Using Guidelines to assist in the Visualisation Design Process

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Abstract

The design process of any visualisation involves many design decisions. One way to assist with these design decisions is to provide guidelines. This paper introduces the MS-Guidelines and the rationale behind them. The MS-Guidelines form a group of structured guidelines intended to help in designing not just visual but also multi-sensory displays of abstract data. They are organised by using the structure and concepts of the MS-Taxonomy. This taxonomy functions as a framework that allows guidelines to be categorised at different levels of detail. High-level or general guidelines can support early design considerations. More detailed, low-level guidelines provide support for more specific design decisions. To assist the designer use the guidelines they are incorporated into a multi-sensory design process called the MS-Process. An introduction to the MS-Taxonomy and the MS-Process is provided and discussed briefly in the context of information visualisation. A summary of the MS-Guidelines for visual display design are also presented.

Keywords: Visualisation, guidelines, taxonomy.[1]

1 Introduction

Designing good visual displays of abstract data is difficult. Indeed Tufte makes this comment on the rarity of good design: "On rare occasions graphical architecture combines with the data content to yield uniquely spectacular graphics. Such performances can be described and admired but there are no principles on how to create that one wonderful graphic in a million" (Tufte 1983).

There are many ways to support better designs for information visualisation. These include provide a framework to categorise design options, providing useful guidelines and following a design process.

Firstly the designer needs a good appreciation of the possible design options. The most common frameworks used to describe the visual design space is proposed by Card and Mackinlay (Card and Mackinlay, 1997) and based on Bertin's seminal work (Bertin, 1981). An alternative framework called the MS-Taxonomy has also been developed (Nesbitt, 2003). This has the advantage over the other frameworks in that it allows design concepts to be generalised across all senses (vision, sound and touch). Thus the MS-Taxonomy is well suited to the task of designing multi-sensory displays.

Understanding the design space can afford the designer some knowledge of possible designs. However, it is also appropriate to provide more direct assistance in design decisions. One way to assist with these decisions is to provide guidelines. This paper introduces the MS-Guidelines and the rationale behind them. The MS-Guidelines is a ordered collection of guidelines intended to help in designing multi-sensory displays. Although the focus in this paper will be on the guidelines that support the information visualisation.

There are some obvious parallels with design of information display and the design of software. In the domain of software engineering the design process is often considered the creative phase of development (Pfleeger 1998, Constantine and Lockwood 1999, Humphrey 2000). This is because this phase often involves the designer making intuitive leaps towards a solution. As Humphrey notes, "design is a creative process that cannot reduced to routine procedure" (Humphrey 2000).

The design phase has also been referred to as an exercise in complex problem solving (Rumbaugh, Blaha et al. 1991, Pfleeger 1998). Pfleeger describes the design phase as "trying a little of this or that, developing and evaluating prototypes, assessing the feasibility of requirements, contrasting several designs, learning from failure, and eventually settling on a satisfactory solution to the problem at hand" (Pfleeger 1998).

This seems to describe very well the way many designers of an information visualisation work. While a framework can help with understanding the design space and guidelines can guide design decisions. A third useful tool is a process that can direct the design steps. A process imposes consistency and structure on a task and provides the following benefits (Kellner 1988):

- it enables effective communication
- it supports process evolution and improvement
- it provides a precise basis for automation
- it facilitates process reuse
- it aids process management.

All of these are arguably desirable points that could be improved in the field of information visualisation.

This paper will also briefly introduce a process called the MS-Process. This defines a series of steps that can be followed for designing both visual and multi-sensory displays. It is an iterative process and includes steps for prototyping and evaluating displays. However, the MS-Process does not aim to be prescriptive; rather, it aims to provide a flexible design path. This design path incorporates the MS-Guidelines both to assist with design decisions and to support evaluation of the display.

2 The Design Space (MS-Taxonomy)

The MS-Guidelines are organised by using the structure and concepts of the MS-Taxonomy (figure 1). In software engineering terms the MS-Taxonomy is akin to a framework (see figure 2). A framework is a generic software structure composed of general components. A framework may be used to realise specific applications (Nierstrasz and Meijler, 1995).

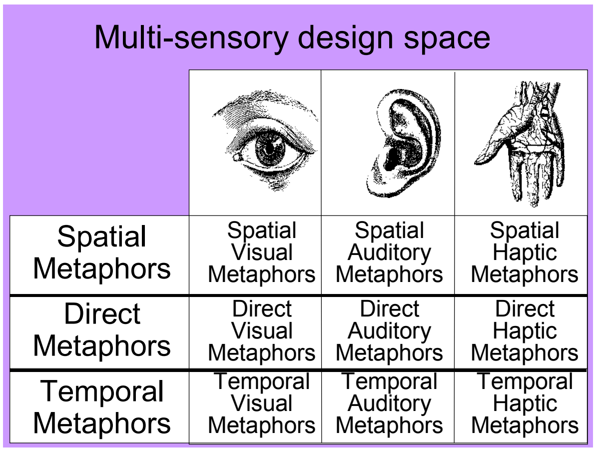

Figure 1. The MS-Taxonomy defines six main classes within the multi-sensory design space.

The MS-Taxonomy is a generic structure composed of generic design concepts and can be used to realise specific designs. As Nierstrasz and Meijler note, "an important complement to any framework consists of documentation and guidelines that aid developers to achieve a mapping from the problem domain to the abstractions provided by the framework" (Nierstrasz and Meijler, 1995). This is indeed one important aim of the MS-Guidelines. That is, to assist designers to make appropriate mappings from the abstract data domain to the artefacts of a visual, auditory or haptic display. Further validation for using this structure to organise the guidelines will be detailed later (section 4).

More detailed descriptions and discussion of the MS-Taxonomy is available elsewhere (Nesbitt, 2003). The focus in this paper is to provide a brief overview of the framework so that the structure of the MS-Guidelines is explained. There are three main groups of concepts used to provide the framework. They are "Spatial Metaphors (figure 3), Direct Metaphors (figure 4) and Temporal Metaphors (figure 5).

Spatial metaphors describe concepts that involve our perception of space. This categorisation differs from more familiar visual frameworks (Bertin, 1981, Card and Mackinlay, 1997) by emphasising display properties such as position and scale of objects. Such properties are dependent on the space in which they are sensed.

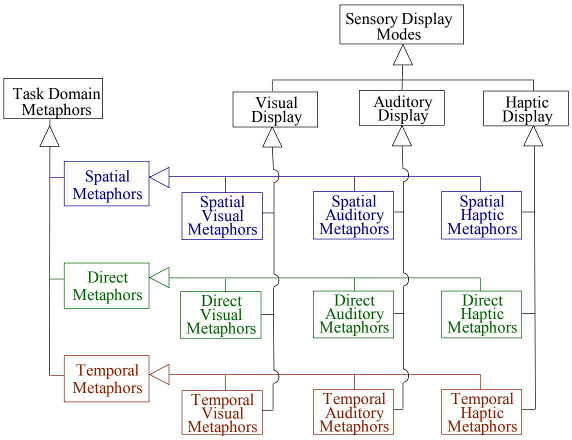

Figure 2. A UML diagram shows the high-level architecture of the MS-Taxonomy. In software terms this is a multiple inheritance hierarchy.

Direct metaphors describe concepts that explain the way our individual senses detect information. Many of the visual concepts are akin to traditional concepts described in other visualisation frameworks (Bertin, 1981), (Card and Mackinlay, 1997).

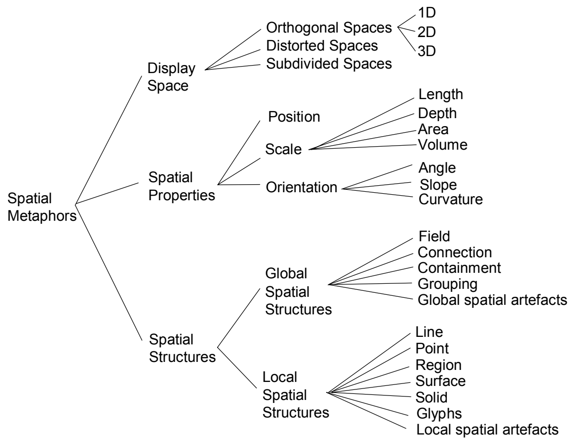

Figure 3. The general concepts that describe Spatial Metaphors. These concepts are most intuitive to vision but can still be applied to the auditory domain.

Temporal metaphors rely on our perception of events in time. Once again the traditional visualisation frameworks do not emphasis the perception of temporal elements or prefer to describe these as animation or interaction (Card Mackinlay, et. al 1999). The focus here is on how information is interpreted from changes over time.

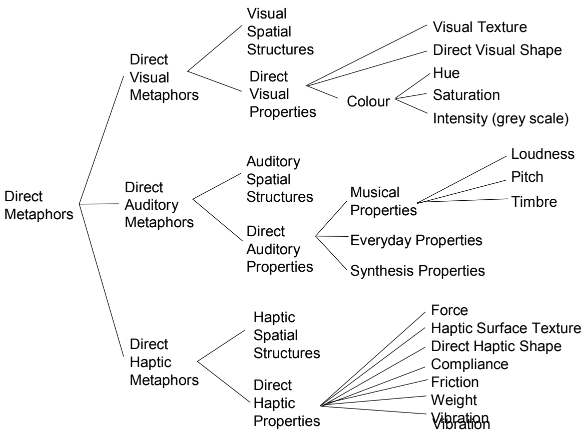

Figure 4. Concepts that describe Direct Metaphors. These concepts are unique for each sense.

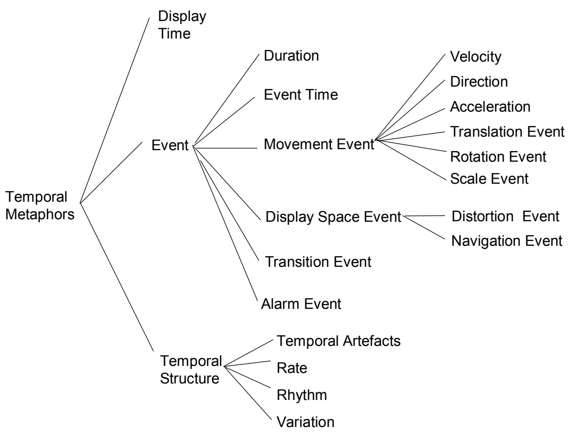

Figure 5. Concepts that describe Temporal Metaphors.

3 The Process (MS-Process)

The MS-Process, described here is based around the structure of the MS-Taxonomy. It is not intended to act as some absolute definition of how displays should be designed. Rather the intention is describe a fairly representative series of steps that can be followed to develop an information visualisation. The aim of using a process is to provide a common context for capturing experience and then passing it on to other designers.

A desirable outcome from all design is to arrive at a quality solution. Using a process as the basis for developing a quality product is the foundation of *Quality Principles* (Deming 1986, Juran and Gryna 1988). Quality principles have been formulated in a number of places. The principles are often described as TQM (total quality management) and since 1985 many manufacturing companies have adopted this approach to improving their products and services (Kan 1995). These quality concepts are also formulated in the ISO-9000 standard (Hoyle 2001). Defining and following a process is fundamental to these concepts as it allows *"us to examine, understand, control, and improve the activities that comprise the process"* (Pfleeger 1998).Given the immaturity of the field of information visualisation and the difficultly with designing good solutions the use for some process provides a pragmatic way to move forward.

The main steps of the MS-Process are (figure 6):

Step 1. Task analysis

Step 2. Data characterisation

Step 3. Display mapping

Step 4. Prototyping

Step 5. Evaluation

The first two steps are designed to understand both the application domain and specific data requirements. The design is driven from a traditional task perspective. Therefore the task for which the visualisation is being designed should be understood in as much detail as possible.

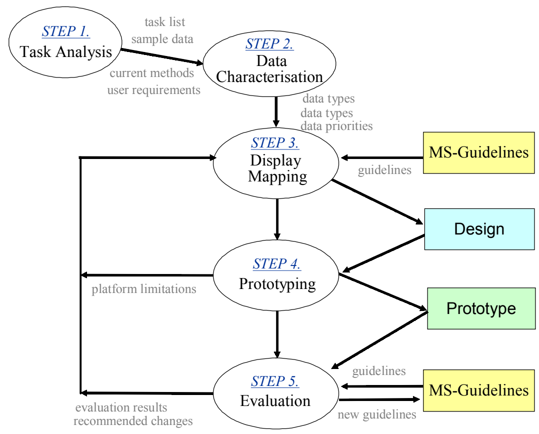

Figure 6. The steps of the MS-Process.

Entry Criteria		Exit Criteria
user goals previous work	STEP 1. Task analysis	task list sample data current methods user requirements
task list sample data current methods user requirements	STEP 2. Data characterisation	data types data priorities data sources
task list current methods user requirements data types data sources data priorities **MS-Guidelines**	STEP 3. Display mapping	design
design sample data	STEP 4. Prototyping	prototype platform limitations
prototype sample data **MS-Guidelines**	STEP 5. Evaluation	evaluation results recommended change new guidelines

Table 1. Entry and exit criteria for the MS-Process.

The last three steps are iterative. It is expected that many visits through these steps may be required to arrive at a final suitable design. The Display Mapping step focuses on describing the mapping of data attributes to display artefacts (figure 7). The prototyping step is used to develop a display to be used in the evaluation step.

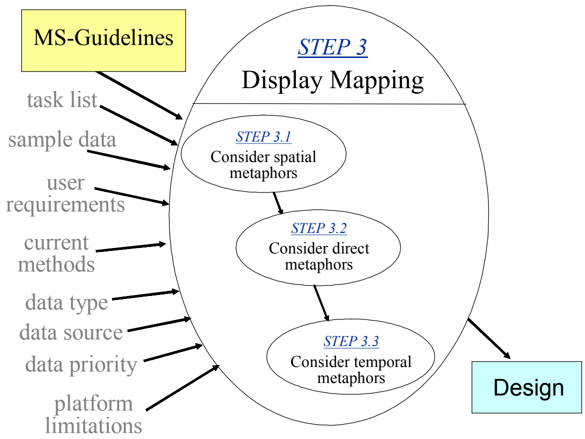

Figure 7. The Display Mapping step of the MS-Process

More detail on the MS-Process is available elsewhere (Nesbitt, 2003). The key in this context is to recognise two distinguishing features of the MS-Process. Firstly the display mapping step is structured around the MS-Taxonomy. During display mapping it is desirable to consider the full range of possibilities from the design space. By using the structure of the MS-Taxonomy and following the MS-Process the designer is directed to consider all such possibilities (figure 8). Secondly the MS-Process incorporates the MS-Guidelines at two places (Table 1). During the display mapping the guidelines help to direct design decisions (figure 7). During the evaluation step the guidelines also serve as a checklist for critical assessment of the design (figure 9).

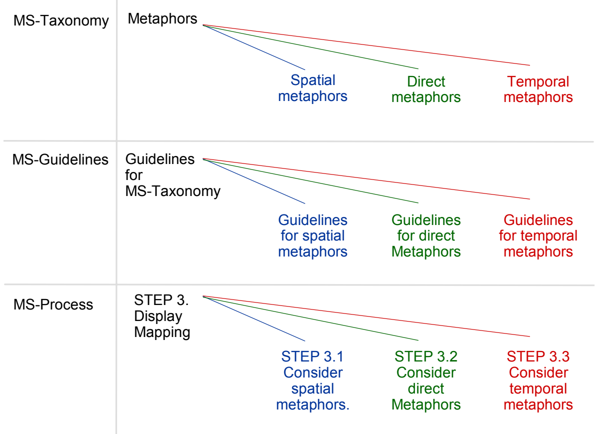

Figure 8. Demonstrating how the MS-Taxonomy is used to structure step of the MS-Process and how the MS-Guidelines also feed into this process.

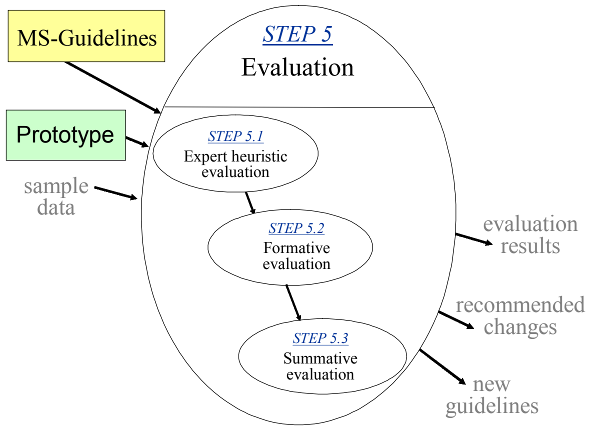

Figure 9. The Evaluation step of the MS-Process

4 The Guidelines (MS-Guidelines)

The notion of *following guidelines* is ubiquitous. For example, there are guidelines available on topics as diverse as conserving nature (Hussey 1991), manufacturing smallgoods (Zemanovic 1992), analysing hazards (NSW 1992), providing medical care (Gunn and Jackson 1991) and writing reports (Blicq 1987). There are even guidelines to assist aspiring professors (Lipstreu and Doi 1963).

There are a number of ways that guidelines can assist with the design of information displays and these include:

- guiding a process
- capturing previous experience
- providing structured knowledge
- providing both general and specific principles
- hiding complexity from the designer
- communicating good solutions
- evaluating the design

4.1 Guiding a Process

Sometimes guidelines are general, such as Johnson's guidelines for teaching mathematics (Johnson and Rising 1972). Other guidelines are more specific, such as the guidelines for dumping packages of radioactive waste at sea (OECD Nuclear Energy Agency 1979). However, in both cases the guidelines aim to assist users follow a process and to ensure the quality of the outcome (Humphrey 2000). In section 3 a process for designing multi-sensory displays was outlines. One goal of the MS-Guidelines is to assist the designer follow this process and so produce a higher quality final design.

Using guidelines to assist engineering design processes is well established. It is not uncommon to find guidelines for designing both hardware and software. There are general guidelines, such as the *"Human Engineering Design Considerations for Cathode Ray Tube-Generated Displays"* (Banks, Gertman et al.

1992). Quite specific guidelines have been developed, for example, to assist in the design of auditory alarms in the work place (ISO 1986) or for developing software for a specific computer platform (Apple 1987). Once again the motivation for providing guidelines for engineering design is to assist users follow a complex process and to try to ensure a level of quality in the outcomes.

4.2 Capturing previous experience

Designing user-interfaces is certainly a complex process and often the business success of a computer system relies on the quality of its interface. Not surprisingly, guidelines to assist in designing user interfaces are often proposed. For example, guidelines have been suggested for designing data displays (Smith and Mosier 1986), user-interfaces (Brown 1988), screen messages (Shneiderman 1982) and application screens (Galitz 1989). Shneiderman notes, *"a guidelines document can help by promoting consistency among multiple designers, recording practical experience, incorporating the results of empirical studies, and offering useful rules of thumb"* (Shneiderman 1992).

However, even the idea of guidelines to assist with the design of abstract data displays is not new. For example, a number of guidelines have been suggested for both visual display (Tufte 1983, Keller and Keller 1993) and auditory display (Kramer 1994, Patterson 1982, Deatherage 1992). Where possible the MS-Guidelines incorporates the knowledge from such existing guidelines.

To capture previous experience, objective findings and useful hints is further goal of the MS-Guidelines. Because the design of information displays encompasses a wide range of disciplines the guidelines are developed and extracted from a variety of sources. These include the fields of perceptual science, human computer interaction, information visualisation and user-interface design.

4.3 Providing structured knowledge

It is not an aim of the MS-Guidelines to propose another set of completely new guidelines. Rather the aim of the MS-Guidelines is to collect existing knowledge and order it in a useful way. This ordering is achieved by using the structure of the MS-Taxonomy (figure 10). Thus the guidelines can be indexed by the concept they are related to. For example guidelines to do with using colour are indexed under the concept of "Colour".

It is expected that knowledge in the field of abstract information display will expand over the future years. Hence it is necessary to consider that the MS-Guidelines will also expand. By using the generic structure of the MS-Taxonomy, new guidelines can always be incorporated at the appropriate level.

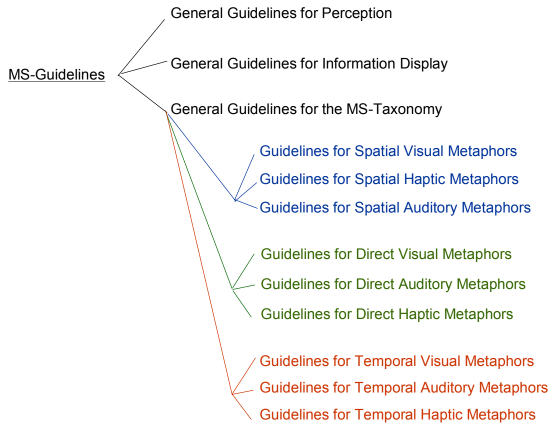

Figure 10. The top-level structure of the MS-Guidelines

4.4 Providing general and specific principles

One problem with guidelines is that they can be hard to interpret (Mahemoff and Johnston 1998). Some guidelines are very specific and detailed while others are more general and abstract in scope. Specific guidelines are precise but are usually numerous. For example, Smith and Mosier provide a very detailed list of almost 1000 guidelines for interface design (Smith and Mosier 1986). The sheer number of guidelines can make it difficult to find the right guideline for any situation. As Wright and Fields note, to be tractable, guidelines need to be relatively small and thus they tend to be general (Wright and Fields et al. 1994). So, general guidelines are often few in number but they may be so abstract that they are open to too much interpretation. For example, Tufte recommends that the display should *"focus on displaying the data"* (Tufte 1983).

However, both specific, detailed guidelines and abstract, general guidelines can be useful in design. Sometimes very specific guidelines can assist with a fine-tuning display performance, while more general principles may assist in setting the overall direction of design.

The approach of the MS-Guidelines is to use a number of levels of complexity and abstraction. These levels have already been defined within the structure of MS-Taxonomy. There are general guidelines about designing spatial visual metaphors. However, there are also more detailed guidelines for lower level concepts in the MS-Taxonomy. For example, it is known when using colour to display data that the surrounding colour can influence the perceived value (Keller and Keller 1993). By using the structure of the MS-Taxonomy the MS-Guidelines are indexed by the relevant design concept. The different levels of the MS-Taxonomy allow the designer to choose guidelines for a general display concept or guidelines that target a very specific concept. Both types of guidelines can be useful at different stages of the design.

4.5 Hiding complexity from the designer

The design of information displays is complex and this provides a further motivation for using guidelines (Wright and Fields et al. 1994). For example, Rasmussen and Vicente use a detailed model of human information processing to manage error in user inputs to software systems (Rasmussen and Vicente 1989). However, they argue that this model is too difficult for software engineers to understand. To solve this problem they simply extract from their model some human factor guidelines for the software designers to use.

The MS-Guidelines work in the same way to help hide the complexity of some domains. For example, the MS-Guidelines include findings from perceptual science. However, it is not expected that the designer needs detailed knowledge of human perception to apply the guidelines.

4.6 Communicating good solutions

User interface designers have found that some design problems often occur over and over again. When a good solution to a common problem has been devised it is desirable to reuse this solution. The issue however, often becomes how to communicate the solution amongst user interface designers. Guidelines have been suggested as a way of overcoming this communication issue (Granlund, Lafrenière et al.1999). In a emerging field of information display it is desirable that guidelines act to communicate good solutions to the common problems that arise when designing information displays.

4.7 Evaluating the design

A final motivating factor for developing guidelines is to act as a means of evaluating the process outcomes. For example, it has been found that guidelines provide a useful method for evaluating software applications (Balbo 1995) and user interfaces (Smith and Mosier 1986). In another example, Bastien and Scapin developed ergonomic criteria for evaluating software (Bastien and Scapin 1993). The MS-Guidelines provide a series of checks that can be applied wither formally or in a more ad hoc fashion to evaluate designs.

5 Example Guidelines

Currently the collection of MS-Guidelines contains over two hundred guidelines and so runs to many pages. Here we only attempt to present a summary of the guidelines that impact on visual display design. Guidelines dealing with other sense, a broader discussion of each guideline and referencing information is available elsewhere (Nesbitt, 2003).

The MS-Guidelines are structured into the main sections shown in table 2. The most general guidelines are those for perception and information display (table 3). These guidelines are not very specific but can be considered in a holistic way with all display designs. There are also guidelines need to be considered in the context of multi-sensory display design as they support decisions about which senses to use for different types of data (table 3). These guidelines may not be relevant to visual information display and are described using the concepts or terminology of the MS-Taxonomy.

Guidelines structured around the concepts of the MS-Taxonomy provide both very specific and more general support for display decisions. The aim is to abstract each guidelines to the highest level possible in the MS-Taxonomy thus making it more general. However some guidelines are very specific to a particular aspect of display. A summary of guidelines is provided for visual spatial metaphors (table 4), direct visual metaphors (table 5) and temporal visual metaphors is also provided. Further guideline for other senses are available elsewhere (Nesbitt, 2003).

General Guidelines
General Guidelines for Perception
General Guidelines for Information Display
General Guidelines for Multi-Sensory Display

MS-Taxonomy Guidelines	
	Guidelines for Spatial Metaphors
	Guidelines for Spatial Visual Metaphors *Guidelines for Spatial Auditory Metaphors* *Guidelines for Spatial Haptic Metaphors*
	Guidelines for Direct Metaphors
	Guidelines for Direct Visual Metaphors *Guidelines for Direct Auditory Metaphors* *Guidelines for Direct Haptic Metaphors*
	Guidelines for Temporal Metaphors
	Guidelines for Temporal Visual Metaphors *Guidelines for Temporal Auditory Metaphors* *Guidelines for Temporal Haptic Metaphors*

Table 2 The structure of main sections that make up the MS-Guidelines

General Perception
GP-2 Perception is approximate.
GP-3 Perception is influenced by cognitive processes. GP-3.1 Perception is influenced by expectations. GP-3.2 Perception is influenced by knowledge. GP-3.3 Perception may be influenced by recognition. GP-3.4 Perception is influenced by attention. GP-3.5 Perception is influenced by context.
GP-4 Perception remains constant.
GP-5 Perception can be biased towards one sense. GP-5.1 Attention can affect sensory bias. GP-5.2 Learning can affect sensory bias.
GP-6 Perceptual responses have thresholds. GP-6.1 Weber's Law GP-6.2 Steven's Power Law
GP-7 Perception groups small elements into larger elements.
GP-8 Seven is a magic number.

Information Display
GD-1 Emphasise the data.

GD-2 Simplify the display.
GD-3 Design for a task.
GD-4 Iterate the design process. GD-4.1 Avoid designer bias.

Multi-sensory Display
MST-1 Use each sensory modality to do what it does best. MST-1.1 Vision emphasises spatial qualities. MST-1.2 Hearing emphasises temporal qualities. MST-1.3 Haptics emphasises movement. MST-1.3.1 Point force-feedback only provides temporal information. MST-1.3.2 Tactile displays are not readily available.
MST-2 Use the spatial visual metaphor as a framework for the display.
MST-3 Increase the human-computer bandwidth. MST-3.1 Use complementary display. MST-3.2 Avoid redundant display. MST-3.3 Avoid conflicting display.
MST-4 Consider sensory substitution. MST-4.1 Adapt spatial visual metaphors to spatial auditory metaphors. MST-4.2 Adapt spatial visual metaphors to spatial haptic metaphors. MST-4.3 Adapt temporal auditory metaphors to temporal visual metaphors. MST-4.4 Adapt temporal auditory metaphors to temporal haptic metaphors.

Table 3 A summary of the general guidelines included in the MS-Taxonomy

Visual Display Space
SV-1 Visual space dominates our perception of space. SV-1.1 Vision has a wide field of view. SV-1.2 Foveal vision is detailed. SV-1.3 Peripheral vision responds to changes.
SV-2 Position in visual space is the most accurate perception. SV-2.1 For spatial location, vision dominates other senses. SV-2.1.1 Visual position dominates auditory position. SV-2.1.1 Visual position dominates proprioceptive position.
SV-3 Design visual space around the most important data variables.
SV-4 Consider Orthogonal Spaces as a first choice in design. SV-4.1 Use a 1D space where appropriate. SV-4.2 Use a 2D space where appropriate. SV-4.3 Use a 3D space where appropriate. SV-4.3.1 Virtual Environments enhance the interpretation of 3D. SV-4.3.2 Be aware of perceptual depth cues. SV-4.3.2.1 Virtual environments provide stereoscopic cues. SV-4.3.2.2 Virtual environments provide movement cues.
SV-5 Consider other uses of space in the design. SV-5.1 Distorted spaces allow for context and detail. SV-5.2 Subdividing the space may be a useful strategy.
SV-6 If time is an important variable then integrate it into the display space.
SV-7 Consider previous organisations of visual space as design options.
SV-8 Objects in visual space can be compared.

Visual Spatial Properties
SV-9 Scale of objects in space provides information. SV-9.1 Visual scale should be proportional to the abstract quantity. SV-9.1.2 Area is not an accurate representation of scale. SV-9.1.3 Minimise the number of display dimensions. SV-9.2 Labelling removes ambiguity. SV-9.3 Perceived size is constant. SV-9.4 Perceived size is affected by context. SV-9.4.1 Perceived size is affected by colour. SV-9.4.2 Perceived size is affected by perceived distance.
SV-10 Orientation of objects in space provides information. SV-10.1 Adaptation to Orientation can occur.

Visual Spatial Structures
SV-11 To represent global structure use a visual display. SV-11-1 The whole is different to the sum of its parts. SV-11-1-1 We perceive figures in front of a background. SV-11-1-2 Contrast between figure and ground causes noise. SV-11-2 Grouping principles apply to objects.
SV-12 Consider providing substructure to objects in space. SV-12-1 Object recognition may use an alphabet of basic features.

Table 4 A summary of the guidelines for Spatial Visual Metaphors

Direct Visual Metaphors
DV-1 Direct visual metaphors are the first choice for displaying categorical data.

Colour
DV-2.0 Colour aids in object searching (speed, accuracy, memorability) DV-2.1 Colour reduces search time. DV-2.2 Colour improves search accuracy.
DV-3 Colour reduces complexity by differentiating structures.
DV-4 Colour does not convey exact quantitative values. DV-4.1 Sudden colour changes are obvious.
DV-5 For ordinal data use ordered categories of colour.
DV-6 For nominal data use distinctly different colour categories. DV-6.1 Focal colours provide effective categories. DV-6.2 Non-focal colours also provide effective categories.
DV-7 Every person perceives colour differently. DV-7.1 Some people suffer from colour deficiency.
DV-8 The perceived colour is affected by its surroundings. DV-8.1 Mach bands can occur with intensity changes. DV-8.2 Colour mixing can occur.
DV-9 Looking at a single colour can cause an afterimage. DV-9.1 Chromatic adaptation affects perceived colour.
DV-10 Colour affects the perceived size of objects.
DV-11 Memory affects colour.

Hue
DV-13 Users can distinguish about 24 steps of hue.

DV-13.1 Hues are continuous without a zero.
DV-13.2 Hues provide a natural metaphor.
DV-13.3 Perceived hue is constant.

Saturation
DV-14 Users can distinguish about 5 steps of saturation.
DV-14.1 Saturation is ordered and continuous.
DV-14.2 Saturation changes can suggest subtle differences.

Colour Intensity
DV-15 Users can distinguish about 100 steps of colour intensity.
DV-15.1 Colour intensity is ordered and continuous.
DV-15.2 Colour intensity is more effective than saturation for order.
DV-15.3 Perceived colour intensity is influenced by surface shape.
DV-15.4 Perceived colour intensity is effected by perceived illumination.
DV-15.5 Perceived colour intensity remains constant.

Visual Texture
DV-16 Visual texture can be used to represent ordinal categories

Direct Visual Shape
DV-17 Direct visual shape can be used to represent nominal categories.
DV-17.1 Perceived shape is constant.
DV-17.2 Perceived shape depends on knowledge.

Table 5 A summary of guidelines for Direct Visual Metaphors

Temporal Visual Metaphors
TV-1 Use temporal visual metaphors to understand change

Movement Events
TV-2 Movement helps organise objects in the scene.
TV-3 Simple motion is perceived by default.
TV-4 Use movement to draw attention to changes.
TV-4.1 The threshold for movement is $^1/_6$ - $^1/_3$ of a degree of visual angle.
TV-4.2 Perception of movement depends on velocity and context.
TV-4.3 Vision responds to optical flow patterns.
TV-5 Movement provides spatial information.
TV-5.1 Movement provides information about shape.
TV-5.2 Movement provides information about depth.
TV-5.3 Movement provides information about form.

Alarm Events
TV-6 The visual system needs time to perceive changes.

Transition Events
TV-7 Perceptual constancy resists change.
TV-7.1 Motion is constant.
TV-8 Moving images must change constantly.

Table 6 A summary of the guidelines for Temporal Visual Metaphors

6 Conclusion

This paper has outlined a group of related tools that support the designer of information displays. The MS-Taxonomy provides a structured breakdown of the multi-sensory design space. This provides a terminology of the concepts that need to be understood for information design. The MS-Taxonomy also provides a useful structure for the MS-Process and the MS-Guidelines. The MS-Process is a flexible process that can be followed during display design. Design decisions in the process are supported by the use of the MS-Guidelines. The guidelines can also assist with evaluating and improving the design.

Evaluating the outcomes of this work is difficult become some qualitative assessment. A single detailed case study using the MS-Process, MS-Taxonomy and MS-Guidelines is available for further reference. Results from this are encouraging but further case studies needs to be completed.

The MS-Guidelines themselves are not currently complete, a shortage of useful guidelines in many areas of the design space are apparent. It is envisaged that over time further literature reviews and more directed experimental work can fill some of these gaps.

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