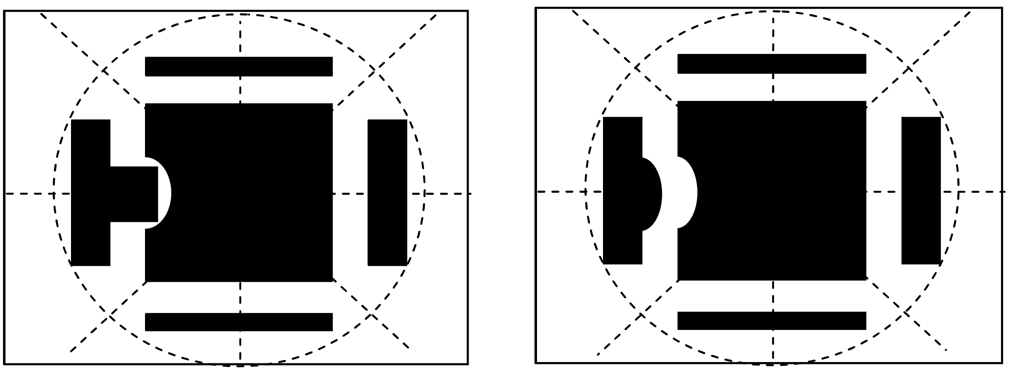


Figure 4-29 An example of Flexibility

4.4.6 How the new principles relate to the original principles

The new set of principles was developed based on Guo's (1995) principles. Figure 4-30 shows the relationship between the new principles and those of Guo.

New Principles	Guo's Principles
• Balanced Weight	• Pingzheng
• Balanced Space and Proportion	• Yunchen
• Avoiding Proportional Prominence	• Rangjiu
• Circular/Elliptical Layout	• Xietiao
• Flexibility	• Bianhua

Figure 4-30 Relationship between the new principles and Guo's principles

4.5 Designing interfaces with the new principles

The following components (Figure 4-31) were used in a prototype of the software to motivate British-born Chinese children to develop their culture of origin. The five new principles were used to produce a harmonious screen interface.

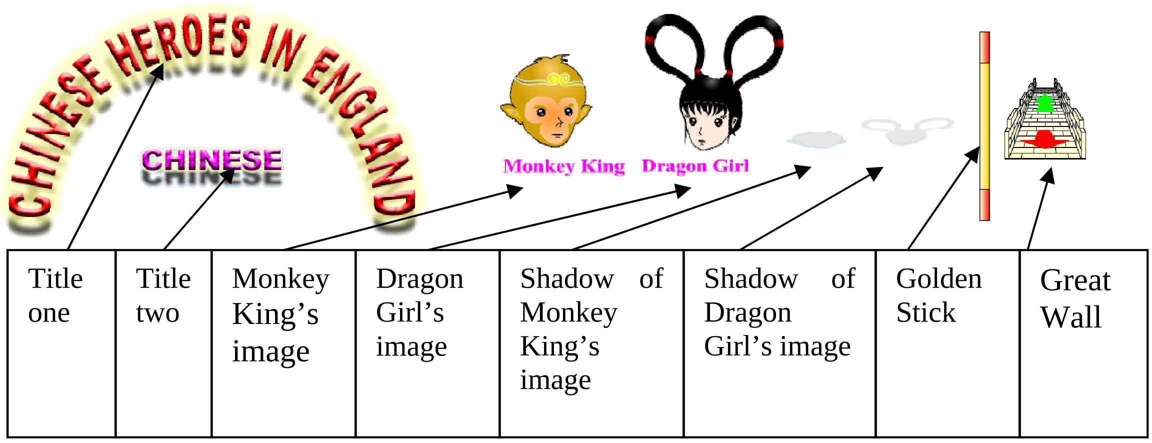


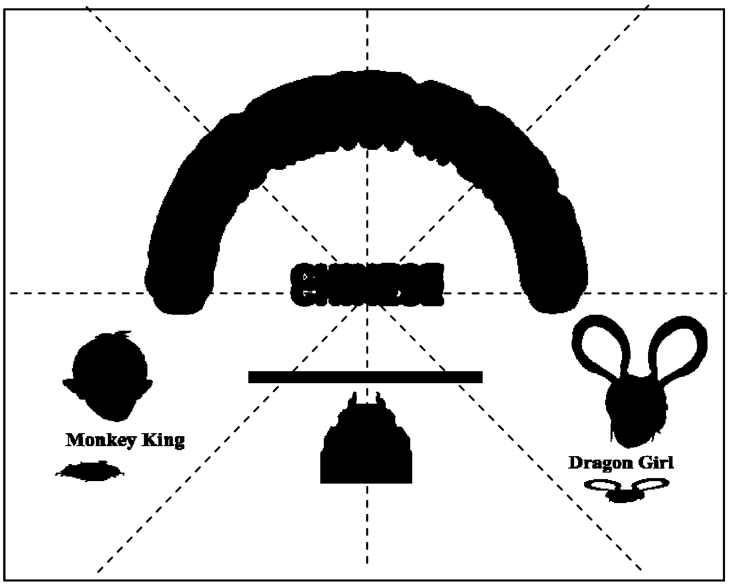
Figure 4-31 The components for demonstrating the principles

4.5.1 Principle One: Balanced Weight

1. Turn each object into a black silhouette to reduce confusion and distraction (Figure 4-32).

Figure 4-32 Remove the colours on the components

2. Set the centre of gravity of the interface at the middle by using the three lines, whilst, the relationships among the components requires extra attention. For instance, the Monkey King’s image has to be always beyond its shadow (Figure 4-33).



Width : Height = 4:3 (regular interface’s dimensional proportion)

Figure 4-33 Build an interface and apply Balanced Weight

3. Ensure the two parts divided by each line approximately contain the same size of black area (Figure 4-33).

4.5.2 Principle Two: Balanced Space and Proportion

1. Locate the centre of gravity of each component.

2. Balance the distance between the centres of neighbouring components. (Figure 4-34). It is unlikely that all distances can be exactly the same, but the designer should get as close to this principle as possible.

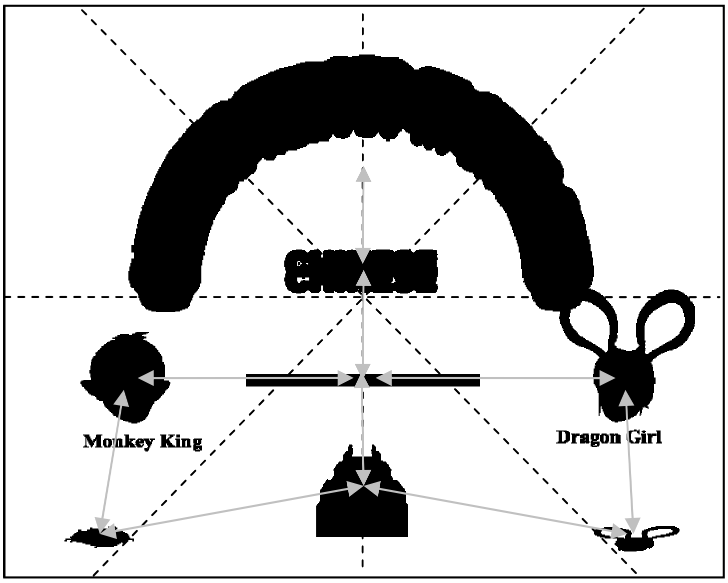


Figure 4-34 Apply Balanced Space and Proportion to the interface

4.5.3 Principle Three: Avoiding Proportional Prominence

1. Identify items that appear to be prominent and resize them. In this example, it is the title one.

2. Rearrange the positions of other components to retain the balanced weight, the centre of gravity of the whole interface and the balanced distances and proportions.

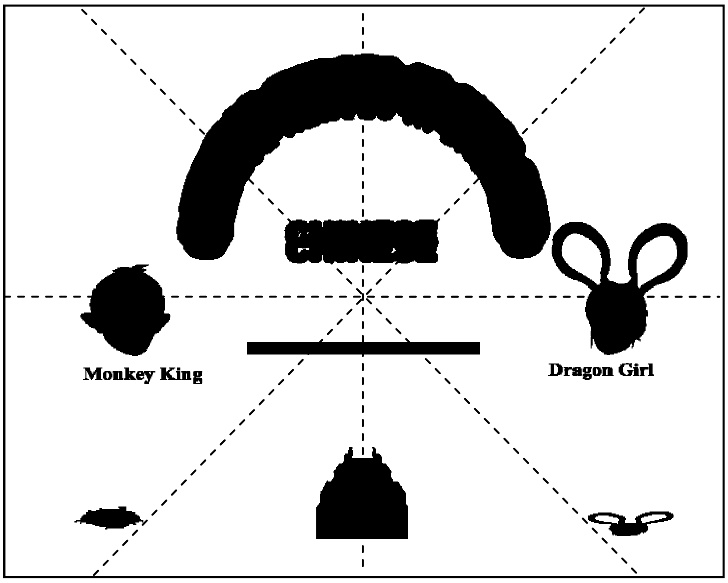


Figure 4-35 Apply Avoiding Proportional Prominence on the interface

4.5.4 Principle Four: Circular Layout

1. Keep the peripheral components on a circle (Figure 4-36).

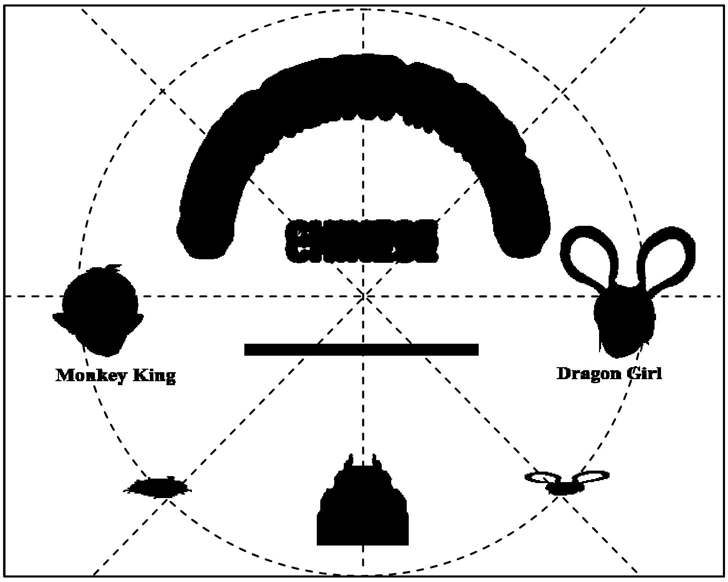


Figure 4-36 Apply Circular Layout to the interface

4.5.5 Principle Five: Flexibility

1. Review the completed design

2. Change components that may harm harmony. In this example, Dragon Girl's hair is too outstanding so it should be made it smaller (Figure 4-37).

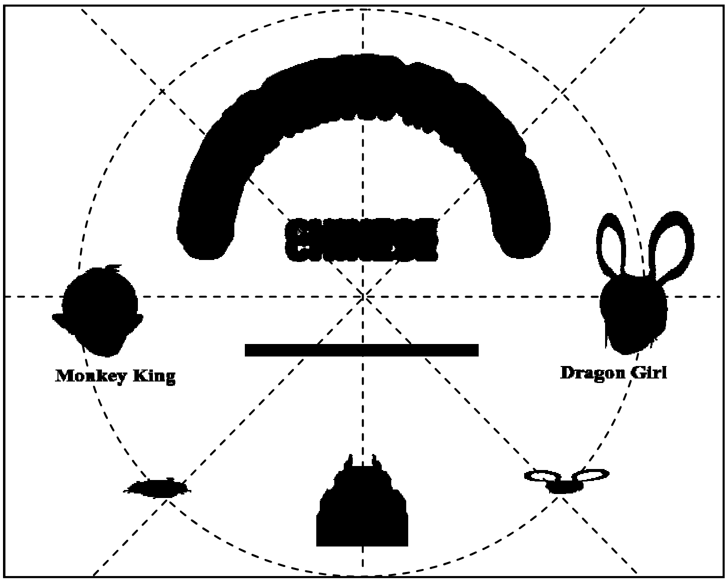


Figure 4-37 Apply Flexibility on the interface

So far, the five principles have been applied. It is time to return to the coloured components and remove the lines (Figure 4-38).

Figure 4-38 Return colours and remove the Judgement Lines

Figure 4-39 displays some screen interfaces with the same components, but each screen interface breaks a least one principle. The finished interface (A) obeys the principles and is visually more harmonious.

The harmonious screen interface

A

Below are some less harmonious screen interfaces

B

C

D

E

Figure 4-39 Examples of interfaces disobeying some of the principles

The interface B mainly breaks the principle of Balanced Weight. Its left half is heavier (cluttered) than its right half. In the interface C, the distances between the centres of gravity are obvious various, which is against the principle of Balanced Space and Proportion. In the interface D, “Monkey King” is too prominent and draws too much attention. In the interface E, it is difficult to draw a circle or ellipse that go through the peripheral components.

4.6 The clarified and ambiguous points in the first refined principles

Based on the thesis author's experience of practicing Chinese regular script calligraphy and analysis on many Chinese characters, the first attempt of converting the Chinese regular script calligraphic principles allowed some general methods to be deducted in the principles published by Guo (1995).

In the first version of the converted principles, the first principle Balanced Weight aimed to cover the concept in the first original principle PingZheng (Guo, 1995), to make a Chinese character look stable. The method was to divide the interface into two halves by a horizontal line, a vertical line and two diagonal lines which cross the central point of the interface, if the weights on any pair of halves are the same, the character will look stable. This could be mathematically deducted, because by calculating how many pixels are occupied by the character's strokes (components in terms of screen interface) in each half, the level of balanced weight can be worked out. This will be explained Chapter 6.

The second principle Balanced Space and Proportion was intended to cover the concept of establishing harmonious relationship between the strokes from the two original principles "Yunchen" and "Xietiao" (Guo, 1995). The method was to calculate the distances between the centres of gravity of the strokes and work out whether they were more or less the same, which was a deductive method as well and will be further explained in Chapter 6.

The third principle Avoiding Proportional Prominence focused on the concept of avoiding dominating sub-character from the third original principle "Rangjiu" (Guo, 1995). The method was to reduce a component's size if it occupied too much space. However, there is no indication of the degree of resizing.

The fourth could be mathematically deductive. The fourth principle Circular Layout was concluded by the thesis author and not in Guo's (1995) principles. Fu (2003) had arrived at the same conclusion as well. A circle or an ellipse can be mathematically described.

The final principle Flexibility was equivalent to “Bianhua” which is Guo’s (1995) final principle. It delivered the concept that some components could be slightly re-designed in order to achieve the first four principles. This is not calculable because the parameters are uncertain.

4.7 Summary

In this Chapter, Guo’s (1995) five principles were first converted into analytical and deductive principles. An example was given to demonstrate the new principles. However, not all the principles could be mathematically described. The principles: Balanced Weight, Balanced Space and Proportion and Circular/Elliptical Layout could be computed, but Avoiding Proportional Prominence and Flexibility were lack of parameters to formulate them. Only two out of three identified points in the first version of the refined principles could be mathematically described.

Chapter 5. The Second Stage of Deducing the Chinese Calligraphic Principles (Version 2)

In the first version, only two out of three identified points in the principles could be mathematically described. The tests with users were made to help discover and clarify some ambiguous points in the principles.

5.1 User trials with the first version of the principles

5.1.1 Aim

In the first version of the principles, the mathematically describable points were:

1. Balanced Weight;
2. Balanced Space and Proportion;
3. Circular/Elliptical Layout.

Those ambiguities that could not be mathematically described were:

1. How much to resize components to reach Avoiding Proportional Prominence;
2. Flexibility.

This study was done to find out how the ambiguities were handled by the users. Another aim was to find out whether there were some undiscovered ambiguities.

5.1.2 Method

Participants

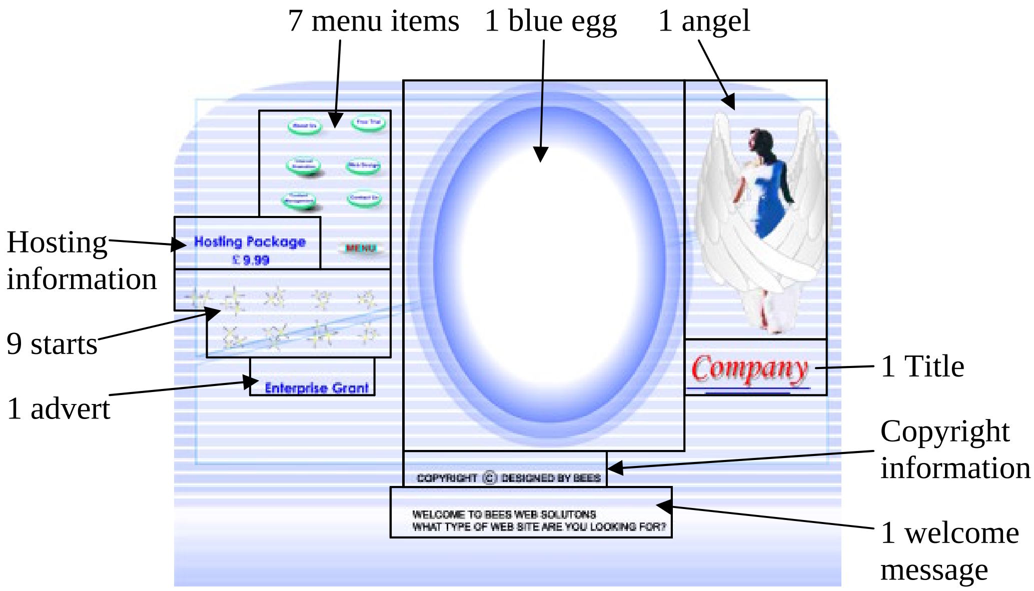
As the aim of the principles was to help novice designers to arrive at harmonious screen interface designs, first year Computing students were used for the survey. 64 first year (2004) computing students doing the Web Application module participated in the experiment. They were all aged less than 40, but 58 of them were about 19. However, only a few of them were female. Before the experiment, they were all trained to use Adobe Photoshop CS2. A reason for choosing computing students was because this research was about HCI, which is important in Web Design. Therefore, the participants should know that this research was relevant to them so they were motivated (Alessi et, al. 2001).

Apparatus

This trial was carried out in a two-hour class. The venue was in the computer laboratory in the Computing and Technology Building at the University of Central Lancashire. Each participant had access to a desktop computer. Adobe Photoshop CS2 was installed on each computer and an overhead projector was used to do the presentation about the principles.

Design the interfaces for evaluation

There was no pre-designed interface for the participants to work on. However, some interface components were pre-designed so the participants did not need to spend time making their own components, and because it would be easier to compare and analyse later. They were grouped according to their types and each of them was put into layers in an Adobe Photoshop readable file (PSD format) (Figure 5-1). The components were seven menu items, one blue egg, one angel, one title, one piece of copyright information, one welcome message, one advert, nine starts and one piece of hosting information.

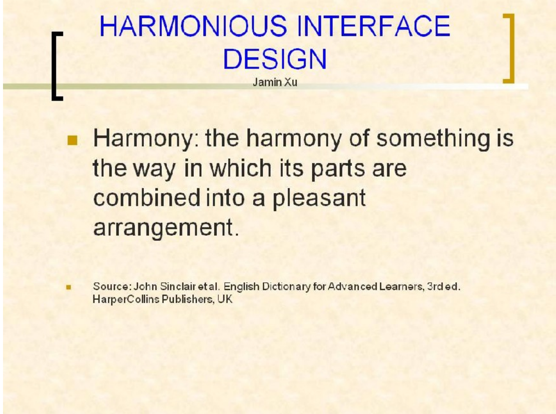


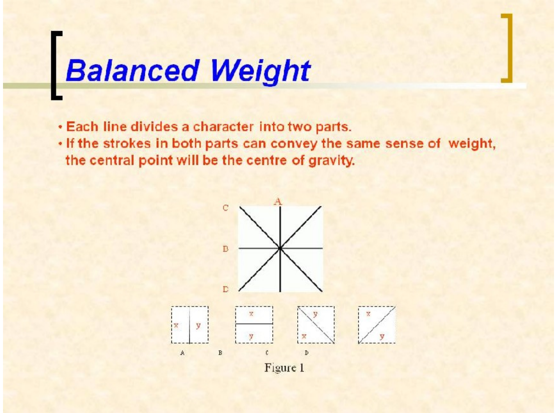
Components grouped (in box) and layered for the participants

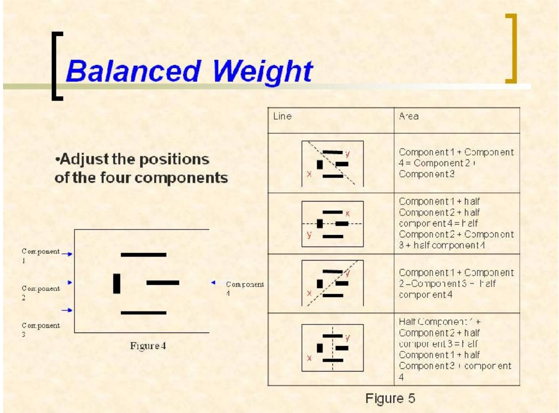
Figure 5-1 Components for the first experiment

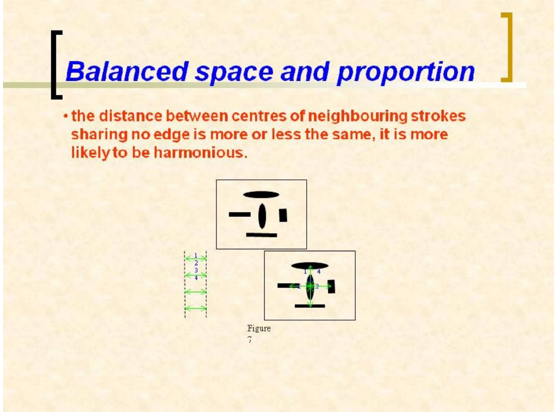
Design instruction

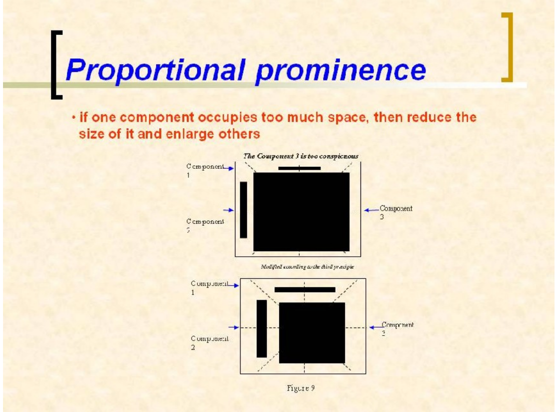
The instruction given to the students were those outlined in Section 4.4 and Section 4.5, except that reference to Chinese characters (Table 5-1).

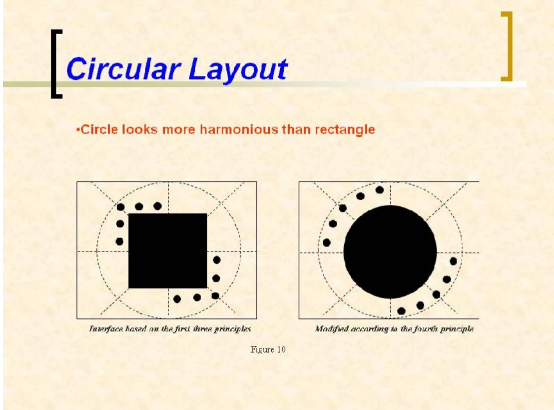


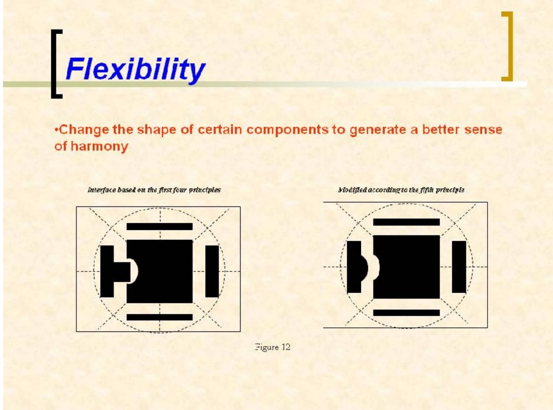


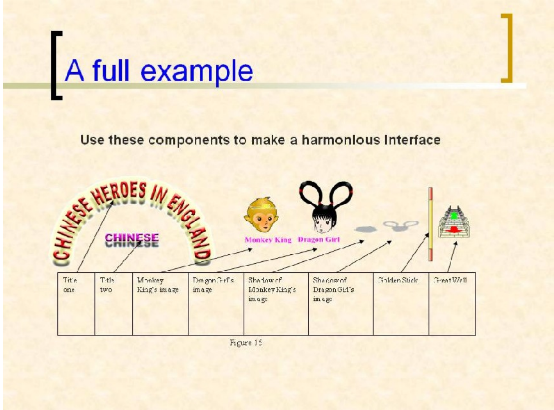


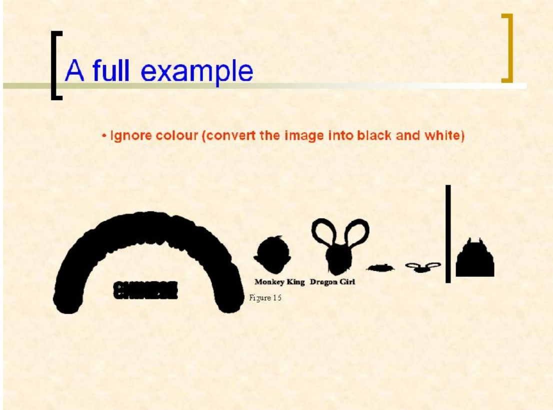


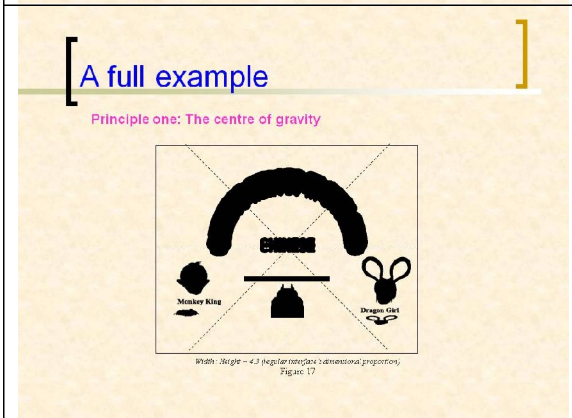


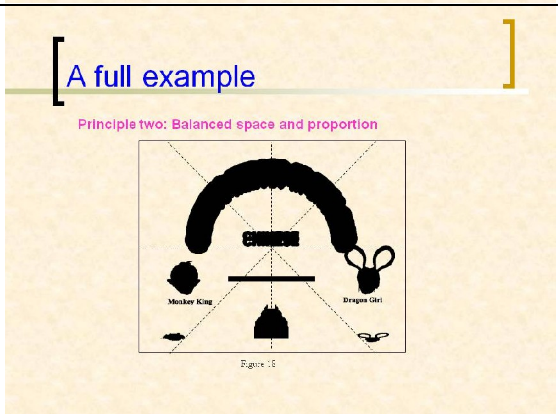

Circular Layout
•Circle looks more harmonious than rectangle
Interface based on the first three principles
Modified according to the fourth principle
Figure 10

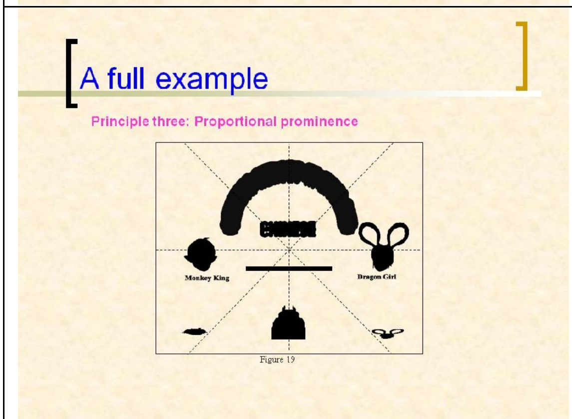

Flexibility
•Change the shape of certain components to generate a better sense of harmony
Interface based on the first four principles
Modified according to the fifth principle
Figure 12

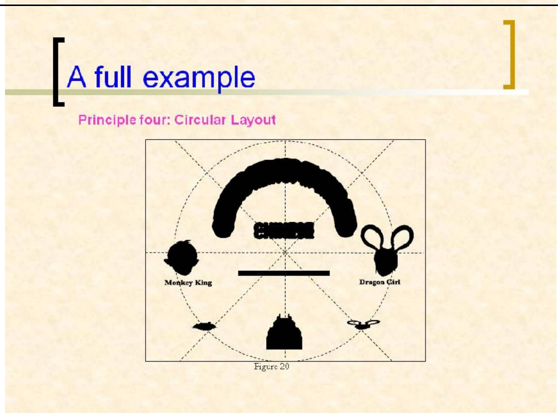

A full example
Use these components to make a harmonious Interface
CHINESE HEROES IN ENGLAND
CHINESE
Monkey King
Dragon Girl
Title one
Title two
Monkey King's image
Dragon Girl's image
Shadow of Monkey King's image
Shadow of Dragon Girl's image
Golden Stick
Great Wall
Figure 15

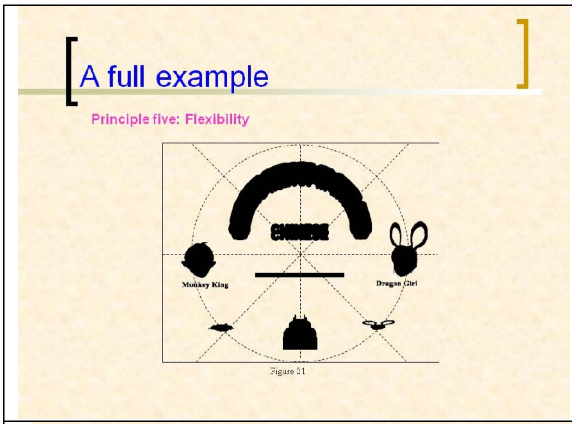

A full example
• Ignore colour (convert the image into black and white)
Monkey King
Dragon Girl
Figure 15

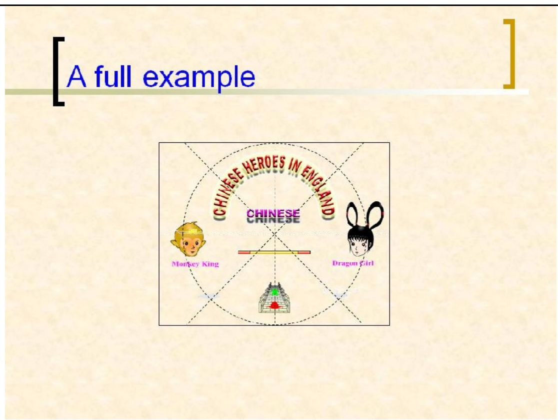

A full example
Principle one: The centre of gravity
Monkey King
Dragon Girl
Figure 17


A full example
Principle two: Balanced space and proportion
Monkey King
Dragon Girl
Figure 18


A full example
Principle three: Proportional prominence
Monkey King
Dragon Girl
Figure 19


A full example
Principle four: Circular Layout
Monkey King
Dragon Girl
Figure 20





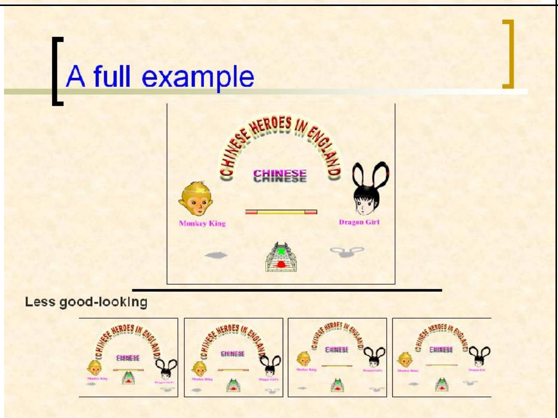


Table 5-1 Instruction slides for the first experiment

The participants were instructed to use only the interface components provided.

The aim of clarifying the ambiguous points was not given to the participants to avoid it becoming focal points in the users' designs.

Procedure

First they were informed of the purpose of research to raise their attention (Alessi et al, 2001). Then the survey went through 4 steps. The participants were asked to use the prepared components in Figure 5-1 to design two interfaces. Then, they were taught the five principles and modified their designs accordingly.

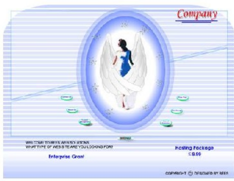
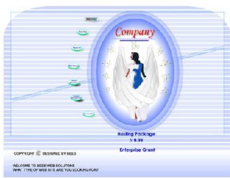
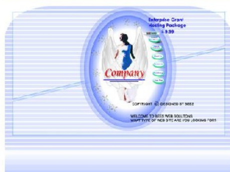
Step One: the participants were required to apply the pre-prepared components to create an interface based on their own perspectives. They were not allowed to add and edit the components with extra graphics except by changing the size. This step lasted about 30 minutes.

Step Two: A 15 minute presentation about the Harmonious Interface Design Principles was delivered to the participants. It consisted of the five principles and an example with a detailed explanation.

Step Three: The participants were asked to modify their designs according to the principles. Finally, they were asked to submit their original designs and final designs by email for further study.

5.1.3 Results

Only 19 participants emailed their designs which are displayed in pairs in Table 5-2. The left ones are their original designs and the right ones are the modified version according to the principles.

	Original	Modified		Original	Modified
1			2		
3			4		
5			6		
7			8		

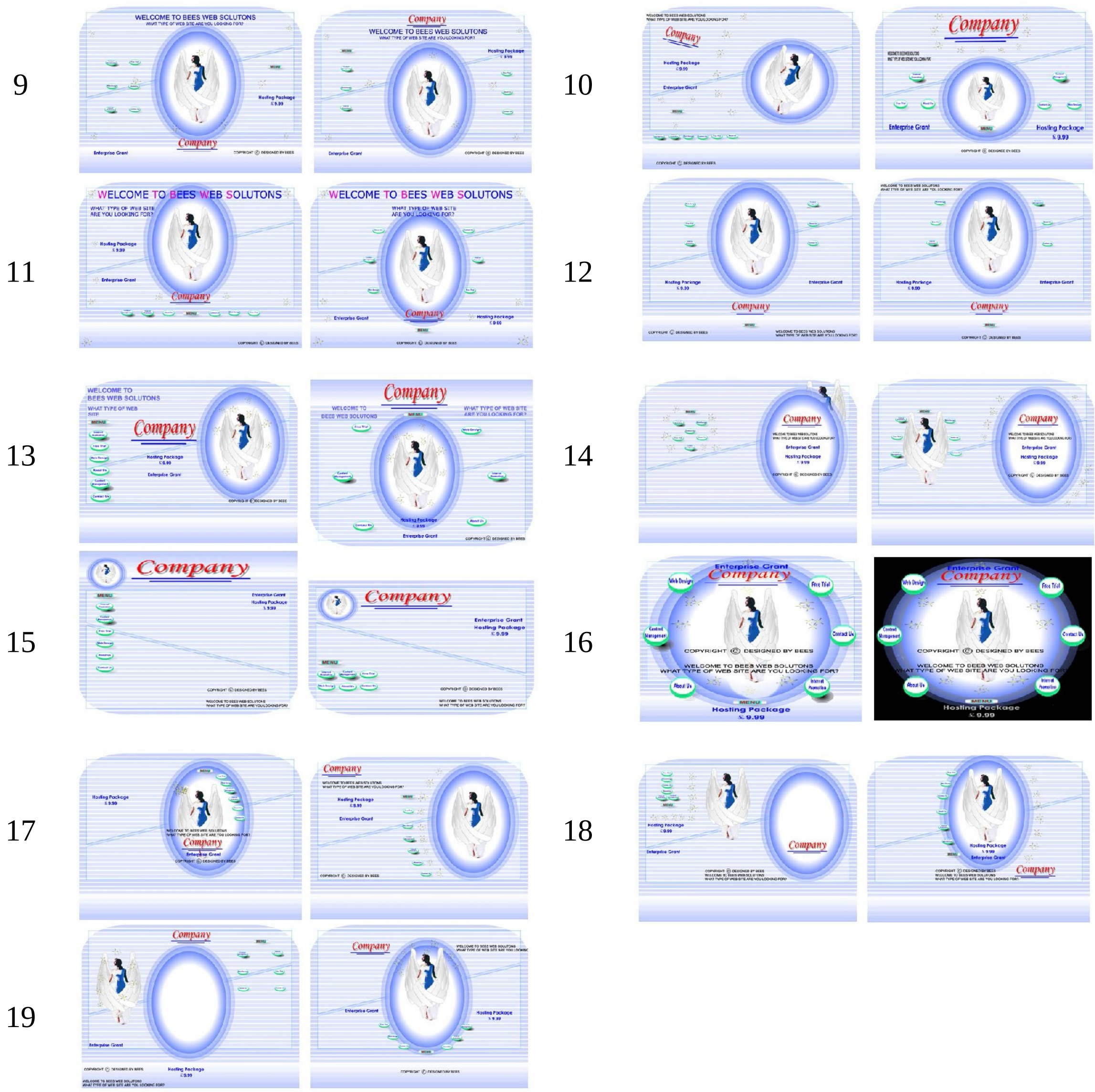


Table 5-2 The participants' original designs and their modified versions in pair (2004)

5.1.4 Analysis

At this stage, the satisfaction of the principles was visually estimated with the Judgement Lines. Below are listed the satisfactions of the five points stated in the aims:

The three mathematically describable points

1. **Balanced Weight** was well applied because the visual weight was better distributed in all modified versions, except those in the pairs 2, 12 and 16. In Pair 2, the left half is obviously "heavier" than the right half in both the original and modified designs. In pair 12, the original design is actually more "stable"

than the modified version, as the "welcome message" on the top-left of the modified version breaks the balance of left and right. There is no difference in Pair 16, just the background colour changed.

2. **Balanced Space and Proportion** was well applied as well because all modified designs are less cluttered and the distances between the centres of gravity are more balanced, except Pair 18 in which the modified version is more cluttered. The action to satisfy this principle forced some components to form a curve. For example, compared to the original designs, the buttons in the modified version of pairs 1, 3, 4, 11, 12, 13, 14, 18 and 19 were changed from straight line formation to curve formation.

3. **Circular/Elliptical Layout** was clearly applied. For instance, the layouts in the modified versions of pairs 2, 3, 4, 6, 7, 8, 10, 11, 12, 13, 18 and 19 are closer to a circular or ellipse than the original ones.

The ambiguous points

1. **How much to resize to reach Avoiding Proportional Prominence?** When applying the principle Avoiding Proportional Prominence, the participants resized the components to various levels. For instance, in pairs 3, 5, 7, 10, 13 and 16, the menu buttons, the angel and the blue egg were resized but in different proportions. That indicates that the participants did not share a common standard in resizing the components.

2. **Flexibility** aims to emphasize that changes should be made to satisfy the first four principles. There was no sign that the participants changed the components in a particular rule.

5.1.5 Discussion

The results from the participants did not clarify the ambiguous points in the first version of the refined principles. Furthermore, another ambiguous point was discovered: the effort to satisfy the principle of Balanced Space and Proportion could result in a curved formation for some components, but sometimes some components had to line up. The idea of grouping components emerged as a principle to avoid this problem.

5.1.5.1 Deriving principle six: Apply Other Principles from Part to Whole

Further analysis of Chinese characters showed that the characters already conveyed the idea of grouping components: some Chinese characters consist of two or more sub-characters. The principles for building a harmonious Chinese calligraphic character are applied to all the sub-Chinese-characters first, and then the sub-Chinese-characters were treated as a 'stroke' for building the full character. This principle would be applied when some components are made up of subcomponents. For example: the Character for river 河 consists of two parts: 氵(three water drops) and 可 (Maybe). 可 consists of two parts: 丁 (single) and 口 (mouth). First, the principles were applied to 口 to make it harmonious and group it, so the 口 had its own centre of gravity. Then the principles were applied to make the 可 harmonious, so that it had got its own centre of gravity (the centres of gravity for this character were visually estimated at that moment and later calculated by the software Autodesk AutoCAD v14 to confirm its accuracy). Finally, the principles were applied to the whole character to make it harmonious (Figure 5-2).

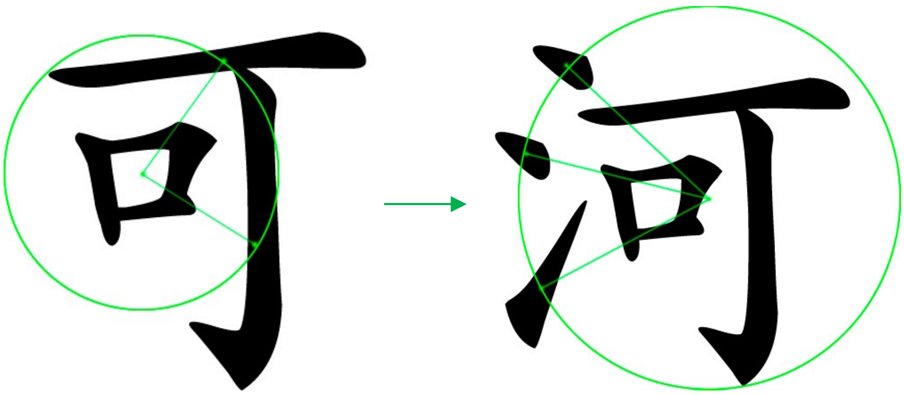
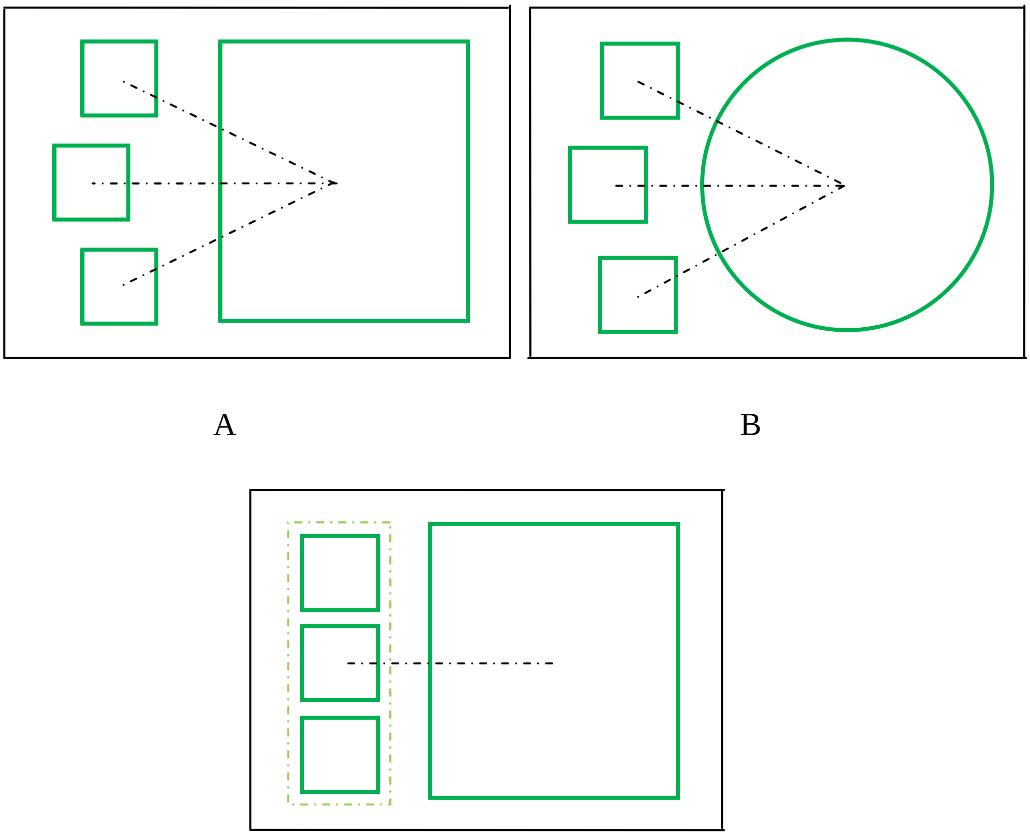


Figure 5-2 Applying the principles from the sub-characters to the whole character

The analysis of characters like 河 led to another conclusion: in interface design, the centres of gravity of small and ungrouped components should form a curve to satisfy Balanced Space and Proportion, like the three left dots on the Chinese character for river. This conclusion supports what the participants did in their designs. However, this conclusion seems to break the principle of Avoid Proportional Prominence. For example, in Figure 5-3, the second small square in A is too prominent when it satisfies Balanced Space and Proportion. There are two solutions to this problem (Figure 5-3):

first, change the large square on the right to a circle, so the distances between the edges of the components are similar, (A to B). Second, the three squares can be grouped to form one component, as in C.



A B

C

Figure 5-3 Grouping components to avoid proportional prominence

The literature also supports the idea of grouping components: grouping components into distinguishable chunks can make it easier for people to understand the embedded functions of the components (Cox, 1993); No matter what the scale, shape, size and style are, the space surrounding them will encourage the readers to read them together (Knigh, 2003). Background colours, clear outline or even Interposition Cue theory (Eysenck, 2000) can be used to group components. Therefore, this feature was taken as a new principle: **Apply Other Principles from Part to Whole.** In other words, group some relevant components and treat the group as a sub-interface. The term “Relevant components” here refers to some components designed with the same or similar functions. The first five principles are applied to the group to make it harmonious. If the group is identified by its background colour and clear outline, then it is a new component of the whole interface. Only a harmonious group can be treated as a new component of the whole interface, because a messy group will damage the overall harmony. Because it is a sub-interface, the space organisation within it can be different from the rest of the interface. For instance, a menu bar consists of many buttons. The area of the interface for the menu bar is pre-determined. The menu can be treated as a sub-interface. The principles will first be applied to make the menu harmonious. Since the principles are first applied to the menu, the spacing among the buttons can be different from the rest of the interface. After that, the menu will become one component of the whole interface. It has its own centre of gravity, size and shape.

5.1.5.2 Identifying the centre of gravity

The newly added principle resulted in another problem: the increased complexity of identifying the centre of gravity. The centre of gravity is an important concept, it was assumed that the participants understood and knew how to find it for each component. In this study, no method was given to the participants to identify the centre of gravity. The more accurately that the designers can locate the centre of gravity of components and interfaces, the better they can apply the principles. When the strokes of a Chinese character or interface components are grouped, the shapes can be very asymmetrical and irregular. In geometry, there are ways to identify the exact centre of gravity of any 2D shape, but it was considered that in calligraphy and interface design, there was no need to be so precise. Simply converting all strokes and components into three common shapes should be enough. The three basic shapes are triangle, parallelogram and circle. These three kinds of shapes' centre of gravity are easy to be identified (Figure 5-4).

- The centre of gravity of a triangle is where the medians cross.
- The centre of gravity of a parallelogram is where the diagonals cross.
- The centre of gravity of a circle is at its centre.

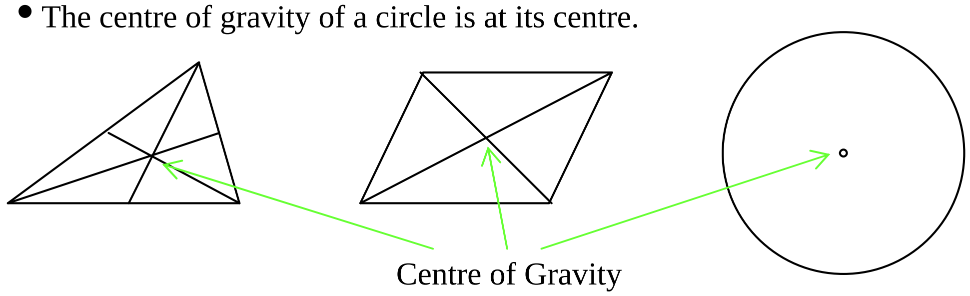
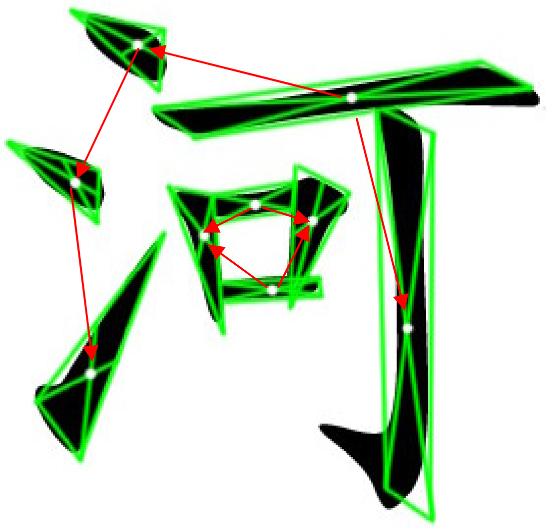


Figure 5-4 the Centre of Gravity of the three basic shapes

Figure 5-5 illustrates some examples of how to roughly identify the centre of gravity in Chinese regular script calligraphy and interface principles. This was presented to the participants in the later studies. This method can be applied to grouped components as well.



Example of Chinese Character

1. The white sports are the centres of gravity
2. Balanced Space and Proportion is judged according to these centres of gravity

Examples of Interface Components

1. As this is interface design, the centre of gravity of each component does not need to be precisely located
2. Each component is converted into a triangle or regular rectangle to roughly locate the centre of gravity the centre of gravity in mind

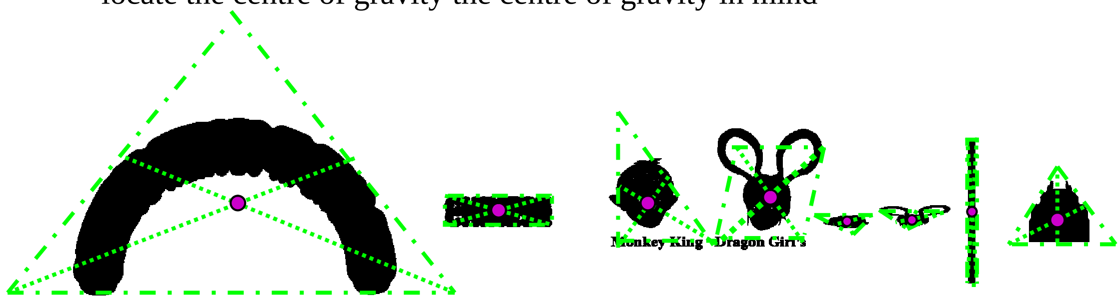


Figure 5-5 Roughly identify the centres of gravity in Chinese regular script calligraphy and interface components.

5.1.6 Conclusion

This study helped to identify that when the designers applied the principles, they tended distribute the components in circle to satisfy the principle of Circular/Elliptical Layout. Further analysis concluded that the sixth principle: “Apply Other Principles from Part to

Whole", should be added. The sixth principle was about grouping some components by applying the principles to these components first. To satisfy the principle of Balanced Space and Proportion, sometimes components will form a curve, which may not be necessary for some components with the same functions, such as menu buttons. Grouping the components can solve this problem.

After grouping some Chinese character strokes and interface components, the complexity of the shapes would be increased, whilst it also increased the difficulty of identifying the centre of gravity. The proposed solution was to convert the components into basic geometric shapes such as rectangle, triangle and circle/ellipse, then locating the centres of gravity.

The idea of grouping components was actually subjective, since it was based on Interposition Cue theory (Eysenck, 2000). This study did not make the principles more mathematically deductive, but added more subjective elements.

5.2 Discussing the principles with Chinese scholars

Since the principles were taken from Chinese calligraphy, it was assumed that Chinese people would be able to identify omissions. There was a seminar at Oxford University where lecturers of Chinese language were gathered together to discuss Chinese language teaching, and a half hour discuss on the reformulated principles was included in this event.

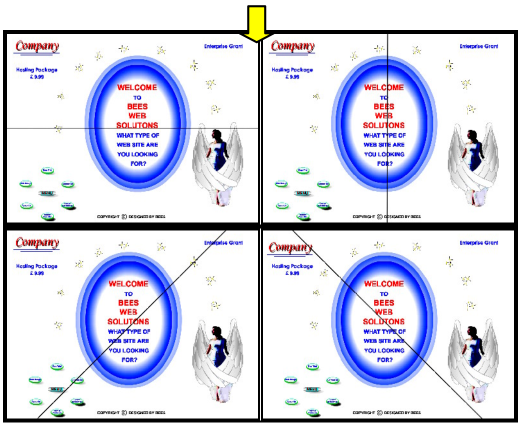
The attendees in the seminar were from different universities in the UK, and aged between 25 and 65, and some of them had PhDs. There were 26 participants, including 22 females and 4 males. 22 of them were Chinese. They were experts in Chinese teaching and familiar with Chinese culture, including Chinese calligraphy.

A copy of the instruction slides was given to the attendees for evaluation, as shown in Figure 5-6. In this investigation, Chinese characters were used as examples, e.g. the Chinese character "purple" (紫) was used to explain the principles and methods instead of patterns, so the audience could understand how the principles were reflected in the Chinese characters.

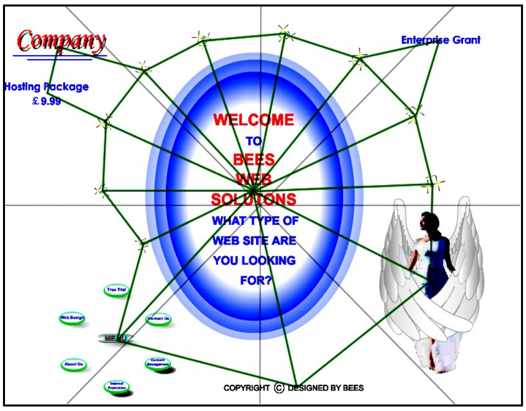
They were then led through the principles for building an interface, which gave them experience of how the interface components were re-positioned according to the principles. First, a draft interface was built with the components. Second, based on the sixth principle, the first five principles were applied to make the sub-interface harmonious, then applying the principles one by one to make the whole interface harmonious, as shown in Figure 5-6.

Using the components to build a draft interface

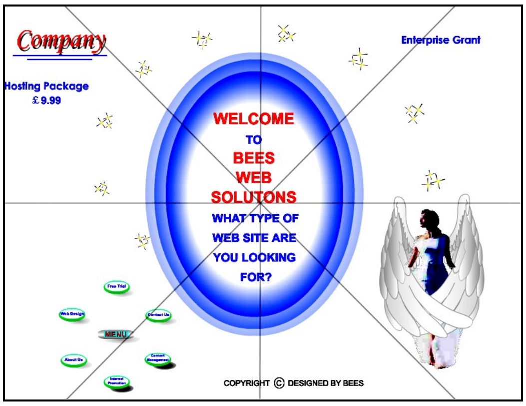
The sixth principle: Apply the principles to make the sub-interface harmonious



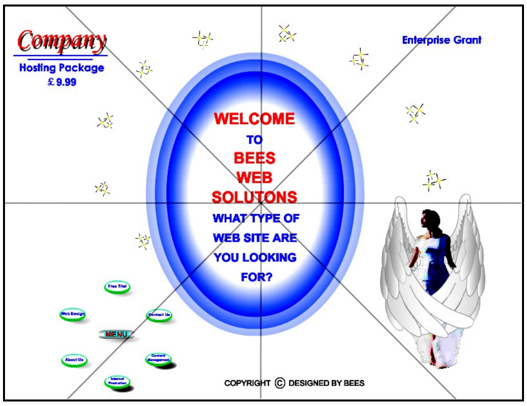
The first principle: Balanced Weight results in repostioning the compoents.



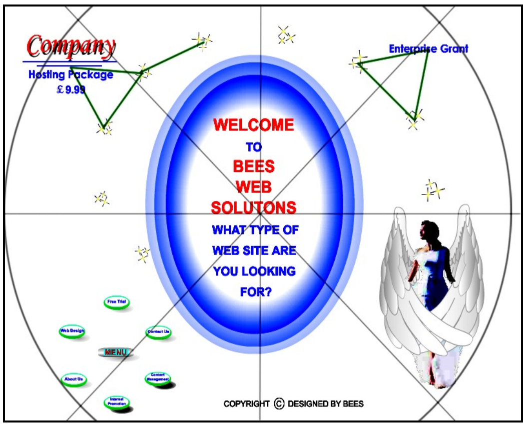
The second principle: Balanced Space and Proportion results in repostioning the compoents.



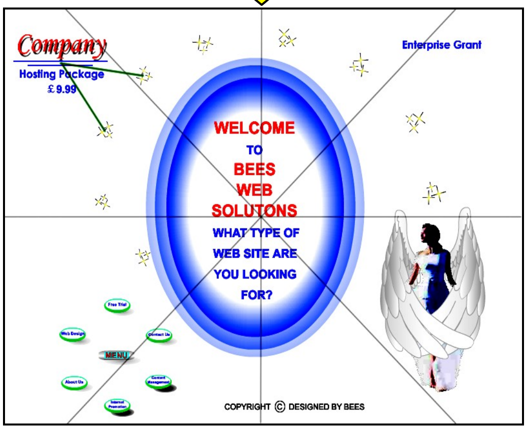
The third principle: Avoiding Proportional Prominence. No change as none of the components is aggressive.



The fifth principle: Flexibility results in merging the two top-left components into one.



The fourth principle: Circular Layout results in repositioning the components. Go through the principle again to balance the needs of the principle



Apply the first and second principles again since some compoents have been changed.

The interface after the application of the principles

The draft interface

Figure 5-6 The interfaces used to explain the principle in the Chinese teaching seminar

During this session, three questions were asked in the seminar:

1. Do the principles correctly deliver the features of Chinese regular script calligraphy?
2. Any suggestions on improving the principles?
3. When you look at the “menu” and the six buttons around it, do you tend to treat them as separated components or as one component?

In the discussion, the participants did not give any comments on how the principles delivered the calligraphic features or suggestions on improving the principles, but 2 of them expressed the view that the principle Flexibility was confusing. One delegate was confused by the new principle of applying the Principles from Part to Whole. When asked the third question, 5 people gave a positive answer and 5 people gave a negative answer. The rest did not reply.

5.2.1 Discussion

5.2.1.1 Distinguish between principle and method

Based on the result, two principles Flexibility and Applying the Principles from Part to Whole required more attention. The reason why they were confusing was found after analysing the difference between them and other principles: If traced back to the original translation, the reason why Flexibility became a principle was that when converting the principles of writing Chinese calligraphy, Flexibility was one of the principles. Actually, when analysing the principle carefully, it can be found that Flexibility does not describe a status of the arrangement of interface components like other principles. It is in fact a method to help to satisfy other principles. In the same way as Flexibility, the “principle” of Apply Other Principles from Part to Whole is not describing a status of the arrangement of interface components. It is actually a method as well.

This study highlighted a problem: The set of the principles includes principles and the corresponding methods to satisfy the principles, which must be separated. Otherwise, it will cause confusion. Based on the attributes, the principles were refined to the following:

Principles: (Describing status)

Balanced Weight: Ideally, the weight should be evenly distributed on an interface. In other words, no matter how you divide the interface into two equal halves, the areas occupied by interface components on both sides are more or less the same.

Symmetrical Space: The distances between the centre of gravity of a component and its neighbouring components' centre of gravity should be more or less the same. The centre of gravity does not need to be accurately identified. Designers can simply convert the components into some simple shapes: Circle, Triangle, Parallelogram and roughly determine the centre of gravity.

Avoiding Prominence: No component should obviously dominate the interface, i.e. be "aggressive" (Figure 5-7).

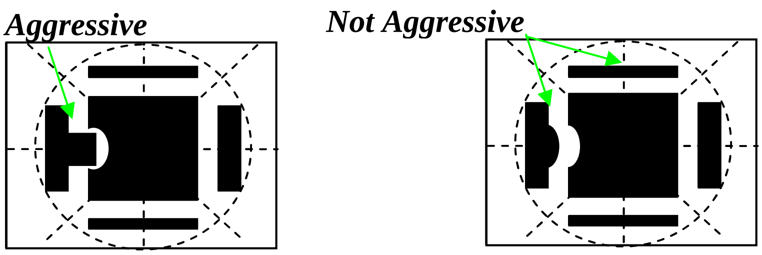


Figure 5-7 Avoiding Prominence, no aggressive

Circular/Elliptical Layout: When looking at the whole interface from a distance, the outline should be a circle or an ellipse. In other words, the most peripheral points of the outer components are on a circle/ellipse.

The ellipse was added to this principle, because most characters look like in an ellipse rather than a circle.

Methods: (Applied to reach the status described by the principles)

Moving Components: to satisfy the principles of Balanced Weight and Symmetrical Space. Because moving component takes place very often in the process of design, 'Moving Components' might be considered too common to be a method, but as changing shapes of components affect the weight/area and the centre of gravity, which results in repositioning the components, so it is emphasized here.

Re-sizing Components: to satisfy the principles of Balanced Weight, Symmetrical Space and Avoiding Prominence. Resizing the components in proportion will not affect the centre of gravity, but it affects the weight and the spaces between components. If re-sizing components is needed, "Moving Components" should be applied after resizing the components to rebalance the weight and space.

Flexing Shapes: for satisfying the principles of Balanced Weight, Avoiding Prominence. For example, in Figure 5-8, the left component of the pattern was changed to satisfy the principles. Once a component's shape has been changed, its weight may be different and its centre of gravity will be affected. Therefore, "Moving Components" should be applied after changing the shapes of components

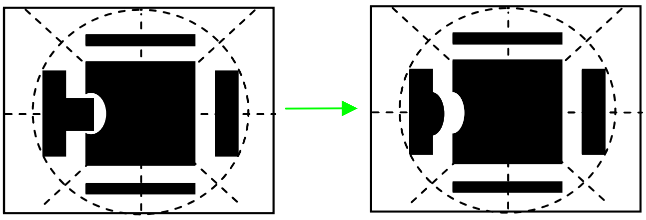


Figure 5-8 Flex Shape

Grouping Components: This method derives from the previous sixth principle: Apply Other Principles from Part to whole. Grouping components can be achieved by using background colours, clear outline and even Interposition Cue theory (Eysenck, 2000). The grouped components should be treated as a sub-interface and apply the four principles to it. This is an important method. If the grouped components are not harmoniously arranged, it can damage the harmony of the whole interface. Since the grouped components form a sub-interface, the distances between the edges, the centres of gravity of the components inside the sub-interface can be different from the rest of the whole interface, which in return makes it distinguishable enough to be a sub-interface. The sub-interfaces are new components to the whole interface. It has its own centre of gravity and weight.

Tool: (For judging how well the principles have been satisfied)

Judgement Lines: The only tool in the set of harmonious interface design principles is the Judgement Lines. Placing the central point of the tool at the centre of the whole interface, it is possible to judge whether the interface has achieved Balanced Weight, Symmetrical Space, Avoiding Prominence and Circular/Elliptical.

5.2.1.2 A new ambiguous point: the centre of gravity of the grouped components

The menu buttons were grouped by having the same spacing but without a clear boundary. Only half of the responses treated them as one component, which raised another ambiguous point: when the Interposition Cue theory (Eysenck, 2000) failed to work, which centres of gravity should participate in achieving Symmetrical Space - The centre of gravity of the whole group or the centre of gravity of each component? A further study of Chinese characters shows that there is no need for the centre of gravity of the whole group for graphical interface (Section 6.3.10).

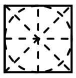
5.2.2 Conclusion

This study clarified two ambiguous concepts from the new set of the principles: Flexibility and Grouping Components, which were categorized as methods.

The six principles were refined to four principles, four methods and one tool, which became the second version (Figure 5-9).

Original Principles (the first version + the 6th principle)

1. Balanced Weight
2. Balanced Space and Proportion
3. Avoid Proportional Prominence
4. Circular Layout
5. Flexibility
6. Apply Other Principles from Part to Whole

One tool: Judgement Lines 

The principles were refined to four principles and four methods (the second version)

Principles: (Describing status)

- Balanced Weight
- Symmetrical Space
- Avoiding Prominence
- Circular/Elliptical Layout

Methods: (Applied to reach the status described by the principles)

- Moving Component
- Re-sizing Components
- Flexing Shapes (Changing shapes)
- Grouping Components

Tool: (Applied to judge how well the principles have been satisfied)

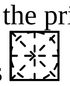
- Judgement Lines 

Figure 5-9 Developed the first version to the second version of the principles

A new ambiguous point about whether it was necessary to identify the centre of gravity of grouped components was added as well.

5.3 Trialling the second version of the principles

5.3.1 Aim

The users' designs using the principles helped to refine them further. After the two previous studies, the principles were refined to four principles and four methods. The method 'Grouping Components' was introduced to help reduce the chance that users distribute components onto a curve in order to satisfy the principle of Symmetrical Space. The previous principle Flexibility became a method so it was removed from the list of ambiguous points, but a new ambiguous point was found, which is the centre of gravity of grouped components needed for achieving Symmetrical Space. This study was to: first, confirm the usage of Balanced Weight, Symmetrical Space and Circular/Elliptical Layout; and second, to clarify the following ambiguous points:

1. How much to resize components to reach Avoiding Proportional Prominence?
2. Do the users apply Grouping Components?
3. If they do apply Grouping Components, do they use the centre of gravity of the grouped components on Symmetrical Space?

5.3.2 Method

Participants

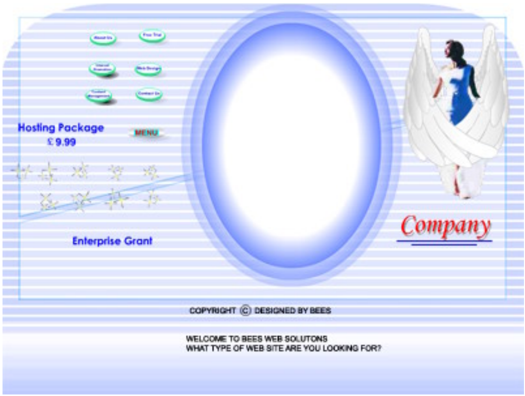
Sixty one first (2005) year computing students studying the Web Application module participated in this experiment. They were aged about 20 of which 5 were female students. A second female dominated group participated in the trial as well. They were first year Art students of 22 of which only one was male. Before the trial, they were all trained with the skill of using Adobe Photoshop CS2.

Apparatus

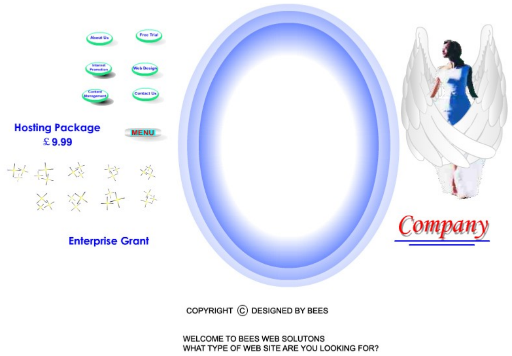
This trial was in a computer laboratory in the Computing and Technology Building at the University of Central Lancashire and lasted for two hours. Each participant had access to a desktop computer and was able to use Adobe Photoshop CS2. An overhead projector was used to do the presentation about the principles.

The interfaces to be evaluated

The interfaces were designed by the participants. The same components used for the first survey were provided (Figure 5-1). Only the background was removed, as it was not taken into account in the principles (Figure 5-10).



With the background



Without the background

Figure 5-10 Components used in the practice experiments

Design of the instruction

New illustrations were created to provide more detailed information and to explain new concepts. Table 5-3 to Table 5-7 display the instruction slides for this trial. For each principle, the relevant patterns were shown first, followed by an example interface.

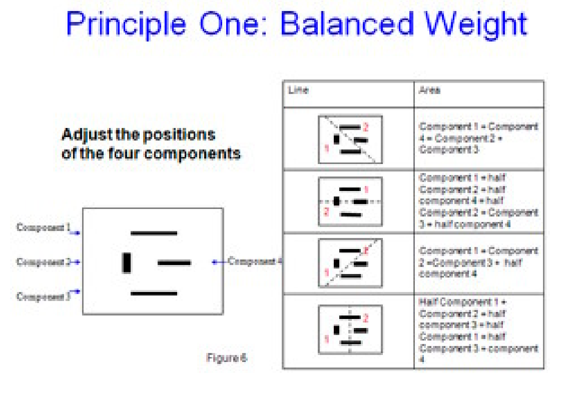
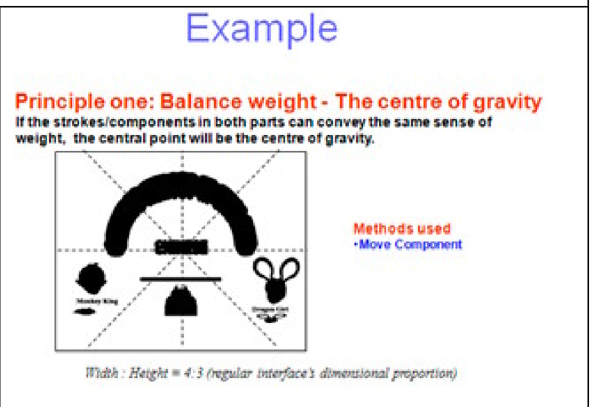
Instruction for Balanced Weight	
	
The pattern and how to apply the judgement lines	Balanced Weight on the example interface and what method was used.

Table 5-3 Instruction for Balanced Weight

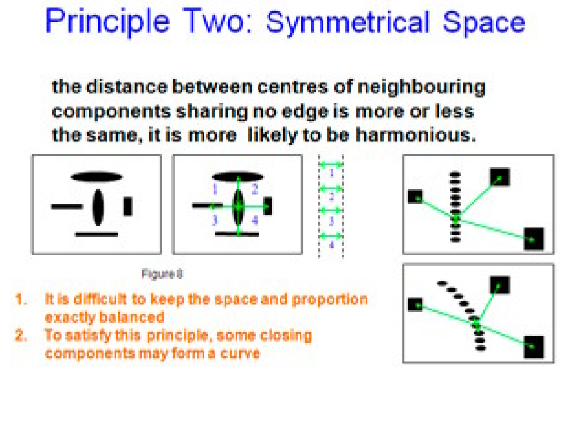
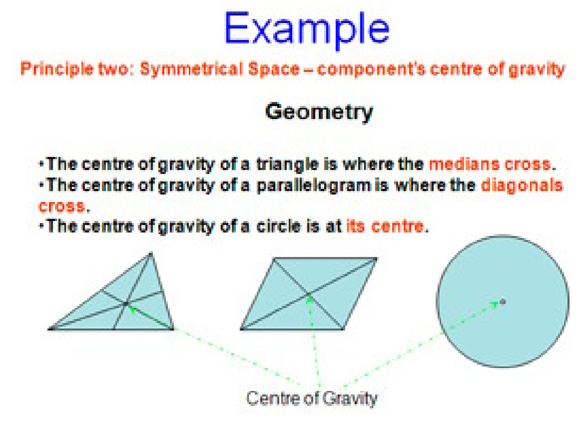
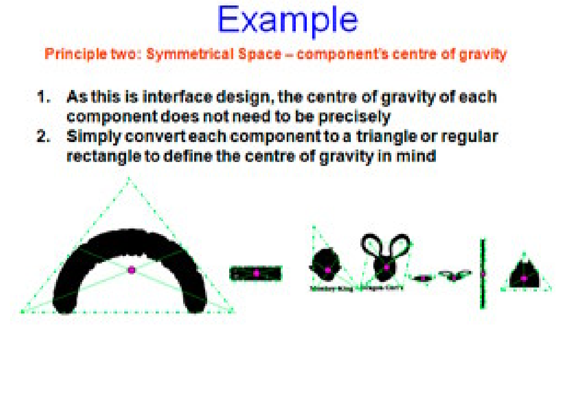
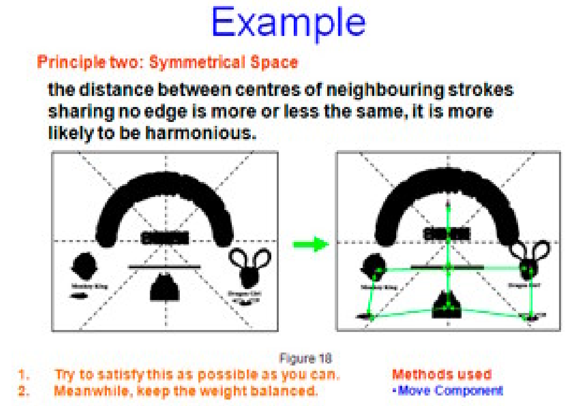
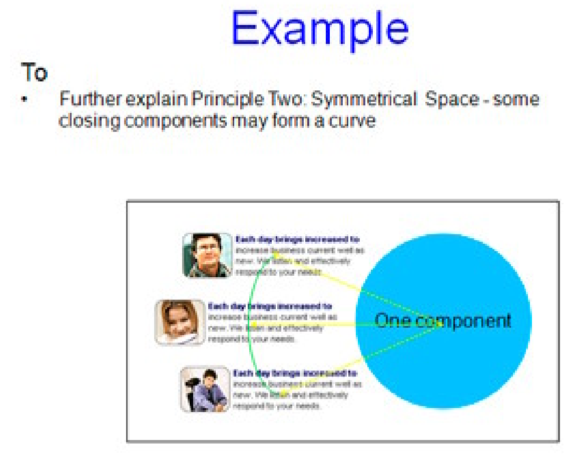
Instruction for Symmetrical Space	
	
The pattern and the idea that ungrouped components may form a curve.	Geometry to quickly identify the centre of gravity
	
Examples of applying the geometry on some interface components	Symmetrical Space on the example interface and what method was used.
	
The idea that ungrouped components may form a curve.	

Table 5-4 Instruction for Symmetrical Space

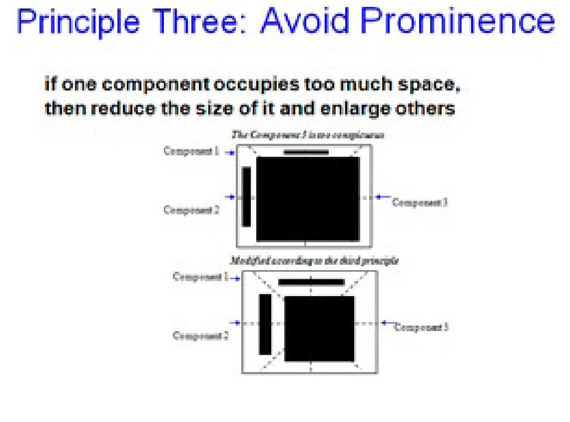
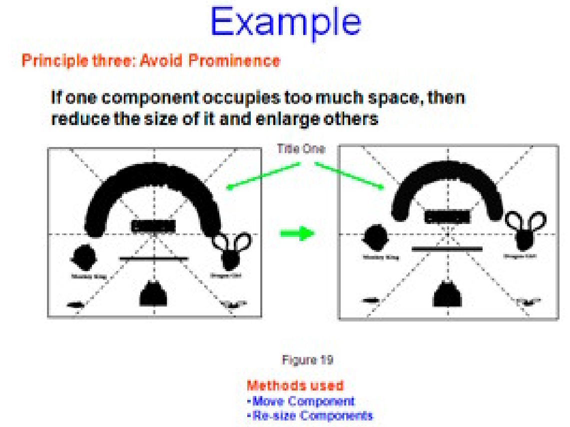
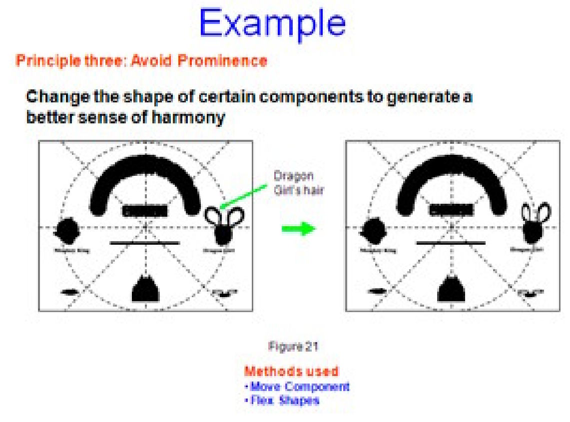
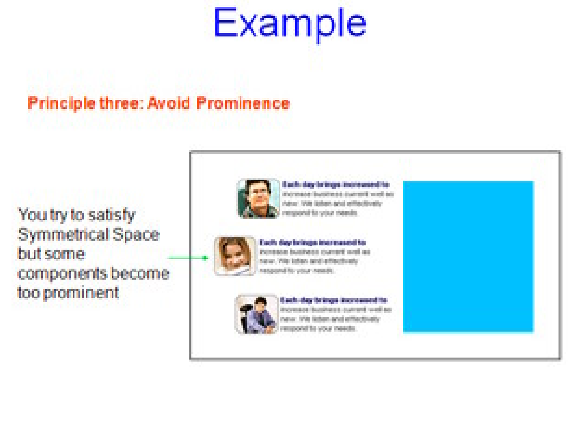
Instruction for Avoiding Prominence	
	
The pattern	Avoiding Prominence on the example interface and what methods were used. – reduce size of a prominent component
	
Avoiding Prominence on the example interface and what methods were used. – Change shape of an aggressive component	Symmetrical Space may result in some prominent components
	
Group the components to avoid prominence	

Table 5-5 Instruction for Avoiding Prominence

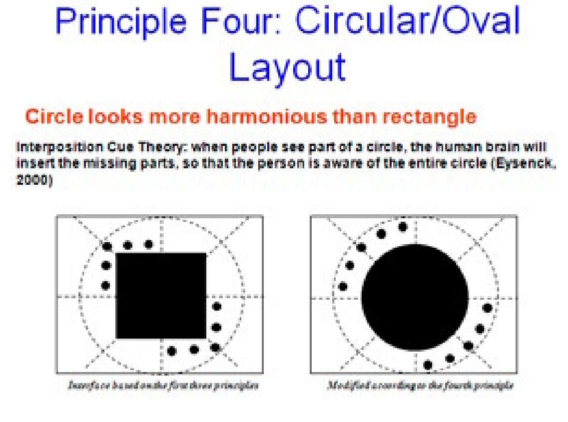
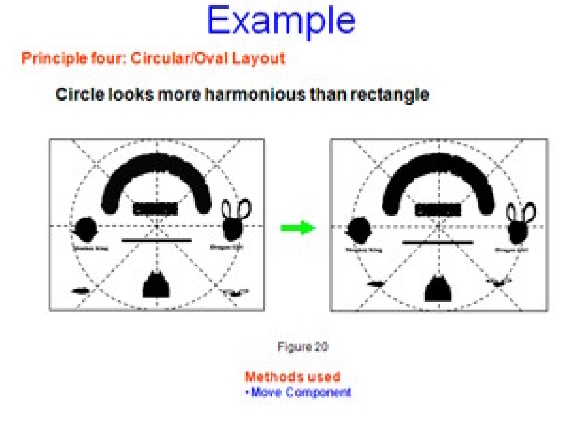
Instruction for Circular/Elliptical Layout	
	
The pattern	Circular/Elliptical Layout on the example interface and what methods were used. – reduce size of a prominent component

Table 5-6 Instruction for Circular/Elliptical Layout

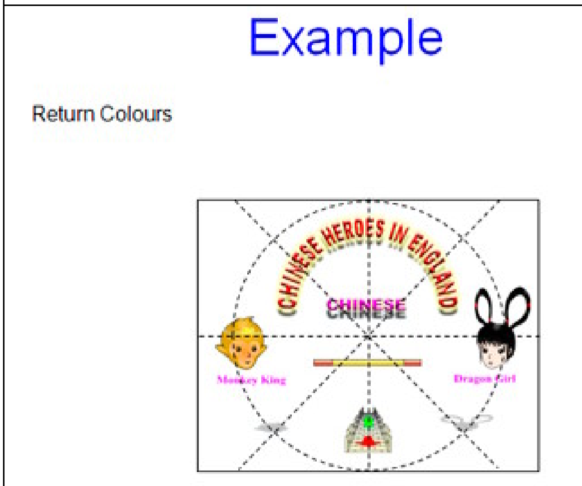
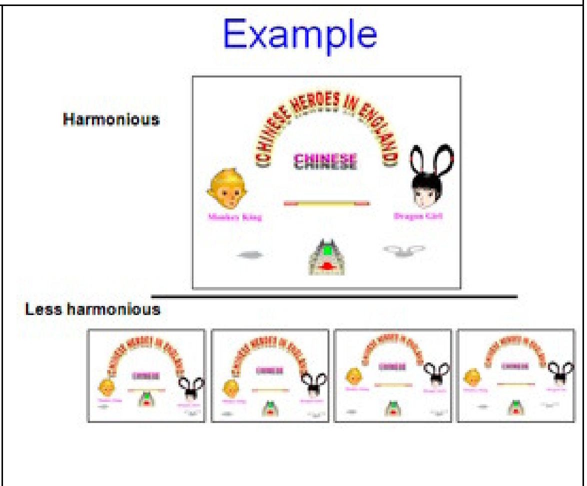
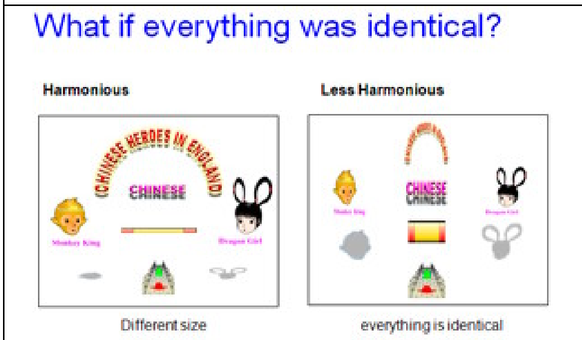
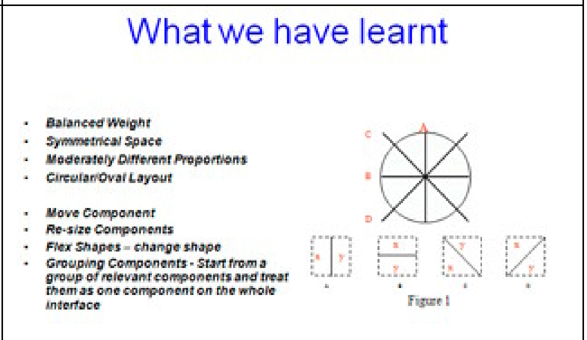
Summary	
	
Return Colours	Comparison between the harmonious one and the less harmonious
	
Harmony in various shapes and sizes	What the participants had learnt

Table 5-7 Summary of the instruction

Again, the aim of clarifying ambiguous points was not given to the participants.

Procedure

The participants used the components to design an interface then learnt and practiced the principles. At the end at the session they were asked to email their work.

5.3.3 Results

Only 17 participants emailed their designs which are displayed in pair in Table 5-8, 6 from the computing students and 11 from the art students. The left ones are their original designs and the right ones are the modified version according to the principles.

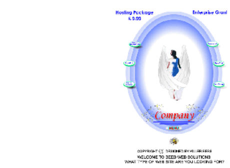
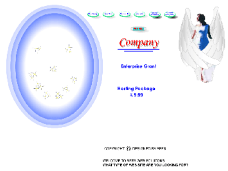
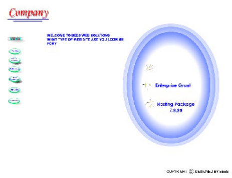
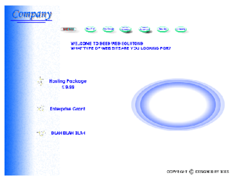
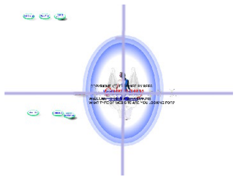
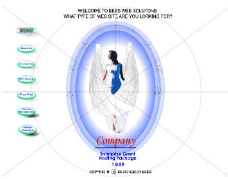
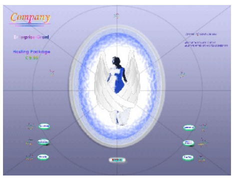
	Original	Modified		Original	Modified
		Computing students			
1			2		
3			4		
5			6		
		Art students			
7			8		
9			10		

Table 5-8 The participants' original designs and their modified versions in pairs (2005)

5.3.4 Analysis

At this stage, the Judgement Lines was the tool to estimate the satisfaction of the principles. Below is listed the satisfactions of the six points stated in the aims:

The three mathematically describable points

1. **Balanced Weight** was improved in all modified versions, except those in the Pair 1 and 7. In Pair 1, the original and modified versions were almost the same. In Pair 7, all components were enlarged in the modified version but the right half is as empty as the original one.

2. **Symmetrical Space** was well applied because the distances between the centres of gravity are more balanced and less cluttered, except pairs 1, 6 and 7 in which the original and modified versions are not much different. Some participants still put some components in a curve to satisfy this principle. They are pairs 2, 3, 8, 10, 11, 15 and 17.

3. **Circular/Elliptical Layout** was applied, but when examining the designs more carefully, some the participants distributed all components to a circle in their modified versions, which is not needed, such as pairs 1, 2, 3, 5, 8, 10, 11, 13, 14, 15, and 17. The participants in the first trail actually made the same mistake, such as pairs 2 3 4 6 10 12 13 18 19 on Table 5-2.

The ambiguous points

1. **How much to resize components to reach Avoiding Prominence?** There is no consistent feature found in the designs for applying the principle Avoiding Prominence. The blue egg was the object that was frequently resized, for example, pairs 4,7,8,13,14 and 17, and other components might or might not be resized. Generally, participants did not appear to closely consider the amount of resizing.

2. **Do the users apply Grouping Components?** Grouping Components was introduced to reduce the chance that users would distribute the components to a curve for Symmetrical Space, which happened to 9 out 19 (47%) of the submitted designs in the first trial group. In this group, it was 7 out of 17 (41%). This indicated that Grouping Component failed in its purpose. The participants may not recognise the need to apply Grouping Components.

3. **If they do apply Grouping Components, do they use the centre of gravity of the grouped components in Symmetrical Space?** There is no strong evidence that they applied Grouping Components. Pair 16 is the only one, because the menu buttons were listed on both side of the blue egg, but they did not form a curve.

5.3.5 Discussion

5.3.5.1 The availability of space is important to Avoiding Prominence and Symmetrical Space

Once again the problem of "how much is Avoiding Prominence" arose again. The key concept in Avoiding Prominence was that no component should obviously dominate the interface. Table 5-9 displays Pair 4 and 13 in a larger scale.

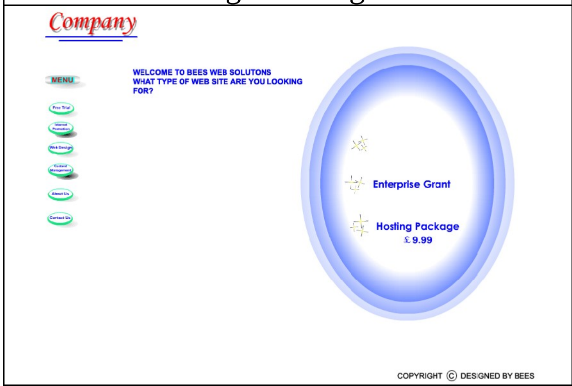
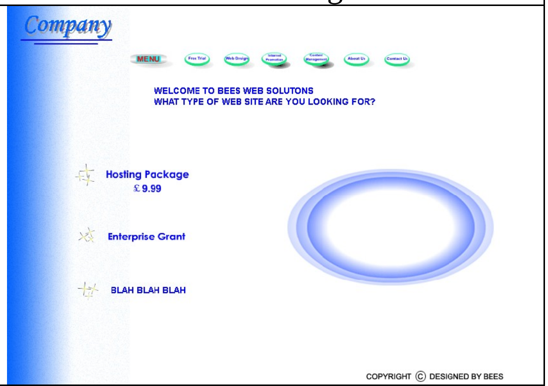
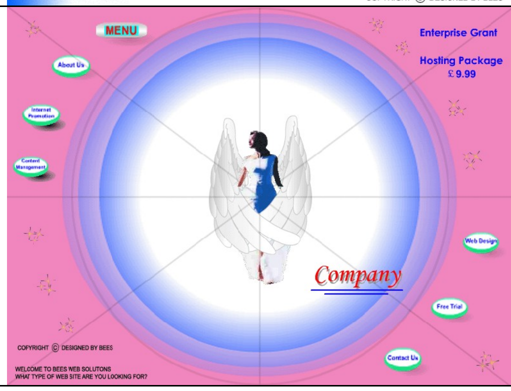
Original designs	Modified designs
	
	

Table 5-9 Are they prominent?

In the first pair on Table 5-9, the participant thought that the blue egg was too prominent so its size was reduced. However, it was a spatial design and the blue egg did not seem to be too prominent in the original design. It was unnecessary to reduce the size of the egg. In the second pair, the designer enlarged the blue egg, and then enlarged the buttons as well to make the blue ellipse less prominent. Nevertheless, the blue egg may be still prominent. At this moment, no clue had been found as to how to produce a standard, but adding a condition to the principle could limit the problem. The designs like the right one on the second pair also raised another concern. That was, if an interface was crowded, applying the principle of Symmetrical Space would be difficult, because there was not enough room to change the distance between the centres of gravity of the components. Therefore, a condition was added to the principles: where there is insufficient space on the interface, Avoiding Prominence has less priority than Symmetrical Space, as nothing will look dominant, aggressive or outstanding (the left pattern on Figure 5-11). In contrast, Symmetrical Space has less priority as there is not much space to achieve the same distances between the centres of gravity of the components (the right pattern in Figure 5-11).

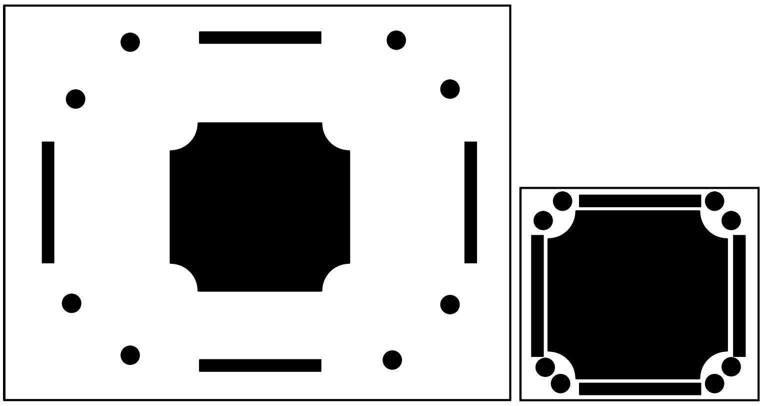


Figure 5-11 Space affects Avoiding Prominence and Symmetrical Space

5.3.5.2 Introducing Key Points for identifying Circular/Elliptical Layout

By analyzing the participants' work, Circular/Elliptical Layout was not appropriately applied and needed more clarification. Because the Circular/Elliptical Layout only suggests that the edge, even a point of the edge component should imply a circle or ellipse, for example, a rectangle actually implies an ellipse layout, as its four corners are on an ellipse, but most participants distributed the components on a circle. The concept of Key Points was added to the principle of Circular/Elliptical Layout. The key points are the most peripheral points of the outer components. They must be on a circle/ellipse. The key points can be identified by moving the four lines from the four side of the screen towards the centre. When a line first touches a point of a component, the point is a key point. If a key point is on a line that is parallel to a side of the screen, the other point of the line is a key point as well. Following this method, three key points can be located on a triangle-like interface (Figure 5-12).

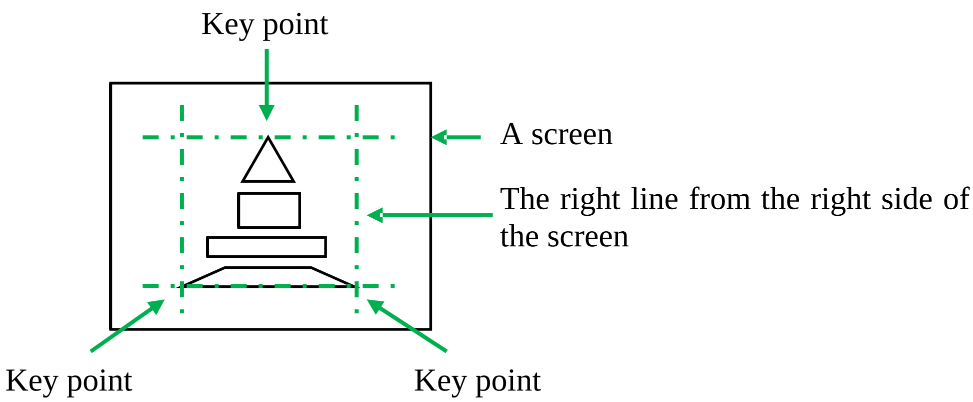


Figure 5-12 The key points on a triangle-like interface

For example, a triangle and rectangle satisfy this principle because their corners are on a circle/ellipse Figure 5-13. It's not necessary for the inner components to form a circle/ellipse. This result is used in the Section 6.3.6 for identifying the key points of Chinese characters.

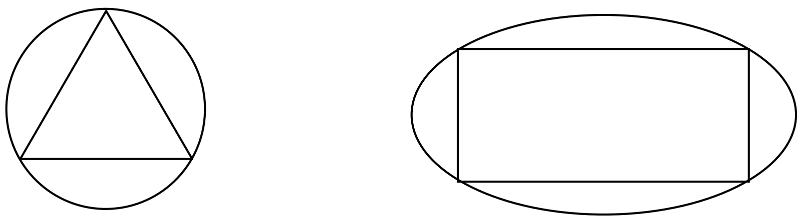


Figure 5-13 Key points determine the Circular/Elliptical Layout

Taking the home page of University of Central Lancashire (UCLan home page screen shot taken on the 19th July 2009) as an example which is displayed in Figure 5-14, the arrows are pointing to the key points which are the most peripheral points of the outer components in the interface. Three of them are on an ellipse, which is the layout. The other components are the inner components and they do not need to be on the circle/ellipse.

Figure 5-14 Key points to determine the Circular/Elliptical Layout of UCLan's home page

If the footer were centralized, then the home page satisfies the principle of Circular/Elliptical Layout very well (Figure 5-15).

Figure 5-15 Apply Circular/Elliptical Layout on the UCLan home page (July 2009)

The Key Points only solved half of the problems of identifying the circle/ellipse for the layout. The remaining problem is how to identify the unique circle/ellipse. For instance, on the UCLan home page, the ellipse could go through another three key points. Which one is the right one (Figure 5-16)? This question is answered in Section 6.3.6: The one with a smaller average distance between the circle/ellipse and the key points is chosen because it is on average closer to the key points.

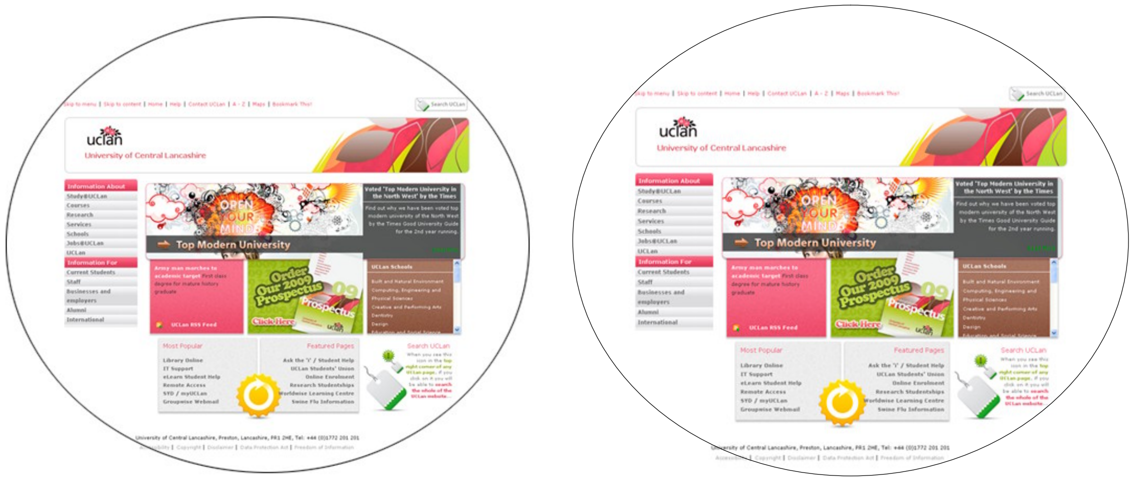


Figure 5-16 Two ellipses go through three key points, which one is the right one?

5.3.5.3 Two categories in interface design: Normal Structure and Graphical Structure

The method, Grouping Components, failed to solve the curve problem in Symmetrical Space. It is important because the components like the inner components in UCLan home page have to line up (Figure 5-14). It was noticed that the difference between the UCLan home page and the interfaces used in the trails was that the content of UCLan home page was organised in rectangular areas, like other websites, each rectangle encloses images and text; the interfaces used in the trails mainly consisted of graphical components. Grouping Components is needed for interfaces with a structure like websites, but not for graphical interfaces. Therefore, screen interfaces were divided into two categories in this research: Normal Structure (content is organised in rectangular areas, such as websites and software) and Graphical Structure. The principles are applied differently in each structure (Chapter 7).

5.3.6 Conclusion

The analysis of the participants' design indicated that Grouping Components failed to reduce the chance that the participants arrange the components in a curve in order to satisfy Symmetrical Space. However, it led to dividing screen interfaces into Normal Structure and Graphical Structure. Some participants distributed all components to a circle to satisfy Circular/Elliptical Layout, but in fact the inner components do not need to be on a circle. The concept Key Points was introduced to solve this problem. The ambiguous point of Avoiding Prominence was still not clarified, but it was identified that the availability of space played an important role in Avoiding Prominence and affected the priority of applying Avoiding Prominence and Symmetrical Space. This inspired the calculation of Avoiding Prominence (Section 6.3.8).

Principles: (Describing status)

Balanced Weight (Unchanged)**:** Ideally, the weight should be evenly distributed on an interface. In other words, no matter how you divide the interface into two equal halves, the areas occupied by interface components on both sides are more or less the same.

Symmetrical Space: The distances between the centre of gravity of a component and its neighbouring components' centre of gravity should be more or less the same. The centre of gravity does not need to be accurately identified. Designers can simply convert the components to some simple shapes: Circle, Triangle, and Parallelogram, then roughly determine the centre of gravity. If there is little background space, then this principle is less important than avoiding prominence.

Avoiding Prominence: No component should obviously dominate the interface, be "aggressive" and distinguishable (Figure 5-17). Keeping the same space between any two components is the key to avoiding aggression and distinguishability. When the spaces between components are large, this principle is less important. The more spacing among the components, the less dominating, aggressive and distinguishable a single component will be. However, when the spacing is increased, more attention should be paid to Symmetrical Space.

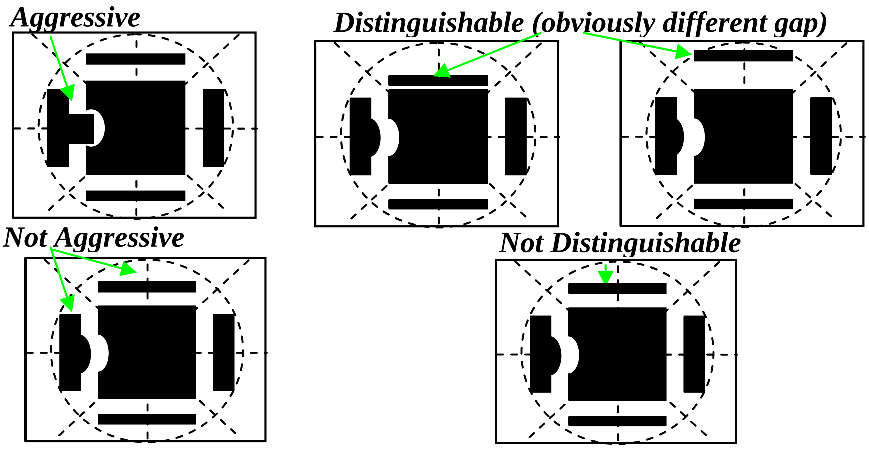


Figure 5-17 Improved Avoiding Prominence

Circular/Elliptical Layout: When looking at the whole interface from a distance, the outline should be a circle or an ellipse. The Key Points which are the most peripheral points of the outer components will determine the circle/ellipse. The inner components do not need to be on a circle or an ellipse.

Methods: (Used to optimise the design according to the principles)

Moving Components (Unchanged**):** to satisfy the principles: Balanced Weight and Symmetrical Space. Changing the shapes of the components affects the weight/area and the centre of gravity, which results in repositioning the components.

Re-sizing Components (Unchanged**):** to satisfy the principles: Balanced Weight, Symmetrical Space and Avoiding Prominence. Resizing the components in proportion will not affect the centre of gravity, but it affects the weight and the spaces between components, "Moving Components" should be applied after resizing components

Changing shapes (Previous name: Flexing shapes) (Unchanged**):** to satisfy the principles: Balanced Weight, Avoiding Prominence. Once a component's shape has been changed, its weight may be different and its centre of gravity is affected. Therefore, "Moving Components" should be applied after changing the shapes of the components

Grouping Components: Background colours, outline or even Interposition Cue theory (Eysenck, 2000) can be used to group components. The grouped components should be treated as a sub-interface and the four principles are applied to it. This is an important method. If the grouped components are not harmoniously arranged, it can damage the harmony of the whole interface. Since the grouped components form a sub-interface, the distances between the edges and the centres of gravity of the components inside the sub-interface can be different from the rest of the interface. The sub-interfaces are new components in the whole interface. It has its own centre of gravity and weight. The most common examples are a menu which consists of many buttons and panels. For example, the home page of UCLan shows smaller distances and the same backgrounds where they are used to group the menus; different background colours were used to group some components and form panels (Figure 5-18).

Figure 5-18 Grouping Components applied on the UCLan home page (July 2009)

Tool: (For judging how well the principles have been satisfied)

Judgement Line: Unchanged

5.4 Ease of identifying the centre of gravity within a reasonable range?

5.4.1 The Aim

The accuracy of identifying the centre of gravity for each component will affect the ability of the principles. The idea was that designers only needed to roughly identify the centre of gravity in order to maintain harmony. A study was arranged to test the accuracy of people's estimates.

5.4.2 Method

Participants

Ten people participated in the study. They were aged between 25 and 40, and consisted of half females and half males.

Design of the shapes to be evaluated

Twenty shapes were provided to the participants. The shapes were randomly picked and included 12 symmetrical shapes and 8 unsymmetrical ones (Figure 5-19).

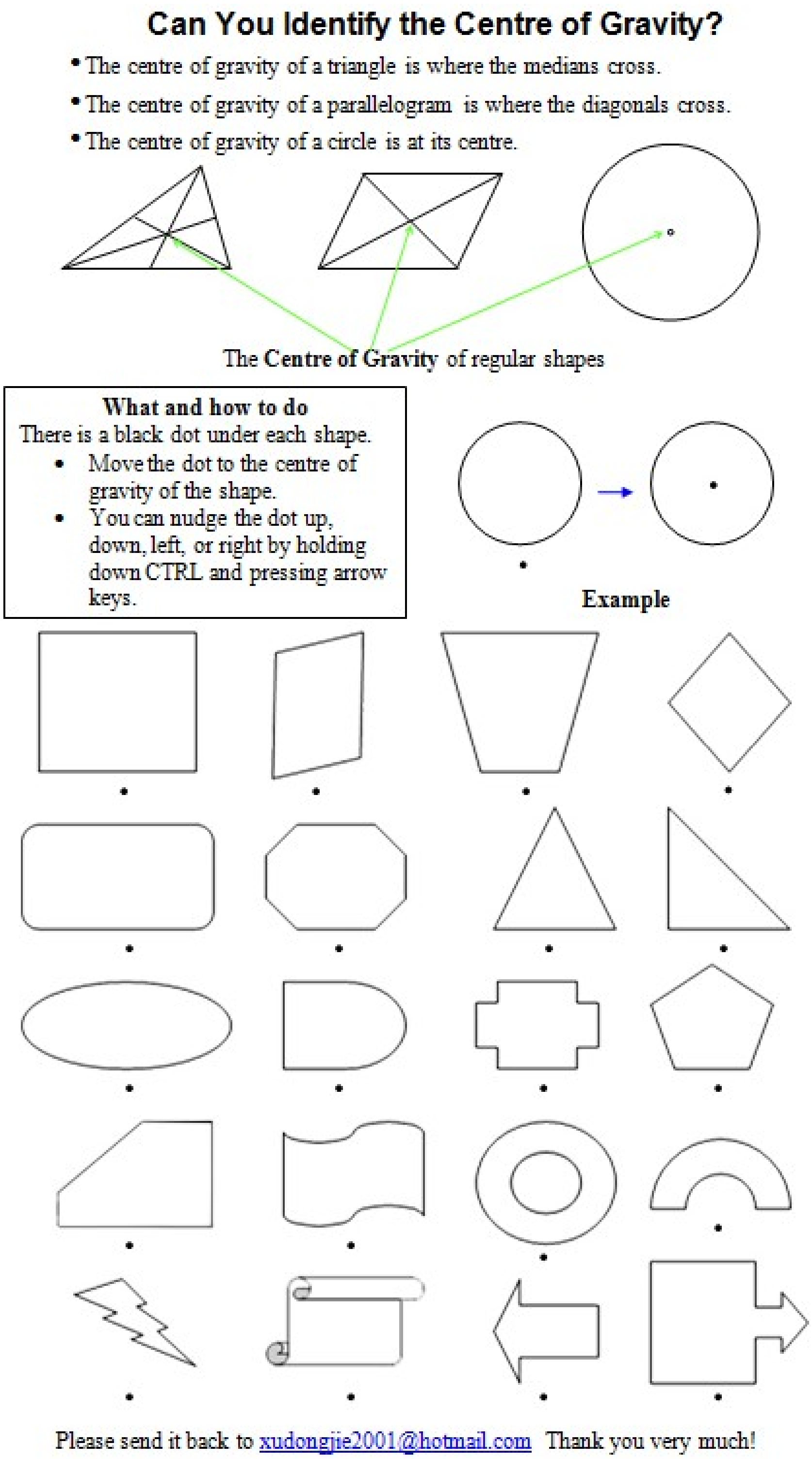


Figure 5-19 The questionnaire for locating the centre of gravity

Design of the instruction

The participants were told to locate the centre of gravity by eye using a dot. The geometric methods for simple shapes: triangle, parallelogram and circle, were provided on the top on the questionnaire (Figure 5-19).

Design of the Survey Instrument

The twenty shapes were listed on a piece of paper based on the order in the Microsoft Word 2003 shapes list. A dot was provided under each shape. If a participant answered the questionnaire with an electronic version (Microsoft Word format), he/she could move the dot to the centre of gravity they located. The way to nudge the dot was explained on the questionnaire (Figure 5-20). For those answering the questionnaire on paper, they just used a pen to draw the dot.

Procedure

The participants were asked first if they would like to join the survey. If they answered positively, they were given the questionnaire in the way they liked, either on paper or as an electronic file. The paper copies were returned on the same day, but it usually took a few days for the electronic ones.

After collecting the questionnaire, the centres of gravity were located by calculation and compared with the feedback.

5.4.3 Results

The Figure 5-20 illustrates the accuracy rate of the people's identifications of the centre of gravity for twenty different shapes. The solid black dots are the accurate centres of gravity. The blue circles are the centre of gravity located by the 10 participants.

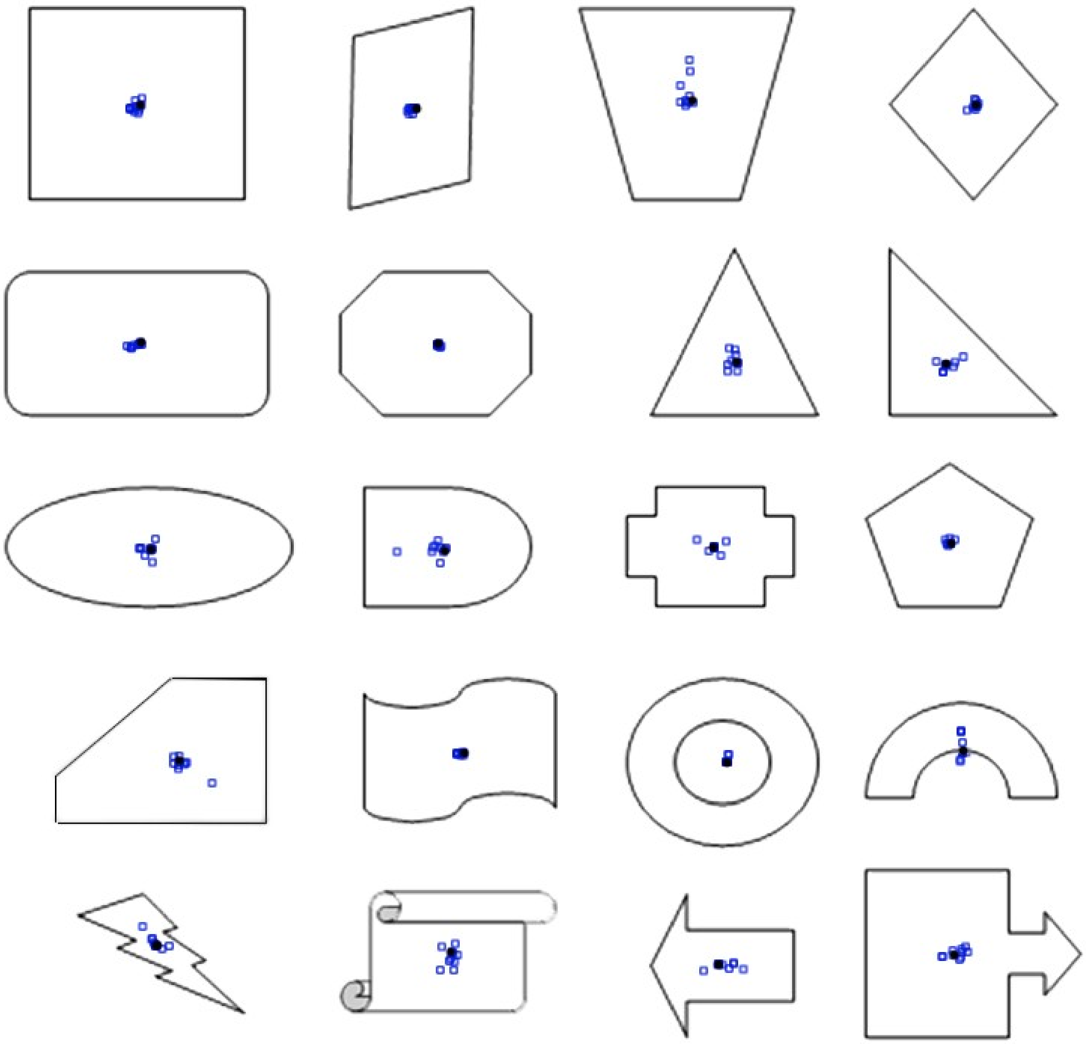


Figure 5-20 How people located the centre of gravity

5.4.4 Analysis

The result shows that the participants tended to be accurate on parallelograms and circles, but less so on other shapes. Some participants could locate the centres close to the actual points and some could not (Figure 5-20). The fourth one on the fourth row shows that the participants tended to locate the centre of gravity on the body of the shape, even though the accurate one is on the edge or outside.

5.4.5 Discussion

5.4.5.1 People can only visually locate the centre of gravity on shapes that are both vertically and horizontally symmetrical

Providing that people have been taught the geometrical way of locating the centres of gravity on circle/ellipse, triangle and parallelogram, people can visually locate the centre of gravity close to the actual points on shapes that are both vertically and horizontally symmetrical. This result is used in the Section 6.3.10 to redefine how to split Chinese characters.

5.4.6 Conclusion

The shapes that people are likely to locate the centre of gravity correctly are those both vertically and horizontally symmetrical.

5.5 Summary

Four studies are presented in this chapter. The main aim was to discover and clarify some ambiguous points in the principles, as well as trying to find out whether they could be mathematically deduced. Based on the users' designs with the principles, the feedback from the Chinese scholars, modifications were made to the principles. The second version of the principles was developed.

In the first study, a group of computing students were asked to learn and practice the principles. The common negative feature in their designs was that some components were placed in a curve line to satisfy Symmetrical Space, which is not always needed. A new principle, Apply Other Principles from Part to Whole, was added in the response to this problem. However, it was based on Interposition Cue theory (Eysenck, 2000) and brought no benefit to mathematically deducing the principles.

In the second study, a group of Chinese language lecturers gathered together to exchange their experience and knowledge of Chinese language teaching. The principles were presented to them with the explanation of how they were translated from Chinese calligraphic principles. It was expected that they would give advice on how to improve the translation. No direct advice was given, but they expressed the view that the last two principles: Flexible and Apply Other Principles from Part to Whole were confusing. By further analysing the principles, it was noticed that the last two principles actually did not describe a status of the arrangement of interface components like other principles, so the principles were refined to four principles, four methods and one tool. The result of this study led to categorising the two ambiguous concepts Flexibility and Grouping Components into methods, so they were not required to be deductive.

Figure 5-9 shows briefly how the original principles were refined.

The only principle that remained subjective was Avoiding Prominence, also the method to identify the circle/ellipse for the layout was not found.

The third study was similar to the first study. The differences were that it was for the second version of the principles and the explanations were more detailed. The analysis of the submitted designs from the participants led to three amendments.

A. Adding a condition for the priority of applying the principles Avoiding Prominence and Symmetrical Space: if the interface is spacing, Symmetrical Space takes the priority. Otherwise, Avoiding Prominence takes the priority. This condition did not solve the problem of how much was Avoiding Prominence. It simply transferred the argument to a question of spacing.

B. The concept of Key Points was introduced to identify the circle/ellipse for the layout, which made the principle Circular/Elliptical Layout more mathematically deductive. However, the problem of identifying the unique circle/ellipse was not solved.

C. Dividing screen interfaces into Normal Structure and Graphical Structure.

The conclusion from the fourth study was that people can only visually locate the centre of gravity on shapes that are both vertically and horizontally symmetrical.

After the four studies, the points that could be mathematically deduced were:

1. Balanced Weight – calculate the area occupied by the components on each pair of halves divided by the middle horizontal line, middle vertical line and the two diagonal lines.

2. Symmetrical Space – calculate the distances between the centres of gravity of each component,

3. Circular/Elliptical Layout (partial) – calculate the most peripheral points of the outer components.

The remaining ambiguous points were

1. Avoiding Prominence – To what extent a component is not prominent.

2. Circular/Elliptical Layout (partial) – How to identify the unique circle/ellipse.

The first two studies led to changing the five principles to four principles and four methods, which was a significant change so it became the second version. The third survey did not add any significant amendments to the second version, only adding more detailed explanations, except the principle of Circular/Elliptical Layout. Therefore, no new version was developed after the third study. Since the principles had became quite stable and there was no helpful user feedback to formulate a mathematically method for Avoiding Prominence, it was time to return to Chinese calligraphy.

Chapter 6. A Set of Fully Deductive and Computable Principles for Chinese Regular Script Calligraphy (Version 3 for Chinese Calligraphy)

Whilst the principles had been delineated, they had not fully achieved the aim of translating the holistic Chinese calligraphic principles into analytic and deductive principles. Balanced Weight, Symmetrical Space and part of Circular/Elliptical Layout could be calculated, but Avoiding Prominence was still based on subjective judgement. Furthermore, the ways proposed in the principles to judge Balanced Weight, Symmetrical Space and Circular/Elliptical Layout for a Chinese character were based on visual inspection. To be useful, they must become fully deductive so they can be computed, which is the main goal in this chapter. Before that, the reason for choosing the font for analysis, the difference between the techniques in the principles of this research and those existing in current Chinese calligraphy and typography are presented.

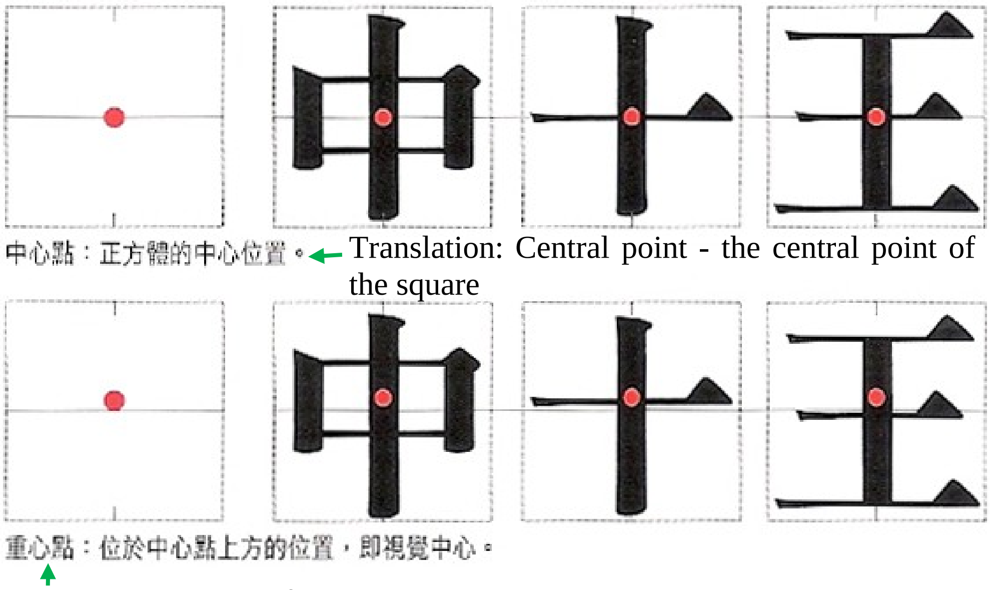
6.1 Why chose Founder regular script font?

The characters used for analysis is in this research were from the Founder regular script font. There are many Chinese calligraphic styles, but only two of them have been adopted in typography: the regular script (Zheng style) and the Di style (Liao, 2009). There are many companies doing typography. The regular script font produced by the Founder Group was chosen because it is a famous Chinese company created by Peking University in 1986. All the characters (about 7,000 characters which were enough for printing) were manufactured from metal types. Unlike the fonts that are pieced together with the aid of a computer, the types were all carved on a piece of metal by hand following the shapes of the regular script characters, and so there was no computable algorithm to produce these types (Liao, 2009). The characters printed from the metal types were scanned into the computer, associated with font codes and packed as the Founder regular script font. The Founder regular script font is very close to regular script calligraphy.

6.2 What is the difference between the new principles and the techniques used in Chinese typography?

The concept of “the centre of gravity” and patterns similar to the Judgment Lines are applied in Chinese typography.

1. The centre of gravity: This concept is in the principles of Chinese calligraphy (Guo, 1995), but it is not defined. It is also adopted in typography, however, it should be noted that in Chinese typography, the centre of gravity of a character is actually defined as a point that is slightly above the central point of the square (Figure 6-1). In this work the centre of gravity is taken as the actual centre of gravity of each character (Figure 6-1).



Translation: Central point - the central point of the square

Translation: Centre of gravity - a point above the central point, which is also the visual centre.

(a) (Liao, 2009: p.46)

The actual centre of gravity in this research:

(b)

Figure 6-1 The difference between concepts of the centre of gravity in the harmonious interface principles and Chinese typography

2. Judgement Lines:

   In a Chinese font set there are usually 6,763 characters. Before the availability of font software, these had to be carved on metal pieces. It took one day for a typographer to produce six characters. Even with the help of computer, a typographer can only produce twenty characters a day, although the typographers only need to produce about 1,700 characters and leave the rest to the computer. As it is a time-consuming job, a group of typographers would usually work on a single font (Liao, 2009). To ensure consistency in this process, patterns are used to make sure each member of the group produce the same style (Figure 6-2). These patterns are used as visual guides for positions, thickness and rotation degrees of the strokes.

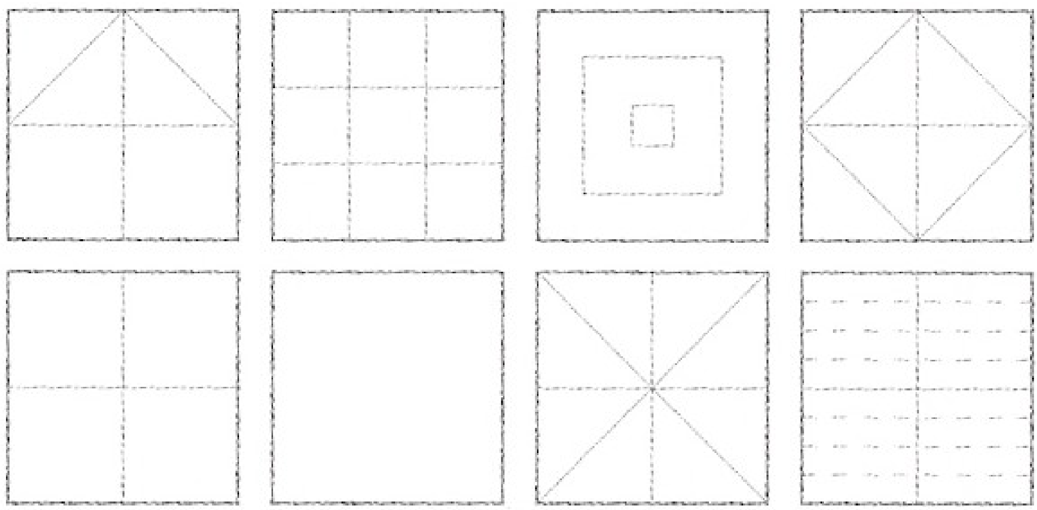


Figure 6-2 Patterns used to keep the consistent style of the characters (Liao, 2009: p.48)

In the harmonious interface design principles, the Judgement Lines are used to assist in satisfying the principles in a similar way.

6.3 Computing the principles

To ensure the characters for analysis were not picked up according to the researcher's preference, the characters considered consisted of 24 characters based on the methodology to find a character in a Chinese dictionary (Xinhua Dictionary printed in 1998 ISBN 7-100-02601-6), plus 15 numeric Chinese characters (Appendix 5 for the details of how the 24 characters were chosen). By doing this, the chosen Chinese characters consisted of simple and complex ones, unique ones and those comprised sub-characters. They became the first set of Chinese characters used in analysis:

Set 1: (The thirty nine characters) 一 one, 二 two, 三 three, 四 four, 五 five, 六 six, 七 seven, 八 eight, 九 nine, 十 ten, 百 hundred, 千 thousand, 萬 ten thousand, 億 100 million, 兆 billion, 丞 assist, 元 primary, 吉 lucky, 玎 sound of jade, 佘 a surname, 耔 plough, 麸 bran, 靓 pretty, 勒 rein, 閙 noisy, 凫 mallard, 黿 turtle, 暢 smooth, 協 help, 聖 holy, 韌 tenacious, 磯 rock, 耵 earwax, 赴 attend, 基 basic, 頂 top, 髡 shave, 鱿 squid, 墨 ink.

6.3.1 Some terminologies in Chinese character

In the analysis below, there are some terminologies frequently used to describe Chinese characters. Their definitions are listed here to ensure the following sections are understandable.

- **Sub-character:** many Chinese characters consist of two parts or more parts. Each part conveys a meaning and named sub-character, e.g. 億,吉, 玎.

- **Unique character:** It means a Chinese character cannot be split into sub-characters or the split parts do not convey a meaning. Example characters: 四, 五, 六.

- **Surrounding structure:** when a Chinese character consists of sub-characters, usually the sub-characters are placed top and bottom or left and right, but sometimes a sub-character is half enclosed by another sub-character, which is a surrounding structure. An example character: 鬧

- **Interleaving structure:** when sub-characters are not clearly separated e.g. 竈, 赴, 基. This is in contrast to characters where a line can be drawn between the sub-characters without crossing any strokes, e.g. 吉, 兆.
- **U-turn stroke:** when a stroke looks like a U. (Figure 6-3).

Figure 6-3 U-turn strokes

- **Diagonal stroke:** when a stroke is leaning towards the middle, it is a diagonal stroke. For example, the character 八 has two diagonal strokes leaning towards the middle.
- **Dot stroke:** a dot stroke is the shortest stroke in Chinese characters. It looks like a drop of water.

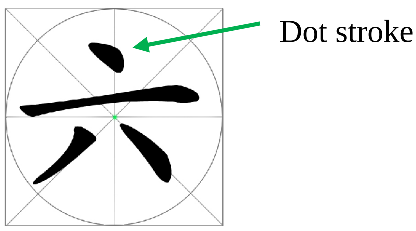


Figure 6-4 Dot stroke

6.3.2 Examining and computing Balanced Weight

- **Balanced Weight (V2):** Ideally, the weight should be evenly distributed in a character. In other words, no matter how you divide the character into two equal halves, the areas occupied by character strokes on both sides are more or less the same.

The areas of the characters calculated using Adobe Photoshop CS3 indicated that description of Balanced Weight given above is a special circumstance of Avoiding Prominence. After placing the centres of gravity of the 39 characters (Set 1) on the central point of the Judgement line, Adobe Photoshop CS3 was applied to calculate the areas and the proportions between the areas split by the horizontal, vertical and diagonal lines. The analysis of the characters shown that the weights on all the halves were not always balanced or close to the same (Small:Big>=90%). For example, for the character 二 two, only the proportion between the left and right parts is closer to 1 to 1 (Table 6-1).

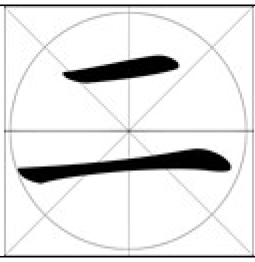
The character	Half : Half, in pixel	Proportion (Small: Big)
	Left : Right = 9368 : 9900	0.95 : 1
	Top : Bottom = 7054 : 12214	0.57 : 1
	Top-left : Bottom-right = 10911 : 8355	0.77 : 1
	Top-right : Bottom-left = 11730 : 7537	0.64 : 1

Table 6-1 The character二 two with unbalanced weight

It happens to other characters as well, such as 兆 (Table 6-2) and 町 (Table 6-3)

The character	Half : Half in pixel	Proportion (Small: Big)
	Left : Right = 14272 : 19109	0.75 : 1
	Top : Bottom = 16406 : 16975	0.97 : 1
	Top-left : Bottom-right = 18879 : 14499	0.77 : 1
	Top-right : Bottom-left = 17046 : 16333	0.96 : 1

Table 6-2 The character 兆with unbalanced weight

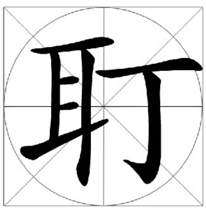
The character	Half : Half in pixel	Proportion (Small: Big)
	Left : Right = 21019 : 14641	0.70 : 1
	Top : Bottom = 18597 : 17295	0.93 : 1
	Top-left : Bottom-right = 18989 : 16903	0.89 : 1
	Top-right : Bottom-left = 17343 : 18548	0.94 : 1

Table 6-3 The character 町 with unbalanced weight

There are 11 characters that behave like this with one half obviously (Small:Big>=90%) heavier than the other half. Their weight will never be balanced based on the definition of Balanced Weight in the second version of the principles (Table 6-4). These 11 characters already occupy 28% of the 39 characters. More could be found if all characters were considered.

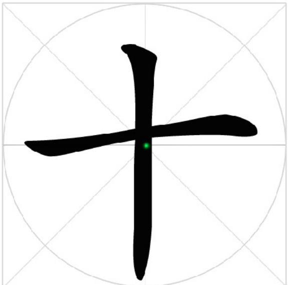
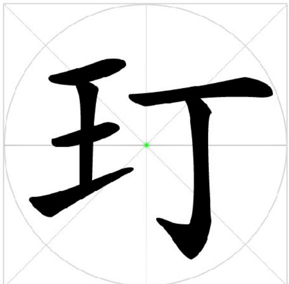
 Top : Bottom = 1 : 0.59	 Left : Right = 1 : 0.79	 Left : Right = 1 : 0.83
 Left : Right = 0.76 : 1	 Left : Right = 0.86 : 1	 Top : Bottom = 0.88 : 1
 Left : Right = 1 : 0.89	 Top : Bottom = 1 : 0.79	

Table 6-4 The characters with less than 90% balanced weight

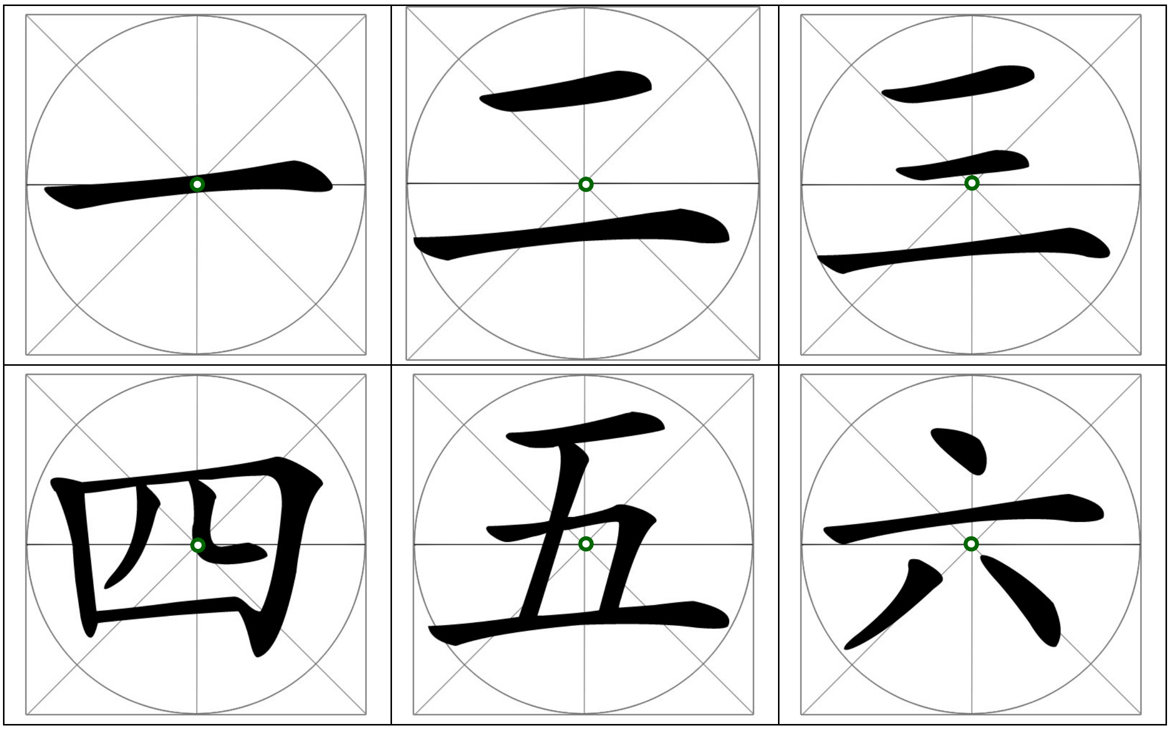
6.3.3 The principle of Balanced Weight for Chinese regular script calligraphy

Based on the analysis above, the explanation of Balanced Weight in the second version did not actually reflect a feature of the Chinese characters in regular script, because a lot of characters do not have the same weight in each half. Therefore Balanced Weight is no longer a principle.

6.3.4 Examining and computing the centre of gravity of a character

The following sections give detailed explanations of the order and the calculations. The font size used in the analysis was 470 pixels (px). The length of the lines of the square of the Judgement Lines is 470 pixels (px). The size was chosen for convenience. When doing the analysis on the characters, the centres of gravity of each character were calculated using the software Autodesk AutoCAD version 14.

The Table 6-5 displays all the thirty nine characters with their centres of gravity. Their centres of gravity ○ are placed on the centre of the Judgement Lines. Table 6-5 shows that 38 out the 39 characters stay within the Judgement Lines. Except for the character 千, whose down stroke slightly exceeds the bottom line for 6 pixels.

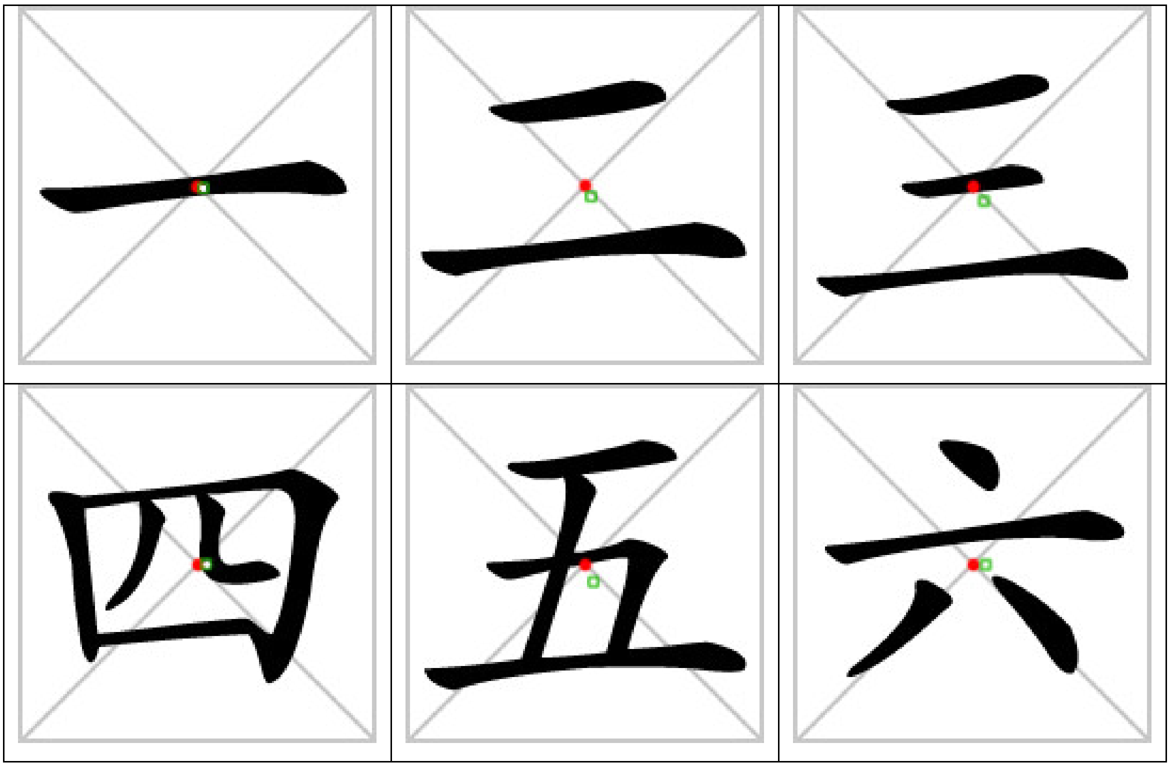


七	八	九
十	百	千
萬	億	兆
丞	元	吉
玎	佘	耔

麩	靚	勒
鬧	鳧	黿
暢	協	聖
韌	磯	耵
赴	基	頂

Table 6-5 The centres of gravity of the thirty nine characters in Set 1

Table 6-6 shows the difference between the centre of gravity and the centre of each character (red dots) in Founder regular script font. The font size is 168 in Adobe Photoshop CS3 which gives a 168px by 168px box for each character. Each character in Table 6-6 is at the default position provided by Founder regular script font. The centre of the box was taken for comparison.



七	八	九
十	百	千
萬	億	兆
丞	元	吉

玎	佘	耔
麩	靚	勒
鬧	鳧	黿
暢	協	聖

Table 6-6 Comparison between the centres of gravity and the centres of the characters in Founder regular script font

Figure 6-5 shows the distances in pixel between the centres of gravity and the centres of the 39 characters in Founder regular script font. The maximum distance is 12px and the minimum one is 0px which mean the centre of gravity and the centre of the character in the Founder font are actually at the same position, and there are four of them. 38 out 39 are within 10px. The average distance is 4.6px and the standard deviation is 3.3px. That is to say, in general, all centres of gravity are close to the centres of the characters.

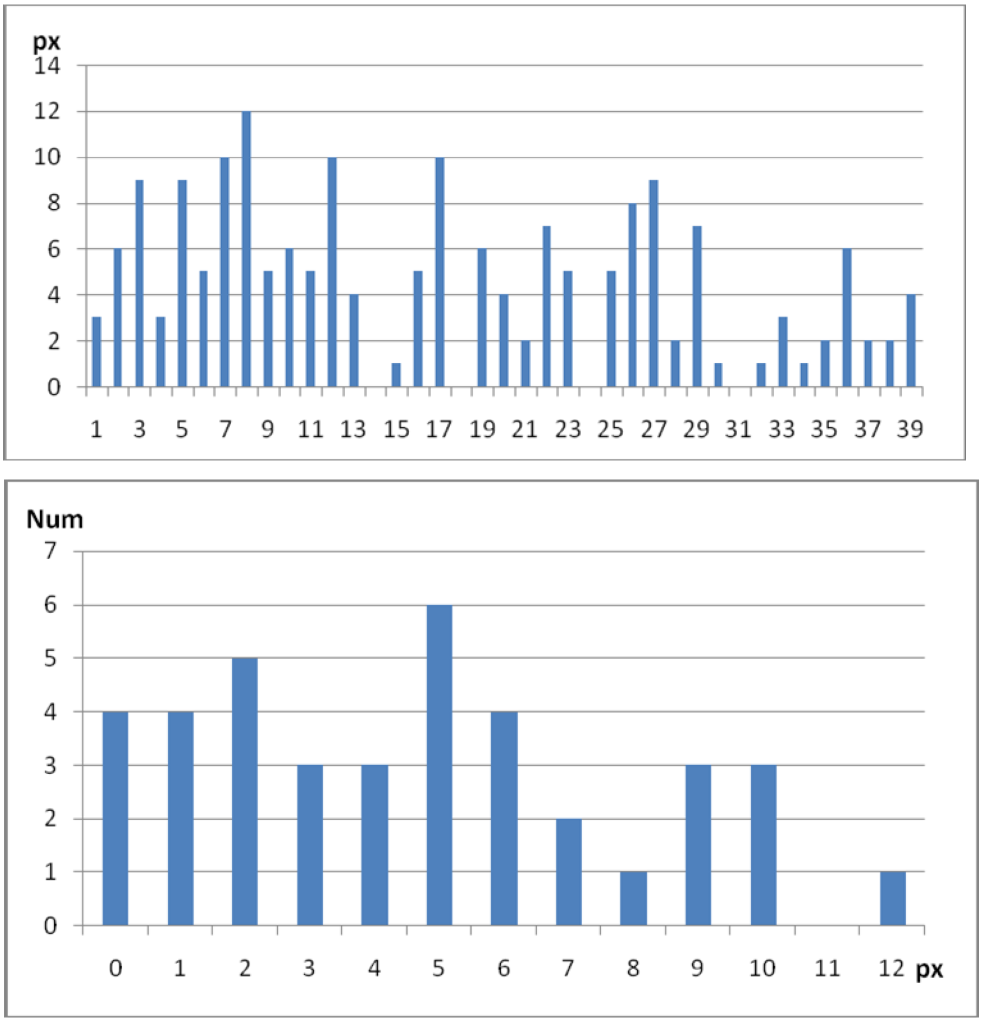


Figure 6-5 Distances between the centres of gravity and the centres of the characters in Founder regular script font

6.3.5 The importance of the centre of gravity – stability

Balance is an important concept of harmony in both Chinese and Western culture (Chapter 2). In physics, the centre of gravity (or more strictly centre of mass) is the average location of the mass in an object. When suspended from an axis through its centre of gravity, an object is perfectly balanced. After generations of elaboration, the Chinese calligraphers managed to approximately locate the centre of gravity at the middle of each character, which is also the visual centre. Namely, when people look at a character, it will visually convey the sense of stability. This discovery confirms the point in Guo's (1995) principle "Pingzheng": the visual weight should be balanced on the left and the right of Y axis (Section 4.3). Furthermore, it is not limited by Y axis. Since it is at the middle point of a character, it will convey the sense of stability on whatever axis. From now on, the stability of Chinese characters is no longer an abstract concept, it can actually be calculated.

6.3.6 Examining and computing the Circular/Elliptical Layout

- **Circular/Elliptical Layout (V2):** When looking at the whole interface from distance, the outline should be a circle or an ellipse. In other words, the most peripheral points of the outer components are on the circle/ellipse. For example, an equilateral triangle and rectangle satisfy this principle because their corners are on a circle/ellipse (Figure 5-13).

After identifying the centre of gravity of the each full character, the Circular/Elliptical Layout is checked. The principles given by calligraphers such as Guo (1995) do not include this principle. Countless circles and ellipses can be drawn on the area occupied by a character. The analysis in 5.3.5 introduced the concept of Key Points. The key points are the most peripheral points of the outer components. The circle/ellipse should go through most key points. However, although it reduces the number of circle/ellipse to a small number, it still does not show the path to be a unique one. However, Autodesk AutoCAD v14 provides a solution: The overall centre of gravity of a Chinese character can be accurately located by Autodesk AutoCAD. After a large number of estimations, the following rules were found:

1. The centre of gravity of a character is placed at the centre of the Judgement Lines.

2. The key points on the four sides are identified. These are the most peripheral outside points on the top, right, bottom and left sides of the character. If two points overlap with each other, they are counted as one point.

3. The centre of gravity is set as the central point and a circle or ellipse is drawn through the key points. Usually it will be an ellipse. If two ellipses go through the same number of key points, the one which is on average closer to the rest of the key points is selected, and the one that is closest to a circle will be chosen.

The character 吉 (Lucky) is a good example. After calculating the centre of gravity of the character 吉, the centre of the Judgement Lines is overlaid (Figure 6-6).

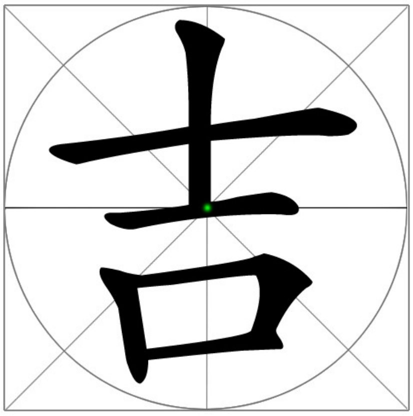


Figure 6-6 The centre of gravity of the character 吉 superposed on the central point of the Judgement Lines

The key points are found as show in Table 6-7. Table 6-7 lists how to apply the four lines and identify the key points. There are four key points on the character 吉.

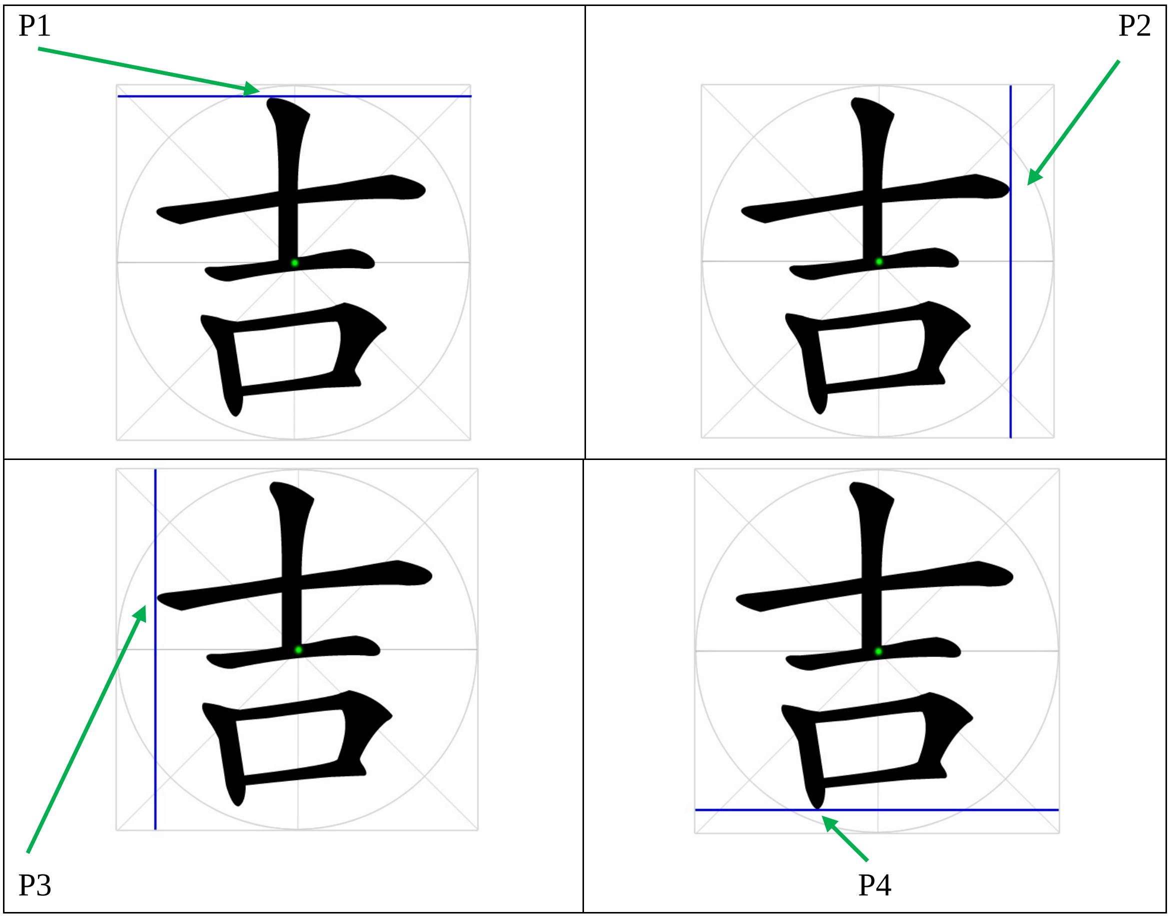


Table 6-7 Move the four lines towards the centre to find the key points on the character 吉

The centre of gravity of the character is used as the central point to draw an ellipse which goes through most key points. The thickness of the ellipse line is two pixels so there are two pixels error, which is very small and can be ignored. An ellipse happens to go through all the four point on the character of 吉 (lucky).

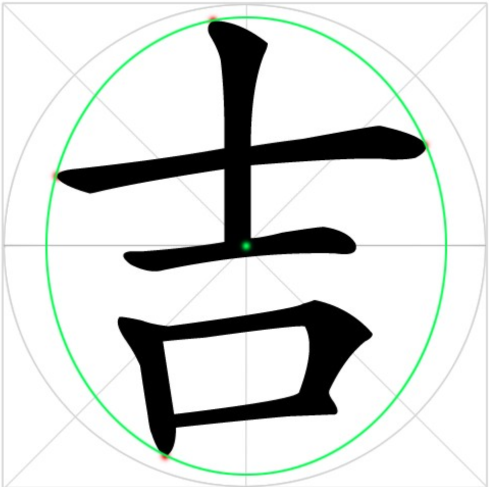


Figure 6-7 An ellipse goes through four key points on the character 吉

However, not every character satisfies this principle perfectly, because the Chinese characters were written by brush and the ellipses were constructed in the mind. Therefore, when the ellipse of a character is found, some parts of the strokes may exceed the ellipse, although not by very much. That is to say, when constructing the ellipse with the key points, some errors are tolerated. The errors were collected from the thirty nine characters. The average of these errors became the reference for the thickness of the ellipse line when programming the Harmonious Interface application. For example on the simplest character 一, first, the lines from the four sides were used to identify the key points (Figure 6-8).

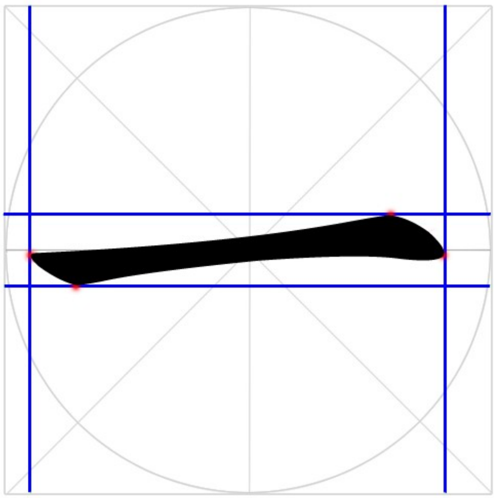


Figure 6-8 The key points on the character 一

For this character, if the centre of gravity of the character is set as the centre of the ellipses, the max amount of the key points that an ellipse can go through are two, and there are two ellipses available (Figure 6-9).

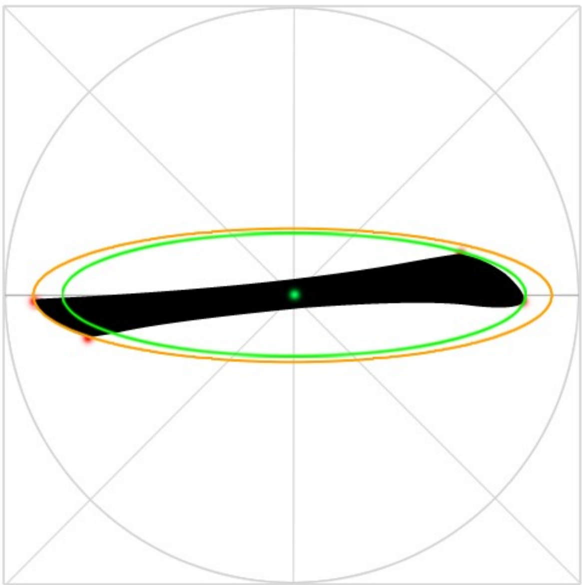


Figure 6-9 Two ellipses available on the character一

In this case, the one that is averagely closer to all key pointers is chosen. It is average (5+17)/2=11px for the outer ellipse and (22+9)/2=15.5px for the inner ellipse, so the outer ellipse is chosen (Figure 6-10). If it happens that the average distances are the same, then the one that closer to a circle is chosen.

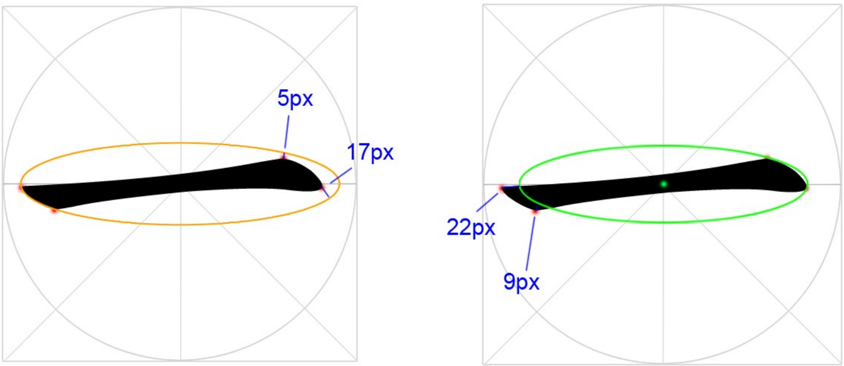


Figure 6-10 Choose the ellipse that closer to another two un-overlapped key pointers on the character 一

Once the ellipse is identified, it is found that generally all strokes are constrained inside the ellipse. Some parts of strokes may be outside the ellipse, but they are generally not far away. The farthest points away from the ellipse on these parts are named "outer points". For example, on the character 墨, when the ellipse is identified, some strokes still stretch to the outside of the ellipse for some pixels (Figure 6-11). Their shortest distances, from the top left go clockwise, to the ellipse are: a) 4px, b) 1px, c) 7px, d) 21px and e) 6px.

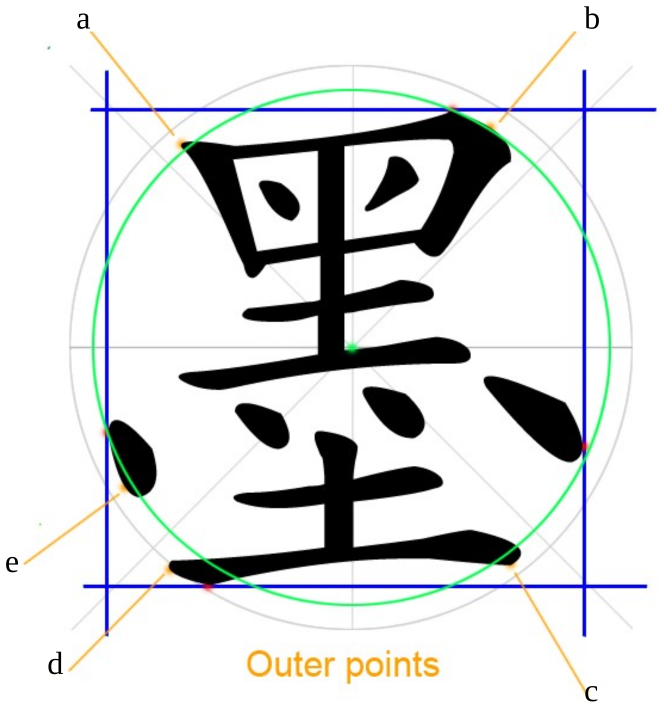
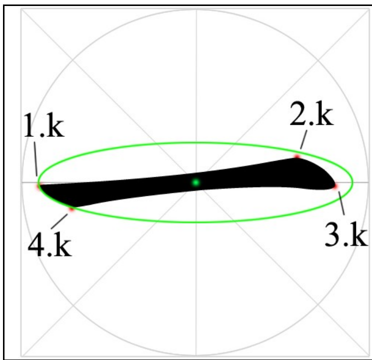
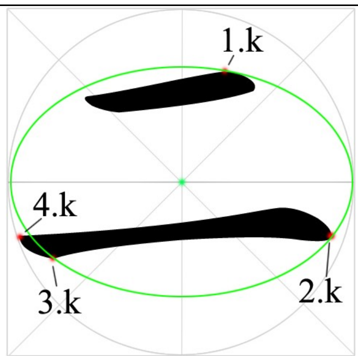
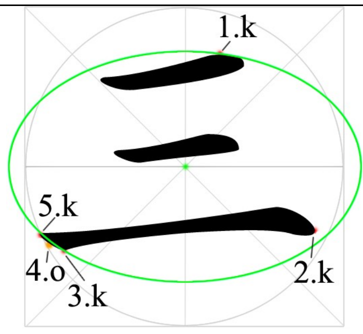
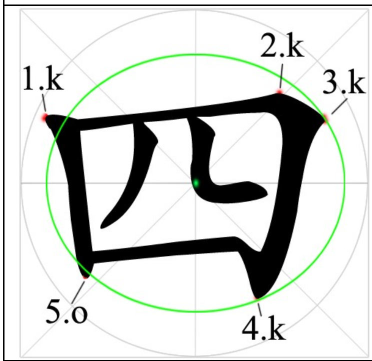
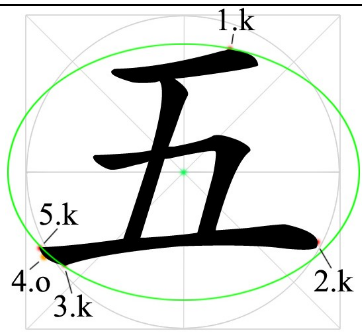
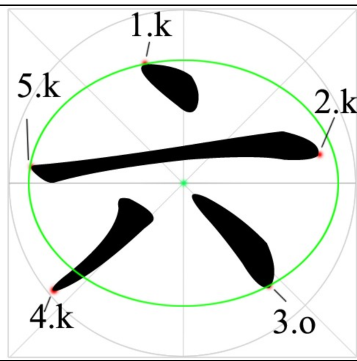
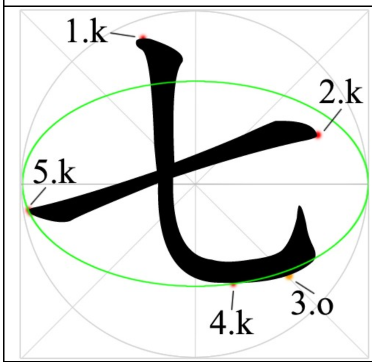
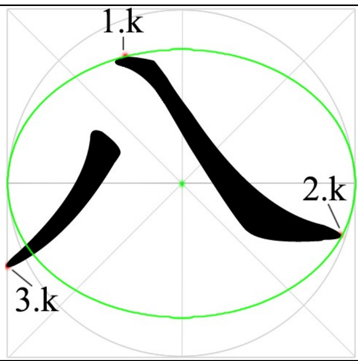
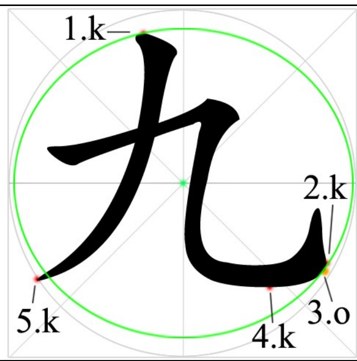


Figure 6-11 Outer points on the character 墨 (ink)

Table 6-8 displays all thirty nine characters with their ellipses and the shortest distances between the ellipse and the key points, and between the ellipse and the outer points. In the table, k stands for key point and o stands for outer point.

		
1) 0px 2) 5px 3) 17px 4) 0px	1) 0px 2) 0px 3) 0px 4) 11px	1) 0px 2) 15px 3) 0px 4) 2px 5) 0px
		
1) 22px 2) 17px 3) 0px 4) 0px 5) 8px	1) 0px 2) 13px 3) 0px 4) 5px 5) 0px	1) 0px 2) 17px 3) 2px 4) 38px 5) 0px
		
1) 62px 2) 26px 3) 4px 4) 0px 5) 0px	1) 0px 2) 0px 3) 37px.	1) 0px 2) 0px 3) 1px 4) 32px 5) 14px.

<table>
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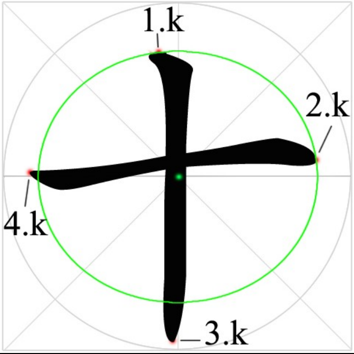
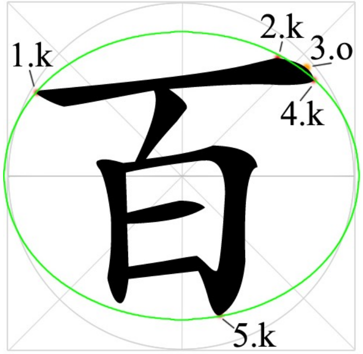
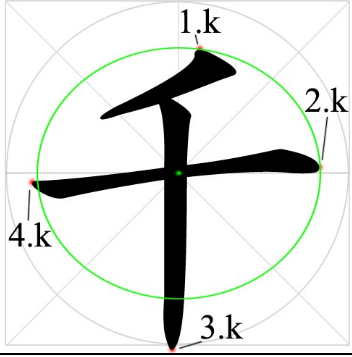
<td>
1) 0px 2) 0px 3) 51px 4) 12px</td>
<td>
1) 0px 2) 2px 3) 2px 4) 0px 5) 0px</td>
<td>
1) 0px 2) 0px 3) 69px 4) 0px</td>
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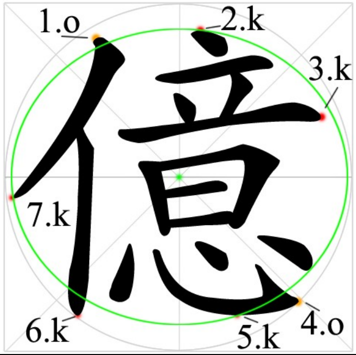
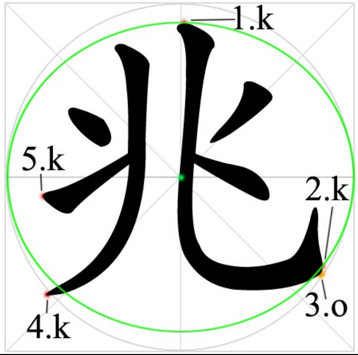
1) 0px 2) 0px 3) 51px 4) 15px 5) 18px</td>
<td>
1) 10px 2) 0px 3) 13px 4) 19px 5) 0px 6) 22px 7) 0px</td>
<td>
1) 0px 2) 0px 3) 3px 4) 18px</td>
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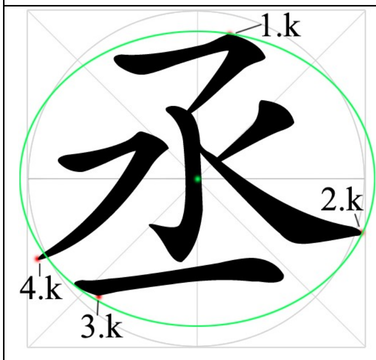
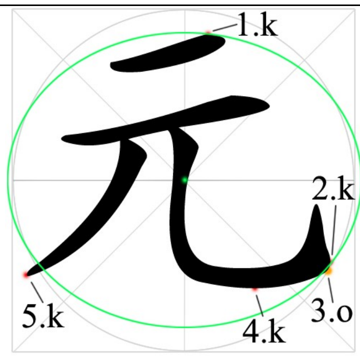
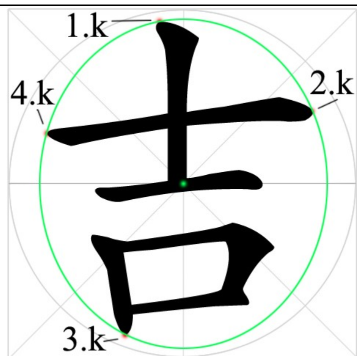
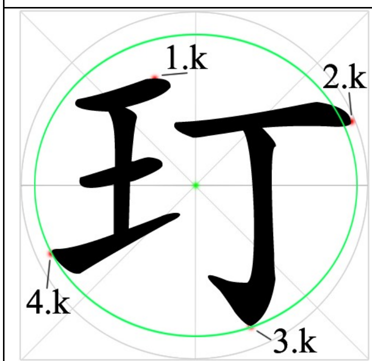
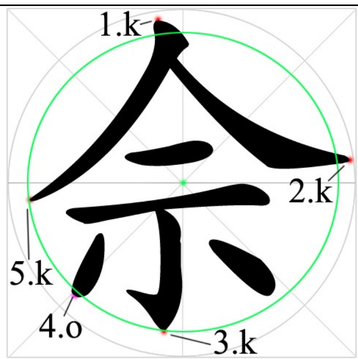
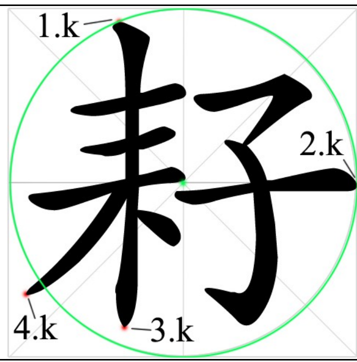
<td>
1) 0px 2) 0px 3) 6px 4) 10px</td>
<td>
1) 0px 2) 0px 3) 2px 4) 32px 5) 22px</td>
<td>
1) 0px 2) 0px 3) 0px 4) 0px</td>
</tr>
<tr>
<td>
1) 50px 2) 8px 3) 0px 4) 0px</td>
<td>
1) 15px 2) 15px 3) 0px 4) 4px 5) 0px.</td>
<td>
1) 0px 2) 0px 3) 22px 4) 23px</td>
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</table>

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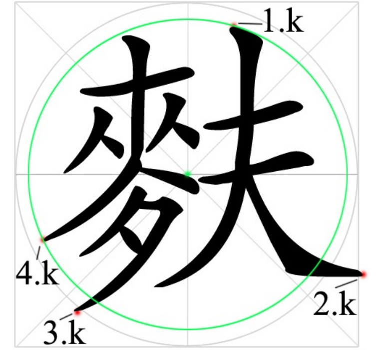
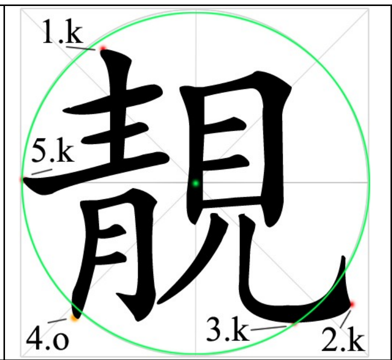
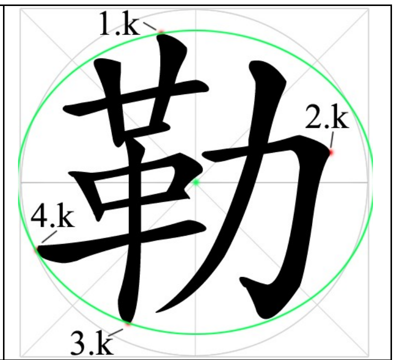
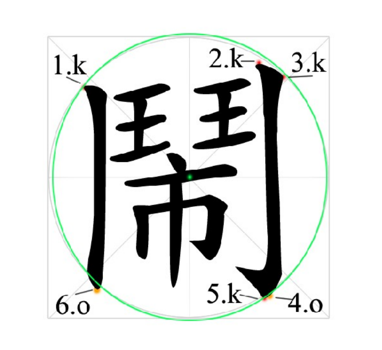
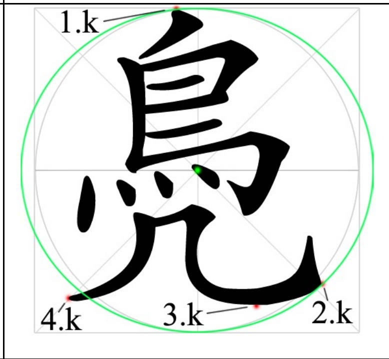
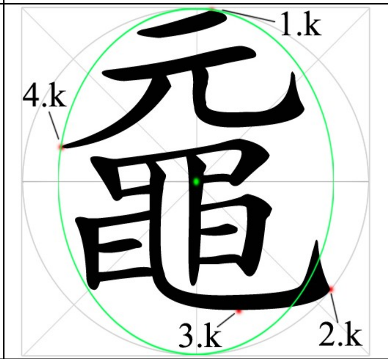
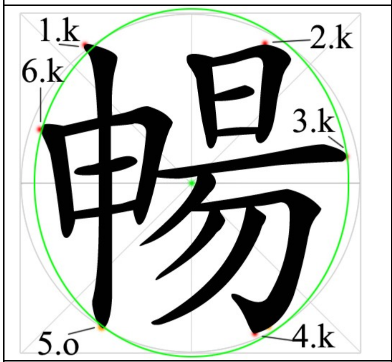
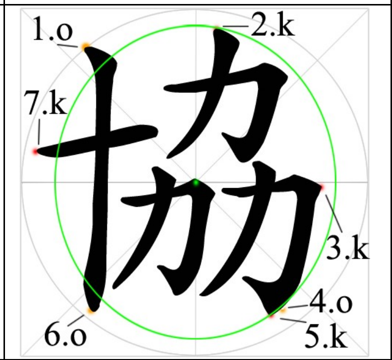
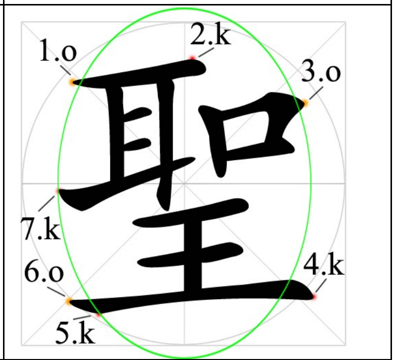
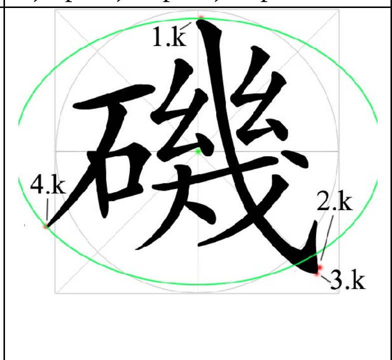
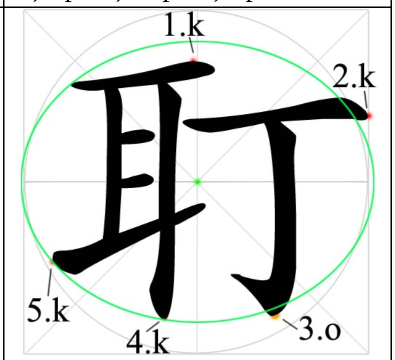
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>1) 0px 2) 58px 3) 24px 4) 0px</td>
<td>1) 10px 2) 31px 3) 0px 4) 9px 5) 0px</td>
<td>1) 0px 2) 35px 3) 0px 4) 0px</td>
</tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>1) 0px 2) 12px 3) 4px 4) 1px 5) 0px 6) 5px</td>
<td>1) 0px 2) 0px 3) 22px 4) 15px</td>
<td>1) 0px 2) 27px 3) 41px 4) 0px</td>
</tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>1) 8px 2) 16px 3) 0px 4) 9px 5) 1px 6) 0px</td>
<td>1) 30px 2) 0px 3) 17px 4) 2px 5) 0px 6) 18px 7) 25px</td>
<td>1) 9px 2) 71px 3) 9px 4) 40px 5) 0px 6) 24px 7) 0px</td>
</tr>
<tr>
<td>
</td>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>1) 5px 2) 0px 3) 0px 4) 9px</td>
<td>1) 0px 2) 17px 3) 25px 4) 0px</td>
<td>1) 25px 2) 15px 3) 8px 4) 0px 5) 0px</td>
</tr>
</table>

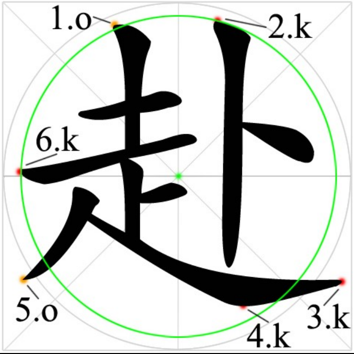
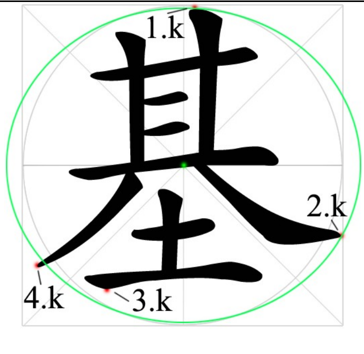
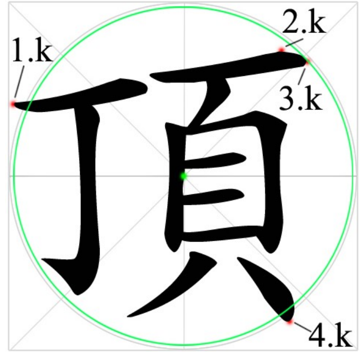
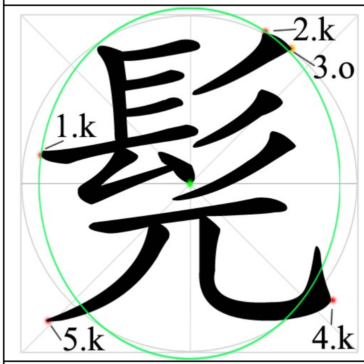
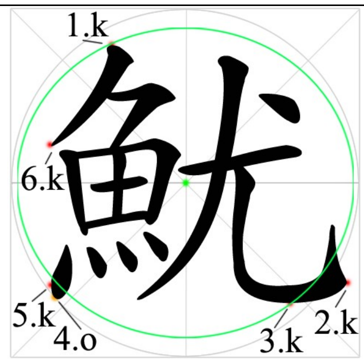
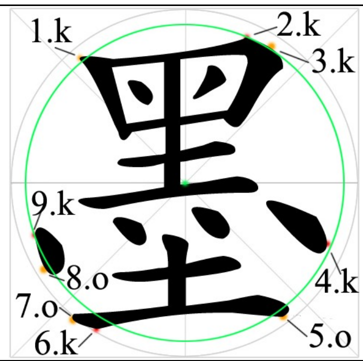
		
1) 3px 2) 0px 3) 45px 4) 16px 5) 35px 6) 0px	1) 0px 2) 0px 3) 22px 4) 10px	1) 18px 2) 16px 3) 0px 4) 11px
		
1) 0px 2) 0px 3) 4px 4) 31px 5) 51px	1) 0px 2) 31px 3) 0px 4) 14px 5) 7px 6) 35px	1) 4px 2) 0px 3) 1px 4) 5px 5) 7px 6) 13px 7) 22px 8) 4px 9) 0px

Table 6-8 Circular/Elliptical Layout on the 39 characters in Set 1

A total of 190 points were gathered from the 39 characters. Figure 6-12 shows the distribution of distances of the points to the ellipses for all the characters.

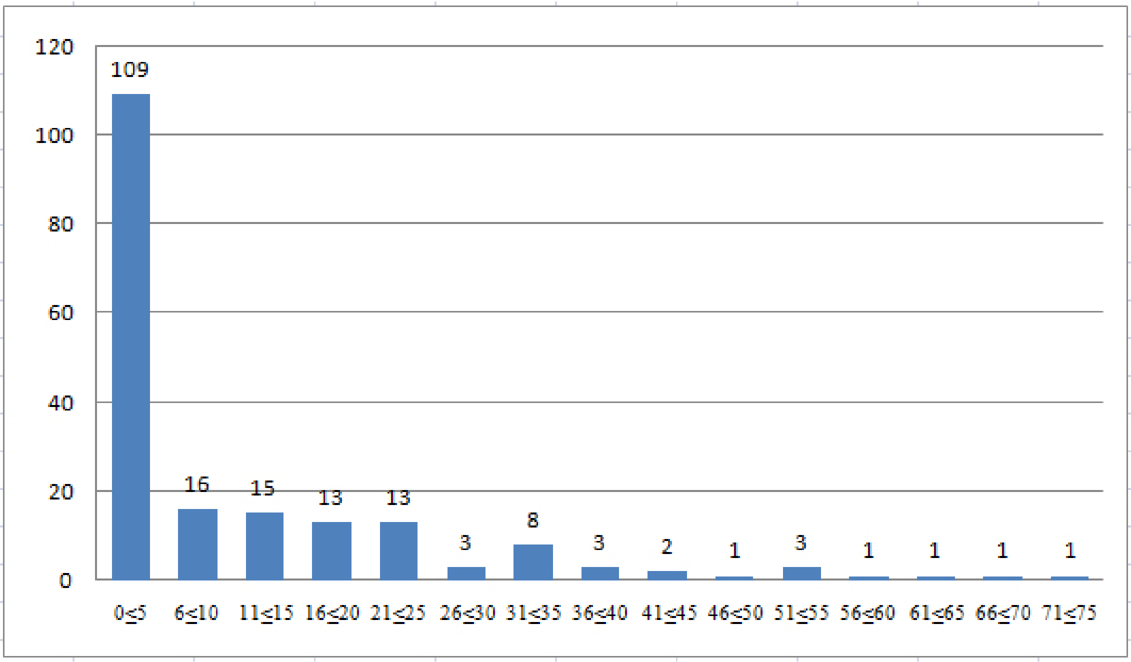


Figure 6-12 Distribution of distances to the ellipses: 5px is the bin size

87% (166) of the points lie on the ellipses (less than 25px, see Section 6.3.3). For the remaining 13%, many of their key points should not be included. The characters with points more than 25 pixels away from the ellipses are 六, 七, 八, 九, 十, 千, 萬, 元, 玎, 麸, 靚, 勒, 黿, 協, 聖, 磯, 赴, 髡, 魷. They can be put into four categories: 1. U-turn strokes; 2. Diagonal strokes; 3. Characters with a 十 (ten); 4. Key points in the middle

6.3.6.1 U-turn strokes

When the U shape stroke (Figure 6-13) has two key points, one of them will not lie on the ellipse. In practice, only one of the two key points is considered when constructing the ellipse. From Table 6-9, it was concluded that the point on the last turn on the stroke should be retained.

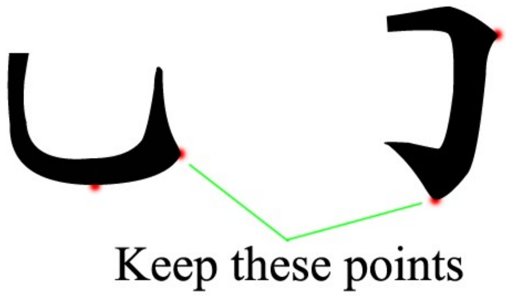


Figure 6-13 Key points on U-turn strokes

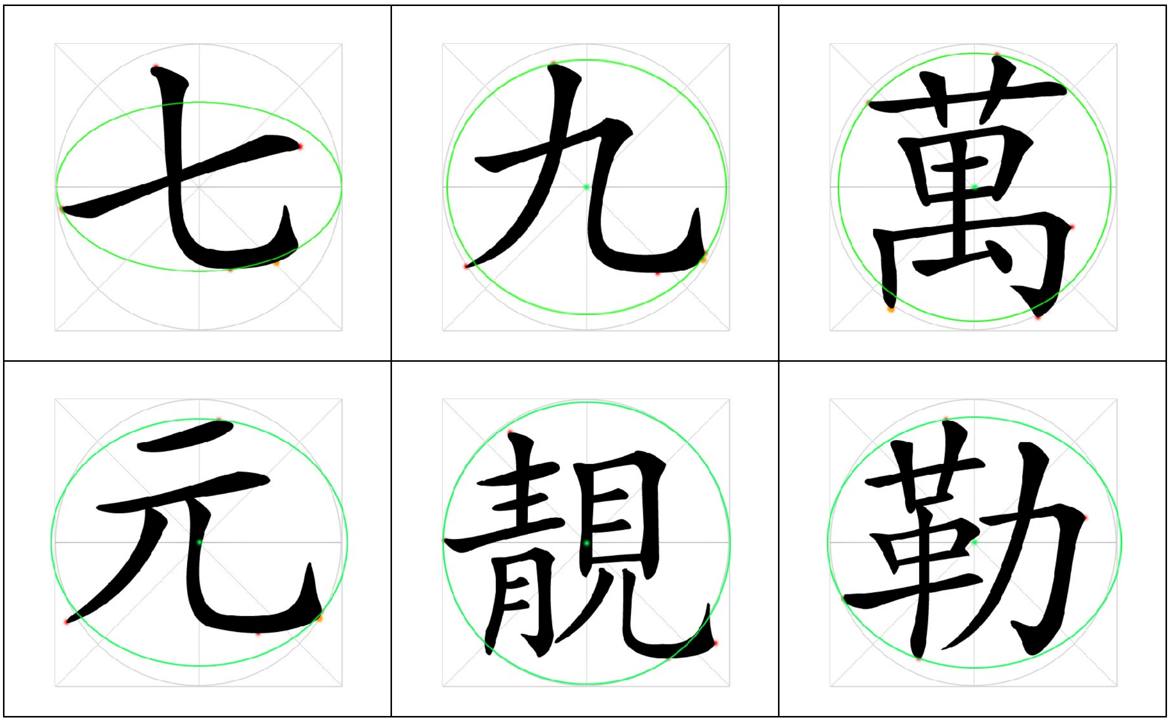
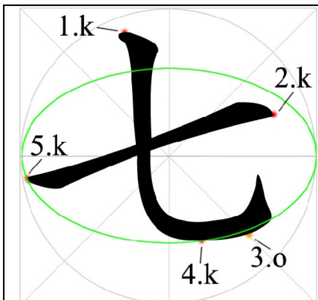
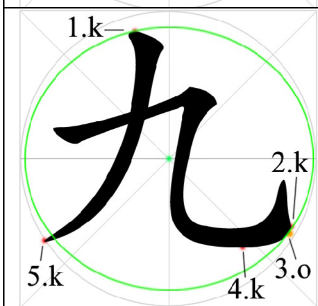
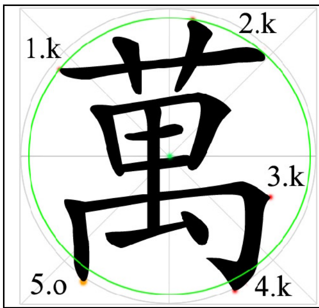
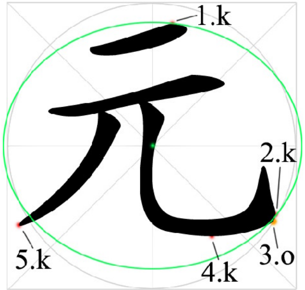
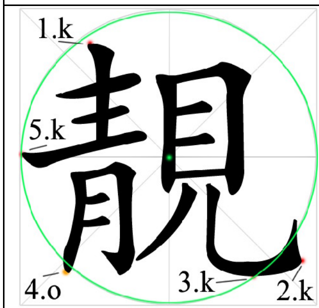
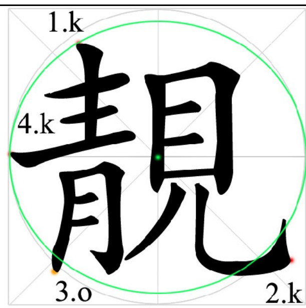
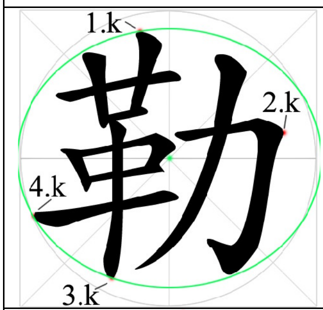
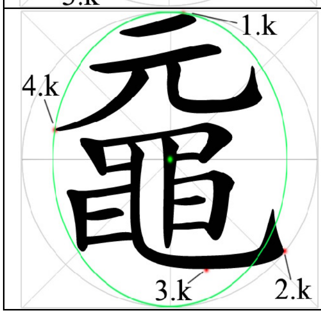


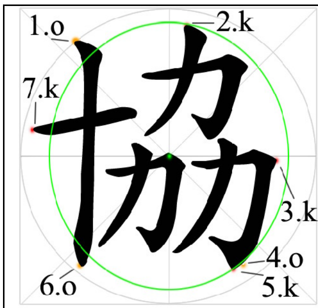
		
		

Table 6-9 When the U-turn strokes happen to have two key points, one will inevitably not lie on the ellipse

In the light of this finding, these characters are reanalysed in Table 6-10.

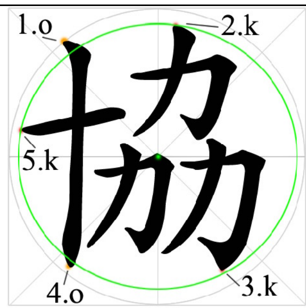
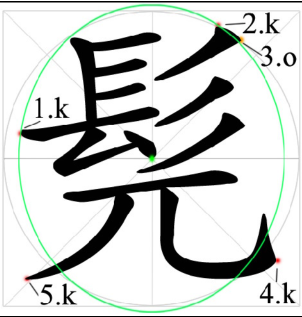
	1) 62px 2) 26px 3) 4px 4) 0px 5) 0px Change: nothing changed because the last turn on the U-turn stroke doesn't own a key point.
	1) 0px 2) 0px 3) 1px ~~4) 32px~~ 5) 14px Change: remove the key point (32px) on the dividing line of the U-turn stroke.

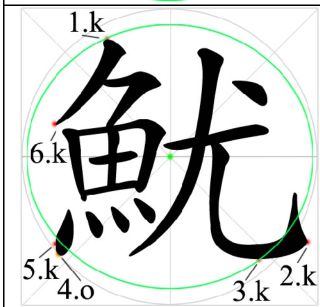
	1) 0px 2) 0px ~~3) 51px~~ 4) 15px 5) 18px Change: remove the key point (51px) on the dividing line of the U-turn stroke.	
	1) 0px 2) 0px 3) 2px ~~4) 32px~~ 5) 22px Change: remove the key point (32px) on the dividing line of the U-turn stroke.	
	1) 10px 2) 31px 3) 0px 4) 9px 5) 0px Change: remove the key point (31px) on the dividing line of the U-turn stroke and reconstruct the ellipse. The new shortest distances between the key points, the outer points to the ellipse (the right one): 1) 0px 2) 36px 3) 17px 4) 0px	
	1) 0px ~~2) 35px~~ 3) 0px 4) 0px Change: remove the key point (35px) on the dividing line of the U-turn stroke.	
	1) 0px 2) 27px ~~3) 41px~~ 4) 0px Change: remove the key point (41px) on the dividing line of the U-turn stroke.	

<table>
<tr>
<td>
</td>
<td>1) 30px 2) 0px 3) 17px 4) 2px 5) 0px 6) 18px 7) 25px

Change: remove the key point on (17px) the dividing line of the U-turn stroke and reconstruct the ellipse.

The new shortest distances between the key points, the outer points to the ellipse (the right one):

1) 20px 2) 0px 3) 4px 4) 8px 5) 0px</td>
<td>
</td>
</tr>
<tr>
<td>
</td>
<td colspan="2">1) 0px 2) 0px 3) 4px 4) 31px 5) 51px

Change: nothing changed because the middle part of the U-turn stroke doesn’t own a key point.</td>
</tr>
<tr>
<td>
</td>
<td>1) 0px ~~2) 31px~~ 3) 0px 4) 14px 5) 7px 6) 35px

Change: remove the key point (31px) on the dividing line of the U-turn stroke and reconstruct the ellipse.

The new shortest ~~distances~~ between the key points, the outer points to the ellipse (the right one):

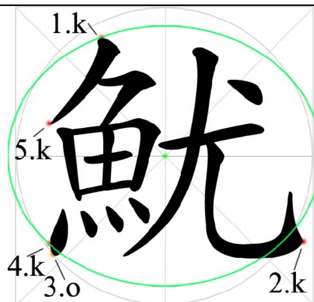
1) 0px 2) 20px 3) 8px 4) 0px
5) 53px</td>
<td>
</td>
</tr>
</table>

Table 6-10 Removed the key point on the dividing line of the U-turn stroke and reconstructed the ellipse

The distribution of error distances is recalculated and shown in Figure 6-14. The total number of points was 182 and the points within the error tolerance increased to 164 (90%), which is a significant improvement.

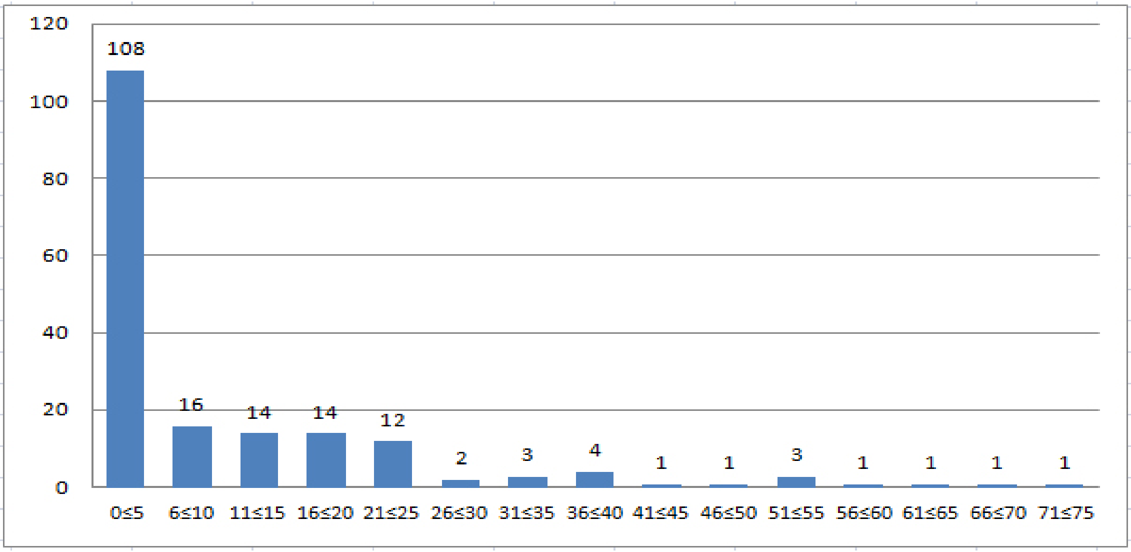


Figure 6-14 Distances to the ellipses after removing the unnecessary key point: 5px is the bin size

6.3.6.2 Diagonal strokes

1. Points on diagonal strokes. These are shown in Table 6-11.

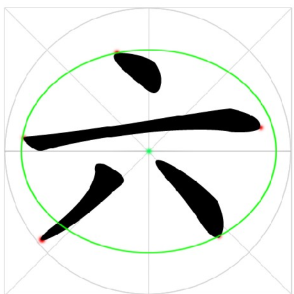
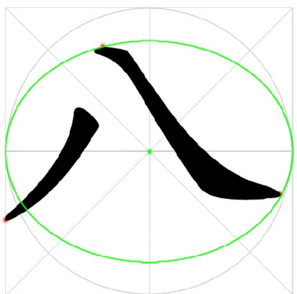
		
		

Table 6-11 When the key points are on one of the two diagonal strokes, they usually do not lie on the ellipse.

It should be a style of the calligrapher who produced the type, because it happens whenever one of the two learning toward centre strokes appear. Some of them can be easily fixed, such as 六 and 八 (Table 6-12).

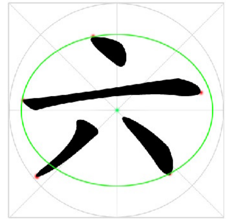
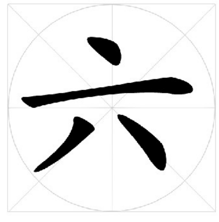
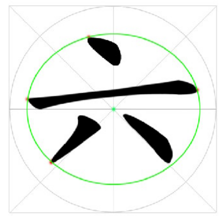
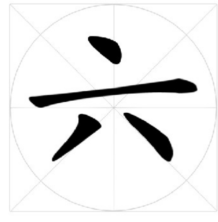
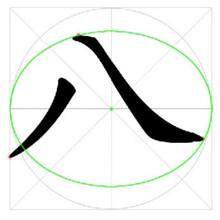
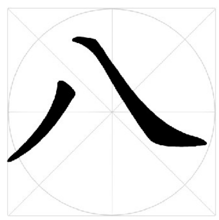
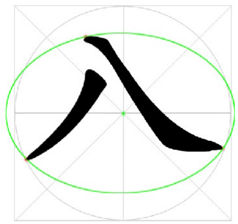
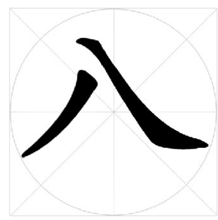
Original		fixed	
			
			

Table 6-12 The characters六and八for Circular/Elliptical Layout.

Another possibility was that the two diagonal strokes demand extra space and are not constrained by the circle/ellipse layout, because on the three characters 麸 礠 and 赴, if the two strokes were forced to stay inside the ellipses, the characters appear distorted. If so, the key points on diagonal strokes should be ignored and their Circular/Elliptical should be recalculated. There would not be any difference for the characters 麸 and 赴 because their ellipses are not determined by the key points on the two strokes, but for the character 礠, it would become the one as displayed in Table 6-13. On this one, the strokes do follow the shape of the ellipse.

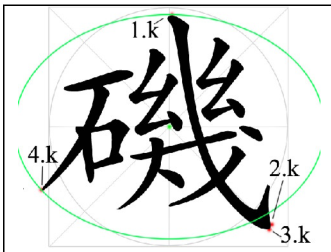
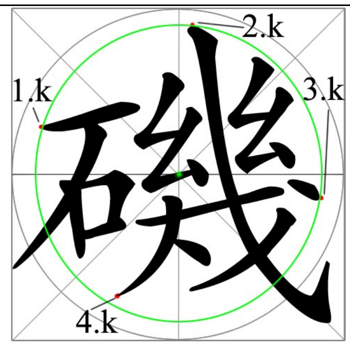
	1) 0px ~~2) 17px~~ ~~3) 25px~~ 4) 0px Change: ignore the key points (17px and 25px) on the two learning toward centre strokes and reconstruct the ellipse. The new shortest distances between the key points, the outer points to the ellipse : 1) 0px 2) 0px 3) 0px 4) 16px	

Table 6-13 Ignoring the key points on the two learning toward centre strokes and reconstructing the ellipse

6.3.6.3 Characters with a 十 (ten)

When a part of the character is based on the character 十. They are: 十 and 千. They can be rationalised as well. For instance, moving the horizontal strokes of the characters 十 and 千 down slightly and making the end of the vertical strokes shorter gives perfect ellipses.

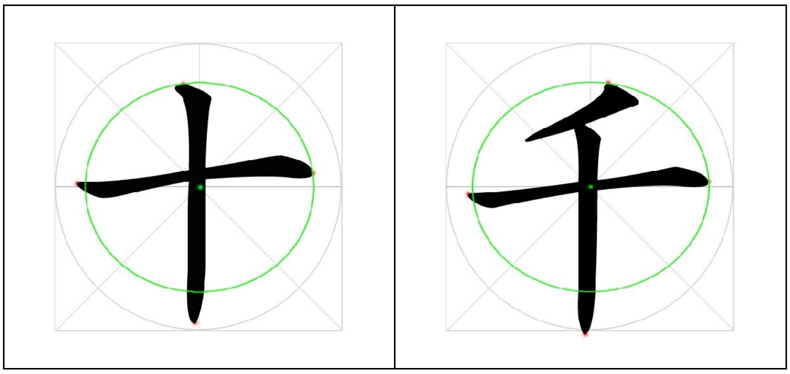


Table 6-14 Characters which break the Circular/Elliptical Layout based on the character十ten

6.3.6.4 Key points in the middle

Key points that are at an end of a horizontal stroke and close to the vertical line crossing the centre of gravity. Examples are: 玎 and 聖 (Table 6-15). These key points should not be counted because they are always further from the circle/ellipse compared to the points at the other end of the horizontal strokes. When this happens, the point at the other end can be considered as the alternative key point because it is always a peripheral point.

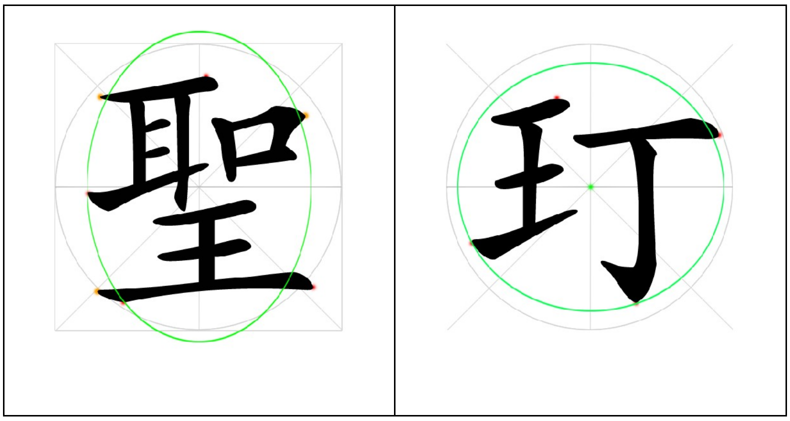


Table 6-15 Characters break Circular/Elliptical Layout when they are with key points on a horizontal stroke and closer to the vertical line crossing the centre of gravity

By changing the styles of second and third categories, fixing the fourth category, more than 90% of the points would land on the ellipses with the error tolerance of 25 pixels.

6.3.7 Determination of the Circular/Elliptical Layout for regular script Chinese calligraphy

This is done by the following steps:

1. Place the centre of gravity of a character at the centre of the Judgement Lines
2. Identify the key points on the four sides. If two points overlap each other, they are counted as one point, as shown in the character 八 in Figure 6-8.
3. The centre of gravity is set as the central point and a circle or ellipse is drawn around to pass through as many key points as possible, minimising the distance of the key points from the circle/ellipse.
4. Once the ellipse is identified, the strokes should be constrained by the ellipse with 5% deviation (error tolerance 25 pixels / font size 470 pixels ˜ 5 %). The 5% deviation is the space for a calligrapher to develop his/her personal style.

6.3.8 Examining and Computing Avoiding Prominence

- **Avoiding Prominence (V2):** No component should obviously dominate the interface, be “aggressive” or distinguishable (Figure 5-17). Keeping the same space between any two components is the key to avoiding “aggressive” and distinguishable. When the spaces between components are large, this principle is less important. The more space between the components, the less dominating, aggressive and distinguishable a single component will be. However, when the spacing is increased, more attention must be paid to Symmetrical Space.

This principle is derived from Guo’s (1995) principles ‘Yunchen’ and ‘Rangjiu’ which are about arranging the proper sizes of the strokes. However, he just expresses the fact that the sizes of the strokes have to be bigger if there are just a couple of strokes in part of the character, or smaller if there are many, and does not provide any measurements for how much the strokes should be resized. It was explained as ‘nothing should be prominent', which is still ambiguous and the participants in the Chinese Teaching seminar did not make any suggestions to further specify it. However, together with the inspiration of the importance of space (Section 5.3.5.1), the computing of Circular/Elliptical Layout gives a method to quantify Avoiding Prominence. After finding the centre of gravity and planning the space for a character, the next step is to assign the space for the strokes of the character. Any parts of the character should give the feeling that they occupy a similar amount of space, and that the total amount of space is limited by the circle/ellipse. Mathematically, it is to do with proportion or ratio. Confucianism values "harmonious yet different" (Hu, 1991), i.e. different shapes and sizes of strokes are allowed, but they have to occupy the space proportionately. This discovery also provides a deductive framework for another Calligraphic principle proposed by other calligraphers: Distributing the white area in the same way as the black area (black strokes with white background) (Zou, 2008).

6.3.8.1 Dividing line and proportional difference

The difficulty with this method is to equally divide the shared space. Not all the characters have their parts clearly delineated. For example, the character 赴 has two parts but it is difficult to draw a dividing line between the two parts. After many trials and errors, a dividing line was allocated, which allowed proportions to be calculated. The dividing line should satisfy three conditions:

1. If the two parts are in left and right structure, the dividing line is vertical. If the two parts are in a top and bottom structure, the dividing line is with an orientation parallel to the 'horizontal' strokes in the character. For instance, if the two parts are clearly separated like the character 吉 the dividing line will be worked out as illustrated in Figure 6-15.

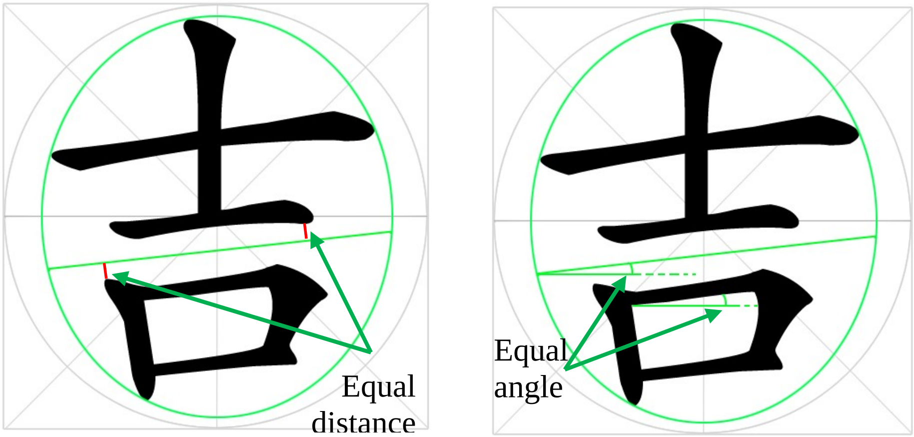


Figure 6-15 How to find the dividing line between two clearly separated parts in a character

2. If the two parts are in an interleaving structure, the way to identify the dividing line is shown in Figure 6-16. Figure 6-16 (a) shows an artificial character consisting of two sub-characters A and B which interpenetrate; sub-character A has a vertical stroke A_1 coming down and sub-character B has two vertical strokes B_1 and B_2 going up. In this example, because the two characters are arranged one above the other, the dividing line between them will be horizontal. In Figure 6-16 (b) a horizontal line has been drawn through A_1 and B_1 dividing the overlapping vertical strokes into two equal parts so that $\Delta_1 = \Delta_2$. This is repeated in Figure 6-16 (c) for A_1 and B_2. It has been found that the line rs in Figure 6-16 (c) where $\Delta_1 = \Delta_2$ and has the smallest possible value gives the best result for calculating Avoiding Prominence.

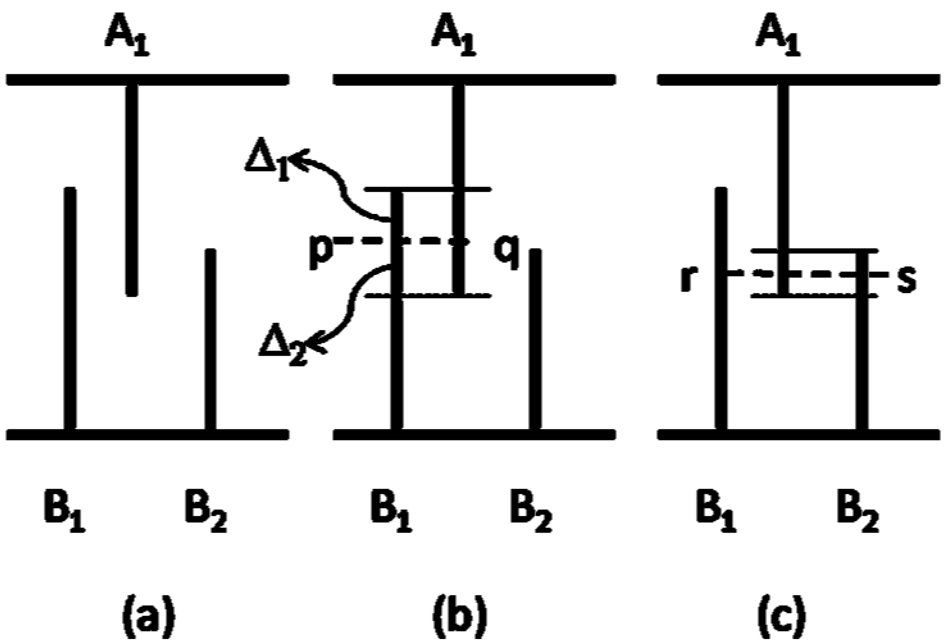


Figure 6-16 Identifying the dividing line in an interleaving character

Consider a character like 墨 which consists of two sub-characters: 黑 black and 土 soil, some of their strokes encroach into each other's space (Figure 6-17).

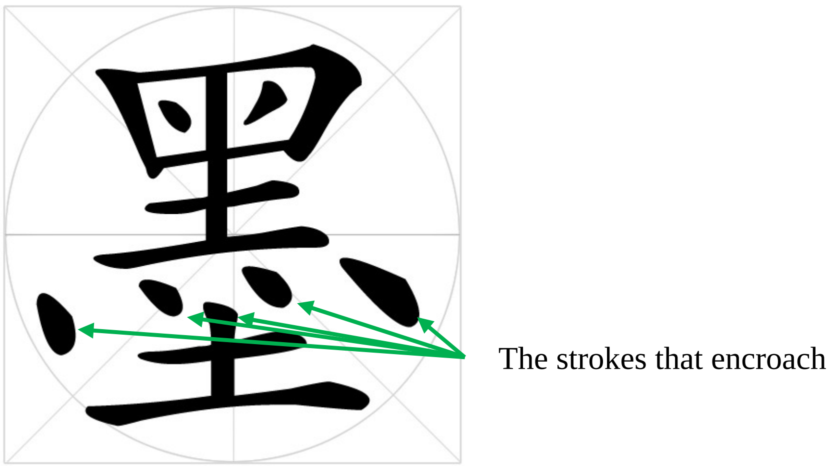


Figure 6-17 Some strokes of the two sub-character of 墨 encroach upon each other

Its dividing line will be worked out as illustrated in Figure 6-18. The distance between the dividing line and the second dot from the left is the same as that between the dividing line and the upright stroke. Meanwhile this distance is the shortest of all the options (Figure 6-18).

Same shortest distances in all the options

Figure 6-18 How to find the dividing line between two separated but interleaving parts in a character

3. If the two parts are in a surrounding structure, it is the same as point 2 but the strokes used to surround another sub-character are not taken into account, because the dividing line found with them apparently does not divide the space for the two characters. Consider a character like 鬧 which consists of two sub-characters: 門 door and 市 market and one sub-character is inside another sub-character, the strokes embracing another sub-character will not be taken into account when identifying the dividing line (Figure 6-19). The best dividing line found with them (the one with a cross in Figure 6-19) is obviously not for dividing the space for the two characters.

Figure 6-19 How to find the dividing line if a character is in a surrounding structure

The character 億 is the perfect example of Avoiding Prominence amongst the 39 characters. This character consists of two parts. Drawing the dividing line between the two parts splits it and its ellipse layout into two parts (Figure 6-20).

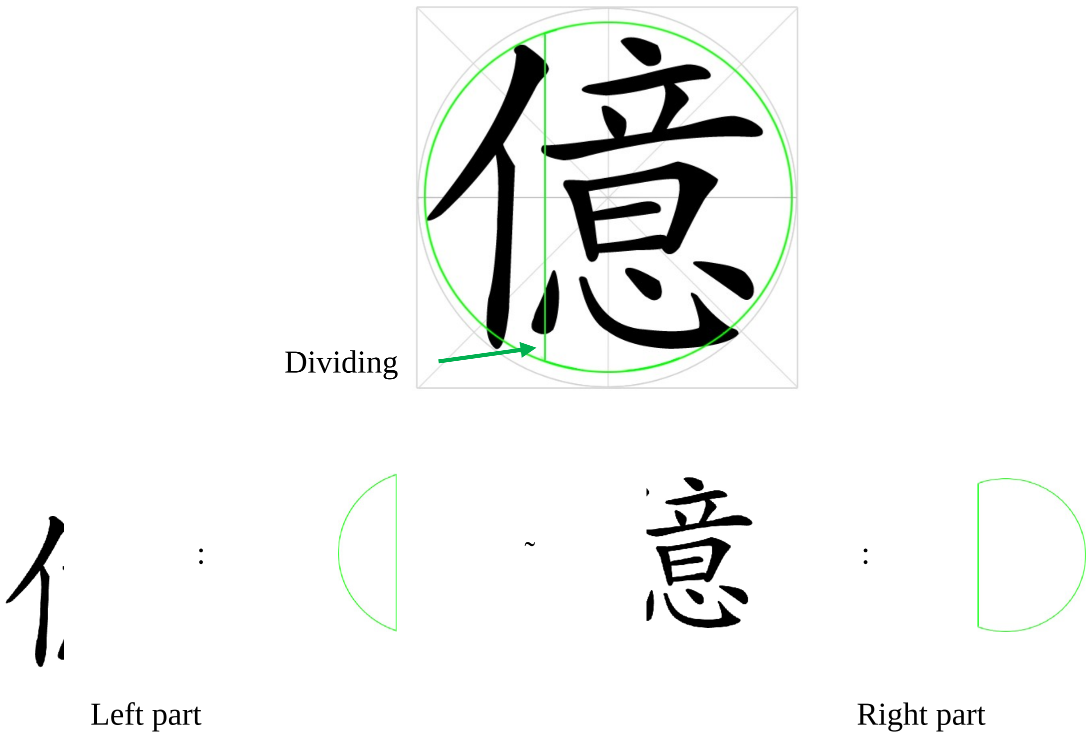
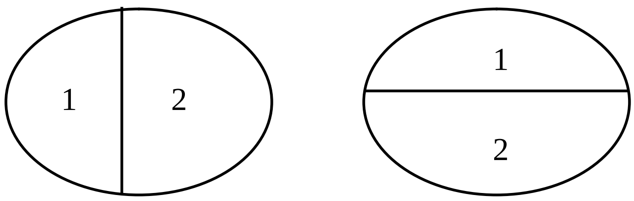


Figure 6-20 The character 億 and its ellipse layout divided into two parts

With the font size of 470px and excluding the part of the stroke outside the ellipse, the number of pixels of the left part in the ellipse is 44352 and the number of pixels in the left part of the character is 11605. The right part of the ellipse consist of 110584 pixels and the bottom part of the character has 28848. The proportions are: the upper part of the character / the left part of the ellipse is 11605 / 44352 ~ 26.17%; the right part of the character / the bottom part of the ellipse is 28848 / 110584 ~ 26.09%. There is only 0.08% difference between the two proportions.

When a character and the space enclosed by its Circular/Elliptical Layout are divided into two halves by the dividing line, the entities needed for Avoiding Prominence can be defined as (Figure 6-21):



Area of space 1 (pixels) = A_1	Area of space 2 (pixels) = A_2
Area of character in 1 (pixels) = B_1	Area of character in 2 (pixels) = B_2
$B_1/A_1=C_1\%$	$B_2/A_2=C_2\%$

Proportional difference, $P=|(C_1-C_2)|\%$

Figure 6-21 Define the entities for Avoiding Prominence

For a character to be ideally balanced, $\frac{B_1}{A_1}=\frac{B_2}{A_2}$.

The weight of the character stroke areas as a proportion of the areas containing them should be equal. This leads to a definition of a measure for Avoiding Prominence:

$$\text{Proportional difference, } P=|(C_1-C_2)|\%$$

6.3.8.2 Proportional differences in the characters

Therefore, the table for showing the satisfaction of Avoiding Prominence can be constructed as Table 6-16, using the character 億 as an example.

	A_1	B_1	C_1	A_2	B_2	C_2	P%
	44352	11605	26.17%	110584	28848	26.09%	0.08%

Table 6-16 The proportion difference for the character 億

The character 吉 lucky also almost perfectly satisfies the principle of Avoiding Prominence. When applying the same method to the “lucky” character 吉, the proportional difference between its upper parts and lower parts is only 0.45% (Table 6-17).

	A_1	B_1	C_1	A_2	B_2	C_2	P%
	82652	18732	22.66 %	53926	12462	23.11 %	0.45%

Table 6-17 The proportion difference for the character 吉

In each character, one part should have at least double the number of strokes compared to the other part, to ensure the visual balance, the size of the part with less strokes is enlarged if it occupies a relatively bigger space, as Guo (1995) described. That is to say, the dividing line can only be applied to the characters that consist of more than two sub-characters, because there is no need to change the thickness of some strokes if a character is unique. Therefore, the Chinese numbers from “one” to “thousand” were removed from the 39 characters for analysis, because the majority of them are unique characters. The characters left were:

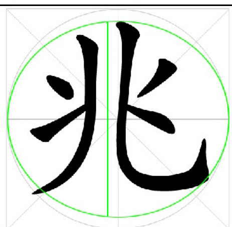
萬, 億,兆, 丞, 元, 吉,玎, 佘, 耔, 麸, 靓, 勒, 鬪, 梟, 鼀, 暢, 協, 聖, 韌, 磯, 耵, 赴, 基, 頂, 髡, 魷, 墨

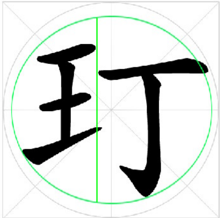
To retain the number of 39 for consistency, the two characters 蘭 orchid and 開 were added from the word “Lancashire”. A further nine characters like the character 吉 with the adjacent strokes from both parts parallel were added to the list as well to increase number. They were the ten characters first encountered from the Chinese dictionary (Xinhua Dictionary printed in 1998 ISBN 7-100-02601-6), and were available in the

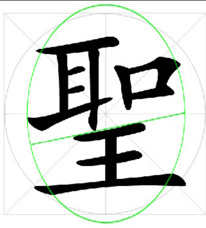
Founder regular script font. They were: 畀 confer, 箅 bamboo steamer, 舶 ship, 曹 a surname, 晨 morning, 呈 present, 亍 a surname, 凳 bench, 胴 trunk, 毒 poison.

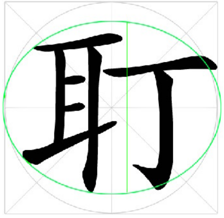
All these formed the second set of the characters (Set 2).

Table 6-18 display the results of the 39 characters in Set 2:

	A_1	B_1	C_1	A_2	B_2	C_2	P%
	34381	10100	29.38 %	120826	29662	24.55 %	4.83%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	44352	11605	26.17%	110584	28848	26.09%	0.08%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	67333	13724	20.38%	86551	19378	22.39%	2.01%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	134616	30799	22.88%	26031	6475	24.87%	1.99%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	19773	3836	19.40%	135596	23820	17.57%	1.83%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	82652	18732	22.66 %	53926	12462	23.11 %	0.45%

	A_1	B_1	C_1	A_2	B_2	C_2	P%
	56818	12771	22.48%	83203	14645	17.60%	4.88%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	56642	14555	25.70%	76890	18895	24.57%	1.13%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	80718	21977	27.23%	74448	17787	23.89%	3.34%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	79871	20320	25.44%	66291	14934	22.53%	2.91%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	67132	19370	28.85%	93008	19452	20.91%	7.94%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	81621	23534	28.83%	74434	18359	24.66%	4.17%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	67328	17396	25.84%	106652	24664	23.13%	2.71%

	A_1	B_1	C_1	A_2	B_2	C_2	P%
	111395	22699	20.38%	75793	14524	19.16%	1.22%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	47116	13466	28.58%	89718	25243	28.14%	0.44%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	65396	19877	30.39%	100160	30629	30.58%	0.19%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	31197	9368	30.03%	114822	30499	26.56%	3.47%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	86977	23373	26.87%	60514	13513	22.33%	4.54%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	79925	24119	30.18%	60838	15895	26.13%	4.05%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	41204	10661	25.87%	93516	29263	31.29%	5.42%

	A_1	B_1	C_1	A_2	B_2	C_2	P%
	85855	22397	26.09%	60148	12579	20.91%	5.18%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	88310	20930	23.70%	57336	15652	27.30%	3.60%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	106462	22670	21.29%	83292	18709	22.46%	1.17%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	60851	11127	18.29%	104368	24566	23.54%	5.25%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	92578	23943	25.86%	69947	14679	20.99%	4.87%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	77128	18705	24.25%	82772	16027	19.36%	4.89%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	102985	25994	25.24%	42406	11608	27.37%	2.13%

	A_1	B_1	C_1	A_2	B_2	C_2	P%
	116714	33689	28.86%	32890	9284	28.23%	0.63%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	65346	18060	27.64%	87998	20198	22.95%	4.69%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	77416	17337	22.39%	75986	18390	24.20%	1.81%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	98489	24410	24.78%	51151	14140	27.64%	2.86%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	69610	20833	29.93%	70954	22459	31.65%	1.72%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	76361	26853	35.17%	41679	12658	30.37%	4.80%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	40170	11657	29.02%	107647	25952	24.11%	4.91%

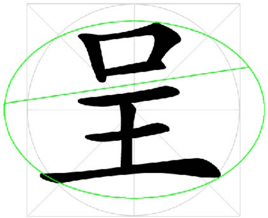
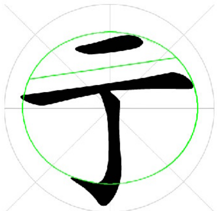
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	57893	11410	19.71%	121187	21487	17.73%	1.98%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	19369	4058	20.95%	86540	15971	18.46%	2.49%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	99928	26322	26.34%	42035	8507	20.24%	6.10%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	59065	16923	28.65%	111832	25795	23.07%	5.58%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	51181	13425	26.23%	89699	25211	28.11%	1.88%

Table 6-18 Characters with Avoiding Prominence in Set 2

In total for the 39 characters the mean percentage difference between left and right or top and bottom sectors is 3%, with the standard deviation of 2%. In other words, 95% (37 out of 39) of them had less than 6% proportional difference.

6.3.9 Final version of Avoiding Prominence for Chinese regular script calligraphy

In constructing a character, the space the character occupies is defined by the enclosing circle or ellipse. If the character is made up of two sub-characters, the circular or elliptical space is further divided by the dividing line. When assigning the spaces for each sub-character, the area of the strokes and the space should be in proportion to each other. The smaller the proportional difference (P), the more harmonious the character will be.

However, not all characters have clearly separated sub-characters, they could be interleaving or in a surrounding structure. The method to find the dividing lines between the sub-characters is:

1. If the two parts are in left and right structure, the dividing line is vertical. If the two parts are in top and bottom structure, the dividing line is parallel to the closest near horizontal line in the character.

2. If the two parts are in an interleaving structure, the dividing line is equidistant from two closet points from each sector (Section 6.3.8).

6.3.10 Examining and computing Symmetrical Space

- **Symmetrical Space (V2):** The distances between the centre of gravity of a component and its neighbouring components' centre of gravity should be more or less the same. The centre of gravity of each component does not need to be accurately identified. Designers can simply convert the components into some simple shapes: Circle, Triangle, and Parallelogram and roughly identify the centre of gravity. If there is not much background space, then this principle is less important than avoiding prominence.

After locating the position for the centre of gravity for a character, defining how much space the character should occupy (Circular/Elliptical Layout) and assigning the space to the strokes of the character (Avoiding Prominence), the next principle is: Symmetrical Space. This was the most difficult principle to make fully deductive and computable. This principle is about the relationship between the strokes. When this principle is satisfied, all strokes will be harmonious and a table characters will be constructed.

This principle was the most difficult one and there were two main difficulties.

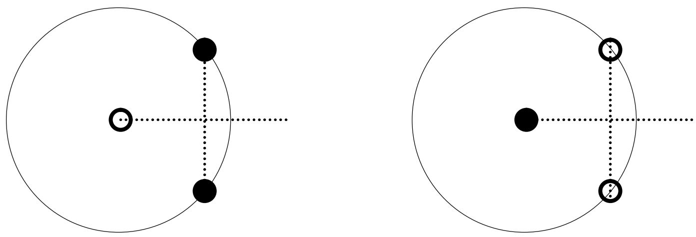
1. Was there a common relationship among the centres of gravity, so the positions of the centres of gravity are predictable?

2. How to locate the centres of gravity of the parts of the stroke?

6.3.10.1 Common rules for the centres of gravity

Two rules were found for the arrangement of the centres of gravity: for simplicity, a centre of gravity is called as a point below.

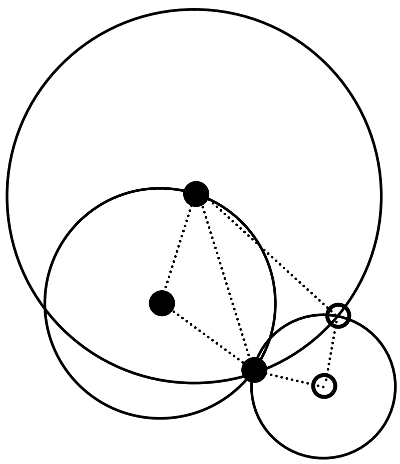
Rule 1. Isosceles triangle: when creating two points next to an existing point, they should be located symmetrically relative to the existing point (Figure 6-22). That is to say, the three points have to form an isosceles triangle.



○ New point ● Existing point

Figure 6-22 Symmetry in Symmetrical Space

Rule 2. When adding new points, they should form isosceles triangles with at least one pair of its neighbouring ones. The more isosceles triangles it can form with its neighbouring pairs, the more harmonious the relationship it can establish with the existing points. This is illustrated in Figure 6-23.



○ New point ● Existing point

Figure 6-23 New centres of gravity should form isosceles triangles with existing ones

In the limit of the angle at the apex going to 180°, the triangle becomes a straight line. (Figure 6-24).

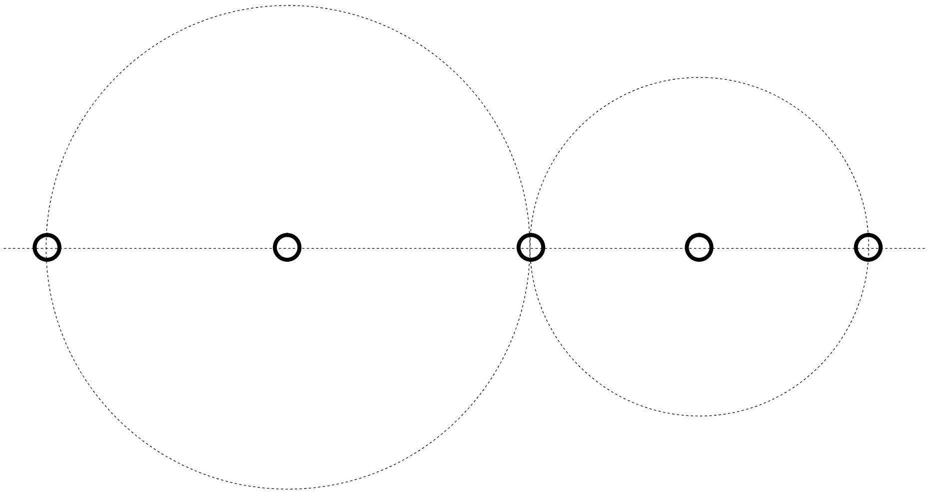


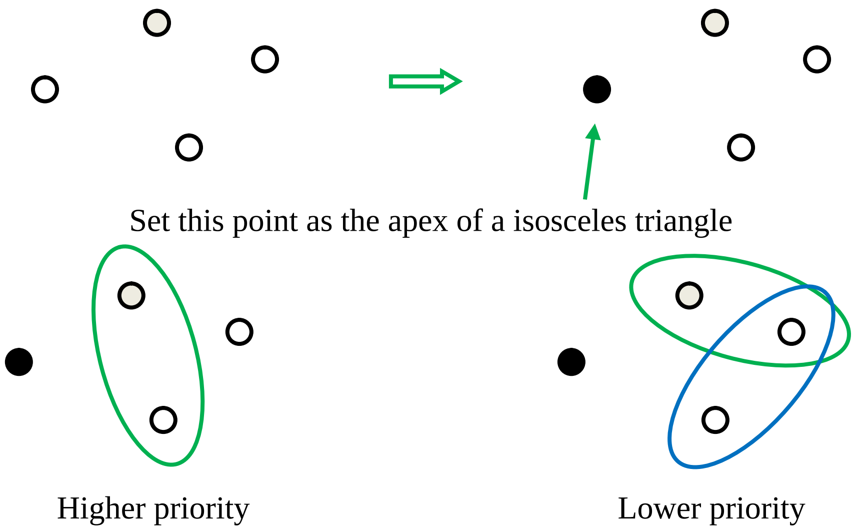
Figure 6-24 Lined up centres of gravity

6.3.10.2 The new rules for neighbouring centres of gravity

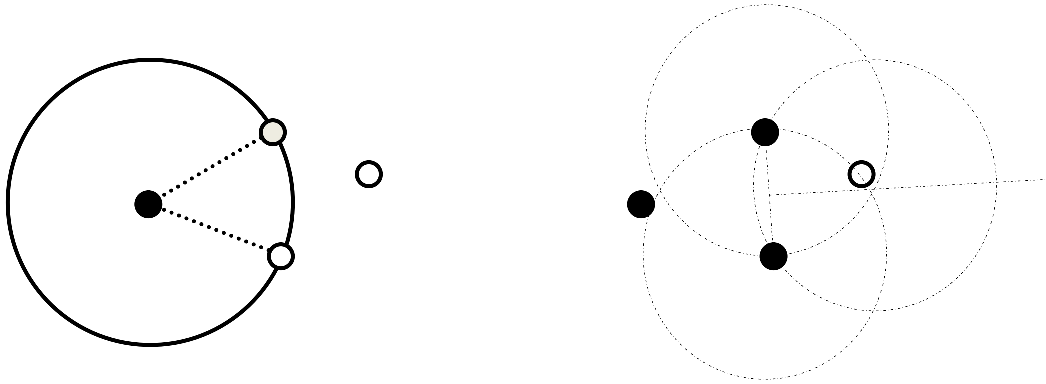
There are three new rules in defining the neighbouring centres of gravity.

1. An isosceles triangle formed by any three centres of gravity does not enclose any other centres of gravity.

2. Closer centres of gravity have a higher priority. Once an isosceles triangle is established, the three centres of gravity will become referencing points to any new centres of gravity (Figure 6-25).



The pair closer to the apex has higher priority than others



The points of an established isosceles triangle will become the referencing points for positioning the next point.

Figure 6-25 Priority and referencing points in terms of neighbouring centres of gravity

3. If two established isosceles triangles do not share points, they should not overlap each other (Figure 6-26).

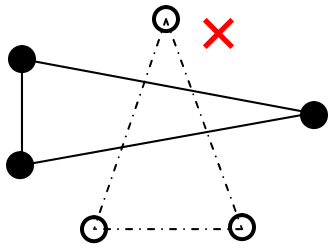


Figure 6-26 Two separated isosceles triangles should not overlap each other

6.3.10.3 Locating the centres of gravity on the parts of the strokes

A stroke is divided into parts by any strokes crossing it, and the shared area between them, as illustrated on Figure 6-27 (Section 4.4.2).

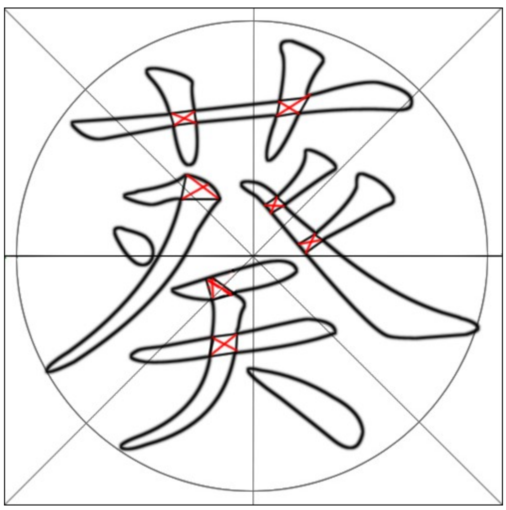


Figure 6-27 Omit the shared areas between strokes

Below is the reason. Figure 6-28 displays the centres of gravity of the parts of the strokes from the character 葵 (sun flower)

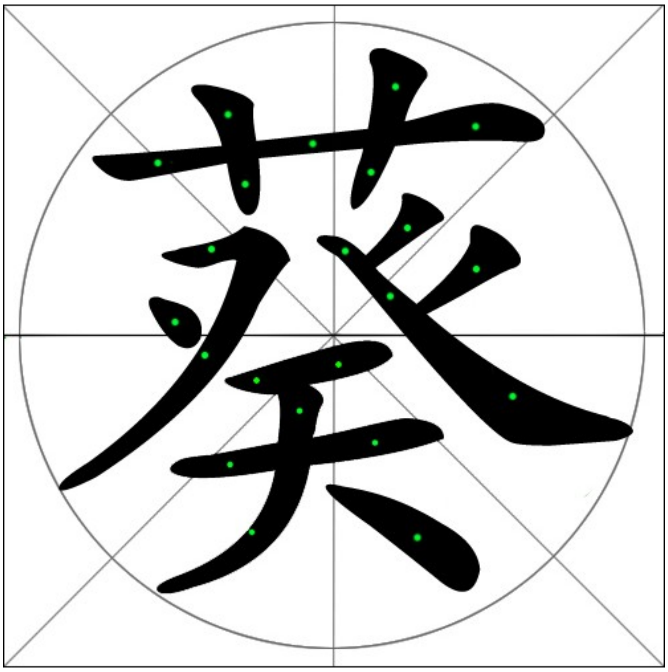


Figure 6-28 Centres of gravity on the character葵 (sun flower)

Balancing the relationship between the parts of the strokes gives more harmonious calligraphy than balancing the relationship between the whole strokes. In Table 6-19, the points on character in the left hand column are the centres of gravity of the whole strokes of the character; the points on character in the right hand column are the centres of gravity of the parts of the strokes defined as above. When working on the left character, only two points had similar distances to their nearest neighbour points. For the right character, it happened to all points. In conclusion, the centres of gravity are those of the parts of the strokes rather than the whole strokes with the overlaps.

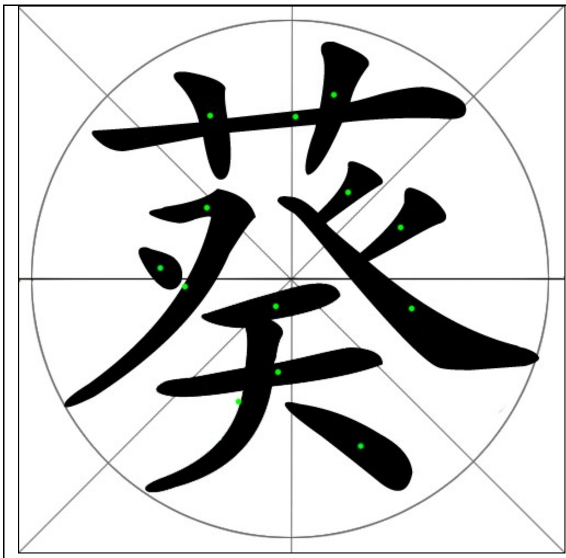
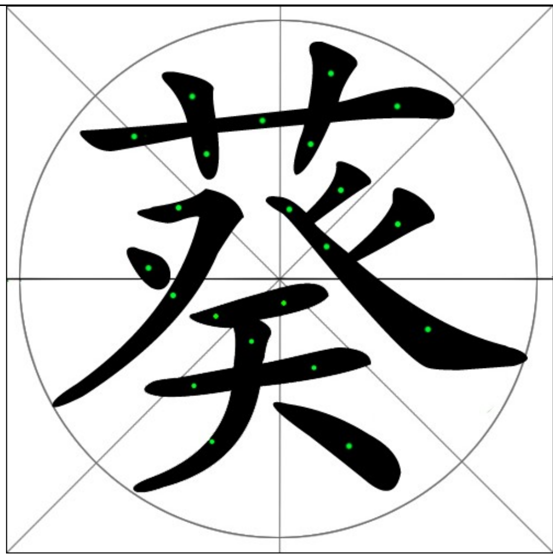
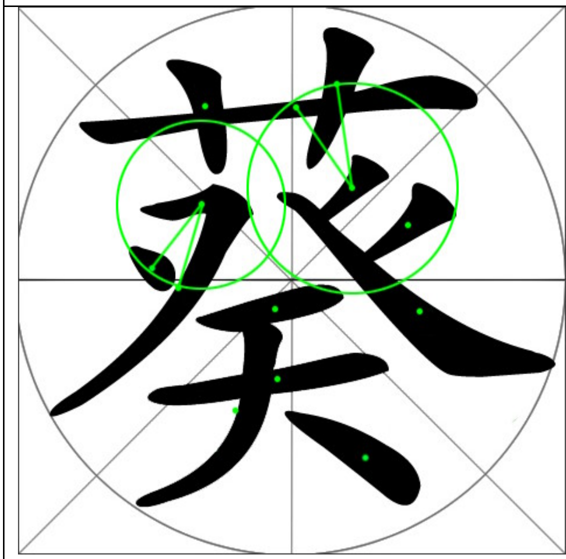
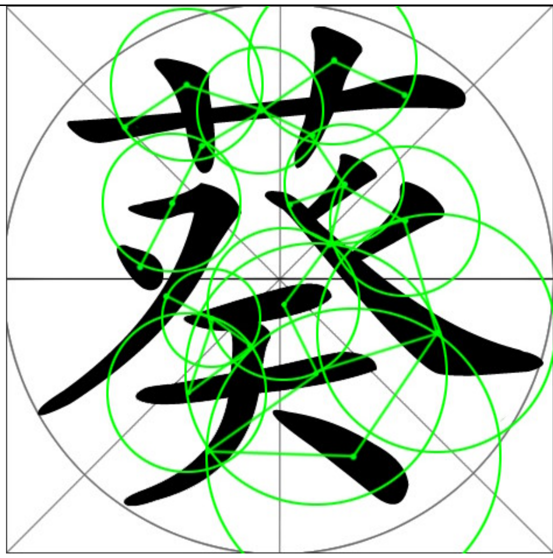
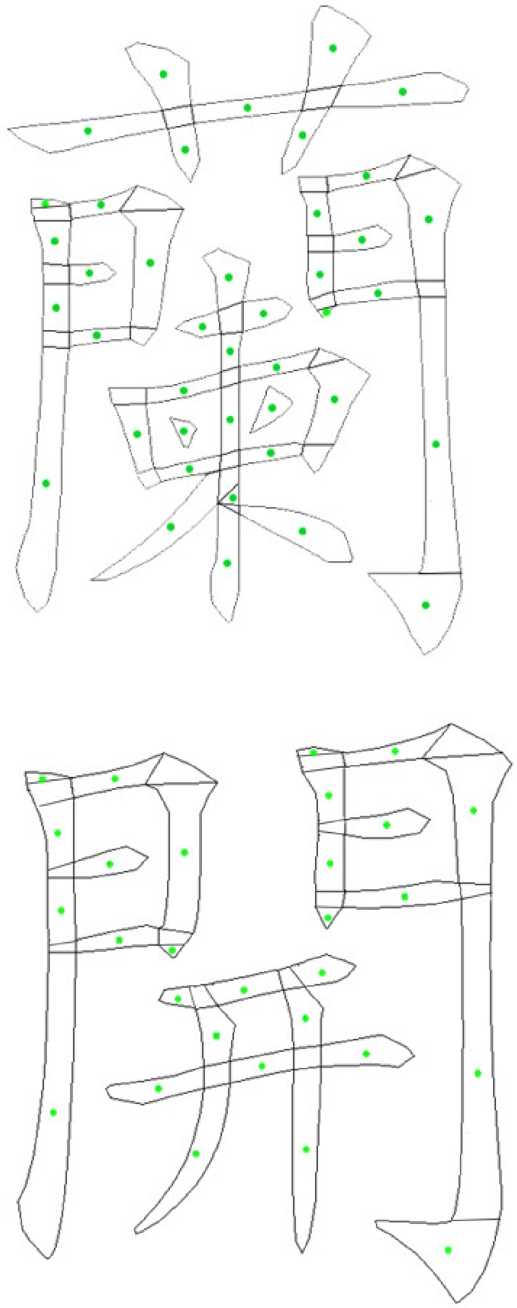
	
	
Centres of gravity on the whole strokes	Centres of gravity on the parts of the strokes

Table 6-19 The distances between the centres of gravity of the part strokes were more or less the same – compare the wholes strokes for the character葵

The Chinese characters “蘭(orchid)開(open)夏(summer)” for “Lancashire” were used as examples:

First, dividing the strokes and locating the centres of gravity (Figure 6-29):



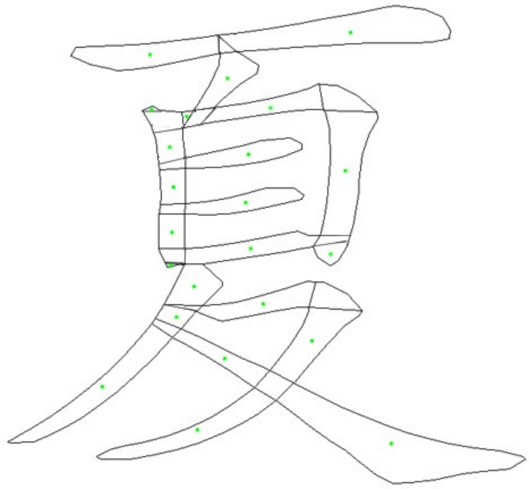
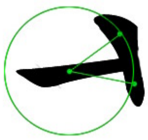
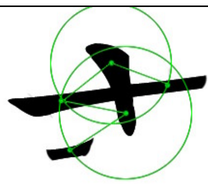
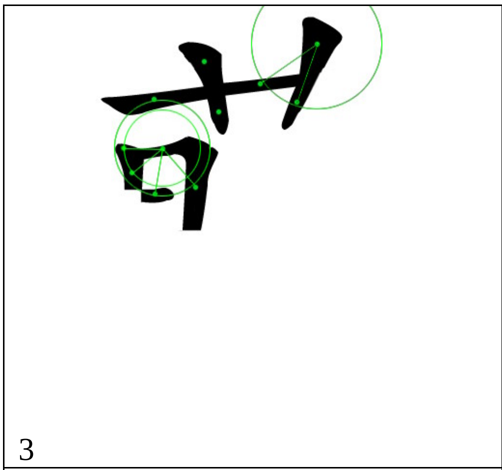
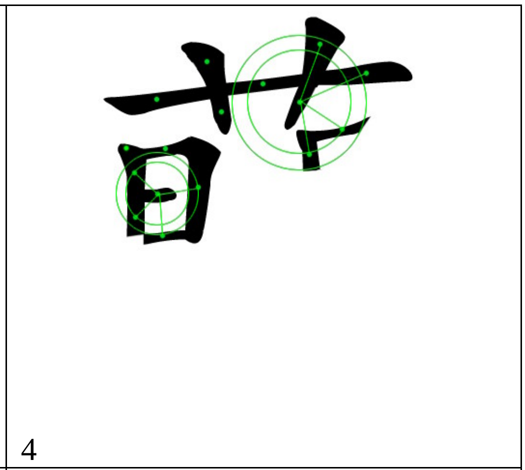


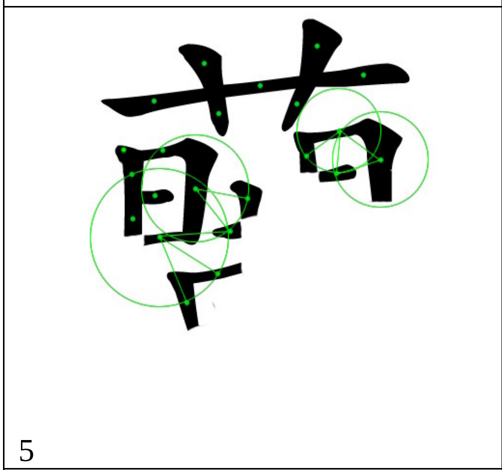
Figure 6-29 the centres of gravity on the characters 蘭開夏

Second, following the rules (Section 6.3.10.1 - 6.3.10.2) to position the centres of gravity and temporarily ignore the strokes. Table 6-20 shows how the decision was made on positioning the centres of gravity based on the rules above. A Chinese character is written from left to right, top to bottom, so the positioning started from the top-left.

 1	 2


3


4


5


6

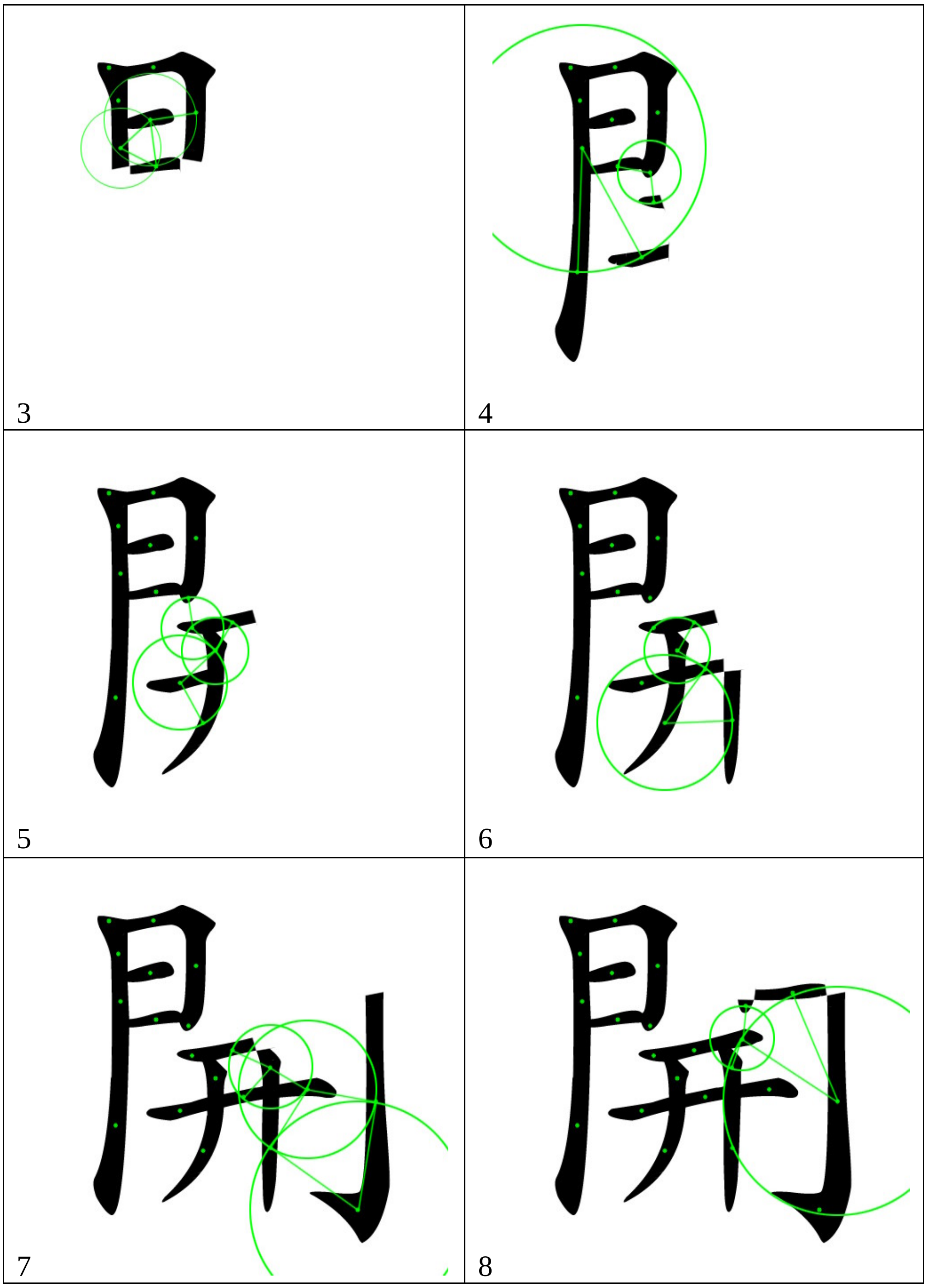

7


8

 9	 10
	

Table 6-20 Symmetrical Space on the character 蘭

 1	 2


3
4
5
6
7
8

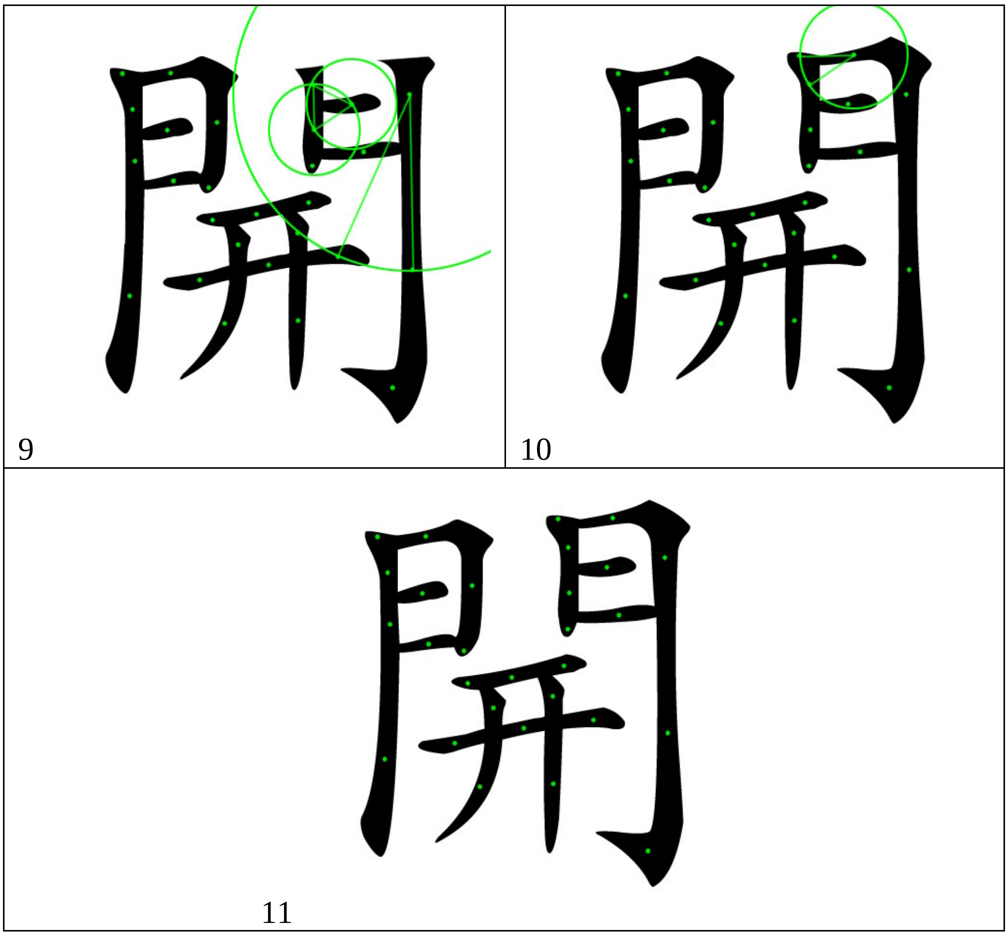
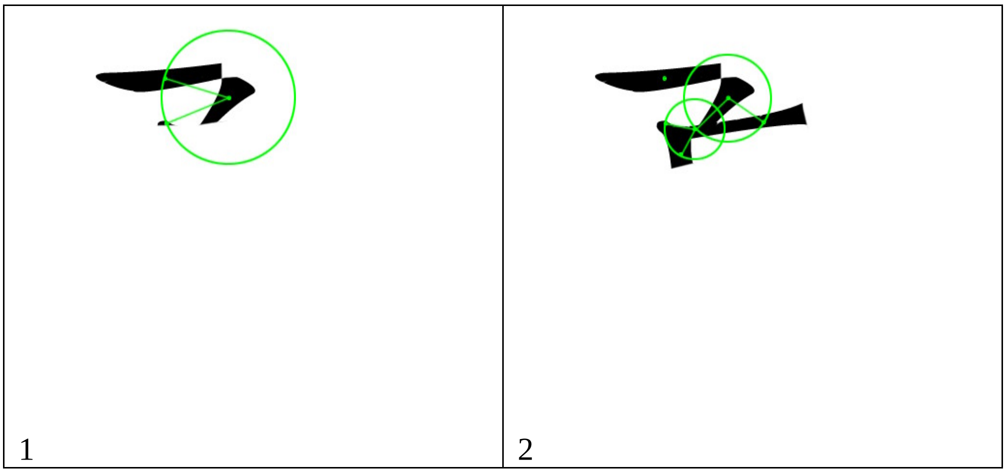


Table 6-21 Symmetrical Space on the character 開



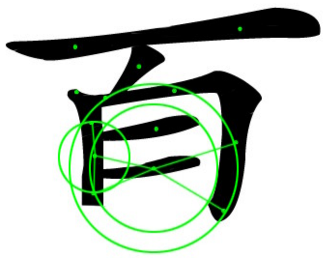
 3	 4
 5	 6
 7	 8

Table 6-22 Symmetrical Space on the character 夏

Among the centres of gravity in the three characters, only two places did not follow the rules (Section 6.3.10.1 - 6.3.10.2). The first one is in the Character 蘭. In the Figure 6-30, among the four points in the highlighted area, no matter which one is set as the central point, its two neighbours are not on the same circle.

Figure 6-30 Improvement needed on the character 蘭, in terms of Symmetrical Space

This problem can be easily solved by slightly moving the two middle points, as illustrated in Figure 6-31

Figure 6-31 Improvement on the character 蘭, in terms of Symmetrical Space

The second one is the character 夏. One of its centres of gravity does not follow the rules very well (Figure 6-32).

Figure 6-32 Improvement needed on the character夏, in terms of Symmetrical Space

According to the rules of Symmetrical Space, its perfect position is illustrated in Figure 6-33.

Figure 6-33 Improvement on the character夏, in terms of Symmetrical Space

There are a total 91 centres of gravity in the three characters, and only 3 of them required rearrangement. That is 96.7% satisfaction rate. Whilst simple, these rules were not obvious in ancient times, and the arrangements of the strokes were all done by calligraphers' hand and intuition. Even after many generations of calligraphers' elaboration, 100% satisfaction of the analytical rules should still not be expected.

6.3.10.4 A stable character after applying Symmetrical Space

Once all rules are followed, a stable character can be constructed. For example, after fixing the problem illustrated in Figure 6-32, a clear and inflexible structure with isosceles triangles has been constructed for the character 夏 (Figure 6-34).

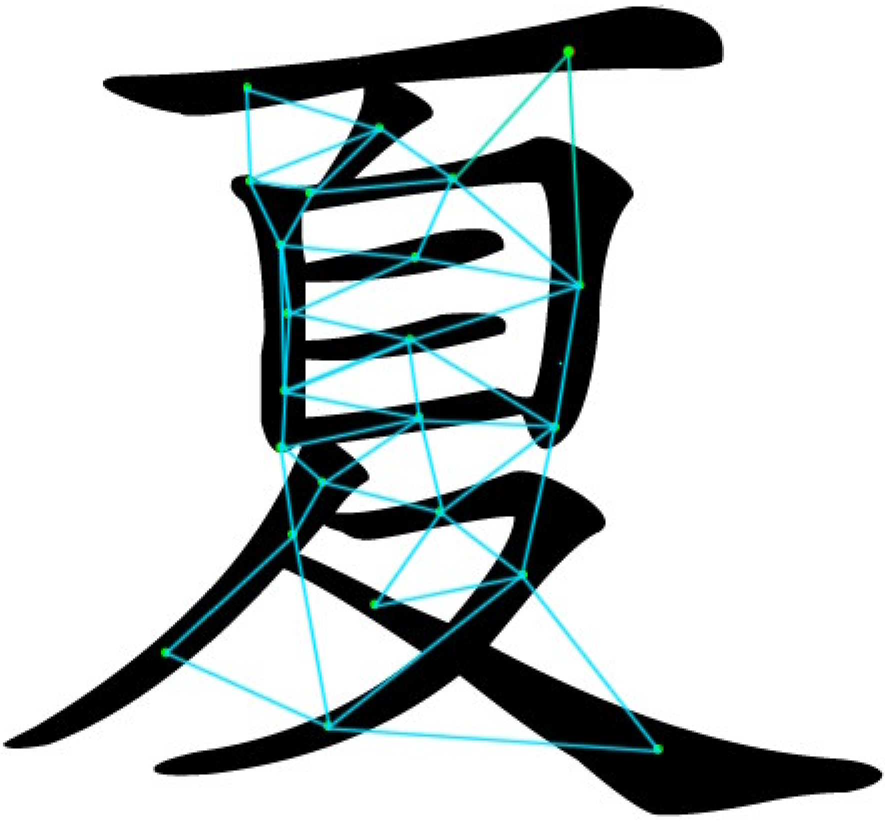


Figure 6-34 A stable character 夏after applying the principle of Symmetrical Space

If the strokes of the character 夏 are randomly resized and rotated, some points will not participant in isosceles triangles and some isosceles triangles are only connected by one joint point, which indicates that the character structure is not stable because the triangles could be rotated around the joint point (Figure 6-35).

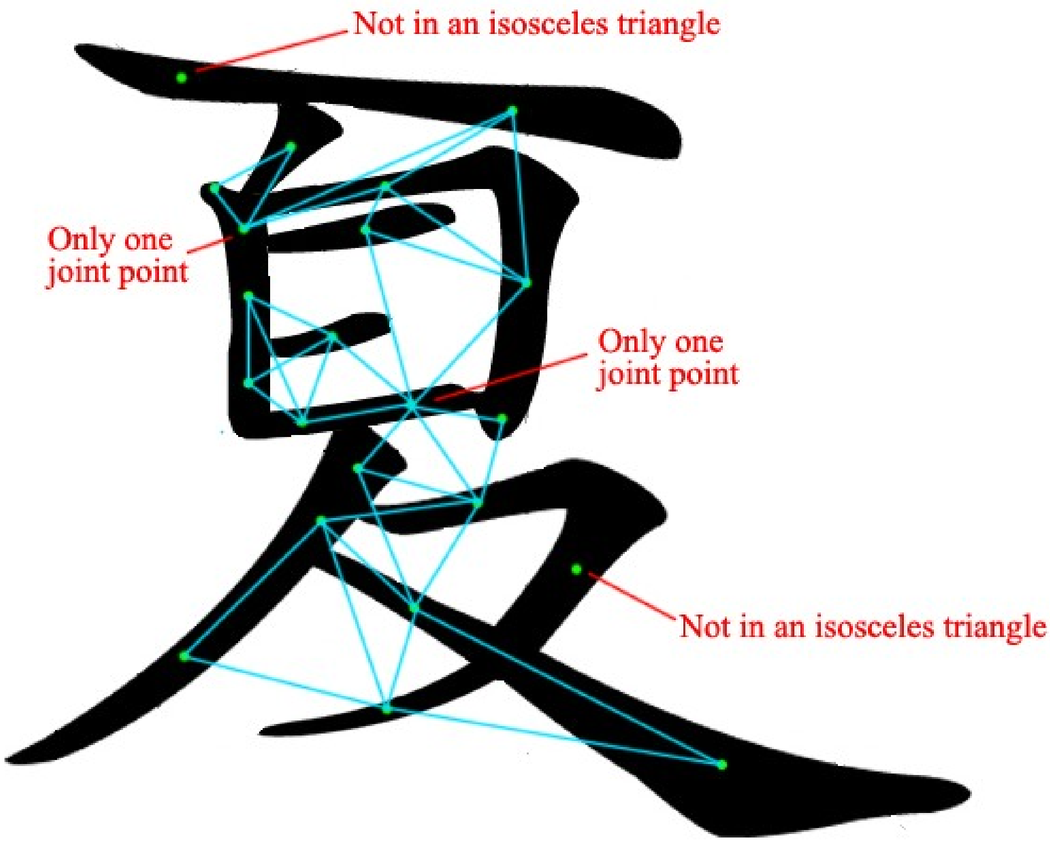


Figure 6-35 An unstable character 夏

6.3.10.5 How to deal with the curve strokes?

Some strokes are too curved to have their centres of gravity within their body.

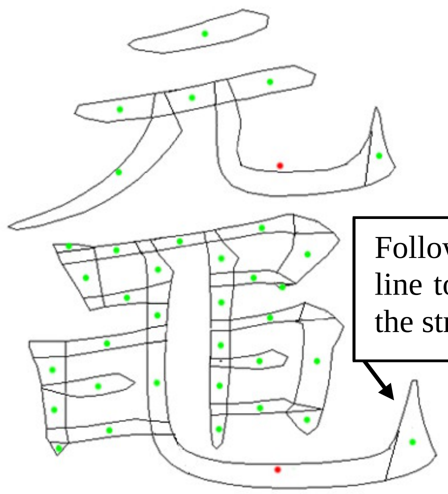
	
Locate the centres of gravity	Highlight the bent strokes

Table 6-23 Locate the centres of gravity on the character 鼋

There are two bent strokes in the character 竃, as highlighted in Table 6-23. The top one does not follow the rules at all and the bottom one has left its right neighbour isolated: they do not form an isosceles triangle with any two neighbours (Figure 6-36).

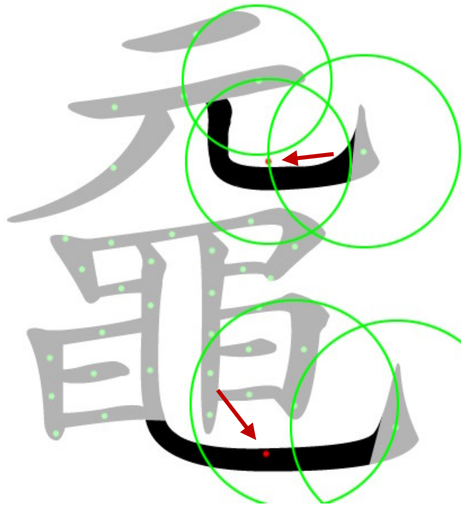


Figure 6-36 The centres of gravity on the two curve strokes of the character 竃

The results from the survey in the Section 5.4 indicated that people tend to locate the centre of gravity in the body of a shape. This suggests splitting bent strokes in order to ensure that all centres of gravity do locate in the body of the strokes. The split starts from the middle of the bend and follow its trend. Figure 6-37 shows how to apply the split and locate the new centres of gravity.

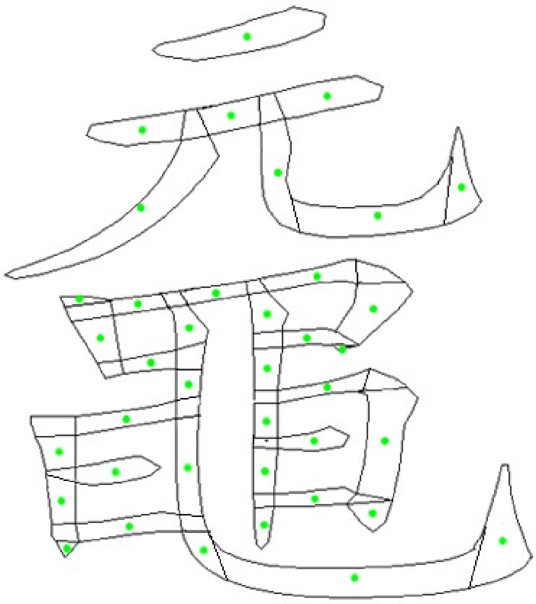


Figure 6-37 Split the curve of the character 竃

Relationships between the new centres of gravity and the existing ones immediately emerge establishing their harmonious relationship. None of the centres of gravity is left alone and all are part of isosceles triangles (Table 6-24).

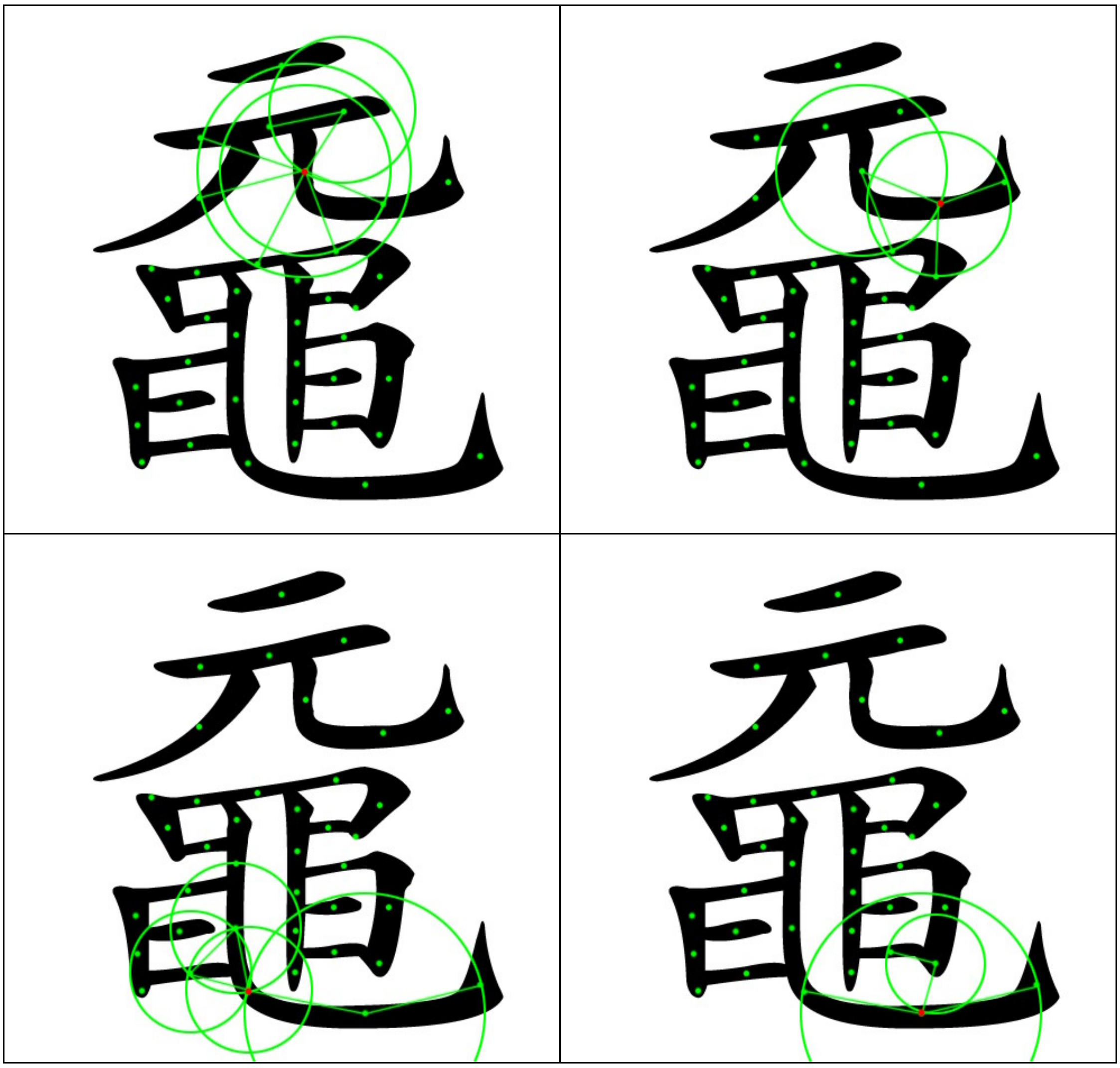


Table 6-24 The new centres of gravity follow the rules and establish their harmonious relationship with the existing ones.

Thus, all complex strokes have been reduced into simple parts. The shapes of all parts are closer to triangles, parallelograms and ellipses, and it is easy to locate the centres of gravity on them.

6.3.10.6 No need for the centre of gravity of grouped strokes

Based in the analysis above, the method “Group Strokes” was actually not needed for establishing the relationship between the centres of gravity. Nevertheless, it still servers the principle of Avoiding Prominence, as some strokes are grouped as a sub-character.

6.3.11 The Final Version of Symmetrical Space for Chinese regular calligraphy

The rule is that each the centre of gravity should form an isosceles triangle, together with its neighbouring paired ones.

Besides the rule (Section 6.3.10.1 - 6.3.10.2), the first step is to divide the strokes as described in the Section 6.3.10.3. All centres of gravity should be located in the body of any divided parts of the strokes.

6.4 The order of application of the principles

The order of application of the principles is as the following:

1. Define the work space - Circular/Elliptical Layout

2. Establish the symmetrical relationships among the centres of gravity – Symmetrical Space. (So you know where to write the strokes and how much space is available to each stroke.)

3. Assign space fairly to each independent part of the character - Avoiding Prominence.

4. Exam the overall centre of gravity and see if it is located at the centre of the space. If not, go through the principles again.

The Chinese regular script calligraphy training can be concluded as the process by which the first four principles are satisfied whilst maintaining the overall centre of gravity at the middle of the space.

6.5 How Chinese character reflects the concept of harmony in Chinese culture

The new set of principles reflects the Chinese concept of harmony. That is: harmony should be established between human beings and the nature/universe, human beings and human societies, human beings and human beings, and within the mind of each human being. Considering each sector of the strokes were a human, first a sector much be well-written (harmony within the mind of each human being); second all the centre of gravity of the sectors should be part of isosceles triangles (harmony between human beings); third each stroke should only occupies the right amount of space and ensure the overall centre of gravity is at the middle of the whole space they work on (harmony between human beings and the society); and finally all sectors should be constrained by the pre-defined space (harmony between human beings and the nature/universe).

6.6 Summary

In this chapter, the second version of the principles was related back to Chinese regular script calligraphy and able to emulate aspects of harmony, and these aspects are computable. It is believed that this is the first time that the principles of calligraphic harmony have been deduced to a number of analytic rules.

The four principles are used in Chapter 8 to develop a software programme. This analyses both calligraphic characters and screen interfaces to generate a number whose value allows the relative harmony of them to be assessed and computed.

The recently published books about Chinese calligraphy still introduce conventional regular script calligraphic principles, such as Zou's "Practical Calligraphy – '*three strokes character' training*" (Zou 2008). Calligraphic fonts produced by computer do not involve calligraphic principles (Liao, 2009) (Section 6.2). The latest researches found about computing calligraphy treated calligraphic characters as images. The process of computing calligraphy was to decomposed the characters and then re-compose the character by database or feature matching (Section 1.4.4).

The principles for Chinese regular script calligraphy in history – all holistic and abstract

- Ouyang, Xun (欧阳询 557-641): "The thirty six principles".
- Li, Chun (Around 1400-1500): "The eighty four principles"
- Huang, Ziyuan (1837-1918): "The ninety two principles"

(Zou, 2008).

- Liu: "The twelve principles" (Liu, 1981)
- Guo: "The five principles" (Guo's, 1995)

The new principles for Chinese regular script calligraphy - The first fully deductive and computable set

- Dongjie Xu (2009): "The four deductive principles"

Basically, the four principles and four methods in the second version were refined into another four principles. The order of applying the principles was established.

The principles are below and in the following order:

1. **Circular/Elliptical Layout:** Determine the space for a Chinese character. The shape of the space should be identifiable by the edges of the peripheral strokes, based on Interposition Cue Theory (Eysenck, 2000). The shape should be a circle or an ellipse (Section 6.3.6).

2. **Symmetrical Space:** Determine the relationships between the centres of gravity of the parts of the strokes of a character. Each centre of gravity should at least form an isosceles triangle with its two neighbouring ones. When an isosceles triangle is formed, no other centres of gravity should be found in the triangle. The strokes are two dimensional, so the shape determines the position of the centre of gravity. That is to say, the shapes of the strokes are decided before applying this principle. Based on the need, the shapes of some strokes can be

different from their original form when they are part of a sub-character. A sub-character is a group of strokes to convey a meaning (Section 6.3.10).

3. **Avoiding Prominence:** Determine the sizes of the strokes of the sub-character in a character. The space should be distributed evenly to each sub-character. Initially, all strokes are in the same thickness, when two or more sub-characters form a character. If a sub-character is comprised of a small number of strokes compared to another sub-character, its member strokes will be enlarged to keep the balance between white space and black area, if the proportions between the sub-characters and the spaces they occupy are more or less the same, it has reached a balance. The sub-characters are grouped strokes, so the method Grouping Components is reflected on the sub-characters (Section 6.3.8).

4. **Overall Centre of gravity:** Examine whether the overall centre of gravity is at the middle point of the space, with the aid of Judgement Line or the "Harmony" application (Chapter 8). If not, repeat the principles again (Section 6.3.6).

A question about why Chinese regular script calligraphy was chosen was asked in Section 4.2. The question was: "in the regular script calligraphy, was there something consistent, deductive and globally accepted as the keys to construct a harmonious character. In other words, when these keys are achieved in a character, people will regard it as a well-written character. Whilst, these keys were flexible so each calligrapher can develop his or her personal style". The new set of principles developed in this research was the answer to this question. The principles are for achieving the harmony among the strokes and irrelevant to style of the strokes, so they will not constraint regular script calligraphers' freedom on personal styles.

The relationships between the sectors of the strokes, the strokes, the sub-characters, the characters and the spaces the characters are written on reflect the concept of harmony in Chinese culture.

Chapter 7. Using the Principles for Harmonious Interface Design (Version 3 for Interface Design)

7.1 The principles for interface design

The new principles for Chinese regular script calligraphy in Chapter 6 are deductive, and can be converted to suit the features of interface structure. It should be noticed that these principles are converted from the principles for Chinese regular script calligraphy. Inevitably they have limitations on images and colours. A study was carried out to confirm the limitations (Appendix 3). Therefore, the impact of images and colours are not considered when applying these principles.

7.1.1 Normal and graphical structures

The idea of two interface structures was initiated in Section 5.3.5.3. This Chapter will further confirm the need of categorising screen interfaces into two types. Basically it is based on how the principles are adapted:

1. **Normal structure:** an interface with normal structure consists of many rectangle divisions. In each division, there can be text and images, because they are clearly organised into a rectangle area, so when calculating harmony on this type, each rectangle division is taken as an interface component and the details inside are ignored. It is the same way as how Ngo (2000) and Zain et al (2007) defined interface components (Section 1.2 and Section 1.4.3).

2. **Graphical structure:** in contrast to normal structure, items in a graphical structure interface are not organized into rectangle divisions. Each item is an individual component and part of a big image.

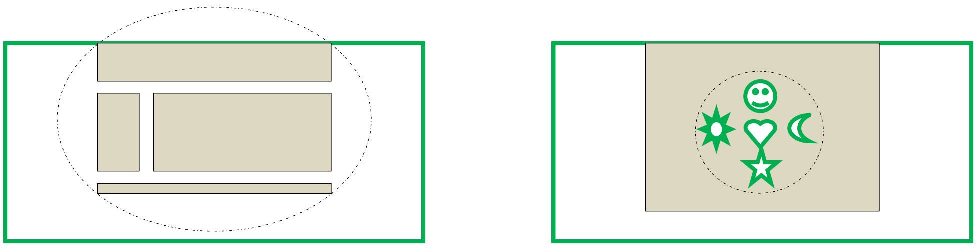
The details of their difference are explained in the following sections.

7.1.2 Adapting the new principles to interface design

1. **Circular/Elliptical Layout:** The space for an interface is first determined. The shape of the space should be identifiable by the peripheral of the edging

component, based on Interposition Cue Theory (Eysenck, 2000). The shape should be a circle or an ellipse.

For a normal interface structure, the circle/ellipse is usually outside the screen. For a graphical interface structure, it could be inside the screen (Figure 7-1).



Normal interface structure Graphical interface structure

Figure 7-1 Circular/Elliptical Layout on the normal and graphical interface structures

In practice, a designer will first plan a circle/ellipse in the design stage, and then constrain all components of the interface by the circle/ellipse.

Normal interface structures can easily fit with this principle. Figure 7-2 displays some example interface structures using this principle.

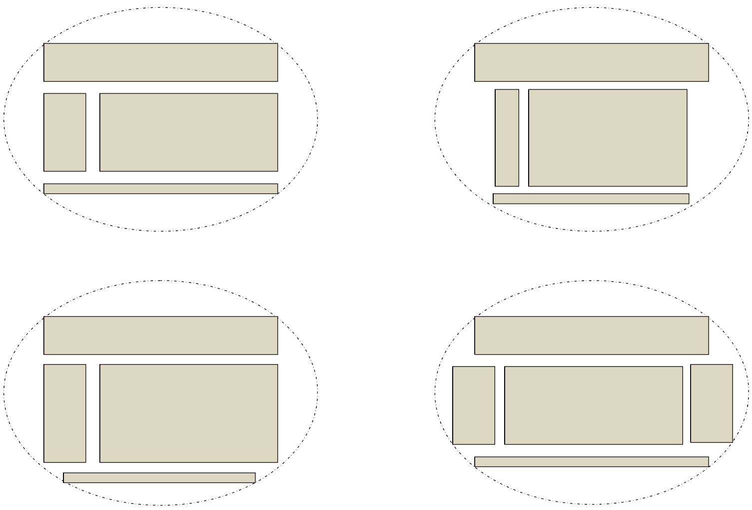


Figure 7-2 Circular/Elliptical Layout on normal interface structures

If an area is clear outlined to work on, then the layout goes through the corners of the area (Figure 7-3).

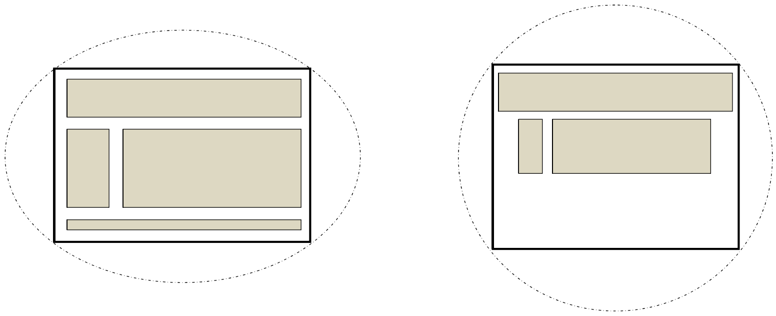


Figure 7-3 Circular/Elliptical Layout with outlined area

For graphical interfaces, there are more options for shapes of the interface components. Figure 7-4 displays some examples of graphical interfaces using the principle of Circular/Elliptical Layout.

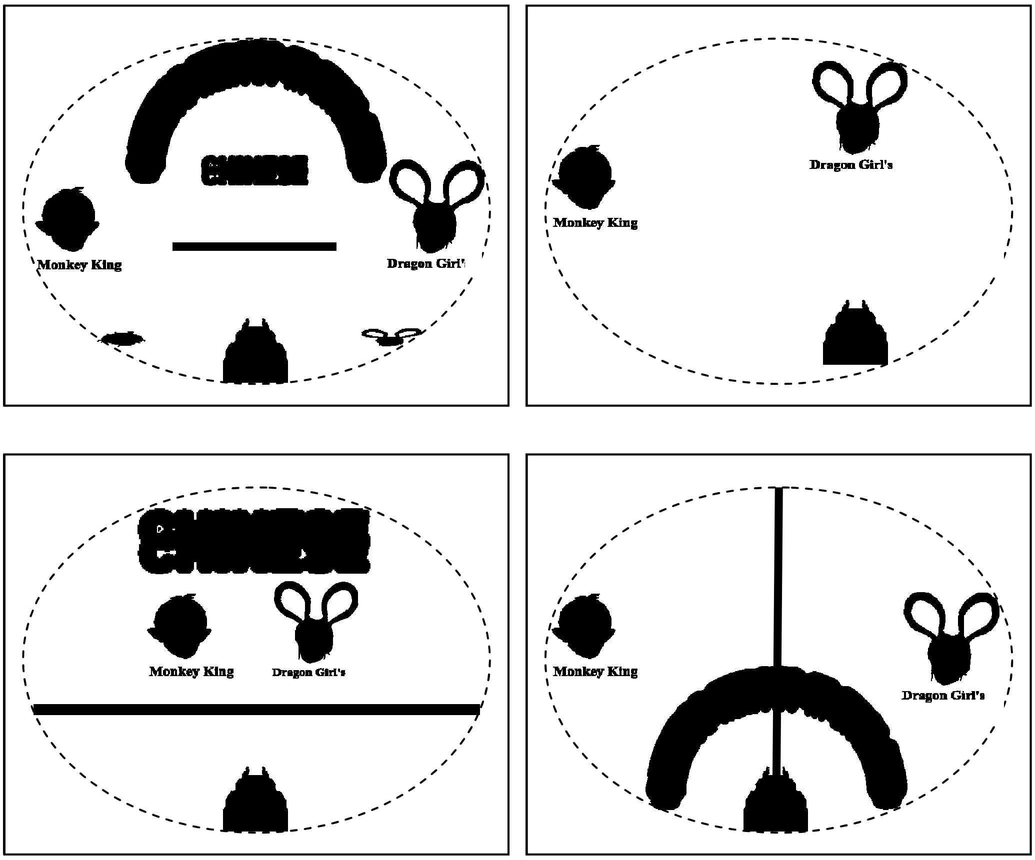


Figure 7-4 Circular/Elliptical Layout on graphical interfaces

One point that must be emphasised is that some components should touch the circle/ellipse. Otherwise, the circle/ellipse is not being used correctly.

2. **Symmetrical Space:** The relationships between the centres of gravity of the interface components are determined. Each centre of gravity should at least form

an isosceles triangle with its two neighbouring ones. When an isosceles triangle is formed, no other centres of gravity should enter the triangle. This set of principles is for two dimensional interface designs only, so the shape determines the position of the centre of gravity. That is to say, the shapes of the interface components are decided before applying this principle. Unlike Chinese characters, there are no original shapes of the interface components to modify. All decisions about the shapes are part of the original design, unless it is found that the design does not satisfy all the principles and the shapes need changing.

Besides the basic rules as specified in Section 6.3.10.1, the interface components also follow the rule of dealing with overlapping components:

a) When planning the structure of an interface, if it looks like two components overlapping each other, then it should be divided in the same way as the Chinese calligraphic strokes, and the shared area is not counted. For example, in Figure 7-5, the bigger component looks like two rectangles overlapping each other. The shared part will be considered for locating the centres of gravity.

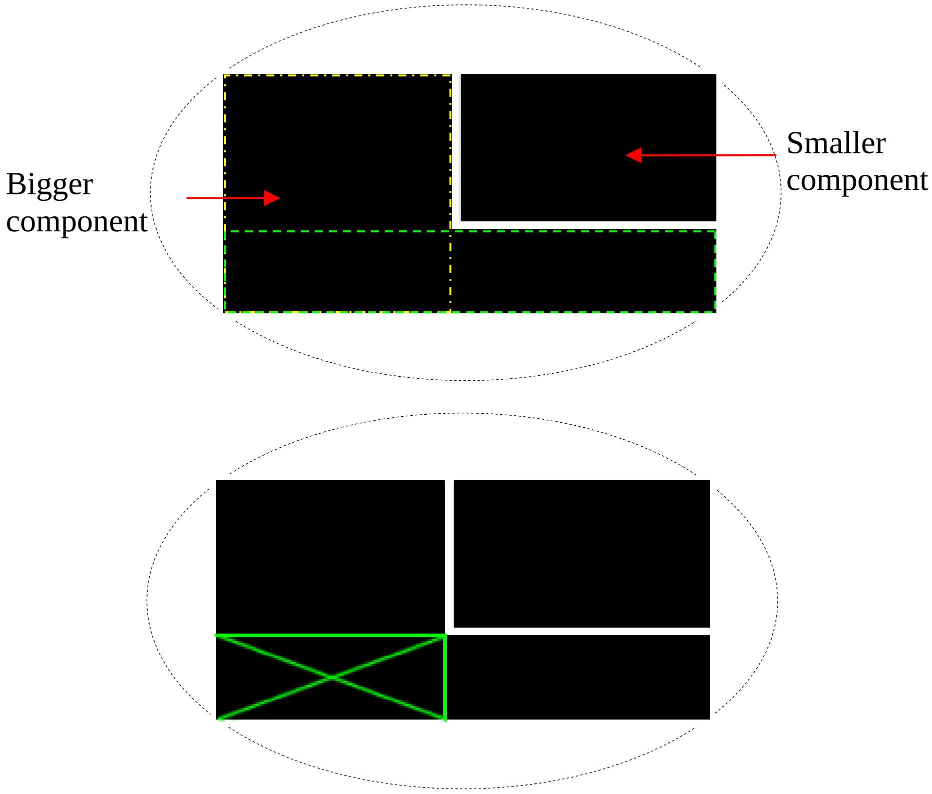


Figure 7-5 Divide the interface component and the shared are is not counted

b) Locate the centres of gravity.

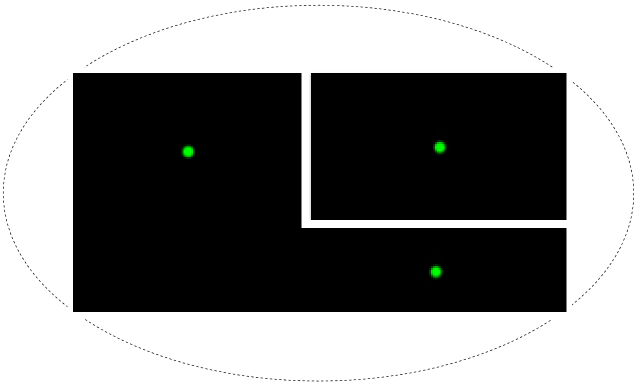


Figure 7-6 Locate the centres of gravity

c) Balance the relationship between the centres of gravity. Obviously, the pattern in Figure 7-5 does not follow the rules because none of them can become the centre of a circle with the other two on the circle. One way to redesign it is to split the bigger component as displayed in Figure 7-7.

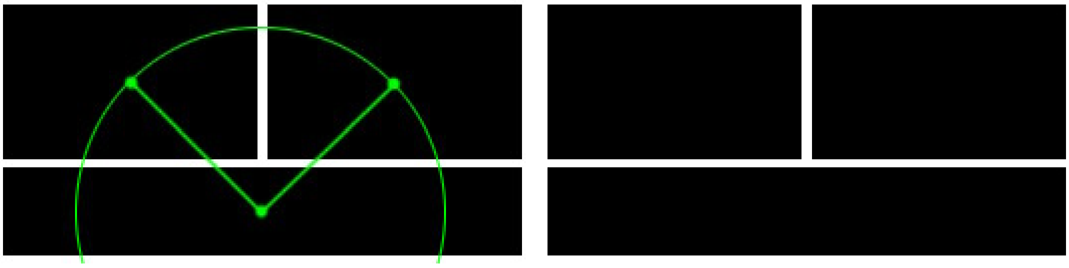


Figure 7-7 Apply the New Symmetrical Space principle with some interface components

For graphical interfaces, each image or pattern will be treated as a component. They do not need to be split like the strokes of Chinese character, because it is not realistic. For instance, an image like  will be treated as a component rather than try to identify the centre of gravity of each triangle.

3. **Avoiding Prominence:** The sizes of the interface components are determined. The space should be distributed fairly to each individual or grouped component. When assigning the space, the proportion between the area occupied by the component and the space should be consistent. Therefore, when a big space is

assigned to a small component, the component's size should be enlarged to reach a balance.

Unfortunately, this does not apply to a normal interface structure, because it is impossible to satisfy two conditions for this principle:

a) Unlike the Chinese characters, the interface components are not required to have the same thickness at the beginning, because different rectangular area contains different amount of information, and usually they are not trimmed to fit into rectangular areas with different size.

b) In a Chinese character, plenty of space is available for resizing the strokes but in normal interface structure, the space is fully occupied.

Nevertheless, this principle could still take the idea from the second version of keeping the same space between two components and lining them up at the same level, because the main idea of Avoiding Prominence is to achieve a balance. Grouped components can have a different internal spacing because they are treated as one component (a rectangle box). The pattern in Figure 4-29 was presented to 14 people who did not know the principles. They were asked to choose which one was more harmonious. 11 of them chose the one which keeps a similar spacing between the components. This is also supported by the study presented in Appendix 3: some participants mentioned that "equal spaces between elements" was a part of harmony.

If it is a graphical interface, this principle is partly applicable. In Chinese character, the dividing lines are found between sub-characters, and usually only one or two dividing lines will be found because most Chinese characters only have two or three sub-characters. In graphical interfaces, there can be many components distributed on the interface and each component can be polygonal. If Section 6.3.8 is followed to identify the dividing lines, there could be many possibilities, such as the design in Figure 7-8, has potentially nine dividing lines (Figure 7-9).

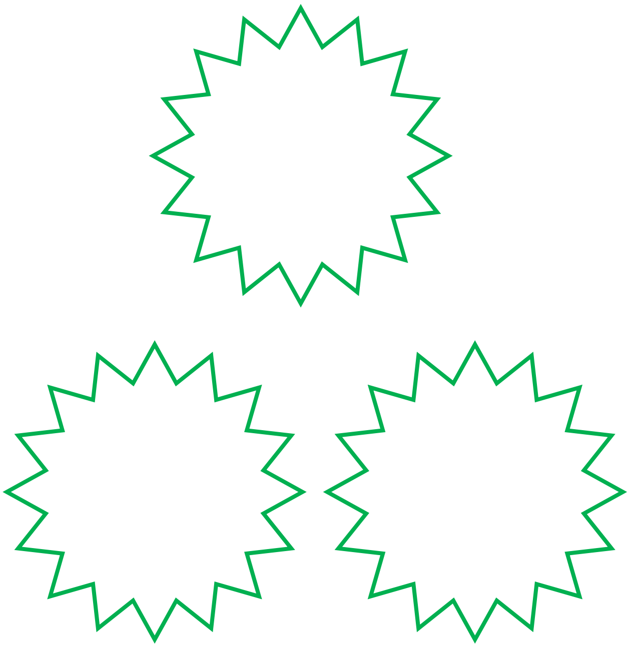


Figure 7-8 a graphical design

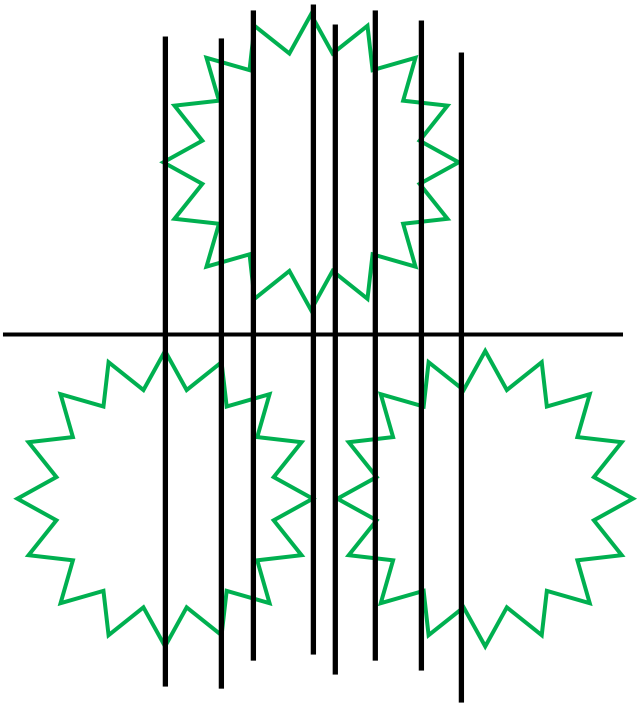


Figure 7-9 the dividing lines in the graphical design

It is necessary to treat each component in a graphical interface as a Chinese calligraphic stroke which usually has four points. Therefore, the points except the four most outer points will be ignored, so the vertical dividing line for the design in Figure 7-8 will be as illustrated in Figure 7-10.

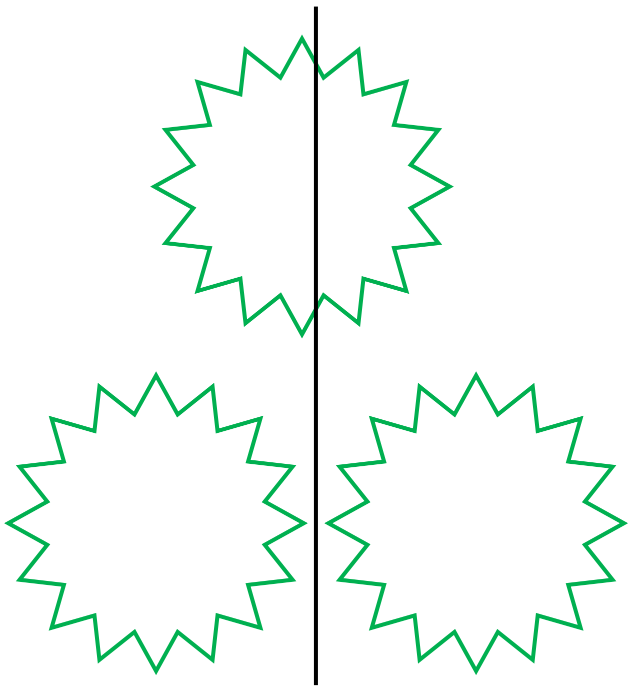


Figure 7-10 the vertical dividing line in the graphical design

4. **Centred Overall Centre of gravity:** The overall centre of gravity is at the middle point of the space. If not, the principles are repeated again.

7.2 Keeping the four methods from the second version of the principles

The four methods, Grouping Components, Moving Components, Changing Components and Resizing Components, in second version are kept in the third version. They are less important than the principles and just a statement of fact that these actions can be taken to achieve harmony.

7.3 An example of applying the third version of the principles on a normal interface structure

1. **Circular/Elliptical Layout:** The space for an interface is determined using and ellipse, Figure 7-11

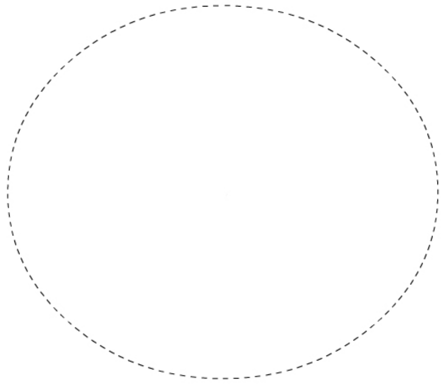


Figure 7-11 Normal interface structure example – Circular/Elliptical Layout

In interface designs with normal structure, the working space is actually a rectangle inside the circle/ellipse as illustrated in Figure 7-12, like most websites.

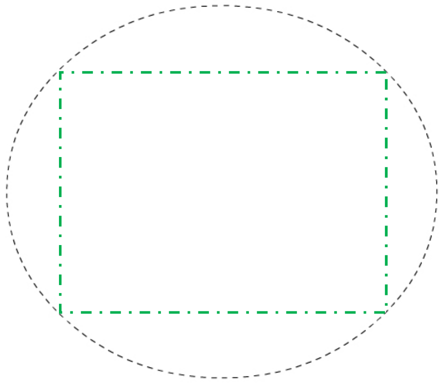


Figure 7-12 Normal interface structure example – Circular/Elliptical Layout

2. **Symmetrical Space:** The relationships between the centres of gravity of the interface components are determined. The first component is a header which is placed on the top. Its width is now the width of the rectangle working space, because the coming components will line up with the left and right of the header.

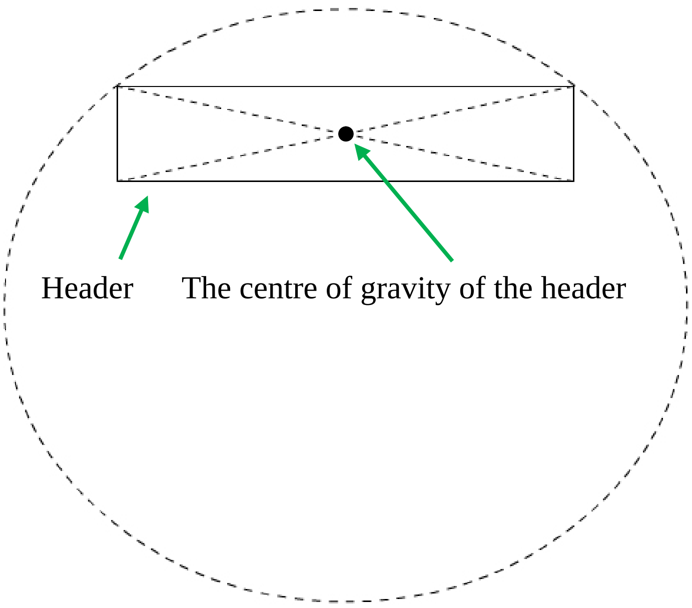


Figure 7-13 Normal interface structure example – Symmetrical Space 1

One of the options to place the centres of gravity of the second and third components could be under the first centre of gravity in a straight line. Followed the rules in the principle of Symmetrical Space, the first and third centre of gravity are on a circle with the second at its middle point (Figure 7-14).

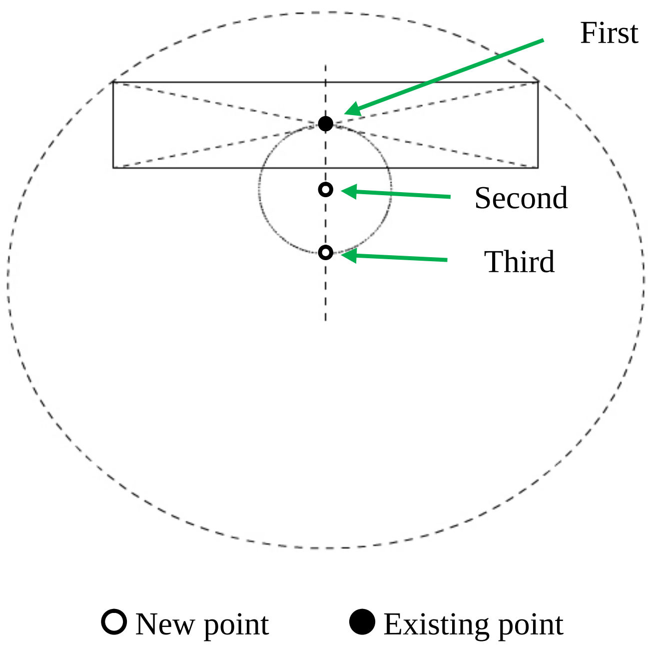


Figure 7-14 Normal interface structure example – Symmetrical Space 2

3. **Avoiding Prominence:** The sizes of the interface components are determined. Because this was a normal interface structure, so Avoiding Prominence here only means keeping the same space between two components and lining them up at the same level (Point 3 in Section 7.1.2). The height of the header has already determined the height of the second component. The height of the third component is determined as well but its width could vary. It could have 100% width or less. Its width would affect the size and the number of the components coming after. In this example, it was designed to have a component on each side (No. 4 and 5) of the third component and two components (No. 6 and 7) below it, so the width of the third component was less than 100% (Figure 7-15).

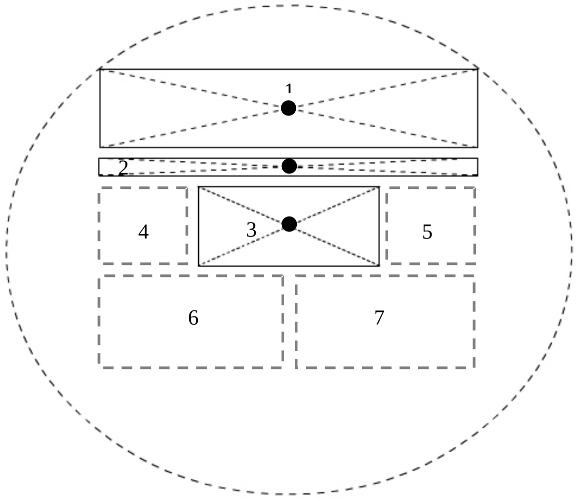


Figure 7-15 Normal interface structure example – Symmetrical Space 3

The centre of gravity of the third component now becomes a reference point for the centres of gravity of further components. To satisfy Symmetrical Space and Avoiding Prominence, the interface shown in Figure 7-16 is achieved. The centre of gravity of the third component became the apex of the two isosceles triangles.

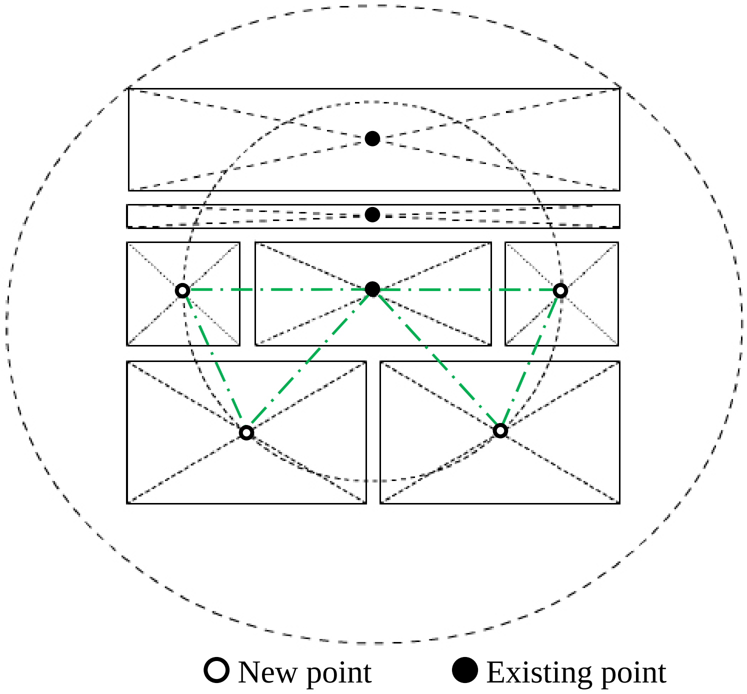


Figure 7-16 Normal interface structure example – Symmetrical Space and Avoiding Prominence 1

There is little space left in the ellipse and therefore, the next component could be footer. The current last two centres of gravity became the base points of the last isosceles triangle (Figure 7-17).

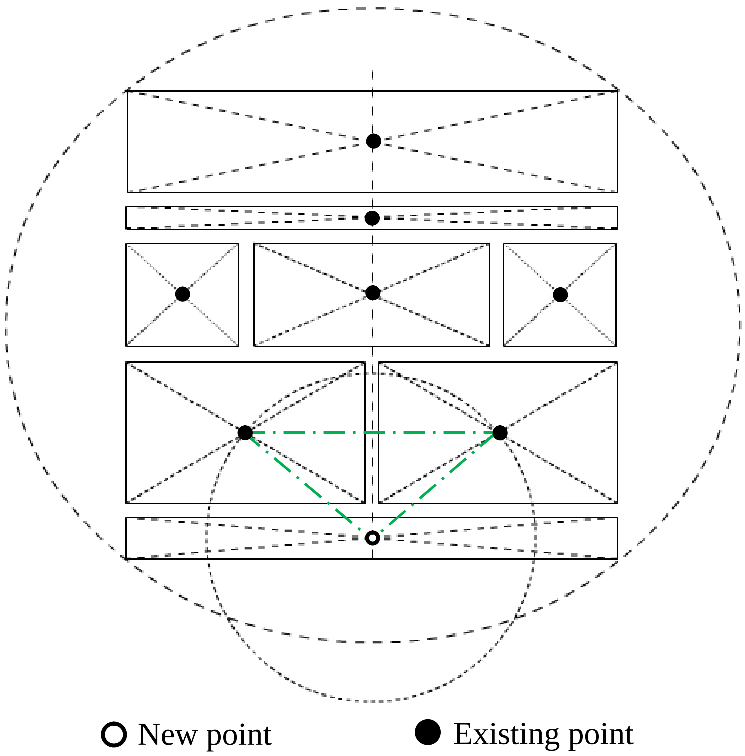
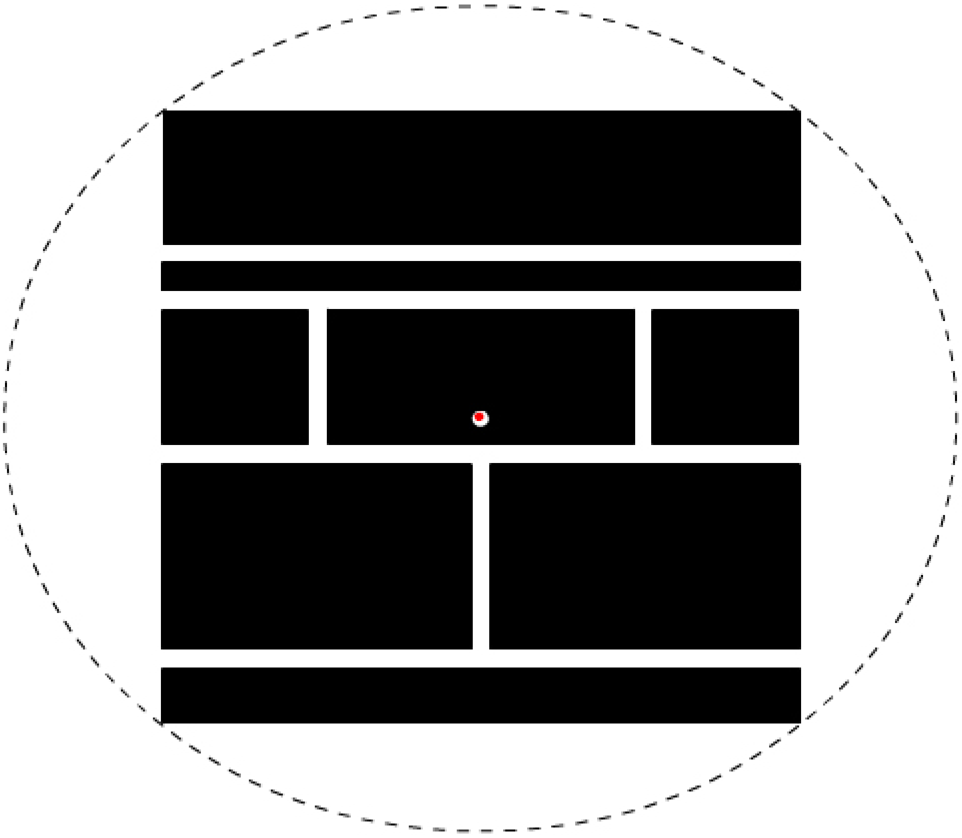


Figure 7-17 Normal interface structure example – Symmetrical Space and Avoiding Prominence 2

4. **Centred Overall Centre of gravity:** The overall centre of gravity is determined to see if it is at the middle point of the space. If not the principles are repeated.

   The calculated centre of gravity of the whole interface was just two pixels away from the ellipse's central point, which is well within the error of the drawing package (Figure 7-18), so it could be claimed that the centre of gravity of the whole interface was at the middle point of the ellipse.

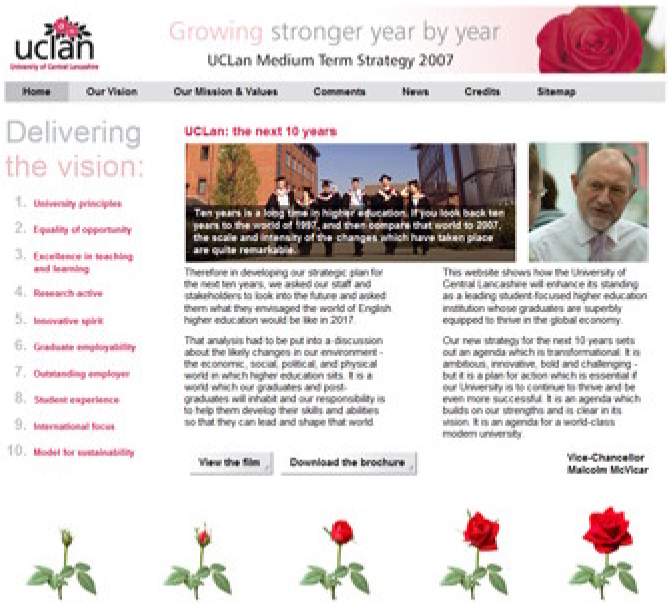


The white dot at the middle is the central point of the ellipse. The red dot inside the white dot is the centre of gravity of the whole interface.

Figure 7-18 Normal interface structure example – Centred Overall Centre of gravity

The new design was filled with the content of the website: http://www.uclanstrategy.co.uk (accessed on the 20/12/2009). The new structure is supposed to more harmonious compared to the original one (Figure 7-19). At least it is not so cluttered because the spacing between the components is balanced in the new design.

UCLan strategy with the re-designed structure



Original UCLan strategy (accessed on the 20/12/2009)

Figure 7-19 Normal interface structure example – filled with the content of UCLan Strategy website

7.4 An example of applying the third version of the principles to a graphical interface structure

A simple banner was used as an example for graphical interface structure here. It consisted of three components which are a man's photo, the UCLan logo and a sentence in Arial font. The banner size was 300px by 250px (Table 7-1).

A man’s photo	UCLan Logo	A sentence
	uclan University of Central Lancashire	UCLan helped me get the qualifications
Required banner size 300px by 250px		
 Banner frame		

Table 7-1 Assets of the graphical interface example

1. **Circular/Elliptical Layout:** Determine the space for an interface.

In this example, since the bottom-left corner of the man’s photo is a right angle, so he would be placed at the bottom-left to avoid the feeling that chopping his body. That is to say, the point of the bottom-left of the banner would be on the circle or ellipse. The rest of the components were not going to touch other corners of the banner and most space would be used, an ellipse covering most space of the banner frame was planned (Figure 7-20). The size of the ellipse can be various depended on the designer’s mind.

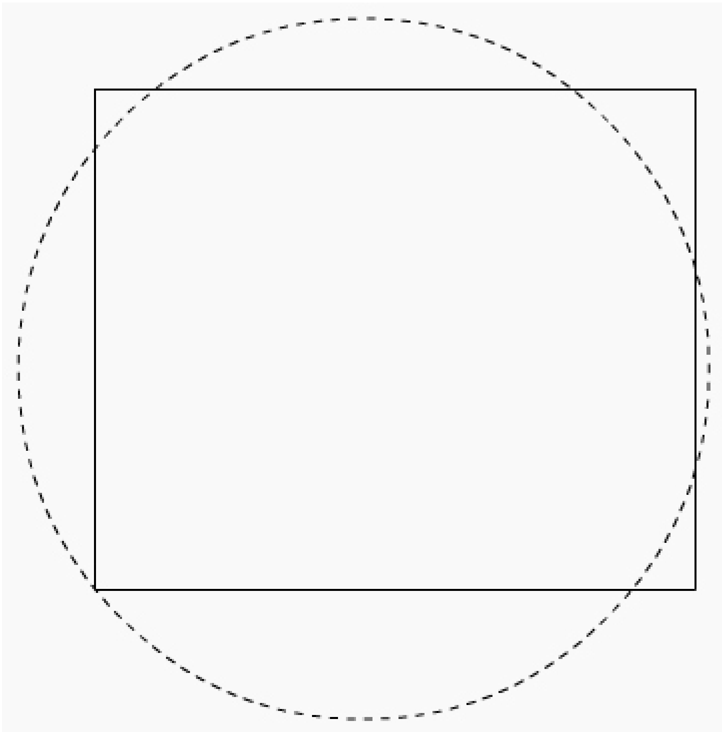


Figure 7-20 Normal interface structure example – Circular/Elliptical Layout

2. **Symmetrical Space:** Determine the relationships between the centres of gravity of the interface components.

First of all, the three components were converted into black silhouettes and their centres of gravity were found as shown in Figure 7-21. The points on them are their centres of gravity.

Figure 7-21 The three components converted into black silhouettes with their centres of gravity

There were only three components so they all had to touch the ellipse to keep the ellipse as it was. Therefore the distances between the centres of gravity and the ellipse border would affect the sizes of the component. Their centres of gravity would just form an isosceles triangle. Anyone of their centres of gravity could be the apex point of the isosceles triangle. Since the ellipse's height was bigger than its width, so the upper one was set to be the top point of the isosceles triangle. Figure 7-22 shows the first attempt to create the interface.

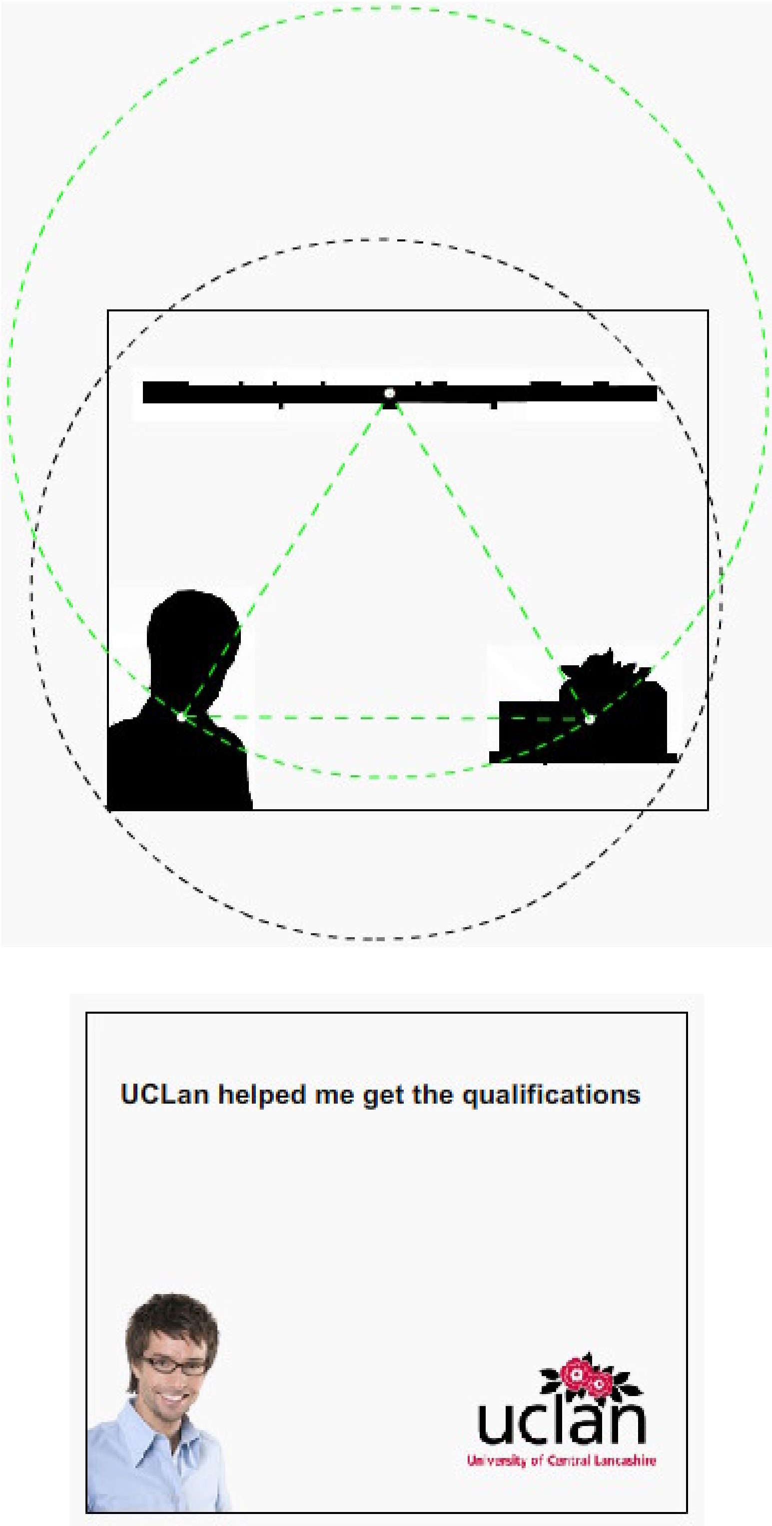


Figure 7-22 Graphical interface structure example – Symmetrical Space 1

3. **Avoiding Prominence:** The sizes of the interface components are determined so that the space should be distributed evenly to any individual or grouped components. When assigning the space, the proportion between the area occupied by the component and the space should be consistent. Therefore, when a large space is assigned to a small component, the component's size should be enlarged to reach a balance.

After identifying the dividing line (Section 6.3.8) and calculating the proportional difference, it was found that the sizes of the components and the space they occupied were reasonable (Table 7-2, see Figure 6-21 for the definitions of A_1, B_1, A_2, B_2, C_1, C_2 and P%). So far, in this banner design, the proportional difference between the top and the bottom was 6.94% and 4.02% between the left and the right, so it was a reasonable difference. However, this was an advertising banner so the components had to be bigger to impress the audience.

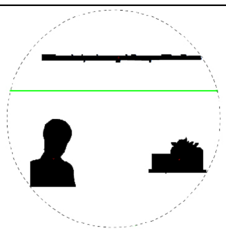
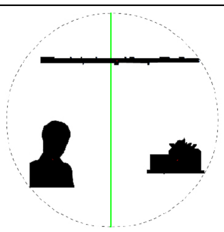
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	32149	2407	7.49 %	62913	9078	14.43%	6.94%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	46588	6585	14.13%	48456	4899	10.11%	4.02%

Table 7-2 Graphical interface structure example – Proportional differences on the banner

The words were too small if they were kept on one line, so they were split into two lines, enlarged and the Proportional difference as well as the centre of gravity recalculated (Figure 7-23).

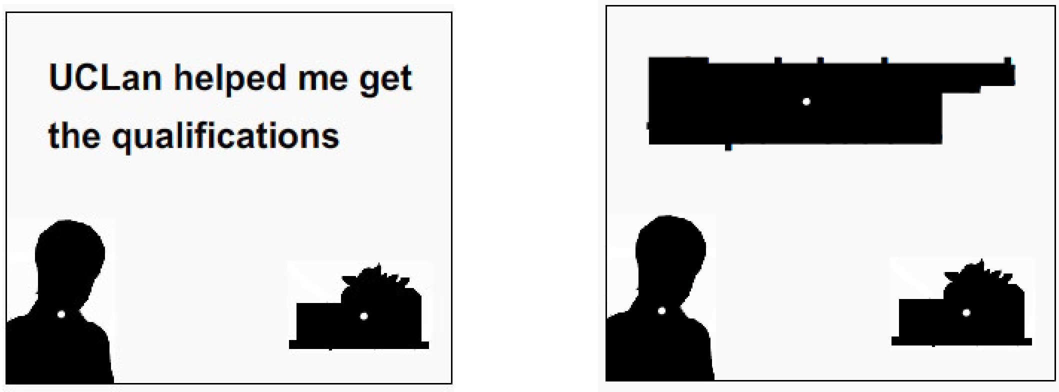


Figure 7-23 Graphical interface structure example – Changed the size of the words

The new result shows that the bottom section occupied too much space (Table 7-3). The proportional difference between the top and the bottom was 12.02%. There was plenty of space for the bottom section to be enlarged. The proportional difference between the left and the right was 4.24%, and the left one was greater than the right one, which indicated that The UCLan logo had more space to be enlarged than the man's photo.

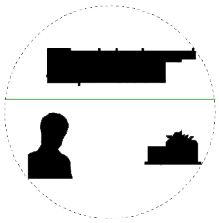
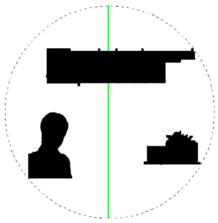
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	40209	11499	28.60%	54772	9078	16.57%	12.02%
	A_1	B_1	C_1	A_2	B_2	C_2	P%
	46588	11077	23.78%	48456	9469	19.54%	4.24%

Table 7-3 Graphical interface structure example – Proportional differences on the banner after enlarging the words

4. **Centred Overall Centre of gravity:** The overall centre of gravity is examined to see if it is at the middle point of the space. If not close, go through the principles again.

Before changing the sizes of the man's photo and the UCLan Logo, the overall centre of gravity had to be checked to ensure the change was allowed. If the overall centre of gravity was below the central point of the ellipse, the size of the words would have to be enlarged or the bottom components would have to be shrunk for the purpose of "centring the overall centre of gravity".

The calculation showed that the overall centre of gravity was above the central point of the ellipse, so there was space for the bottom two components to enlarge or to shrink the size of the words, in order to move the centre of gravity lower (Figure 7-24).

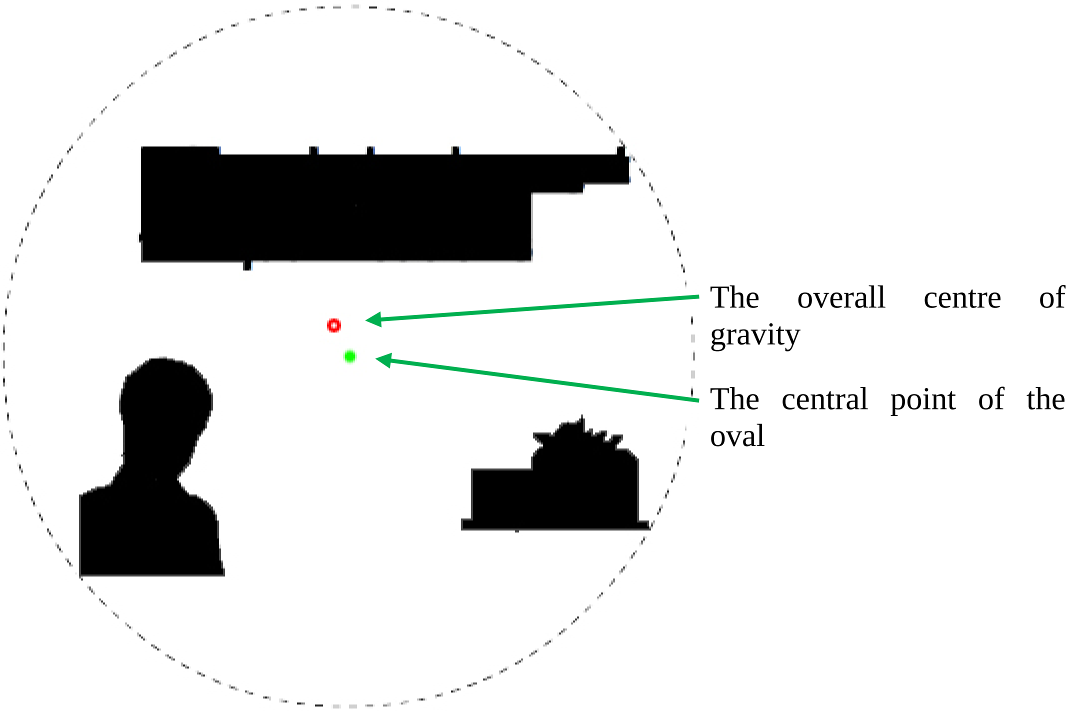


Figure 7-24 Graphical interface structure example – The overall centre of gravity

By trial and error the components were changed to achieve the arrangement in Figure 7-25.

Figure 7-25 Graphical interface structure example – final outcome in actual size

The final design satisfies the principles as follows.

1. Circular/Elliptical Layout: The space for an interface is determined.

A space was defined by an ellipse. There were only three components in this interface, so they all had to touch the ellipse. In the final outcome, the three components still touched the ellipse, so this principle was satisfied (Figure 7-26).

Figure 7-26 Graphical interface structure example – Circular/Elliptical Layout satisfied

2. **Symmetrical Space:** The relationship between the centres of gravity of the interface components is established.

In the final outcome, the three components still retain the isosceles triangle relationship, with the centre of gravity of the UCLan logo as the apex (Figure 7-27).

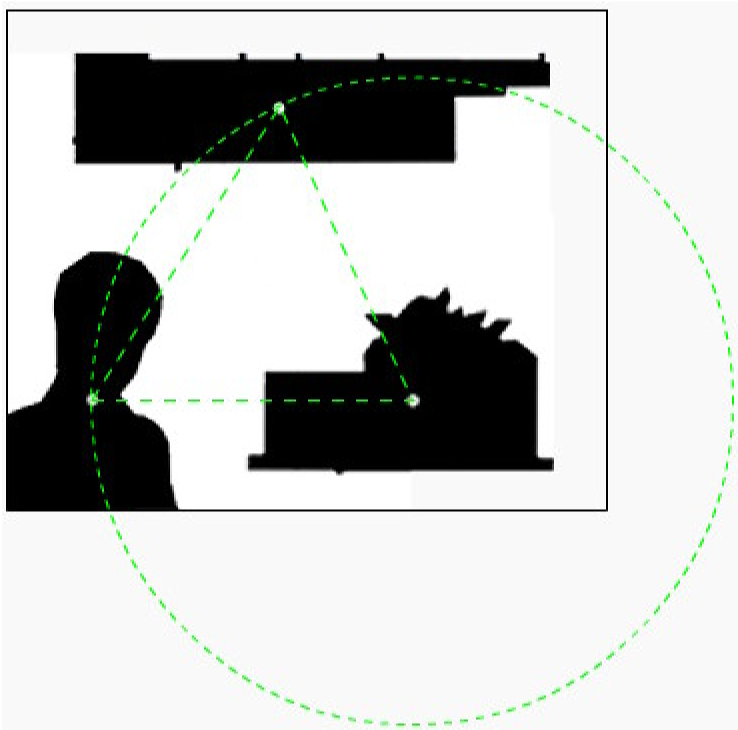


Figure 7-27 Graphical interface structure example – Symmetrical Space satisfied

3. **Avoiding Prominence:** The sizes of the interface components are determined.

The proportional differences in the final outcome were 0.01% between the top and bottom, 0.6% between the left and the right (Table 7-4).

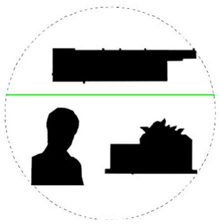
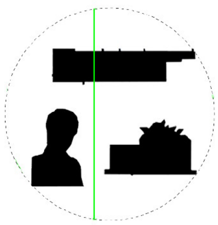
<table>
<tr><td rowspan="2"></td><td>A_1</td><td>B_1</td><td>C_1</td><td>A_2</td><td>B_2</td><td>C_2</td><td>P%</td></tr>
<tr><td>37212</td><td>10684</td><td>28.71%</td><td>57850</td><td>16602</td><td>28.70%</td><td>0.01%</td></tr>
<tr><td rowspan="2"></td><td>A_1</td><td>B_1</td><td>C_1</td><td>A_2</td><td>B_2</td><td>C_2</td><td>P%</td></tr>
<tr><td>38574</td><td>11214</td><td>29.07%</td><td>56468</td><td>16074</td><td>28.47%</td><td>0.6%</td></tr>
</table>

Table 7-4 Graphical interface structure example – Proportional differences on the banner after enlarging the words

5. **Centred Overall Centre of gravity:** The overall centre of gravity is at the middle point of the space. If not, the principles are repeated again.

The overall centre of gravity was 9px away from the central point of the ellipse within the error of the drawing package.

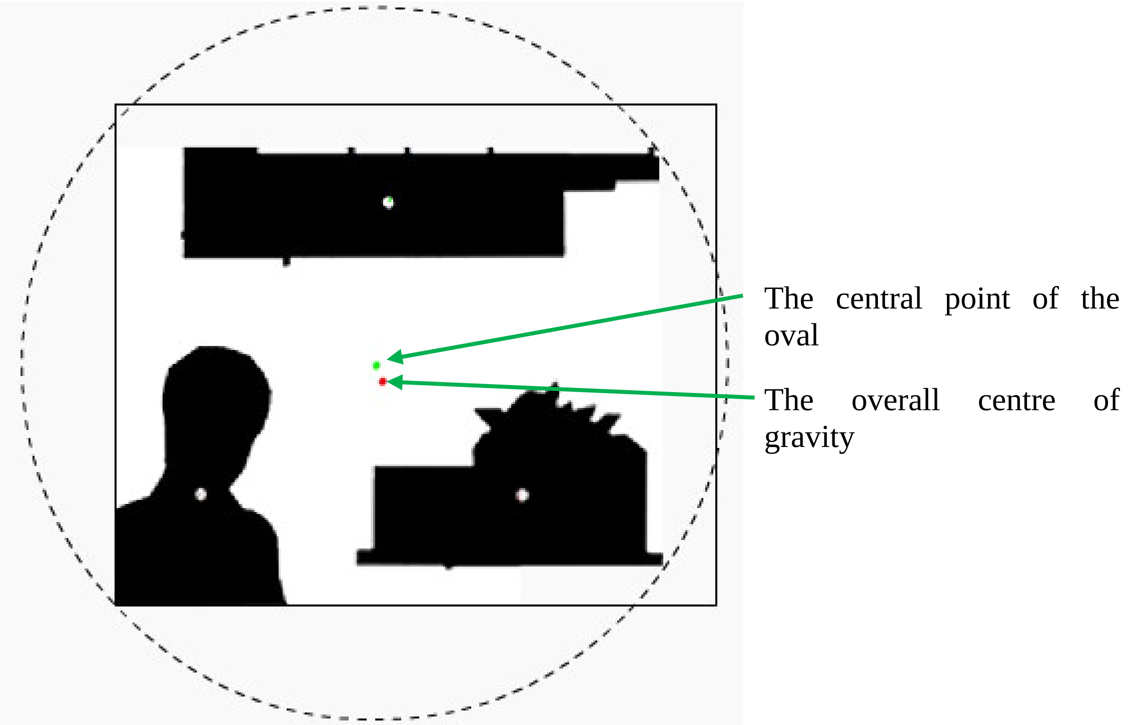


Figure 7-28 Graphical interface structure example – Centred Overall Centre of gravity satisfied

7.5 Summary

In this chapter, the four fully deductive Chinese calligraphic principles created by the author of the thesis were converted into interface design principles. Based on how the principles are adapted, two divisions are provided in the new principles for interface design: one is for normal interface structure which consists of rectangle structural components, such as a website and software interfaces and the other one is for graphical interface structure. For each of them, an example was used to illustrate how to apply the principles. It was time-consuming to create the examples, even with the help of Adobe Photoshop CS3 and Autodesk AutoCAD v14, because there was a lot of calculation needed. An application for the purpose of harmonious interface design would be developed based upon the new principles.

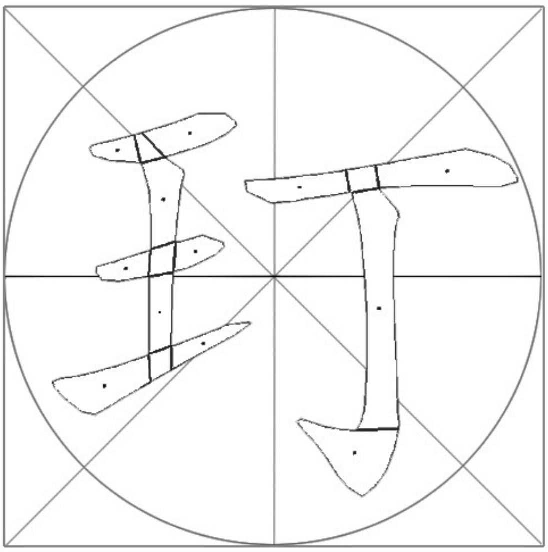
Chapter 8. The Development of The "Harmony" Application to Give A Measure of Harmony

The principles and how a harmonious character or interface can be determined have been outlined in Chapter 6 and Chapter 7. In this chapter a method will be presented in which the four principles are used to generate a percentage harmony score and then the overall harmony score is the average of these four percentages. An application has been written in ActionScript3 which enables these harmony scores to be easily calculated.

8.1 The centre of gravity and the calculation of its value

Calligraphic strokes and interface components are two dimensional. In the "Harmony" application, a centre of gravity is found by dividing an object into many small triangles, calculating the centre of gravity of each triangle and finally work it out the overall centres of gravity of the object from the centres of gravity of the triangles. The results from Harmony and the results from Autodesk AutoCAD v14 are identical.

Figure 8-1 shows the centres of gravity for the strokes of the Chinese character 打 calculated by Autodesk AutoCAD.

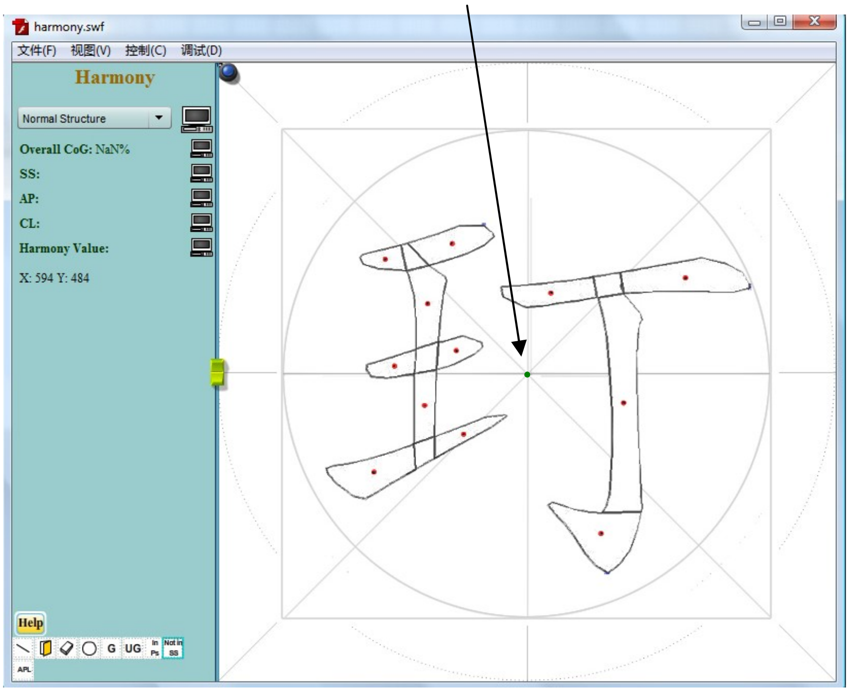


The dots on the character are the centres of gravity of the divided strokes.

The overall centre of gravity is the lines crossing point at the centre.

Figure 8-1 Centres of gravity calculated by Autodesk AutoCAD

The overall centre of gravity calculated by the “Harmony” application



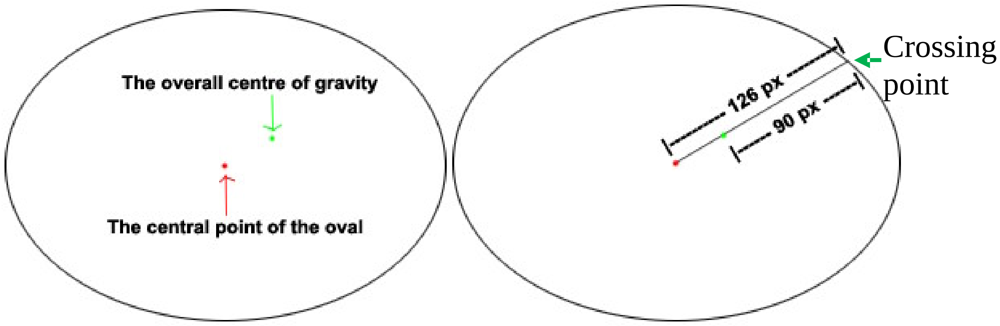
The red dots are the centres of gravity of the divided strokes calculated by the “Harmony” application

Figure 8-2 The centres of gravity calculated by the “Harmony” application

Figure 8-2 shows the centres of gravity calculated by the “Harmony” application. drawing a line from the central point of the ellipse to the centre of gravity of the whole character (Overall CoG), which will be a unique line and cross the ellipse (Crossing point). The percentage is worked out by dividing the distance between the overall centre of gravity and the crossing point, with the distance between the central point of the layout and the crossing point, as shown in Figure 8-3. The distance between the overall centre of gravity and the crossing point is 90 pixels. The distance between the central point of the ellipse and the crossing point is 126 pixels. Therefore, the overall centre of gravity gives 90 / 126 * 100% = 71.43% close to the central point of the ellipse (satisfaction value).

Therefore, the formula of how close the overall centre of gravity to the centre of the layout is:

$$Overall\ CoG\ value = \frac{Distance\ between\ the\ Overall\ CoG\ and\ the\ crossing\ point}{Distance\ between\ the\ centre\ of\ the\ layout\ and\ the\ crossing\ point} \times 100\%$$



90 / 126 * 100% = 71.43%

Figure 8-3 A example which illustrates how to calculate how close the centre of gravity is to the centre of the Circular/Elliptical Layout

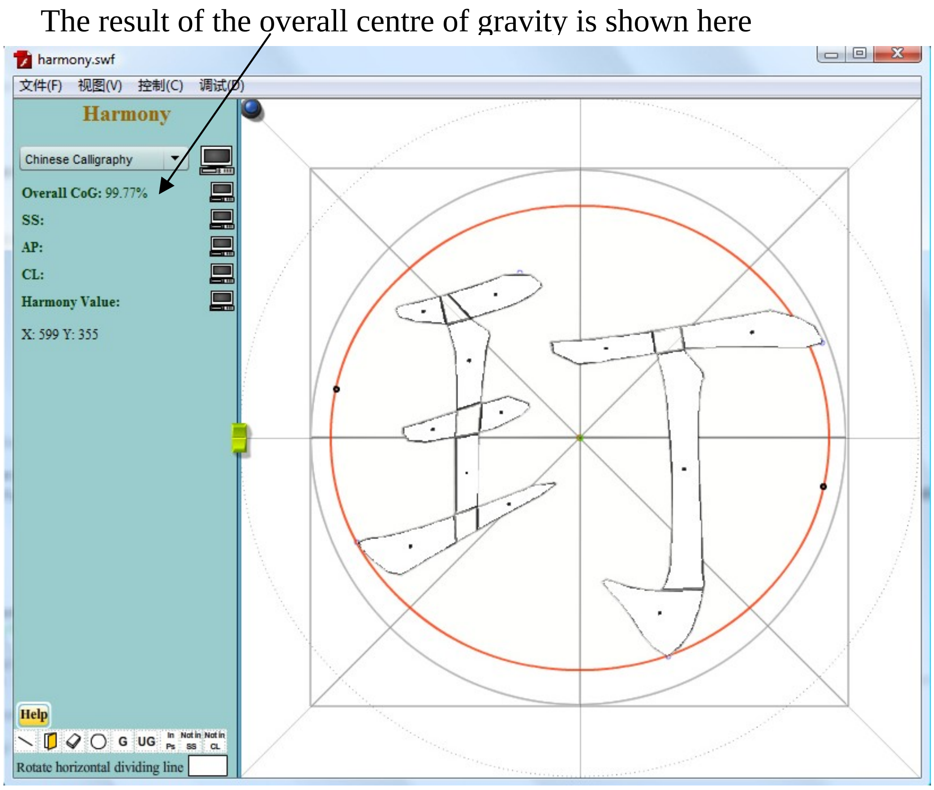


Figure 8-4 The satisfaction of the overall centre of gravity (Overall CoG) calculated by the "Harmony" application

In the example of 玎, after defining the ellipse layout, the application calculated that the overall centre of gravity achieved a 99.77% satisfaction (Figure 8-4).

8.2 Symmetrical Space and the calculation of its value

The key feature of the principle of Symmetrical Space is that all the centres of gravity of the divided strokes or interface components can be located on isosceles triangles, which do not enclose any other centres of gravity. Considering the difficulty in visually estimating two lines with exactly the same length, a 5 pixel variation was allowed in the application. The satisfaction value of Symmetrical Space is calculated by the number of centres of gravity involved in forming triangles divided by the total number of centre of gravity. For instance, in the character 玎 in Figure 8-5, there are 11 centres of gravity on the divided strokes and all of them satisfy the condition of being a member of an isosceles triangle whilst not solo joint point (Figure 6-35) is found, so it satisfies the principle of Symmetrical Space at the level of 12/12*100%=100%.

The result of Symmetrical Space is shown here

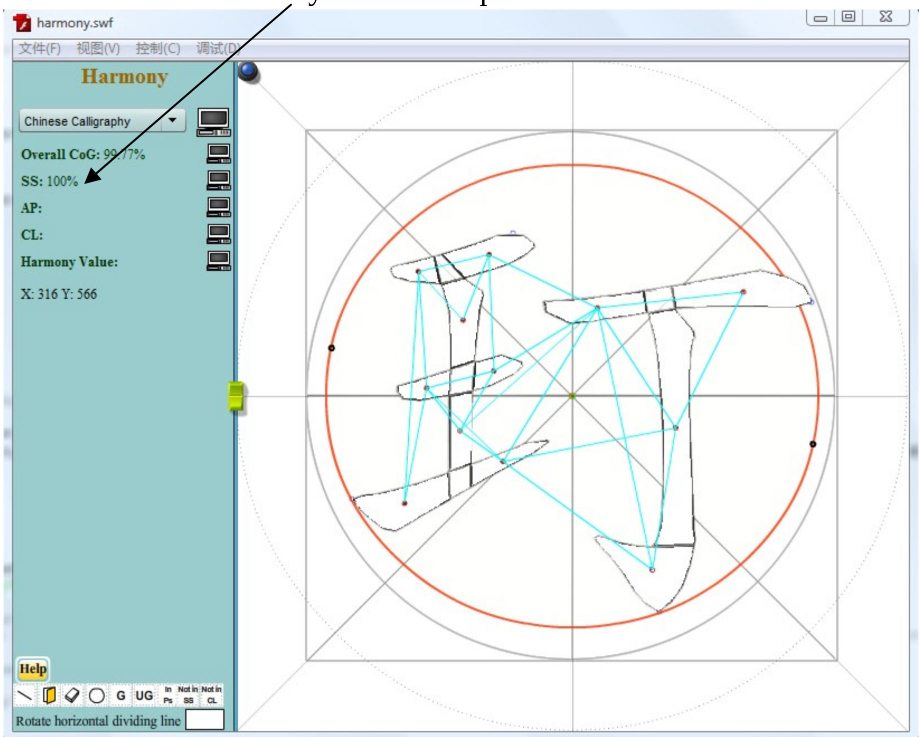


Figure 8-5 The isosceles triangles on the character 玎 and the satisfaction of Symmetrical Space (SS) calculated by the "Harmony" application

Each solo joint point means a Chinese character or an interface is divided once, which means the value of Symmetrical Space is divided as well. That is, if there are more than two centres of gravity, the formula for Symmetrical Space (SS) value is:

$$\textit{Symmetrical Space value} = \frac{\textit{No. of centres of gravity participated in isosceles triangles}}{\textit{Total number of centres of gravity}} \times \frac{1}{1 + \textit{No. of solo joint point}} \times 100\%$$

If there are less than three items so a triangle cannot be formed, the value for Symmetrical Space will be automatically given 100% if there is only one. The reason why it is 100% rather than 0% is that there are no other strokes/components with which to establish any relationships, and the satisfaction of the overall centre of gravity already tells us how much a stroke/component strays away from the overall centre of gravity. If there are two strokes/components, the two centres of gravity will always be located on each side of the overall centre of gravity but the three centres of gravity will not necessarily line up. Therefore, when the two centres of gravity and the overall centre of gravity form a triangle, if the angle faced by the line linking the two centres of gravity is obtuse, 100% will be given. If it is 90 degrees angle, 50% will be given. Otherwise, 0% is assigned (Figure 8-6).

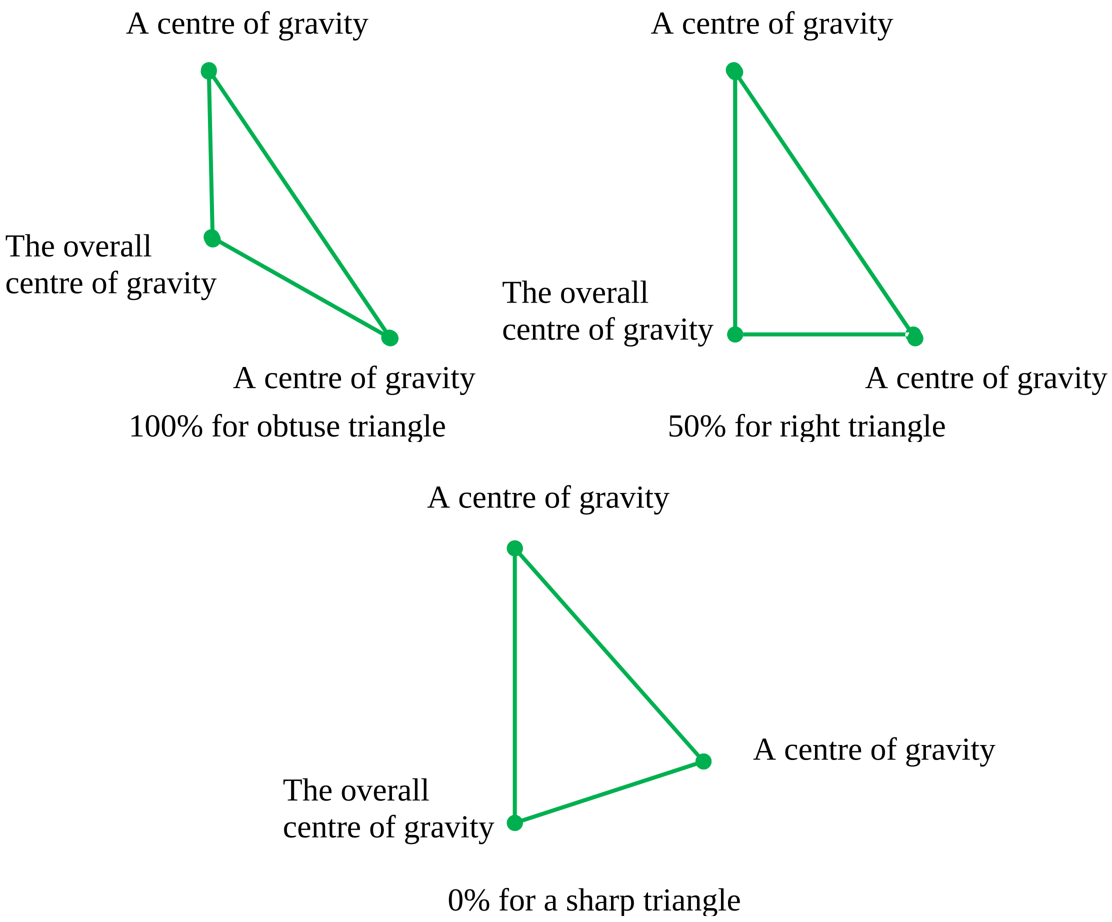


Figure 8-6 The satisfaction of Symmetrical Space if there are only two strokes/components

8.3 Avoiding Prominence and the calculation of its value

If there is only one calligraphic stroke or interface component, Avoiding Prominence is satisfied 100%. If more than two, the principle of Avoiding Prominence has difference features for Chinese characters, graphical structures and normal structures.

8.3.1 Chinese characters

The principle of Avoiding Prominence is that each group of strokes or interface components occupies the right amount of space (Section 6.3.8.1). The Harmony application provides a tool to group calligraphic strokes and interface components. When calculating the Avoiding Prominence parameter, the application finds the dividing line between two components or groups based on Section 6.3.8.1. According to the formula for Avoiding Prominence in Figure 6-21, the satisfaction parameter of the principle of Avoiding Prominence is calculated by 100% minuses the average differences between the two parts divided by the dividing lines. For instance, in Figure 8-7, there are three components and there are two dividing lines between them. The proportional difference in the left one is $\left|\frac{5148}{167930}-\frac{7750+2754}{25900}\right|\times 100\% \approx 9.79\%$. The proportional difference in the right one is $\left|\frac{5148+7750}{33232}-\frac{2754}{9438}\right|\times 100\% \approx 9.63\%$

Therefore the Avoiding Prominence value (AP) is 100%-(9.79%+9.63%)/2=90.29

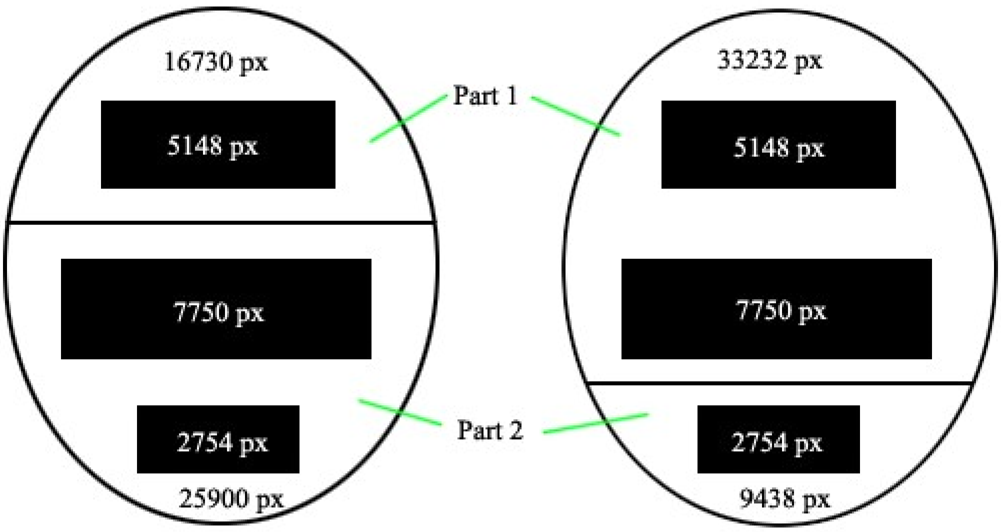
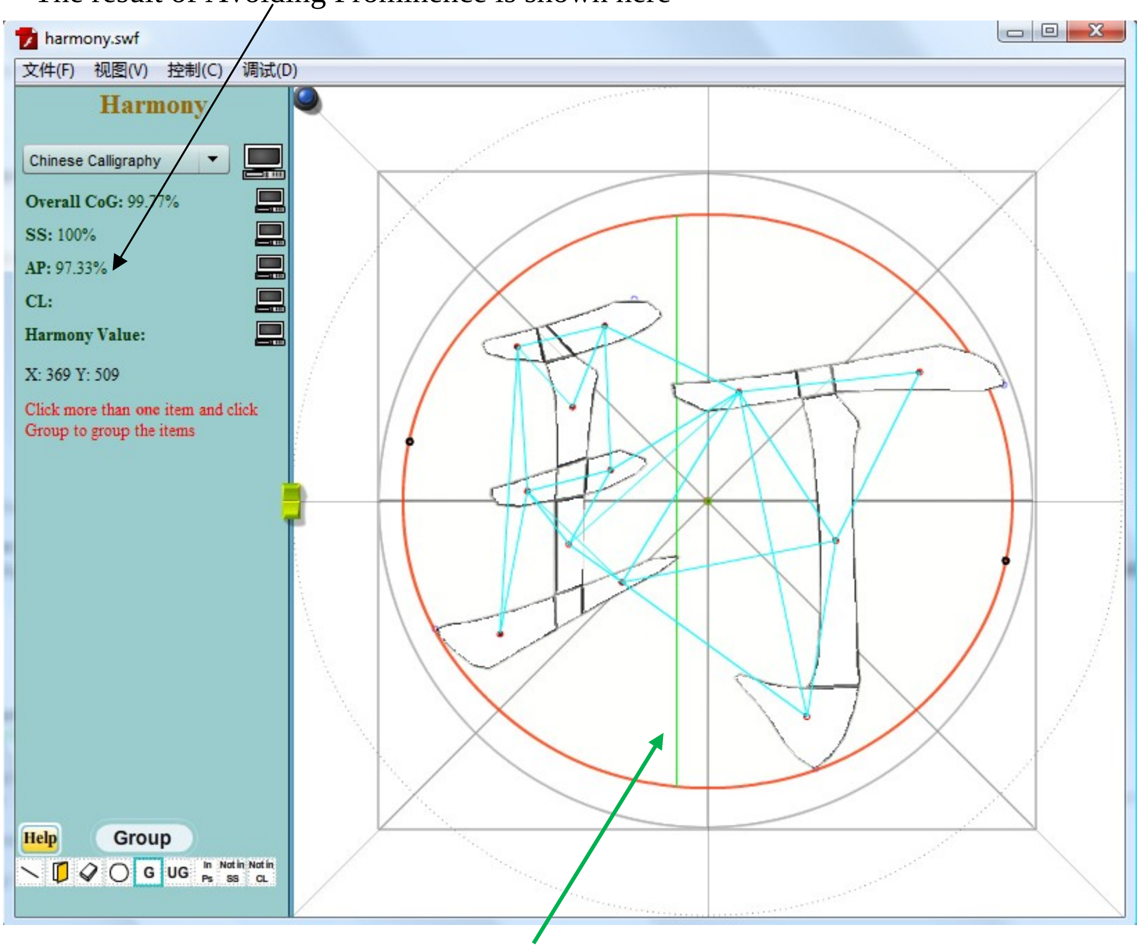


Figure 8-7 Two dividing lines between components and the areas calculated by Adobe Photoshop

Figure 8-8 shows the dividing line of the character 玎 found by the Harmony application, and the satisfaction of the Avoiding Prominence is 97.33%.

The result of Avoiding Prominence is shown here



The dividing line found by the application

Figure 8-8 The dividing line and the satisfaction of Avoiding Prominence (AP) calculated by the Harmony application

8.3.2 Graphical structures

The application calculates the dividing lines based on the description in Section 7.1.2, and works out the satisfaction parameter of Avoiding Prominence in the same way as Chinese character. For instance, the application calculated two dividing lines in the graphical interface design in Figure 8-9, and the satisfaction value of Avoiding Prominence is 91.98%.

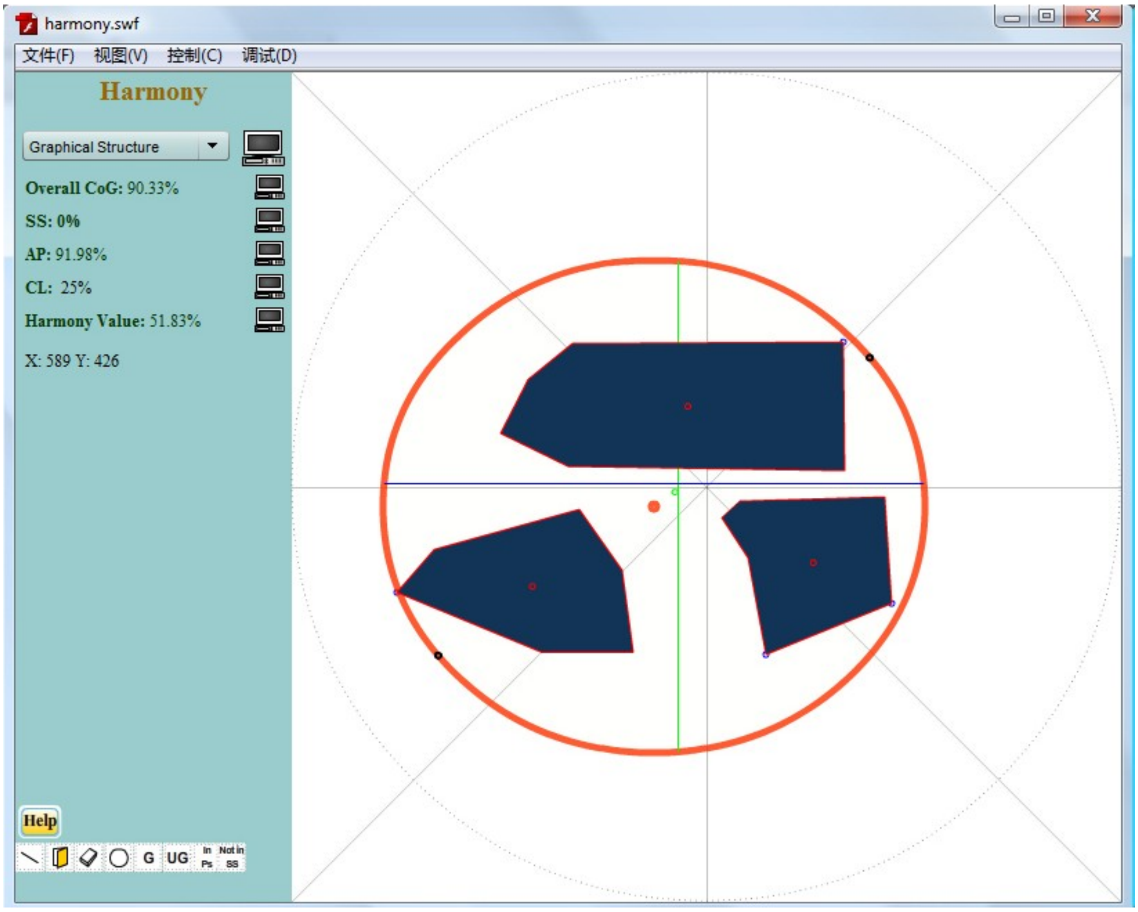


Figure 8-9 The dividing lines in a graphical interface design

If no dividing line is found, the satisfaction of Avoiding Prominence is worked out with the horizontal and vertical lines across the central point of the Circular/Elliptical Layout, according to the idea of balance from Zain et al (2007, see Section 1.4.3). For instance, the application could not find any dividing lines in the design in Figure 8-10, so the horizontal and vertical lines crossing the central point of the ellipse were used instead, and the satisfaction value of Avoiding Prominence is 88.81%.

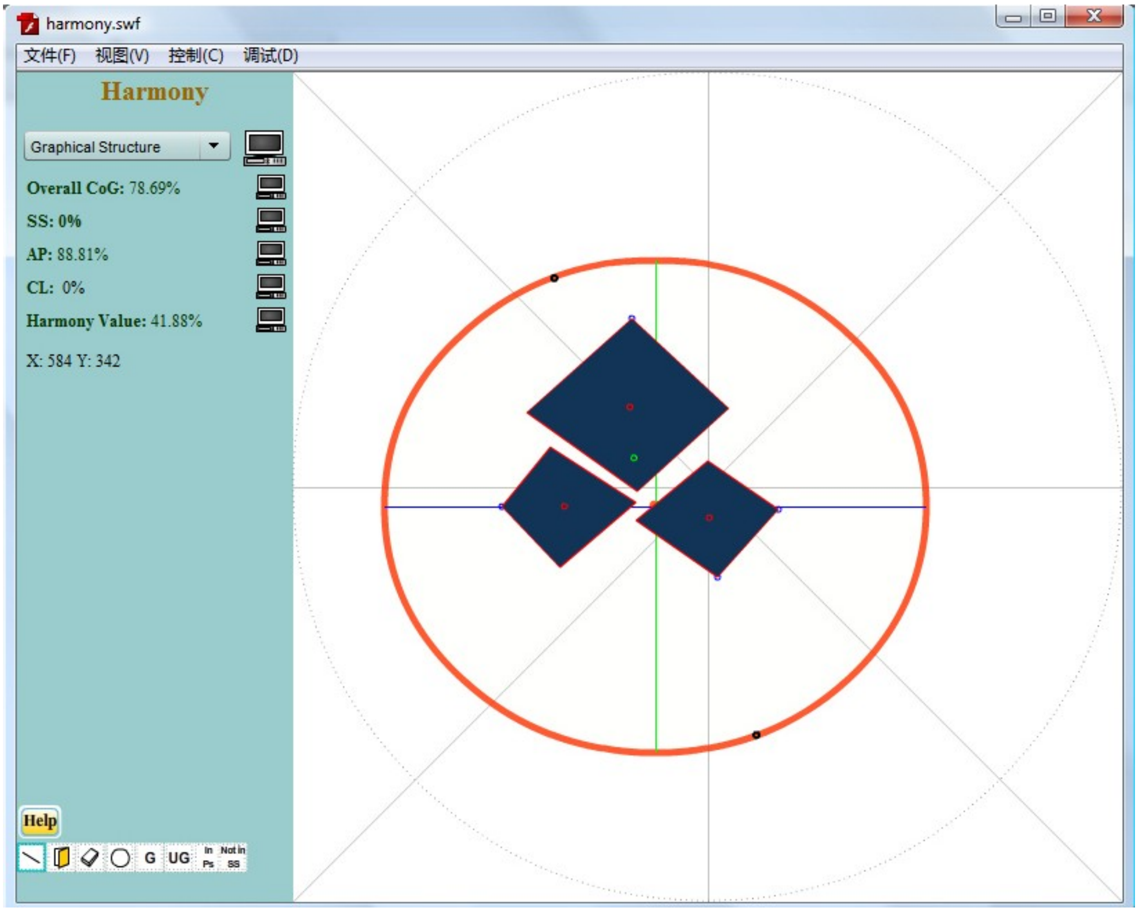
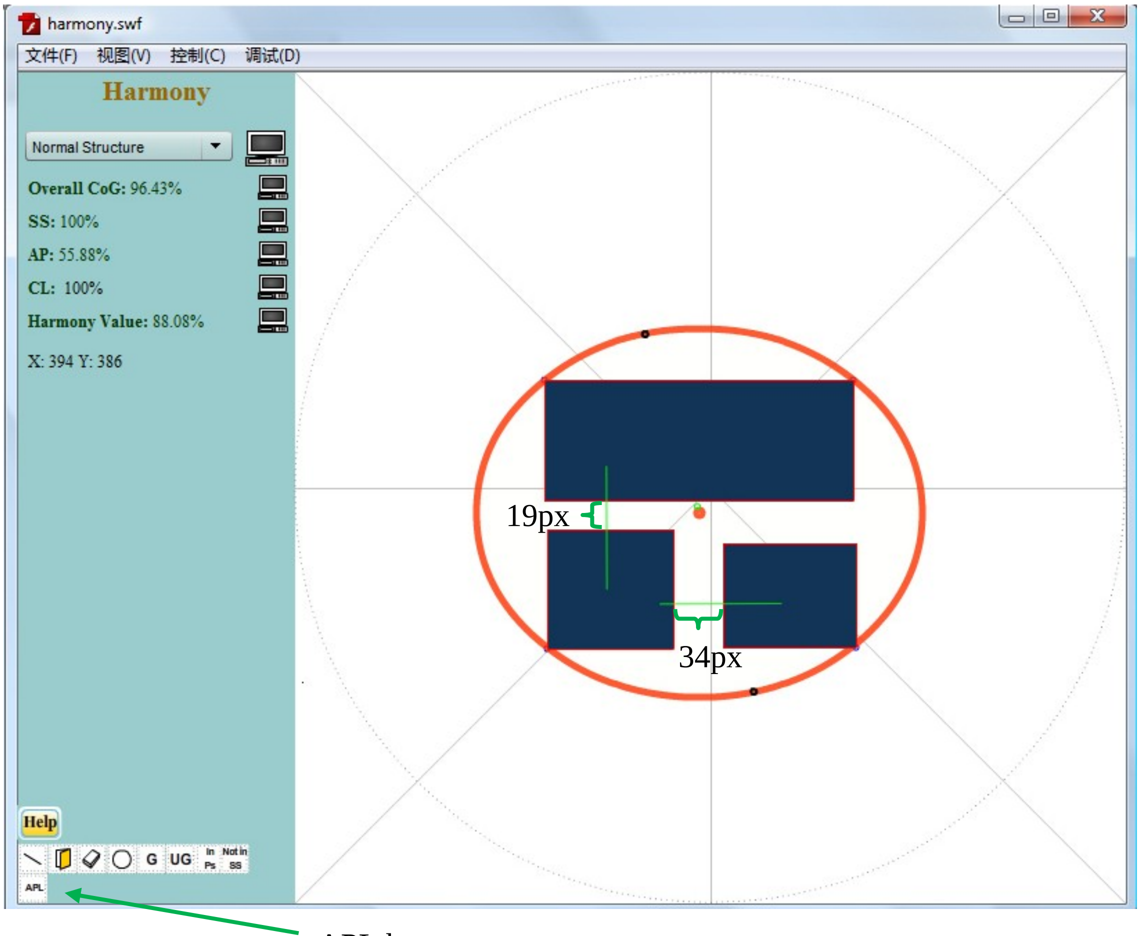


Figure 8-10 A graphical design with no dividing lines

8.3.3 Normal structures

The Avoiding Prominence for a normal structure interface is described in Section 7.1.2. Its satisfaction value is calculated by using the shortest gap divided by the biggest gap. Making the application automatically identify the sizes of the gaps proved difficult. Instead, an "APL" (Avoiding Prominence Lines) button was created. When a user clicks the button, he/she can draw two lines crossing the smallest and biggest gaps identified by eye. The application calculates the sizes of the gaps and work out the satisfaction value. For instance, after drawing the lines across the smallest and biggest gaps in the design in Figure 8-11, the application worked out the satisfaction value for Avoiding Prominence was $\frac{19}{34} \times 100\% \approx 55.88\%$.



APL button

Figure 8-11 The smallest and biggest gaps in a normal structure design

8.4 Circular/Elliptical Layout and the calculation of its value

Ideally, the key points (see Section 6.3.6) of a Chinese character or an interface should be contained in a circular or elliptical outline with no features outside (see Section 6.3.6). This gives 100% satisfaction for the principle:

$$\frac{Number\ key\ points\ on\ the\ layout}{Number\ key\ points}\times 100\% \quad = 100\%$$

An outer key point will add a portion of negative impact to the outcome, so the calculation is conducted in this way (CL):

$$Circular/Elliptical\ Layout\ \ value = \frac{Number\ of\ \ key\ points\ on\ \ the\ \ layout}{Number\ of\ \ key\ points + number\ of\ \ outer\ \ points}\times 100\% \, .$$

The screen shot in Figure 8-12 shows that the character 玎 gains 50% satisfaction of the principle Circular/Elliptical Layout, because there are four key points and two of them are on the ellipse, and there is no outer point.

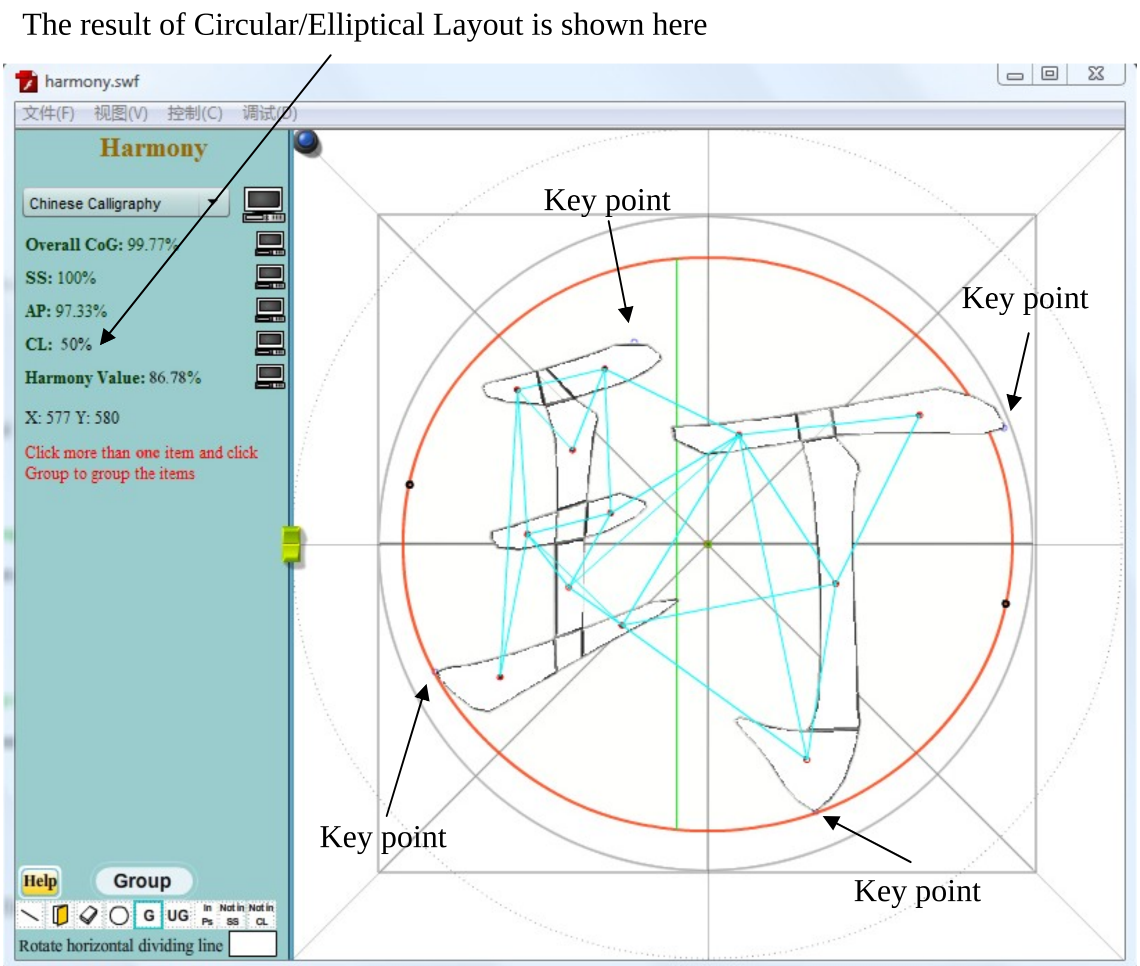


Figure 8-12 The satisfaction of Circular/Elliptical Layout (CL) calculated by the Harmony application

Currently, there is no code written to draw curved lines. Instead, a curved line is treated as a group of short lines (Figure 8-13).

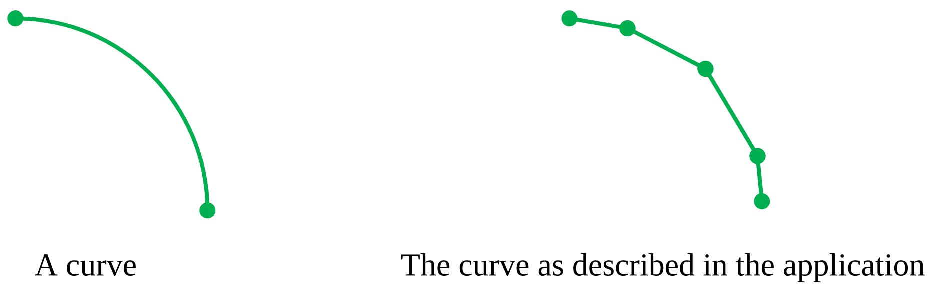


Figure 8-13 How a curve is described in the application

This makes it more difficult to identify the key points and outer points for graphical structures and Chinese characters. For the time being, a function was written to exclude the points on the curly line for Chinese characters if they are counted as outer points (Figure 8-14), but this function is not applicable to normal and graphical interface designs. The solution for curly lines will be part of the future work, as well as the special key points mentioned in Section 6.3.6.1 to 6.3.6.4.

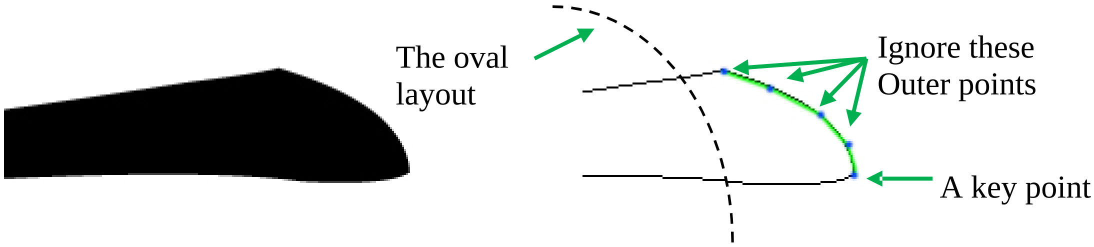


Figure 8-14 The application will ignore the outer points on a curly line for Chinese characters

8.5 Harmony value

It could be that one principle were more important than another and should be given more weight. A study could be arranged to sort the importance of the principles by satisfy one principle and break others. However, the weight of each principle will be difficult to find out, because it is hard to measure the influence of each principle and people value the influences in different ways. Due to the limitation of time, this will be part of the further work. For time being, the overall harmony value is the average score from the satisfaction values of the four principles, same as Zain's (2007) work (Section 1.4.3). For instance, in the character 玎, the satisfaction values of the principles are Overall Centre of Gravity: 99.77%, Symmetrical Space: 100%, Avoiding Prominence: 97.33% and Circular/Elliptical Layout: 50%, which gives an average (99.77+100+97.33+50)/4=86.78% harmony value (Figure 8-12).

The formula of harmony value is

$$Harmony\ value = \frac{Overall\ value + SS\ value + AP\ value + CL\ value}{4}$$

8.6 Summary

This chapter explains how the values of the principles and the overall harmony value are calculated in the “Harmony” application, and the difference in calculation for Graphical Structure and Normal Structure in terms of Avoiding Prominence. The further work for computing a curve and weights given to different principle in Harmony Value are pointed out as well.

The “Harmony” application allows the degree of harmony to be assessed in a two dimensional black and white figure. It also allows the designer to move objects around the work area to maximise the harmony parameter.

Chapter 9. Testing the Third Version of the Principles

9.1 The Aim

The Principles of design taken from Chinese calligraphy have been developed in this thesis into four principles which are analytical. In Chapter 9 a Flash application called “Harmony” was developed to measure the degree to which a design might be described as being harmonious within the four principles. In this chapter the four principles will be tested with a group of students. The aim of this study was to test whether the principles had captured some key aspects of harmony. If they did, the application should be able to predict people’s preference based on harmony when the impact of images and colours were minimised.

9.2 Method

Participants

62 computing students (April 2010) participated in the study. Their cultural background was; 33 British; 13 Asian (8 stated that they were British Asian), 16 no disclosed cultural background. Their gender breakdown was 55 male, 5 female and 2 did not state their gender. 52 of them were 25 years old or under, 6 were over 25 and 4 did not state their age group.

Apparatus

Paper questionnaires were designed for the participants to rank the pre-designed interfaces according to how harmonious they appeared. Also the Harmony application was used to score the interfaces. The definition of harmony was not given to the participants so that they had to use their own subjective judgement.

Design of the Interfaces to be evaluated

To avoid the impact of colours and images, only black and white shapes were used in the designs. All the shapes were chosen from the Microsoft Word 2007 shapes library together with a number of rectangles. Together they could not easily build a meaningful image. Eight rectangles and shapes were created for normal and graphical structure respectively (Section 7.1.1). To avoid any bias from the researcher, five European Computing staff designed the interfaces to fit a given box (Figure 9-1).

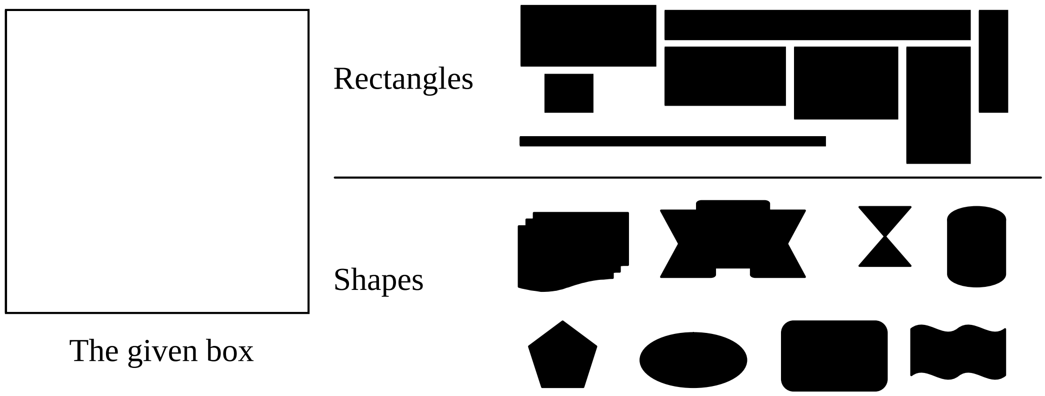


Figure 9-1 The rectangles and shapes for constructing interfaces

Five pairs of interfaces were returned (Table 9-1). It was surprising that one of the staff managed to build a “face” with the shapes (Pair Five in Table 9-1). Since it stood out as unusual, Pair Five was not included in the test.

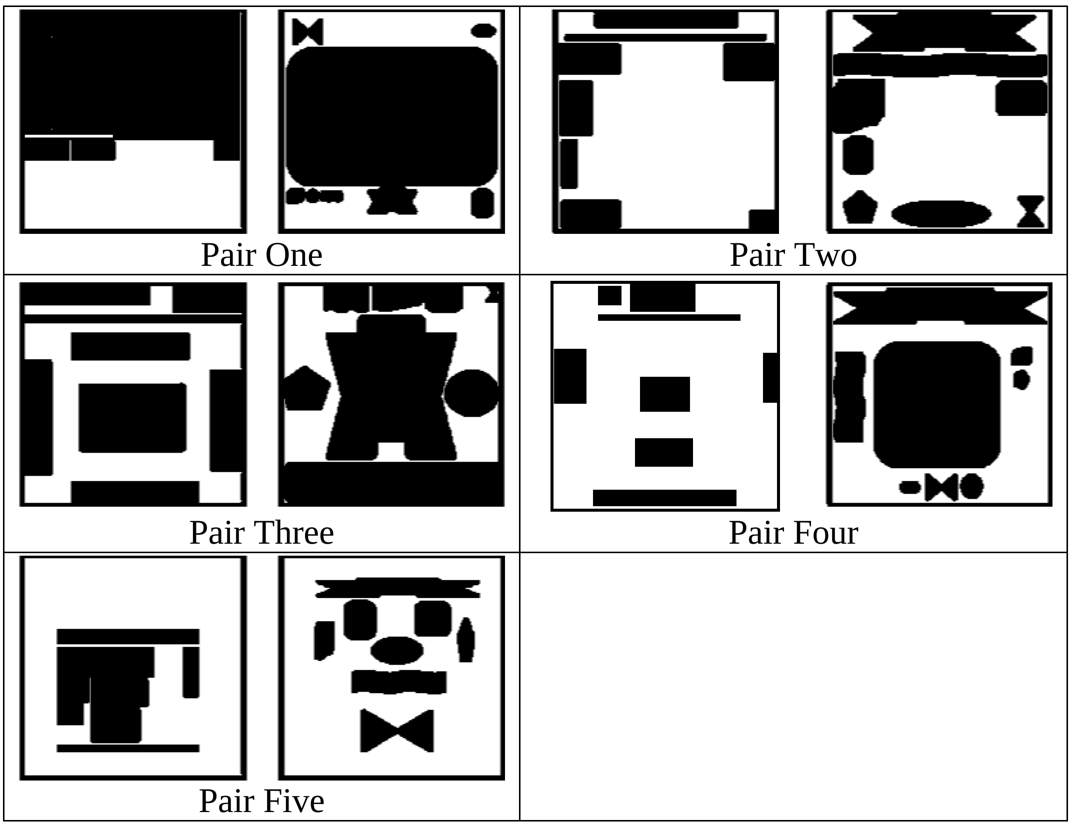


Table 9-1 Five pairs of interfaces for harmony sorting questionnaire

Pair one to four were put on a questionnaire for the participants to sort into their perceived order of harmony.

Design of the instruction

The instruction for answering the questionnaire was as follows:

> Would you please sort the following four patterns in order based on how harmonious they are? Please put 1, 2, 3 and 4 into the brackets.
>
> Please give
>
> **4 to the most harmonious**
>
> **1 to the least harmonious**
>
> **In each set, please DO NOT give the same number to more than one pattern.**

Design of the Survey Instrument

Optional questions were given to collect data about the participants' gender, age group and cultural background. The designs with the rectangles and shapes were put on a questionnaire and shuffled according to Figure 10-2 to avoid any biases of ordering. The orders were named A, B, C and D. (Appendix 4 consists of questionnaires for Rectangle – Order A and Shapes – Order A)

1	2
4	3
Order A	

2	3
1	4
Order B	

3	4
2	1
Order C	

4	1
3	2
Order D	

Figure 9-2 The orders in the harmony sorting questionnaire

Procedure

The orders were distributed as evenly as possible to the participants in classes. It only took them five minutes to complete the questionnaire. Meanwhile, the interfaces were imported into the Harmony application to calculate their score of harmony.

9.3 Results

The results from the participants

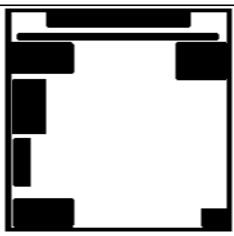
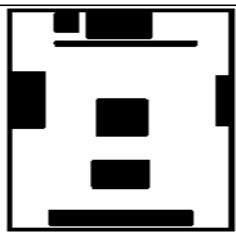
	Order	 A	 B	 C	 D
1	A	1	3	2	4
2	B	1	2	3	4
3	A	1	3	2	4
4	C	3	2	1	4
5	B	2	3	1	4
6	B	2	4	3	1
7	**A**	**1**	**4**	**2**	**2**
8	A	3	2	1	4
9	D	2	3	1	4
10	C	1	3	2	4
11	C	1	3	2	4
12	C	2	4	1	3
13	D	2	4	3	1
14	C	2	4	3	1
15	B	2	3	1	4
16	C	1	3	2	4
17	D	2	4	3	1
18	A	3	4	2	1
19	D	1	4	3	2
20	C	4	1	3	2
21	D	2	3	4	1
22	B	3	2	4	1
23	A	1	3	4	2
24	**A**	**4**	**1**	**3**	**1**
25	B	1	4	2	3
26	A	1	3	2	4
27	**A**	**7**	**8**	**8**	**7**
28	C	3	1	4	2
29	D	3	2	4	1
30	A	2	3	4	1
31	C	4	2	3	1
32	A	1	3	4	2
33	B	4	2	3	1
34	B	1	3	2	4

Table 9-2 Sorting result for the rectangle group by the participants

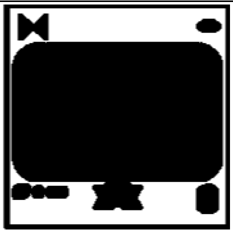
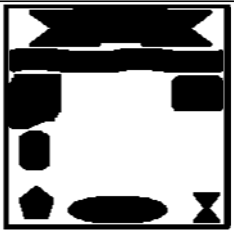
	Order	 A	 B	 C	 D
1	B	4	3	1	2
2	D	4	2	1	3
3	A	4	1	2	3
4	A	4	2	3	1
5	C	4	1	2	3
6	D	4	2	1	3
7	C	4	3	4	1
8	B	4	3	1	2
9	A	4	1	3	2
10	C	2	1	4	3
11	B	3	2	4	1
12	A	2	1	3	4
13	B	4	1	2	2
14	C	1	4	2	3
15	D	1	4	2	3
16	D	4	1	3	2
17	A	2	4	1	3
18	A	4	1	2	3
19	C	3	4	1	2
20	A	4	3	1	2
21	B	1	4	2	3
22	B	3	4	1	2
23	C	2	3	1	4
24	D	1	2	4	3
25	D	4	2	1	3
26	B	3	1	4	2
27	D	1	3	4	2
28	A	3	1	2	4

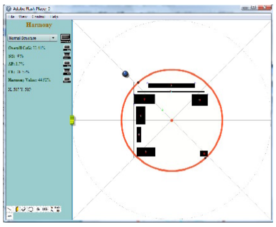
Table 9-3 Sorting result for the shape group by the participants

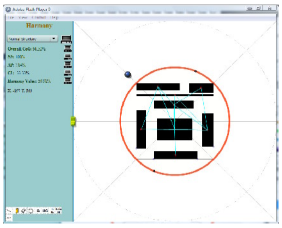
Table 9-2 and Table 9-3 show the sorting results from participants. The people who did not follow the instruction properly are highlighted in the tables and were removed from analysis.

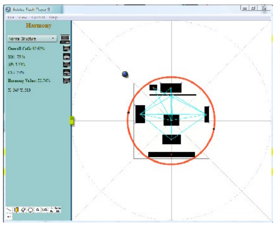
For the rectangle group of interfaces, there were 31 valid questionnaires, 8 sorted Order A, 8 sorted Order B, 9 sorted Order C and 6 sorted Order D.

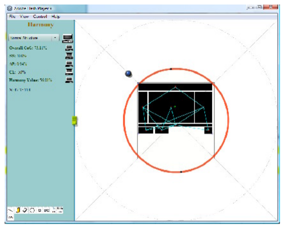
For the shape group of interfaces, there were 27 valid questionnaires: 8 sorted Order A, 7 sorted Order B, 5 sorted Order C and 7 sorted Order D.

The results from the "Harmony" application


Order A

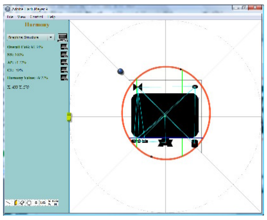

Order B

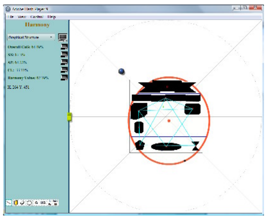

Order C

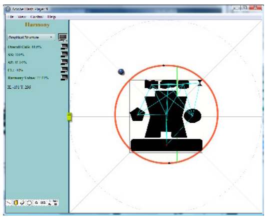

Order D

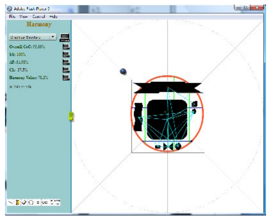
Order	A	B	C	D
Overall centre of gravity	72.41%	98.52%	92.62%	73.11%
Symmetrical Space	0%	100%	87.5%	100%
Avoiding Prominence	3.7%	7.84%	5.33%	0.94%
Circular/Elliptical Layout	28.57%	33.33%	25%	50%
Harmony Value	26.17%	59.92%	52.61%	56.01%

Table 9-4 Harmony values for the rectangle group from the "Harmony" application


Order A


Order B


Order C


Order D

Order	A	B	C	D
Overall centre of gravity	92.34%	64.49%	88.6%	93.33%
Symmetrical Space	100%	75%	100%	100%
Avoiding Prominence	74.72%	64.22%	81.04%	81.98%
Circular/Elliptical Layout	50%	33.33%	40%	35.7%
Harmony Value	79.27%	59.26%	77.41%	78.2%

Table 9-5 Harmony values for the rectangle group from the "Harmony" application

The Table 9-4 and Table 9-5 show the calculation results from the Harmony application.

9.4 Analysis

The rank sums for the rectangle and shape groups, and their Harmony Values are shown in Table 9-6 and Table 9-7.

Order	A	B	C	D
Harmony Value	26.17%	59.92%	52.61%	56.01%
Rank sum	62	90	79	79

Table 9-6 Rank sums for the rectangle group

Order	A	B	C	D
Harmony Value	79.27%	59.26%	77.41%	78.2%
Rank sum	80	61	58	70

Table 9-7 Rank sums for the shape group

9.5 Discussion

9.5.1 Comparison of perceived and calculated harmony

Matching the scores given by participants with those generated by the "Harmony" application could be problematical, because each participant assigns different values to the numbers. For example, "1" to Participant A may value the same as "2" to Participant B. However, sorting a group of interfaces does not have this problem because the numbers are ordinal. If the principles were the determining factors that affect people's judgements on harmony, their preferred order for the interfaces should be in the same way as ordered by the application. That is to say, this test was a nonparametric test on a one-tailed trend. This would avoid the problem in Zain's (2007) research (Section 1.4.3).

For the one-tailed trend test, two options can be considered: Jonckheere's Test and Page's L Test. The difference is that Jonckheere's Test focuses on the trend between groups and Page's L Test is on a repeated measure. In detail, for Jonckheere's Test, there are a few groups (3 or more) and each group will receive a difference treatment. These treatments are in a sequence. It is expected that the feedback from each group reflects the volume of each treatment. Page's L Test is to find out whether an order sorted by subjects/participants matches the order predicted (BS ISO, 2006). Its outcome is reliable when there are more than 20 assessors with any conditions (interfaces in this study). Page’s L Test matches the requirements and situation of this study so it was chosen for the statistical test. The hypotheses in this test would be:

$H_{0:}$ The participants tended to give the same ranking on each screen interface.

$H_{1:}$ The participants tended to rank the screen interfaces in the predicted order.

For the rectangle group, the predicted ascendant order according to the Harmony Values calculated by the Harmony application is: Order A < Order C < Order D < Order B. Table 9-8 shows the Harmony Value and rank sum for each interface in the predicted order.

Order	A	C	D	B
Harmony Value	26.17%	52.61%	56.01%	59.92%
Rank sum	62	79	79	90

Table 9-8 Harmony Values and rank sums for the rectangle group

After entering the values into the formula of Page L test, the result calculated rejects the null hypothesis (H_0). (Page coefficient L: 817, L’=2.262>1.64 (at the 0.05 risk. For the 0.01 risk it is 2.33). That is to say, the order of Harmony Values by the Harmony application matches people’s order of harmony on the interfaces with the rectangles.

For the shape group, the predicted ascendant order according to the Harmony Values calculated by the Harmony application is: Order B < Order C < Order D < Order A. Table 9-9 shows the Harmony Value and rank sum for each interface in the predicted order.

Order	B	C	D	A
Harmony Value	59.26%	77.41%	78.2%	79.27%
Rank sum	61	58	70	80

Table 9-9 Harmony Values and rank sums for the rectangle group

The result of the calculation of Page L test rejects the null hypothesis (H_0). (Page coefficient L: 707, L’=1.85>1.64 (at the 0.05 risk. For the 0.01 risk it is 2.33). That is to say, the order of Harmony Values by the “Harmony” application matches people’s order of harmony on the interfaces with the shapes.

It can be noticed from the results, the “Harmony” application gave a more accurate result on the interfaces with the rectangles than those with the shapes. It could be that the interfaces built with shapes still looked like objects to some extent, which causes some bias in the participants' judgements.

9.5.2 Comparison of Eastern and Western perceptions of harmony

The four principles were developed from Chinese culture. The majority of the participants in the experiment were educated in the West. The literature shows that harmony in Western culture is mainly about formatting the arrangement of the objects, and in Eastern culture it is about the relationships hidden behind the objects (Chapter 2). The relationships embedded in Chinese regular script calligraphy have been quantified. The result of this study indicates that the quantified relationships are also accepted as elements of harmony in Western culture, especially the relationship between the centres of gravity, as the principle Symmetrical Space was on average 82.81% satisfied in the designs by the European Computing staff.

9.6 Summary

In this study, the participants and the Harmony application both ranked four interfaces built with either rectangles, or with shapes. The results by the Page L trend test show that the two ranking orders matched up, which supports the hypothesis that after minimizing the impact of colour, the principles would be the determining elements that affecting people's judgements on harmony. The East and West actually share more common values in terms of harmony than would be deduced from the literature.

Chapter 10. Conclusion and Recommendations for Further Work

10.1 Thesis aims

The initial hypothesis was that holistic Eastern design principles from Chinese regular script calligraphy can be converted to Western analytical and deductive design methods. It led to three goals.

1. To investigate and discover the quantifiable features of harmony in Chinese regular script calligraphy;
2. To develop new mathematical principles for Chinese regular script calligraphy, and convert the new principles for application to harmonious interface design;
3. To create and evaluate an application for measuring harmony in Chinese calligraphic characters and interface designs.

10.2 Main original contributions

10.2.1 A set of fully mathematically deductive and computable principles for Chinese regular script calligraphy

About 1800 years ago, “Zheng” style Chinese calligraphy was created by Zhong, You (锺繇 151-230). Many people devoted their lives and try to master the spirit of its irresistible elegance. 500 years later, Yan, Zhenqing (颜真卿 709-785) managed to keep the elegance in his style and soon it became very popular throughout China until the present day. It became the standard form for Chinese characters and was entitled “Regular Script” (楷书). Successful calligraphers put effect into unlocking the elegance of Chinese regular script calligraphy. Based on the features they found, many sets of principles were developed for calligraphic novices. The numbers of these principles range from a few, such as Guo’s (1995) five principles, to nearly one hundred, such as Ziyuan’s (1837-1918) ninety two principles (Zou, 2008). However, these principles are holistic and difficult to quantify and measure. In fact, they are guidelines for the characters achieving the right “feel”. It is true that every person will have different judgements on feelings. However, since the elegance of Chinese regular script calligraphy has been acknowledged by Chinese people for at least 1500 years, there must be some universally perceived properties hiding in the calligraphy, which make the characters harmonious, and which have the potential to be quantified. From the features described by the principles, it can be concluded that the aim of the principles are to achieve harmony among the calligraphic strokes (Section 2.2.3 and 4.3). It is not surprised because harmony is a central theme in Chinese culture (Chapter 2).

In this age of computing, the way of transferring Chinese regular script calligraphy into fonts is still mainly conducted by hand: regular script calligraphers write down hundreds of Chinese characters which are scanned into a computer and analysed by software for the traits of the strokes, so a typographer can piece the strokes together for the rest of the characters (about 7000 characters) (Liao, 2009) (Section 6.1). The latest researches of auto-generating calligraphic characters treated them as images. Decomposing the characters and then re-composing the character by database or feature matching is an important theme in computing Chinese calligraphy (Dong, 2008; Xu, 2009) (Section 1.4.4).

In this research, the harmonious features of Chinese regular script calligraphy were deduced and quantified. It is not claimed that harmony can be completely measured, but identifies some commonly shared aspects of harmony in Chinese calligraphy, that translate into measurable properties which produce harmonious screen interfaces.

10.2.2 A set of harmonious interface design principles from a Chinese perspective

Aesthetics is becoming increasingly important in HCI. It has been connected with usability of interfaces (Section 1.2). However, most aesthetic principles for interface designs are adapted from Western culture, even when designing interfaces for other cultures, (Shen et al, 2006). There are many differences between Western and Eastern cultures. In terms of harmony, the Western view of harmony is mainly an aesthetic state which consists of balance, unity and consistency; the Chinese view covers the relationships between human beings and all the subjects in the universe. This is reflected in Chinese art (Section 2.2). Confucius gives a good summary of these relationships: “harmonious yet different” (Hu, 1991). Chinese calligraphy is very important in Chinese art. Being fostered by Chinese culture for 1500 years, Chinese regular script is rich in conveying the ideas of Chinese harmony, so it was chosen for the development of the set of harmonious interface design principles.

Guo’s (1995) five principles were chosen because they are the simplest set and focus on achieving the harmony in the characters, rather than categorising the characters’ structures. Effort was put to converting Guo’s (1995) principles into a new set of analytical and deductive principles which was the first version. However, not all points in Guo’s (1995) principles could be successfully deduced (Chapter 3). The tests with users helped to understand why some points were ambiguous. Four studies were conducted (Chapter 5). The first two studies discovered that the first version actually consisted of principles that describe the harmonious features and the methods to satisfy the principles. Therefore the five principles in the first version were refined to four principles and four methods. The third study identified two categories in interface design: normal structure and graphical structure. Besides, the names and explanations of the principles were improved in the third study but no other ambiguous points were clarified. This indicated that the tests with users would not produce any new outcomes, so it was decided to test the second version with Chinese regular script calligraphy. The fourth study provided knowledge to split “U” shape strokes in Chinese calligraphy. The fifth study successfully deduced all the harmonious features conveyed by the principles and led to the third version.

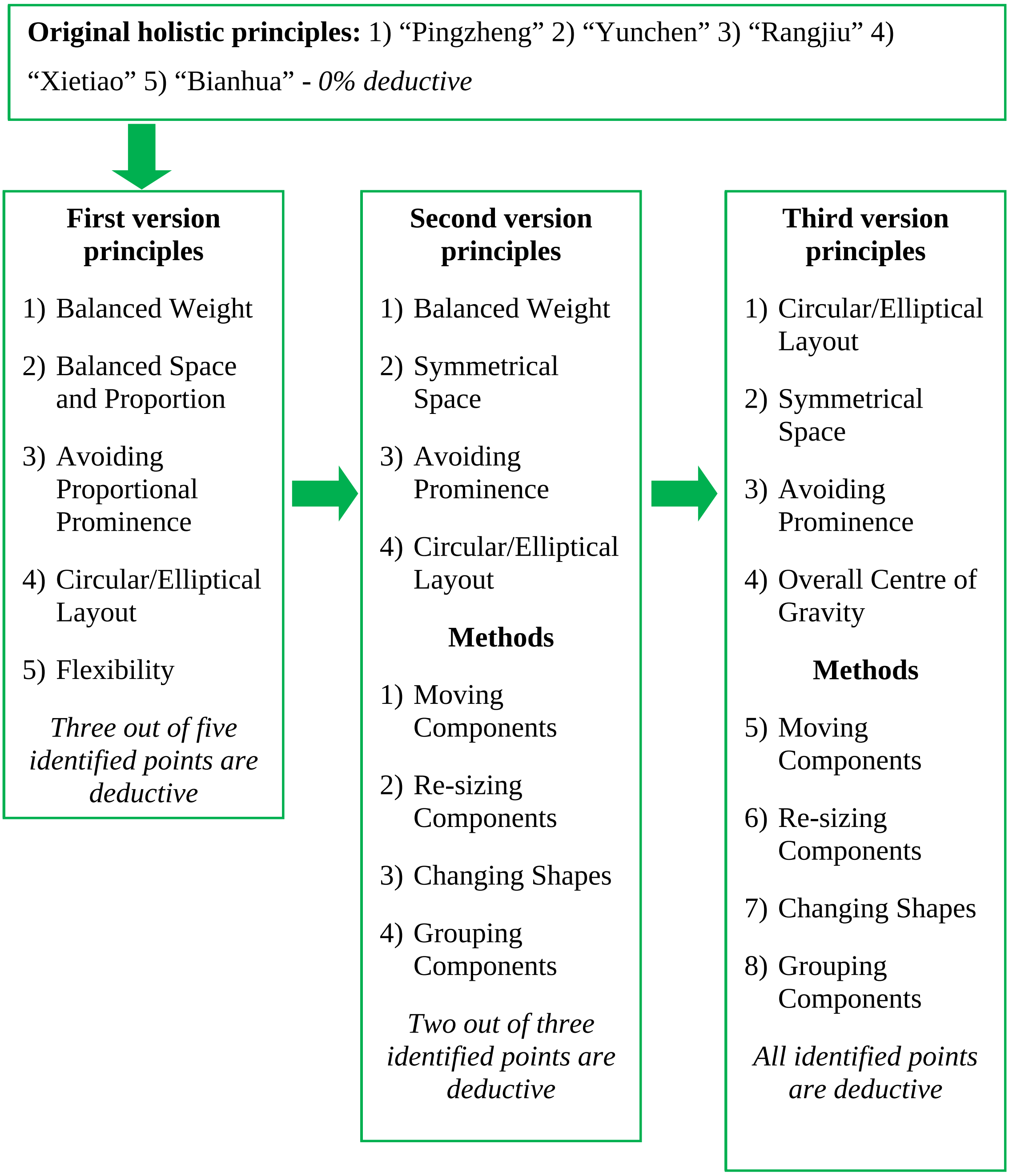


Figure 10-1 The flow of the developments of the principles

Figure 10-1 shows the flow of the developments of the principles. The development started from Guo's (1995) five principles which are not deductive. In the first converted version, Balanced Weight, Balanced Space and Proportion and half of Circular/Elliptical Layout could be deduced so it was that three out of five identified points became deductive (Section 4.6). In the second version, the fifth principle in the first version was categorised into Methods and the concept of Key Points was introduced for Circular/Elliptical Layout, so the deductive rate rose to two out of three

(Section 5.2). All the answers for the remaining ambiguous points were found when applying the second version on Chinese regular script calligraphy. After adapting the new principles for Chinese regular script calligraphy to interface design, all identified points in the principles finally became mathematically deductive and computable – the third version (Chapter 7). The order of applying the principles was established in the third version.

Since the new set of harmonious principles is derived from Chinese calligraphy, it does not having anything to say about colours and images (Appendix 3), which is a limitation. Only if the impact of colours and images are minimized, are the principles effective (Chapter 9).

In Chinese culture, harmony is required to be established between human beings and nature/universe, humans and human society, between individuals and their own minds (Jia, 2008) (Section 2.1 and 2.2). The new set of principles now reflects this concept into harmonious interface design. Same as the sectors of the Chinese calligraphic strokes, if each interface component acted like a human being, they would establish their relationship in the following ways (Section 6.5):

1. Each one should organize its internal information harmoniously (harmony within the mind of each human being).

2. All the centres of gravity of the components should be part of isosceles triangles (harmony between human beings) – Symmetrical Space

3. Each component should only occupy the right amount of space and ensure the overall centre of gravity is at the middle of the whole space in which they work (harmony between human beings and society) – Avoiding Prominence and Overall Centre of Gravity

4. Finally all sectors should be constrained by the pre-defined space (harmony between human beings and the nature/universe). – Circular/Elliptical Layout

10.2.3 An application for judging harmony in calligraphy and interface designs

The “Harmony” application is a piece of software that provides quantitative feedback on how well a calligraphic character is constructed in the “Zheng” (regular script) style. Compared to other researchers’ recent work (Section 1.4): the existing applications for Chinese calligraphy which are mainly about decompose the Chinese characters as images and recompose them (Dong, 2008; Xu, 2009)), the website designed by Shen et al (2006) which embedded cultural elements into designs, and the Aesthetics-Measurement Application developed by Zain et al (2007) which was mainly about calculating the formation of the rectangle divisions in an interface, the “Harmony” application calculates the relationships between the sectors of the strokes, and the strokes and the whole character, and also does the same calculation for interface designs (Chapter 8). In each case it is able to calculate a number which is indicative of the harmony of the character or design. The Normal and Graphical Structures are two categories of interface designs in the “Harmony” application. The differences between them are 1) the interfaces with normal structure are built inside a rectangular space and consists of rectangle divisions, which affect the principles of Circular/Elliptical Layout and Avoiding Prominence; 2) the calculation for the interfaces with a graphical structure adapt everything for Chinese regular script calligraphy, except that the way to identify the dividing lines is simpler.

The “Harmony” application was tested with some Chinese characters and eight interface designs (Chapter 9). It matches people’s perspectives of harmony for interfaces when the impacts of colours and images are minimized.

The “Harmony” application provides an example of principles based software for Chinese calligraphy and interface designs.

10.3 Other original contributions

Other original contributions not included in the main contributions are listed below.

1. **People mix attractiveness, pleasantness and harmony on designs – colours and images affect people’s judgement on harmony but not covered by the new principles**

A study with 50 participants discovered that people thought attractiveness, pleasantness and harmony all involved colours and images. That is to say, colours and images affect people’s judgement on harmony, which is not covered by the new principles because they derived from the principles for the organisations of a set of strokes in monochrome colour (Appendix 3).

2. **The East and West share more values in terms of harmony**

   The positive result from the study for testing the efficiency of the harmonious interface design principles indicated that the Eastern values of harmony actually exist in Western people’s perspectives of harmony (Section 9.5.2).

10.4 Recommendations of further work

A number of new research questions emerged in the course of the project. These questions provide the basis of further work.

1. **The effect of coloured interfaces and interfaces with images**

   In the project, the impact of colour and image was minimised because they can negatively influence people’s judgement of harmony. It would be instructive to look at the assessment of harmony in the light of introducing colour and then images.

2. **Application of the set of principles to 3D interfaces**

   Most interfaces used in the experiments were two and two and half dimensional. In theory, the set of principles should be applicable to various interfaces, including 3D. Testing the principles on 3D interfaces could also be part of the further work.

3. **Discovery more harmonious values in Chinese calligraphy**

   The chosen original set of calligraphic principles was one of the simplest one. Although it covers all the major harmonious values in Chinese characters, new harmonious values may be found from other sets of principles. The principles of harmony developed here could be further refined.

4. **Test the new principles with novice calligraphers**

The new principles are deductive so they are easier to understand than the conventional Chinese calligraphic principles. A study with novice calligraphers could be conducted to find out how the new principles improve their skills in Chinese regular script calligraphy.

5. **Development of the “Harmony” application**

The “Harmony” application was completed to meet the basic needs for calculating the principles. A usability test on the application was not carried out, and there is a lot of opportunity to improve the usability of the application in the further work.

The “Harmony” application can calculate the harmony in Chinese characters and interfaces, but not everything in the application is automatic, for example, there is no tool to draw curve lines and all points on the Chinese character strokes and interface components have to be identified manually. The computing of the joint points for the isosceles triangles by Symmetrical Space was not completed. The application could be made more efficient and effective in the future.

An electronic brush can be developed with touch screen technology. When a novice calligrapher uses the brush and writes a character on a computer monitor, the “Harmony” application could catch the strokes and automatically work out how the character satisfies the “Harmony” principles.

6. **Weight of each principle in the Harmony Value**

The overall harmony value in the “Harmony” application is the average score from the satisfaction values of the four principles. However, one principle could be more important than others and should be given more weight, which could affect people’s judgement of harmony on an interface. Another study should be arranged to find out the answer.

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Glossary of Terms

1. **Centre of gravity** was a direct translation from a principle for Chinese calligraphy. In practice, it is the centre of mass because only two dimensional designs were dealt in this research. When it is a two dimensional object, its centre of gravity and centre of mass are at the same place, so the phrase "centre of gravity" has been kept in the translated principles.
2. **Confucianism** is the dominant philosophy in Chinese culture. Confucius emphasized education and human relationships. He advocated the virtues of filial piety, kindness, loyalty etc and knowledge to build up a harmonious society (Yao, 2000, Pang, 2000).
3. **Culture** defined by Hofstede (1984) is that 'the collective programming of the mind which distinguishes the members of one human group from another' (Hofstede, 1984: p.21). This means that people from different countries and areas adopt different ways in thinking and behaviours. They have different values, beliefs, and perceptions. The values also affect people's preferences on art. 'Users of the Latin alphabet and users of the Chinese alphabet have different visual preferences' (Probhu & Harel 1999, quoted by Strom, 2005: p.301).
4. **Harmony** 'of something is the way in which its parts are combined, so that when you look at the whole arrangement you feel that it is elegant' (Sinclair, 2001: p.716), but different cultures will have different interpretations.
5. **Heuristic Evaluation** 'developed by Jakob Nielsen and Rolf Molich, is a method for structuring the critique of a system using a set of relatively simple and general heuristics' (Dix et al, 2004: p.324).
6. **Human Computer Interaction (HCI)** the term was adopted in the mid-1980s. There is no general and unified definition of HCI. Preece et al (1994) define HCI as a discipline concerned with the design, evaluation and implementation of interactive computing systems for human to perform a task effectively and efficiently.
7. **Paradigm and Paradigm shifts** (Kuhn 1996) is used to describe scientific revolution. The word "paradigm" means any scientific disciplines here. Paradigm shifts means that when enough significant anomalies appear and

cannot be explained by the current paradigm, the paradigm will start to adapt the anomalies and redevelop. Finally, a new paradigm will be born.

8. **Screen interface** is an interface's static print. Since this research did not consider motions on an interface, and only static graphics were used, screen interface is an alternative way to refer an interface.
9. **Statistical test** (statistical hypothesis test, hypothesis test) is a research method for making decision from research data. There are a Null Hypothesis (H0) and an Alternative Hypothesis (Ha or H1) in each test. Null Hypothesis is an equation, for example: there is no difference before and after the application of the principles. Alternative Hypothesis is the opposite of Null Hypothesis, for example: there is difference, including better and worse, before and after the application of the principles (two-tails); it will be either better or worse after the application of the principles (one-tail). Statistical significance indicates the possibility (p value) to reject the null hypothesis. Commonly if the p value is less than 0.05, the null hypothesis is rejected (Argyrous, 2005).
10. **Taoism** is another important Chinese philosophy. Tao means the 'Way' or 'Order of Nature'. It is a naturalist approach to human existence. In other words, Tao is the hidden rules of all existences. Obeying the rules leads to prosperity; disobeying the rules leads to decline. Tao changes when the relevant attributes change. Taoism proposed the concept of 'Yin' and 'Yang'. 'Yin' and 'Yang' are believed to be two fundamental forces in the universe. Their balance affects the harmony everywhere. For instance, Man versus Woman; Hot versus Cold (Rawson & Legeza, 1973).
11. **Usability** 'is concerned with the extent to which users of an application are able to work effectively, efficiently, and with satisfaction in their particular contexts.' (Stone et al, 2005: p.7)
12. **User Interface (UI)** here does not refer to any machines physical interface. Its scope narrows down to the computer screen interface only. The Goals of User-Interface Design are a) saving users' time to learn how to use the commands relevant to a set of tasks; b) increasing their speed of performance; c) reduce rate of errors by users; d) retention of knowledge over time and e) subjective satisfaction including various aspects of the system (Shneiderman, 1998). Item e is the primary concern in this thesis. 'Mostly, interface design is concerned with

effectiveness and usability of a software interface but this should also extend to the usefulness and purpose of the product too’ (Shedroff, 2001: p.109)

Appendices

Appendix 1. Design Principles

Design Principles (Stone at al. 2005: pp. 170-176)

- **Simplicity**: ‘Simplicity is a design principle which emphasises the importance of keeping the UI as simple as possible.’
- **Structure**: ‘Structure is a design principle that emphasises the importance of organizing the UI in a meaningful and useful way.”
- **Consistency**: ‘Consistency is a design principle that emphasizes the importance of uniformity in appearance, placement, and behaviour within the user interface to make a system easy to learn and remember’
- **Tolerance**: ‘Tolerance is a design principle that emphasizes the importance of designing the user interface to prevent users from making errors.’

Ten Usability Heuristics (Nielsen, 2005)

“These are ten general principles for user interface design. They are heuristics because they are not specific usability guidelines.

- **Visibility of system status** The system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
- **Match between system and the real world** The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.
- **User control and freedom** Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Support undo and redo.
- **Consistency and standards** Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.
- **Error prevention** Even better than good error messages is a careful design which prevents a problem from occurring in the first place. Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.

- **Recognition rather than recall** Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.
- **Flexibility and efficiency of use** Accelerators -- unseen by the novice user -- may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.
- **Aesthetic and minimalist design** Dialogues should not contain information which is irrelevant or rarely needed. Every extra unit of information in a dialogue competes with the relevant units of information and diminishes their relative visibility.
- **Help users recognize, diagnose, and recover from errors** Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
- **Help and documentation** Even though it is better if the system can be used without documentation, it may be necessary to provide help and documentation. Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large."

Layout guide-lines (Cox, 1993: p.195)

- **Balance**
- **Regularity** (of elements), **symmetry** (axial duplication), **predictability** (no surprises).
- **Economy** (enough to give the message)
- **Sequential** (use in order you read).
- **Proportion** (e.g. Golden rectangle 1 height: 1.618 wide)

The Layout (Giles, 1996: p.140)

- **Balance**: Balance means 'the distribution of headlines and picture highlights – of display ingredients – that takes best visual advantage of the page, whatever its shape, and in a way that responds to editorial values.'

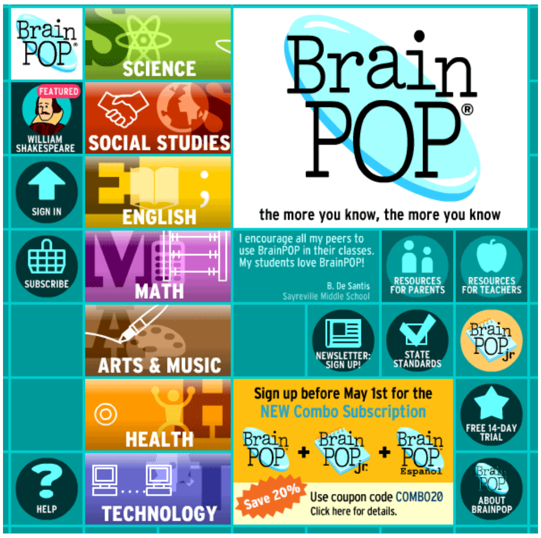
- **Variety:** It cannot be too much or too litter. ‘Variety is thus a necessary but subtly used weapon’.
- **Emphasis:** ‘The visual highlights of the design should reflect the relative importance of the items’

Appendix 2. Interfaces in Your Mind

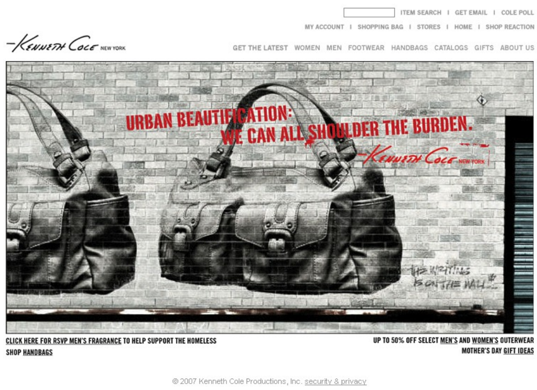
How do you describe the most attractive interfaces? (Please write down your keywords)

How do you describe the most unattractive interfaces? (Please write down your keywords)

Please have a look at the following interfaces and answer the questions.

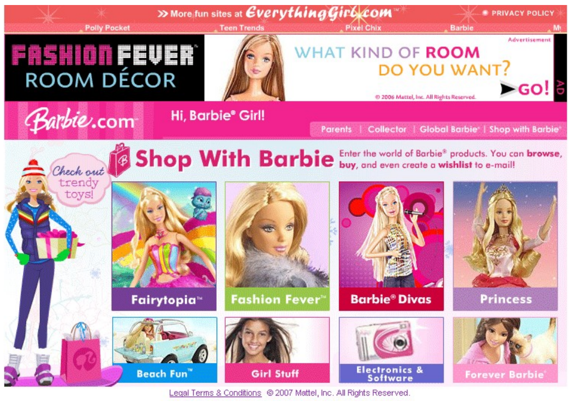


Interface 1



Interface 2

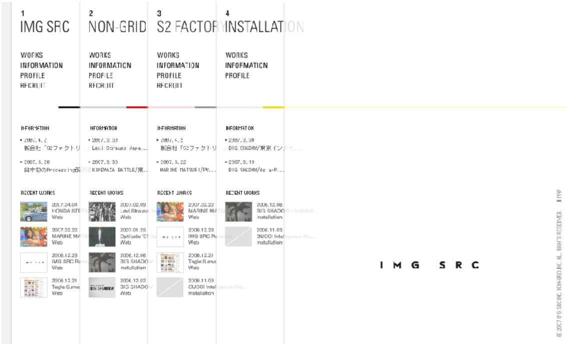
Interface 3



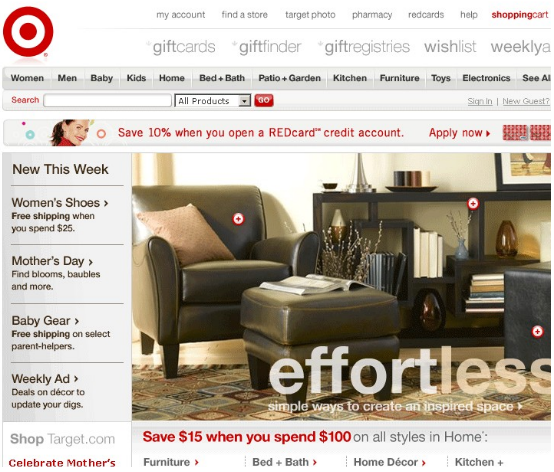
Interface 4

Interface 5

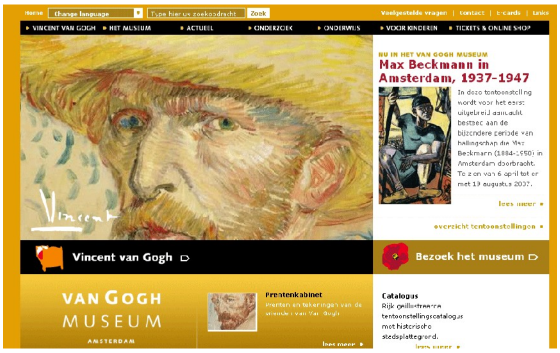
Interface 6



Interface 7 Interface 8

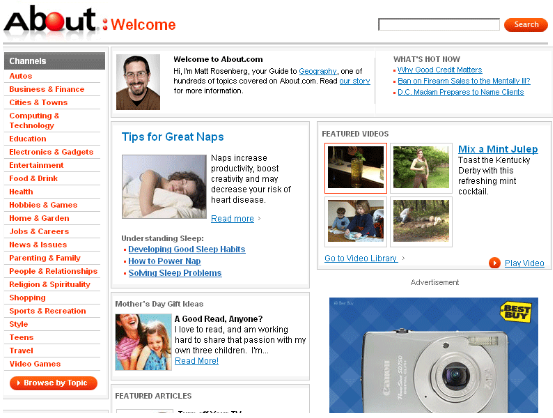


Interface 9 Interface 10



Interface 11 Interface 12

Interface 13 Interface 14



Interface 15

Among the fifteen interfaces above:

Which interface is the most attractive design? Interface _______

Which interface is the second attractive design? Interface _______

Which interface is the third attractive design? Interface _______

Please explain why you put then in such order?

____
____
____
____
____
____
____

____
_

Which interface is the most unattractive design? Interface _______

Which interface is the second unattractive design? Interface _______

Which interface is the third unattractive design? Interface _______

Please explain why you put then in such order?

____
____
____
____
____
____
____

____
_

In design many different words are used. One such word is **harmonious** interface design – when you see this word (harmonious) what other words come to mind? (Please write down your keywords)

____
____
____
____
____
____
____
______

In a similar way, what words come to mind when you think about **pleasing** interface design? (Please write down your keywords)

____
____
____
____
____
____
____
______

Appendix 3. What are People’s Perceptions of Harmony – the Limitation of Harmonious Interface Design

Since the principles were developed from Chinese calligraphy, it was not expected that they will cover all the aspects of harmony. This appendix is about the perception of harmony and the limitations of the principles.

a. Do images and colours really affect people’s judgements of harmony?

The principles were developed from Chinese regular script calligraphy. The number of unique shapes in Chinese character strokes is about fourteen, and usually, the characters are written in one colour. That is to say, the impact of images and colours is not considered in Chinese calligraphy, and consequently, the harmony delivered by the principles does not cover images and colours. However, in interface design, various images and colours are inevitable. Dake (2005) advocates that People usually connect an object’s properties, such as size, colour and value, with other familiar objects, which stimulate the cognitive aesthetic judgement. This study was to confirm that images and colours influenced people’s perception of harmony.

b. Method

Participants

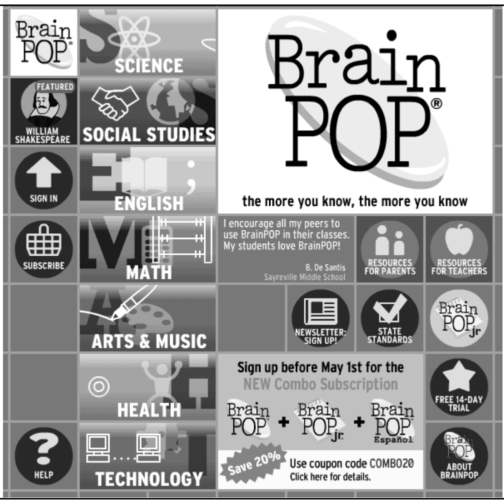
Fifty first year computing students participated in the study in 2010. They were all aged about 18 to 20. Four of them were female.

Apparatus

The survey in this study was based on a paper questionnaire only. The survey was carried out in a two hours class, but it was expected that the participant could finish the survey within 20 minutes.

Design of the Interfaces to be evaluated

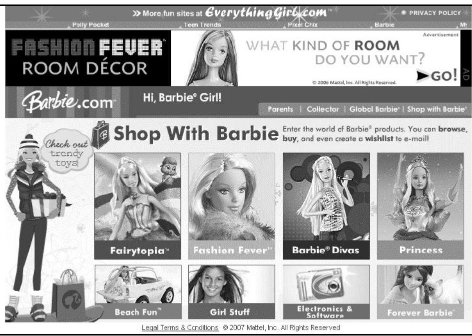
For the sake of data reliability, it was decided to choose fifteen screen interfaces from the book: “Web Colour Design” (I.R.I, 2002), so less personal preference was involved. The screen interface was presented to the participants in black and white (gray scale) to minimize the influence of colour (Table b-1).



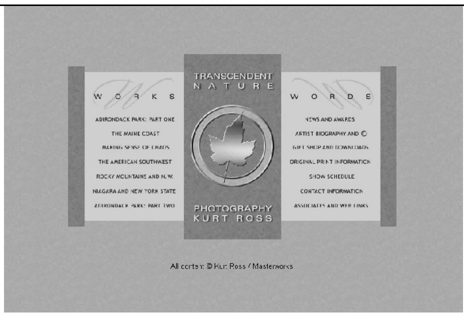
Interface 1

Interface 2

Interface 3

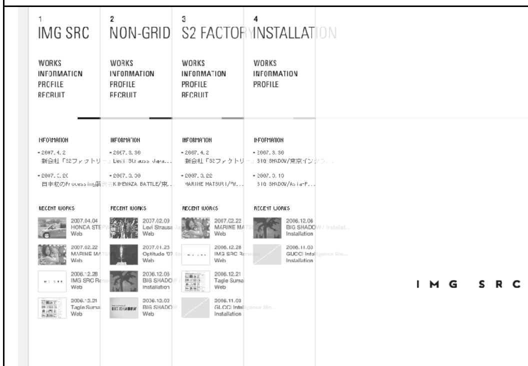


Interface 4



Interface 5

Interface 6



Interface 7

Interface 8

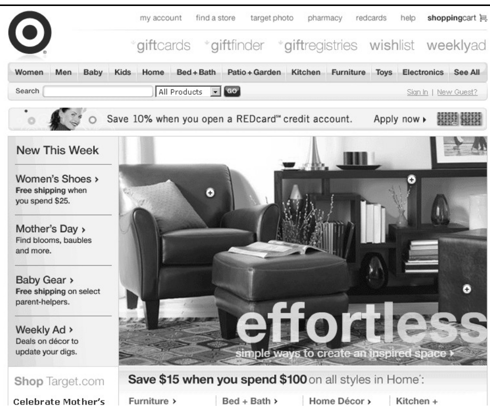
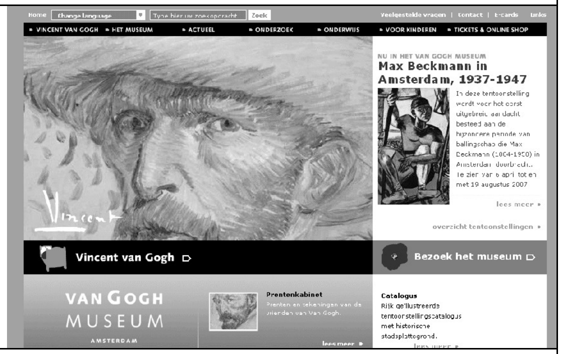
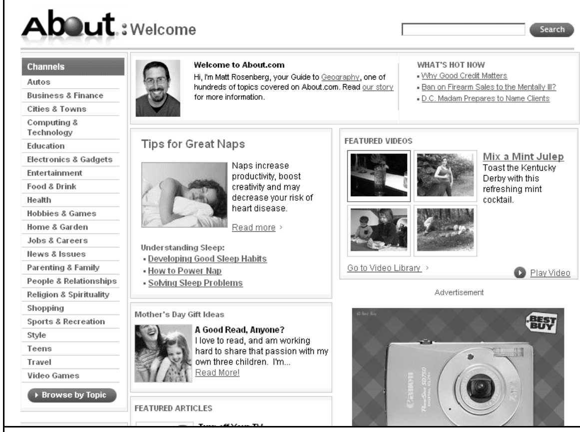
	
Interface 9	Interface 10
	
Interface 11	Interface 12
	
Interface 13	Interface 14
	
Interface15	
The 15 interfaces in black and white	

Table b-1 The fifteen interfaces in colour and gray scale

Design of the instruction

There was no instruction given. What the participants needed to do was written on the questionnaire. All of them were simple tasks.

Design of the Survey Instrument

The questionnaire was designed to find out the correlation between "attractiveness" "Pleasing" and "harmony". No definition was given for these three terms. Questions were asked to gather keywords for the three terms according to the participants' own understanding.

The questions were:

1. How do you describe the most attractive interfaces? (Please write down your keywords)
2. How do you describe the most unattractive interfaces? (Please write down your keywords)
3. In design many different words are used. One such word is **harmonious** interface design – when you see this word (harmonious) what other words come to mind? (Please write down your keywords)
4. In a similar way, what words come to mind when you think about a **pleasing** interface design? (Please write down your keywords)
5. Some questions about their preferences on the 15 interfaces

Procedure

The procedure was completing the questionnaire.

c. Results

The gathered keywords were sorted into categories.

Words for Attractive

---The pool---

<u>Uncluttered</u>

simple;	less text;	simple but effective;	compact;	not cluttered;
minimalist;	uncluttered;	good use of space	clean;	not too much on one page;

not messy; clear; information spaced and separated appropriately;

spread out stuff; spacious;

Ease of use

simple to use; easy to find information; not overload with information;

good navigation; easy navigation; simple navigation; simple to navigate;

easy to navigate; well organised; logical; easy to understand layout

user friendly; correct text input gets focus when loading; easy to use;

easy to understand; easy to read; easy to view; easy to follow;

clearly labelled pages/headings; navigate with lots of images; good layout;

clear menus; consistent; good search engine; good buttons;

big buttons to click; customisation;

Appropriate content

functional; informative; multi functional; purposeful; most effective;

focused on target audience; relevant to the subject;

New, cutting-edge technology

JavaScript or flash on the interface; innovative; Modern; video etc;

contemporary; contemporary; interesting; animation;

exciting looking; bold; stand out; excellent; 3d graphics;

professional look and feel;

Aesthetically pleasing design features

artistic; stylish; good design; sleek; smooth; not garish colours;

Not very colourful; few choice colours; make three colours; images;

Eye catching; bright; graphical; matching colours; good use of colour;

colourful; bright in colour but not blinds your; light and contrasting colours;

appropriate colour choices; light colours; bright; appealing colours;

good colour scheme; nice colours; straight lines; boxes; balance text and graphics;

complementing colours; vibrant colours; attractive colours;

black silver colour scheme; good use of pictures; good high definition pictures;

professional looking images; professional looking buttons; buttons;

smooth buttons; square buttons; background not contrast the text or images;

grab attention by using images, most attractive; attractive; look nice;

appealing to the eyes; good looking background; appropriately themed;

basic colours; not bright; nice size of font; gradient;

big medium images; correctly formatted text;

Words for Unattractive

--The pool--

Messy interface

cluttered; busy; lots of text; irrelevant images; sloppy;

too many pictures; messy; full of text; chaotic; jumbled;

crowded; too much information;

Difficult to use

inconsistent navigation; difficult to understand the layout; unintuitive;

confusing; unclear; hard to use; uncomfortable; difficult to navigate;

inconsistent layout; hard to find information; overcomplicated;

not user friendly; difficult to use; no sections; inconsistent;

complicated to understand; unorganised; long complex menu; unclear layout;

unconstructed;

Poor content

dull; boring; uninteresting; dreary; tedious;

hardly any information; not relevant to the subject;

Poor use of technology

flash animations; windows; Internet Explorer; slow loading; crashed;

Unpleasant design features

unpleasing on eyes; small font; unmatched colour scheme; difficult to read;

ugly; too many contrasting colours; too many text styles; too many font sizes;

blocky; ragged; garish; vibrant colours; no images;

too many colours/colourful; over contrasting colours; font too small;

font too large; childish colours; bad use of colours; rough images;

black and white; bright colours; no gradient; not nice;

unattractive colours; clashing colours; too bright; badly designed;

no colour; colour issues; too dark; un-readable font; large font;

low resolution; poor quality; plain; poorly formatted; no font

Words for Harmonious

--The pool---

Calm

peace; serene; quiet; calm; tranquil; no harm;

pure; relaxing

Uncluttered

equal spaces between elements; good use of white space; easy; simple;

Connected

ordered; flowing; well together; connected;

fits; not conflicting; consistent; group; working together;

collective; communicate well; harmony; complimentary; efficient;

working; links up; uninterrupted; linked; partnered;

inter linked; complementing;

Nature

trees; birds; nature; pandas;

Feels good

happy; acceptable; feels right; nice; enjoyable; agreeable; wonderful; sensual; sweet; warm; friendly; majestic; joy; upbeat;

Aesthetically pleasing appearance

colours; images; fonts; styles; matching colours; clear; well designed; symmetrical; light colours; smooth; beautiful; light; pleasingly attractive;

complimentary image;

Musical

music; tuneful; harmonica;

Words for Pleasing

---The pool---

Uncluttered

not too cluttered; simple; quiet; not cluttered; basic; clear; clean; minimalist;

Simple to use

easy to navigate; consistent; ease of use; easy; easy to find things; feedback and help; straight; making the user happy;

Suitable content

meeting user needs; complete; not being one sided (i.e. biased, gender, age);

appropriate information; effective; suiting; interesting; stimulating; involving;

Feeling good

satisfying; fulfil; comfortable; content; delightful;

likeable; decent; good; pleasing; cheerful; happy;

smile;

Aesthetically pleasing

easy on the eye; colourful; eye-catching; stylish; nice; appealing;

pleasant; good design; good layout; attractive; subtle colours;

not a lot of images; professional looking; white; simple colouring; colours;

text; graphics; quality; above average

Active

dynamic; fun; spontaneous;

Associations

old men's feet; Barbie dolls; food; sleep;

d. Analysis

This section is mainly about the overlaps between attractiveness, pleasantness and harmony

There are 114 keywords/phrases gathered for attractiveness, which were sorted into five categories. 65 keywords/phrases gathered for pleasing, which were sorted into seven categories. For harmony there are 69 keywords/phrases sorted into six categories. The categories and some examples of the keywords/phrases were listed in Table d-2.

Attractiveness	Pleasing	Harmony
Aesthetically pleasing design features Examples: artistic; images; colourful;	Aesthetically pleasing Examples: easy on the eye; colourful; good layout;	Aesthetically pleasing appearance Examples: colours; images; well designed;
Uncluttered Examples: simple; less text; spacious;	Uncluttered Examples: simple; quiet; not cluttered;	Uncluttered Examples: equal spaces between elements; good use of white space; simple;
Ease of use Examples: easy to find information; simple navigation; easy to read;	Simple to use Examples: easy to navigate; easy to find things; feedback and help;	
Appropriate content Examples: functional; purposeful; relevant to the subject;	Suitable content Examples: meeting user needs; not being one sided (i.e. biased, gender, age); appropriate information;	
New, cutting-edge technology Examples: JavaScript or flash on the interface; video etc; 3d graphics;	Active Examples: dynamic; fun; spontaneous;	
	Associations Examples: old men's feet; Barbie dolls; food	Nature Examples: trees; birds; nature; Musical Examples: music; tuneful; harmonica;
	Feeling good Examples: satisfying; fulfil; comfortable;	Feels good Examples: happy; acceptable; feels right; Calm Examples: peace; serene; quiet;
		Connected Examples: ordered; flowing; goes well together;

Table d-2 Keywords/phrases and categories for attractiveness, pleasing and harmony

If some categories from these three types are about the same thing, they are put in the same row with the same background colour. “Aesthetically pleasing” and “uncluttered” are the common features among attractiveness, pleasing and harmony. In the participants’ keywords, colour and image are the main things in “aesthetical pleasing”, whilst pleasing and harmony also involve overview design such as layout and space. “Uncluttered” is about the use of space. In the participants’ opinions, attractiveness and pleasantness were almost the same thing, except pleasing was attached with associations and positive emotions. Harmony only shared two features with attractiveness, but like pleasing, harmony was also associated with positive emotions. Unlike pleasing, the associations and emotions in harmony were more likely to be about a peaceful mind.

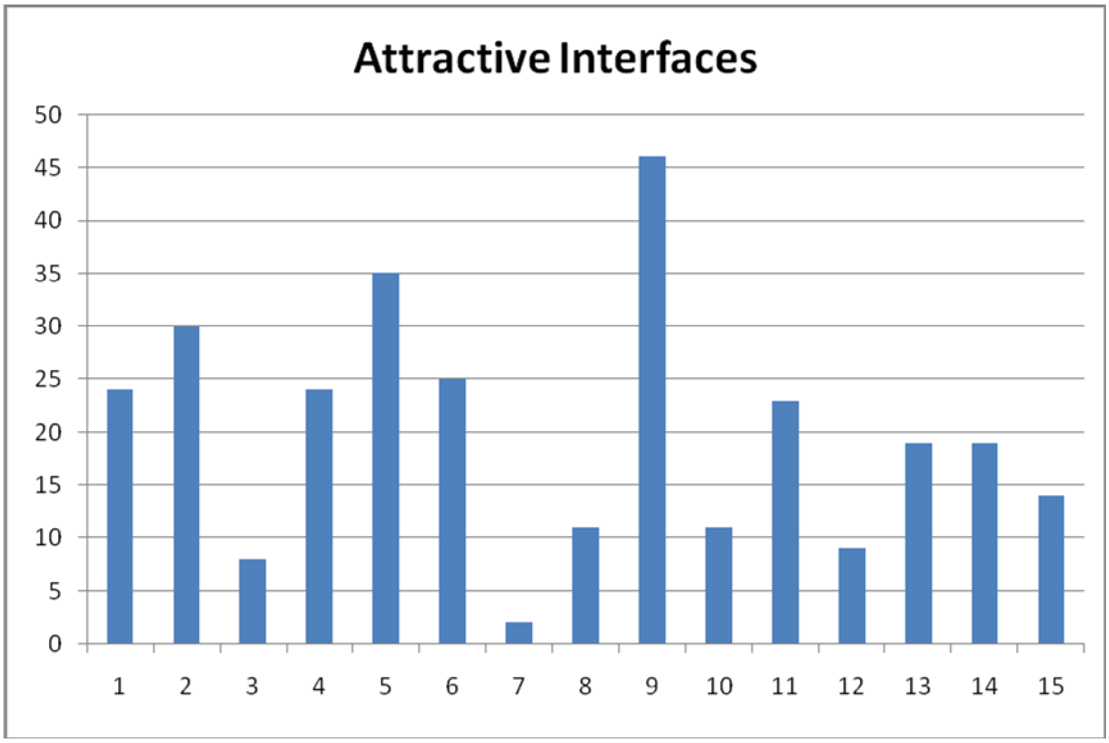
e. Discussion

i. The participants' perspectives of harmony is in accord with the literature review

The main feature of harmony was about the arrangement of interface components. Words like ordered, flowing, going well together, not conflicting, consistency, grouping, working together, uninterrupted, partnered, equal spaces between elements etc were given, plus the keywords/phrases in the "Uncluttered" category. This is in accord with the literature review in Section 2.3 that in Western art, harmony is mainly an aesthetic state. It is a combination of balance (goes well together, not conflicting, equal spaces between elements), unity (ordered, group, working together, partnered) and consistency (flowing, consistent, uninterrupted). In the screen interface design, it is the arrangement of the interface components.

ii. Images affect harmony

The participants were asked to choose the top three attractive and unattractive designs from the fifteen screen interface (Table b-1). Three points were given to the most attractive and unattractive designs. Two points were given to the second attractive and unattractive designs. One point was given to the third attractive and unattractive designs. The points were summed up so the preferences on the interfaces could be illustrated (Figure ii-1).



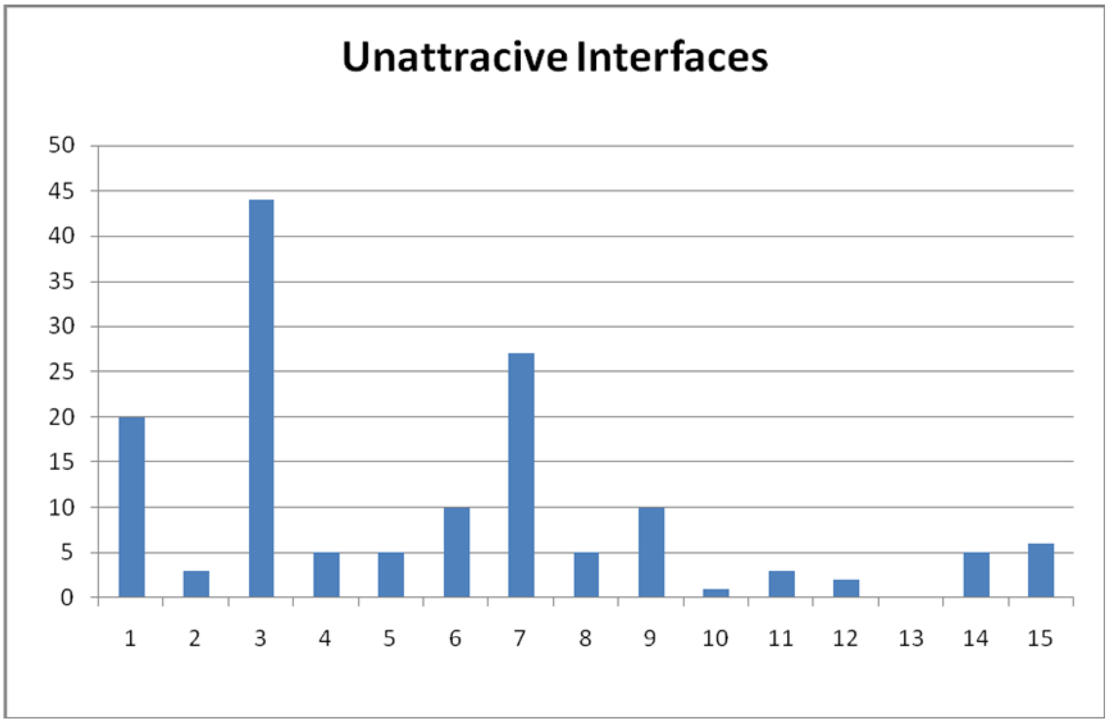
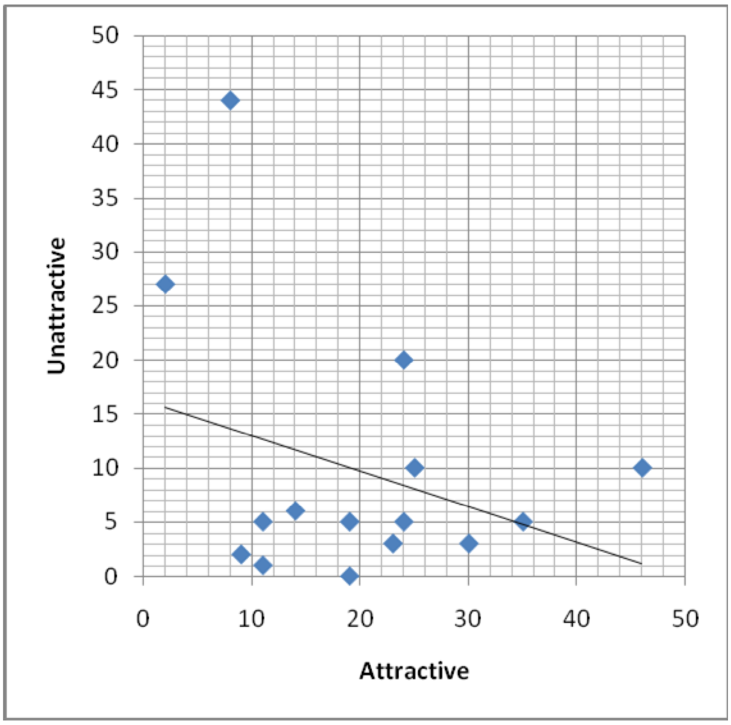


Figure ii-1 The preferences on the fifteen interfaces

The interfaces were presented on a page and excluded some features which the participants might have used to judge the attractiveness: They could not browse the websites to experience usability and technologies, also the interfaces and text were quite small, so they only focused on the categories of “aesthetical pleasing” and “uncluttered”. The keywords/phrases gathered from the participants indicated that the judgement on "aesthetical pleasing" and "uncluttered" affect people's perspective on harmony as well. Colour and image are the two main things in the Aesthetical Pleasing category based on the participants' keywords. The interfaces were presented in gray scale, so the impact of colour was reduced to minimum. Therefore, images and the use of space were the main references in the participants' judgements of attractiveness. The charts in Figure ii-1 show the sums of the scores given by the participants for each interface, in terms of Attractive and Unattractive.



———— The correlation line

Figure ii-2 Correlation between the Attractive and Unattractive

The Figure ii-2 shows that there is a small negative correlation between the Attractive and Unattractive scores. That is to say, it is not necessary that the most attractive interface on the Attractive Interfaces chart is the most unattractive one on the Unattractive Interfaces chart. There is no strong connection found on these two charts except the two worst designs which are mainly text. It indicates that the images, together with the use of space, deeply influence people's perspective of attractiveness. Since image and space are part of harmony in the participants' opinions, they will influence people's judgement on harmony as well. The use of space is handled by the harmonious interface design principles, but images are not covered.

iii. Colours affect harmony

In the participants' opinions, harmony involves colours and emotions about a peaceful mind. That means those colours that can raise other emotions will have an impact on harmony. Do colours give people different feelings and raise different emotions? The answer is yes. A colour image space map was created by I.R.I Colour Research Institution (Korean). This map displays all the web colours and their relative feelings, and feelings for peaceful mind are only part of them, such as "natural", "idyllic" "and comfortable" (Figure iii-3). Certain combinations of colours can give people a feeling of harmony (Garua, 1993; Whelan, 1994).

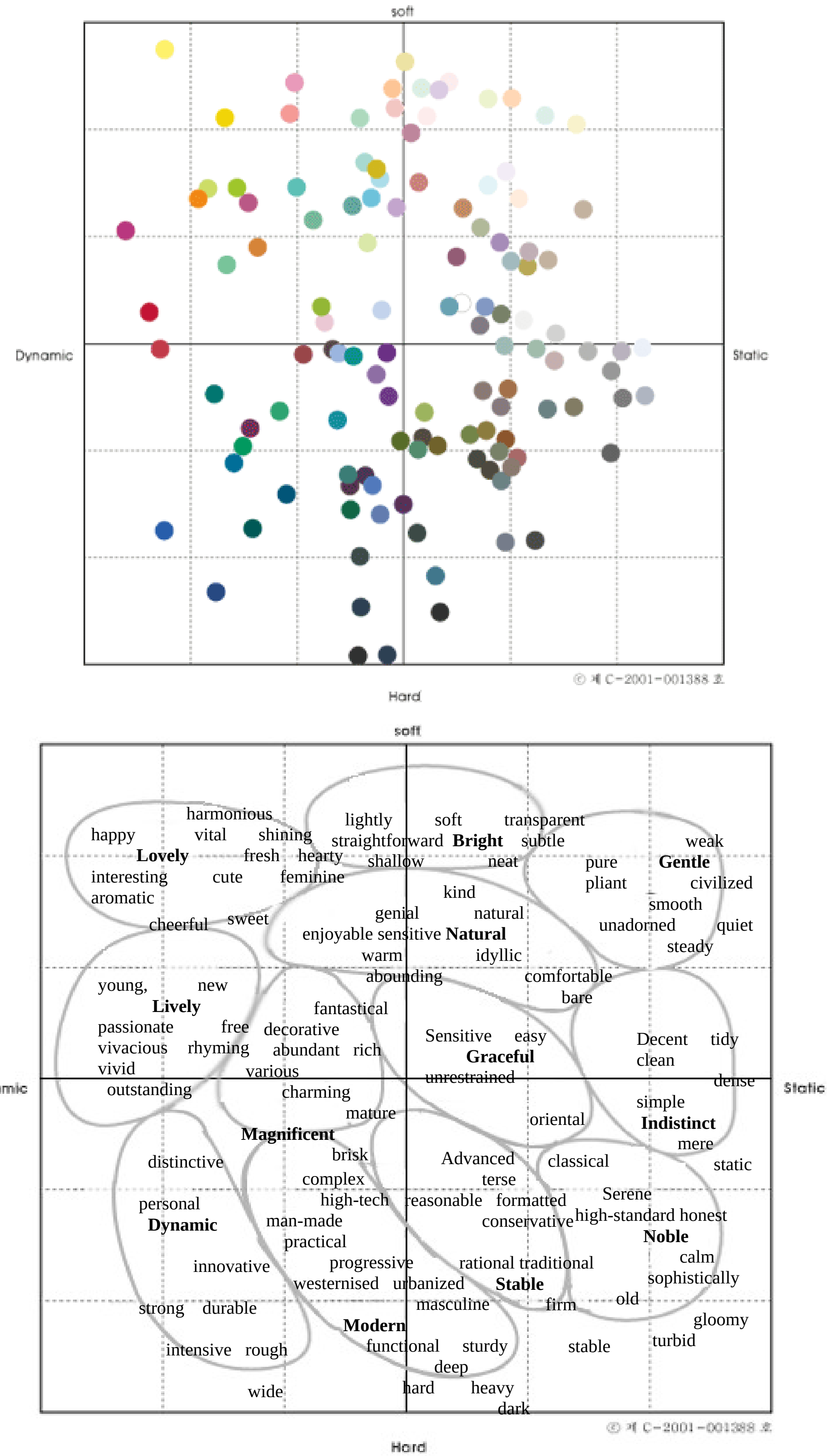


Figure iii-3 Colour image space map by I.R.I (2002: p24, 26)

f. Summary

This study indicates that colours and images on an interface exert influence on people's judgements on harmony. People tend to associate a pleasant impression with harmony. When images and colours are rich on an interface, the pleasantness produced by the principles might be overtaken by the images and colours. In other words, images and colours can dominate the impression of harmony. However, harmony also involves the use of space and the arrangement of the interface components, which are covered by the harmonious interface design principles.

Appendix 4. Sorting harmony

Rectangle – Order A

Would you please sort the following four patterns in order? Please put 1, 2, 3 and 4 into the brackets.

Please give

4 to the most harmonious

1 to the least harmonious

In each set, please DO NOT give a number to more than one pattern.

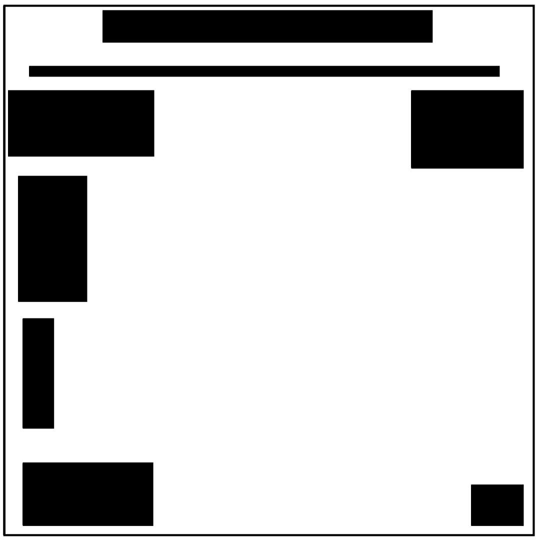
Thank you very much.

Before you start, could you please answer these questions?

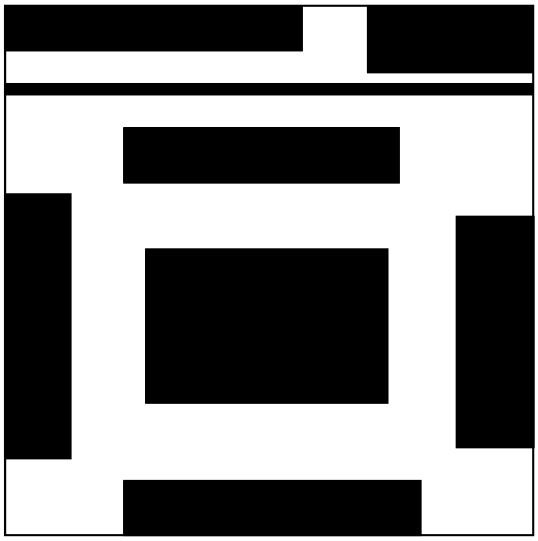
You are: a) Male b) Female

a) Under 25 (include 25) b) Over 25

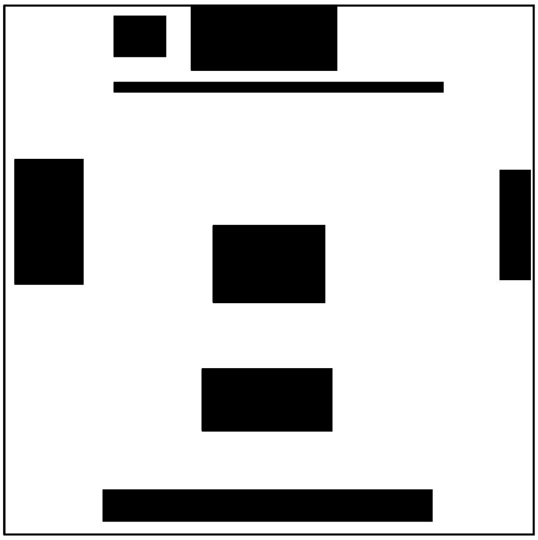
Your cultural background is ________________________



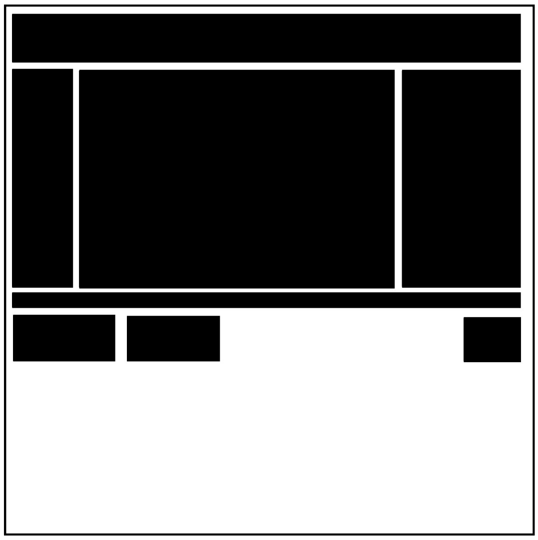
a (   )



b (   )



c (   )



d (   )

Shapes – Order A

Would you please sort the following four patterns in order? Please put 1, 2, 3 and 4 into the brackets.

Please give

4 to the most harmonious

1 to the least harmonious

In each set, please DO NOT give a number to more than one pattern.

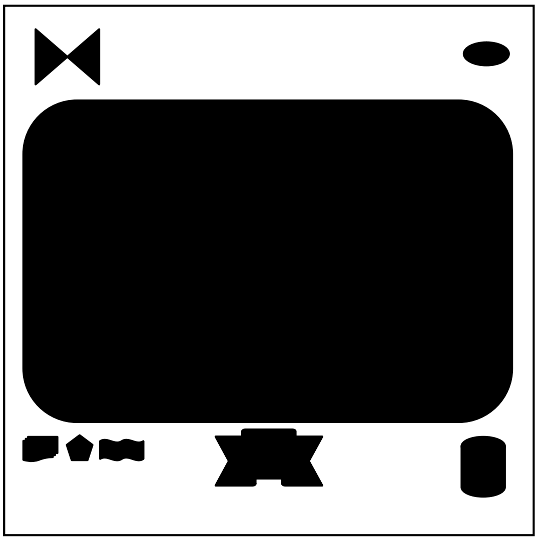
Thank you very much.

Before you start, could you please answer these questions?

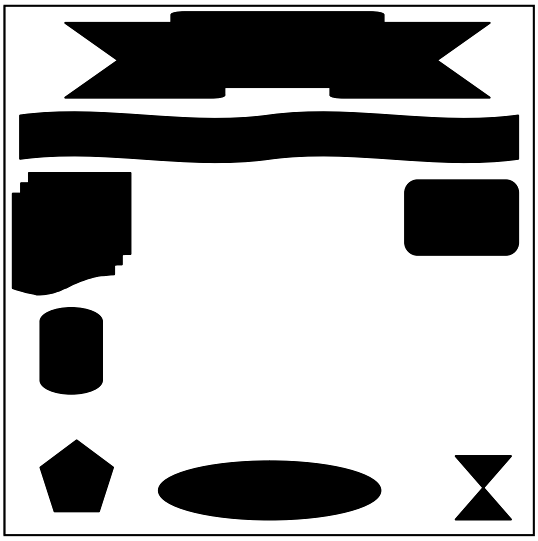
You are: a) Male b) Female

a) Under 25 (include 25) b) Over 25

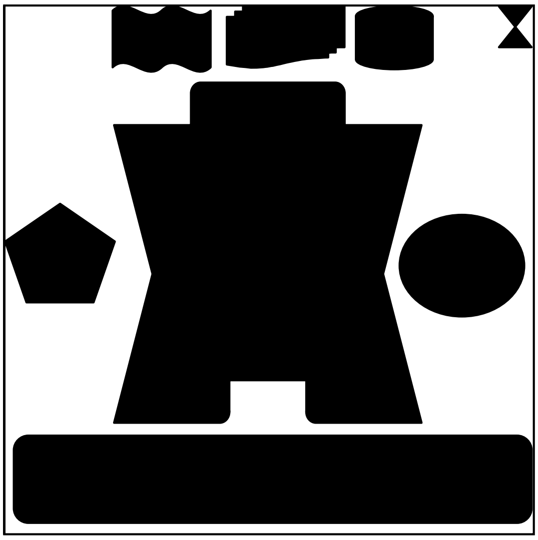
Your cultural background is ________________________



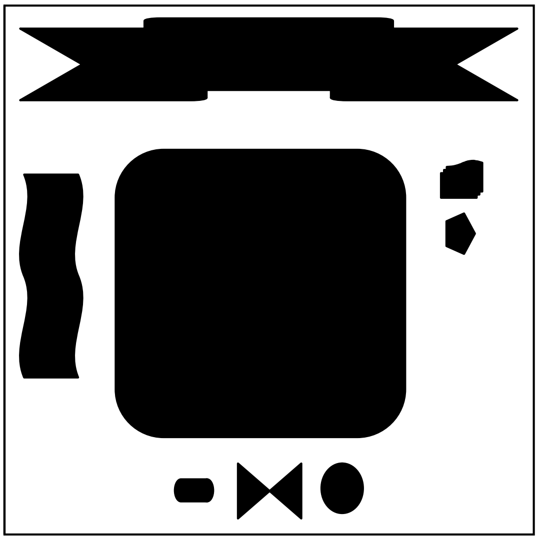
a (   )



b (   )



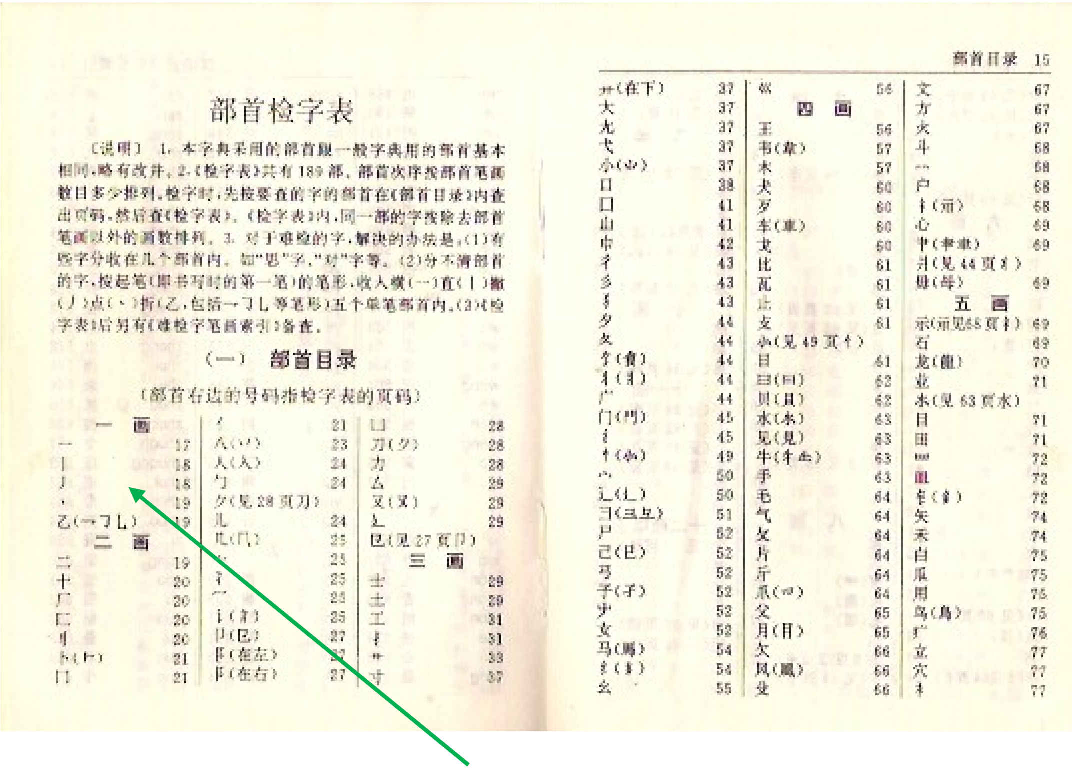
c (   )



d (   )

Appendix 5. Choose the 24 characters

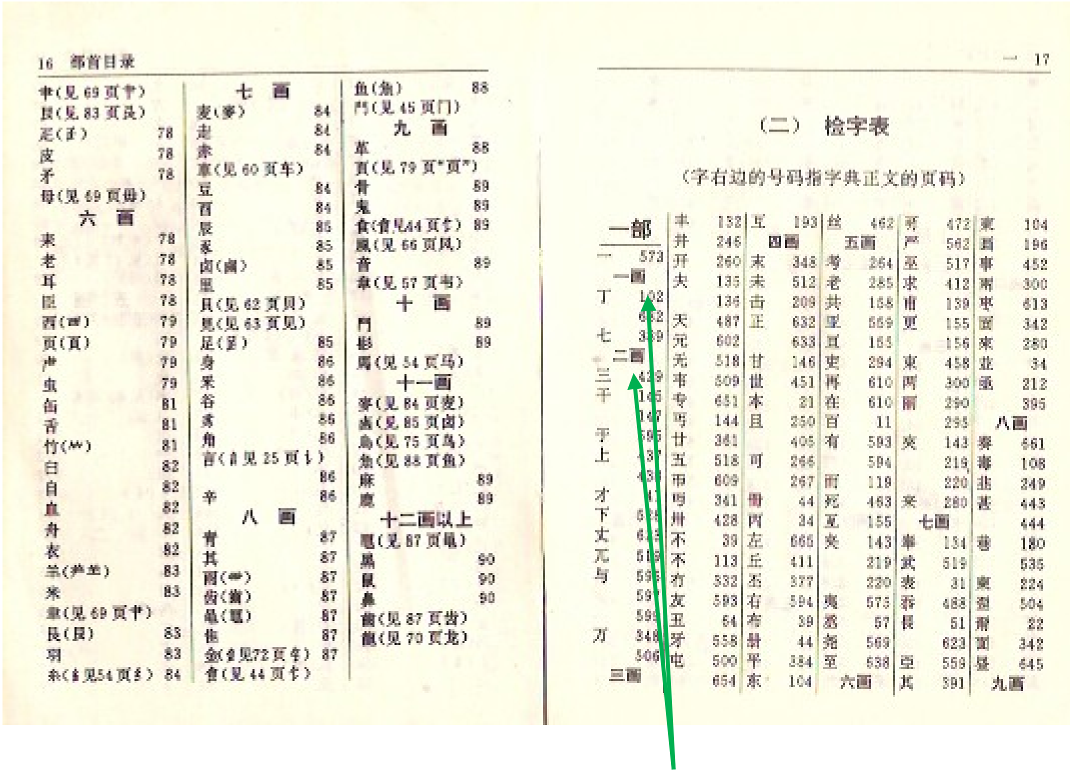
The way to look up a character in a Chinese dictionary: In Chinese dictionary, reference parts are used to look up a character. The references parts are placed on a "Radical Chart" (Appendix Figure 1). They are categorised into reference divisions based on the amount of strokes. For instance, 一丨丿乙, each of them has only one stroke, so they belong to the One Stroke Reference Division.



One stroke reference division

Appendix Figure 1 Radical chart

Each reference stroke leads to a collection of characters which are also sorted by the amount of strokes excluding the reference part (Appendix Figure 2). For example, the character 丁, excludes the reference part 一, only one stroke left, so it is in the One Stroke Sub-division; the character 三, excludes the reference part 一, only two strokes left, so it is in the Two Strokes Sub-division.



Strokes sub-divisions

Appendix Figure 2 Character reference chart

Here is full example to look up the character 开: the reference part of the character 开 (Open) is 一 which is one stroke. The first step is to go to the One Stroke Reference Division and find out the page where all the characters referenced by 一 locate. For the character 开, there are three strokes excluding reference part, so it can be found in the Three Stroke Sub-division in the collection of the characters under the division of reference part 一.

The 24 characters were chosen through the following path: chose the first unrepeated reference parts in each reference division, then chose the first character which consists of a least two parts; chose the second unrepeated reference parts in each reference division, then chose the first character which consists of a least two parts and one part consists of at least double amount of stroke as the other part. If it was unavailable in the Funder Regular Script font, then the next character was chosen. In this way, the chosen characters covered few strokes to many strokes and simple structure to complex structure. The dictionary used was a Xinhua Dictionary printed in 1998 (ISBN 7-100-02601-6).

Appendix 6. Publications Relating to this Thesis

Peer reviewed publications and international conference presentations

Xu, D. (2005). Using MCAI to arouse interest of British children of Chinese origin in learning mandarin. [利用多媒体软件激发华裔儿童学习中文的兴趣]. *Overseas Chinese Education*. 6 (1), 48-53.

Xu, D. and Nicholson, I. (2003). Multimedia software to motivate ethnic minority children to learn about their culture and language of origin. In: MacFarlane, S., Nicol, T., Read, J. and Snape, L.(eds.) *Proceedings of the 2003 conference on Interaction design and children*, Preston, England, ACM. pp.159 - 159.

Xu, D. and Nicholson, I. (2005). Harmonious screen interface design. In: Mackinnon, L., Bertelsen, O. and Bryan-Kinns, N.(eds.) *the 19th British HCI group annual conference - the bigger picture* Vol. 2, Edinburgh, British HCI group. pp.58 - 62.