Chapter 7: Discussion

Many chapters of this thesis (3.1, 3.2, 4, 5 and 6) detail individual research studies, and have discussion sections of their own. However, there are general points that can be discussed in light of their combined findings. This chapter considers how such findings might inform the practice of information presentation in HTA, and suggests what possibilities the future holds for information graphics in this area of health policy research.
7.1 Overall summary of results

The narrative of this thesis is told through four separate research studies, which each inform the design and development of 10 information graphics. The journey of an information graphic from user need, through specification, development and testing is presented through example. Each of the five studies adds to the understanding of how such graphics can be created and used. Brief summaries of the most important points from the studies detailed in Chapters 3, 4, 5 and 6 are presented below.

7.1.1 Current use of information graphics

Chapter 3.1 detailed a systematic content analysis of 50 assessment reports produced for the NICE appraisal process in the UK. This revealed substantial use of information graphics, but with a limited range of techniques. The reports can only provide greyscale, static graphics, which tend to be produced in standard spreadsheet software. This should be very much generalisable to other areas of HTA.

There are commonly used techniques that have been designed specifically for the presentation of health research, such as the forest plot (Lewis & Clarke 2001). There are, however, many kinds of information graphics that cannot be created with the resources available to the technology assessment teams that produce the reports, such as Sankey diagrams, link diagrams, radar charts as well as more complex multi-dimensional and interactive information graphics.

7.1.2 Needs of decision-makers at NICE

Chapter 3.2 detailed a series of interviews, performed to assess the information needs of decision-makers at NICE, as a basis for designing new prototype graphical information presentations.

They highlighted a need for quick understanding of complex data. New information graphic techniques may be able to help to present the results of systematic reviews or mathematical modelling. This might be particularly important where multiple compounding complexities exist in reports.
Interactive, screen-based information graphics might also be useful, particularly for linking modelling with the scientific evidence. This is not a main focus of the research in this thesis, however, due to the limitations of the established media used to present research in the UK’s NICE appraisals process at the time of writing.

These needs for quick understanding of complex information may also be important in other areas of HTA, and indeed outside HTA. The provision of a quick overview of complex data is therefore the main focus of the information graphics described in this thesis.

### 7.1.3 New prototype information graphics

The remaining studies showed how information graphic techniques might be designed, developed and evaluated for use in HTA. Two of these techniques were taken from initial concept, through design, specification, development, and evaluation stages. GOfER (Graphical Overview for Evidence Reviews) is used to display an overview of the studies included of a systematic review. SOC (State Occupancy Display) is used to display the time-based outputs from a multi-state Markov model.

Either of these two information graphics could now be used in the NICE appraisal process. Subsequent to the research studies detailed here, a GOfER display was incorporated into a NICE MTA appraisal for Alzheimer’s disease drugs (Bond et al. 2010) (see Figure 7.1 – 1). This display was anecdotally a success from the perspective of peer reviewers and NICE committee members. If this technique became used often, the next stage of development for this technique would be to perform a monitoring study of the performance of the graphic in actual appraisals. This would aim to test whether the theoretical benefits of the GOfER display were being realised in practice, fulfilling the ‘monitoring’ step of David Sless’ model of communication research (Sless 2008). In the case of GOfER, this could take the form of a questionnaire for decision-makers about if and how they used the graphic in coming to their decision.

These two techniques could also be used in other situations, possibly even outside HTA. GOfER could be used anywhere where there is a need to give a quick overview of a large systematic review, particularly in situations where meta-analysis is not appropriate. SOC could be used where an understanding of the accumulation of values over time in two or more arms of a Markov model...
<table>
<thead>
<tr>
<th>author</th>
<th>location</th>
<th>no. of centres</th>
<th>design, size &amp; follow-up</th>
<th>baseline MMSE</th>
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<tr>
<td>Rogers &amp; Friedhoff</td>
<td>?</td>
<td>N = 161</td>
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<td>ADSCS-CGIC, QoL</td>
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<td>Rogers et al.</td>
<td>?</td>
<td>N = 473</td>
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<td>ADSCS-ADL, DAD, PDS</td>
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<tr>
<td>Rogers et al.</td>
<td>?</td>
<td>N = 468</td>
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<td>Burns et al.</td>
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<td>ADSCS-ADL, DAD, PDS</td>
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<td>Greenberg et al.</td>
<td>?</td>
<td>N = 60</td>
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<td>Homma et al.</td>
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<tr>
<td>Mohs et al.</td>
<td>?</td>
<td>N = 431</td>
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<td>ADSCS-ADL, DAD, PDS</td>
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**Figure 7.1 – 1**
GOFER display produced for Alzheimer’s report (Bond et al 2010)
is necessary. It could be used to help give a more precise grasp of the way a model produces an ICER of a particular magnitude.

It is likely that other techniques could be developed. Chapter 4.2 shows specifications for eight other possible techniques, and Chapter 4.3 includes initial development for three of these. However, other information design work in this area could produce more.

Generally, information graphics seem to be good at giving a general picture rather than specific data. They should not be used in place of reporting numerical values, but can certainly help to give a quick overview of important information.
7.2 General conclusions

The central research question of this thesis concerned the design, production, and use of information graphics in HTA:

*How should information graphics be designed, produced and used in health technology assessment?*

The following recommendations can now be made:

### 7.2.1 Design of information graphics in HTA

The chapters of this thesis have shown examples of many stages of the proposed design process model introduced in Chapter 2 (shown again in Figure 7.2 – 1). Chapter 3 showed two studies used as part of the needs assessment process. Chapter 4 detailed the specification of 10 information graphics, and initial development of five of these. Chapter 5 showed a comparative evaluation study, and Chapter 6 an individual one.

While Chapter 3 presents some examples of formal information needs studies, the initial stage of the design of information graphics is a complex process, which is hard to define in a simple, linear manner. The inspiration for an effective information presentation is likely to come from observations made during the production of HTA work. These might be a researcher’s frustration in trying to present the data that they collect, or the difficulties experienced by people that need to interpret and use that data. As such, the first stage in designing an information graphic is likely to be the discovery of an information communication need. This may be identified during an informal conversation, responses to conference presentations, or intentional elicitation through a research study.

The next stage in the process is to consider different ways of presenting data to meet these needs, often combining graphical, numerical, and textual information. The people responsible for presentation of HTA research data has, in the past, been the researchers that perform reviews or modelling work themselves. They have made use of the office-based software available to them to present their data, using the limited visual presentation techniques that these afford. In the future, researchers may have access to more sophisticated graphical presentation tools. However, for the development of new and/or
Figure 7.2 – 1
Design process for information graphics in HTA

INFORMATION NEEDS

SPECIFICATION

PROTOTYPE

COMPARATIVE STUDY

INDIVIDUAL STUDY

DEPLOY

MONITOR

needs research studies
informal conversations

informal advice
pilot testing

initial design work
real data incorporation

research outputs
report-specific visual information displays, researchers need to be supported by specialists in visual information presentation. Information design courses are not common, but some undergraduate graphic design courses (such as the University of Plymouth's Graphic Communication with Typography course (University of Plymouth 2010)) now feature information design modules, and the University of Reading now runs an MA in information design (University of Reading 2010). Those with background training in information design could offer specialist skills in the visual presentation of research data in HTA, or other data-heavy areas of applied research.

If separate data presentation experts are commissioned, the process of producing a new information graphic to present HTA research data would require the identified need(s) to be communicated to the graphic’s designer(s) – often in the form of a difficulty in presenting data, or in interpreting it. Different designers, or design teams, are likely to produce different designs in response to such needs. Several design writers have taken the approach of producing systems of categorising visual elements that can be used to present data (Bertin 1981; Few 2006; Ware 2004). The wide variety in these typologies show that different design writers think about the graphical presentation of information in very different ways. It is therefore likely that different designers will have different approaches to the representation of data. It is therefore essential that the designs with the strongest communicative power are chosen, and that designs are constantly questioned and updated.

A designer, once they have considered the different presentation methods that they might use, and the media available to distribute these, they should be able to produce a design specification, with the help of topic experts. These would perhaps be akin to those detailed in Chapter 4.2. Consultation with topic experts could help the designer to resolve uncertainties, choose between different options, and ensure that the designer correctly understands the information communication need. This specification should be a collaborative process, and form an agreement between the designer and the expert in question, who takes the role of the ‘client’ in the model suggested by the Design Council (2007).

After agreement on the specification, the designer can begin to iteratively produce prototype representations with real data, as recommended in (Thomas & Cook 2005). At this stage, the designer would work in close collaboration with the health research expert, adding real data as shown in Chapter 4.3. After several relatively quick initial iterations, a semi-developed prototype can then be tested with an evaluation study. The information
graphic may be designed to replace another presentation (such as numerical data tables). In this case, it can be tested against the existing presentation, with an experimental study. This will be able to show the displays’ comparative performance, as in Chapter 5. If it is a completely new representation, it can be tested alone, to make sure that the design is correctly interpreted by its intended audience, as in Chapter 6. The testing can be performed by the designer themselves, or by another researcher in consultation with the designer. This can lead to publishable research outputs at this stage, which will be of use to researchers, and potentially the wider academic research community. The data used in such publications could also be of use to the designer, telling them how their design functions under test conditions.

The research data would allow a designer to adapt their design before it is widely distributed and used. If the changes are substantial, further testing may be necessary. Once expert participants can be shown to understand the display, and agree on its usefulness, it can be deployed in a real situation. As suggested by David Sless (2008), the design can then be monitored with further research studies, which can assess whether the graphic is performing as expected in practice. These could be carried out by the designer if they have research experience, or other HTA researchers, and could potentially lead to more publishable outputs.

### 7.2.2 Production of information graphics in HTA

Once the benefits of a particular information graphic have been shown, in both experimental conditions and live use, there may be sufficient interest in the technique to begin to consider how it might be produced more widely, with the possibility of it becoming a standard visual display tool for researchers to use. There are three possible ways in which information graphics can be produced in HTA:

1) Using standard visualisation tools in spreadsheet software (current situation – suitable for HTA professionals)

2) Developing new specialist software for use by HTA professionals (such as currently used for forest plots)

3) Designing graphics on an individual basis (i.e. in collaboration with trained information design professionals)
7.2.2.1 Production with standard spreadsheet software

The technology assessment report review in Chapter 3.1 showed that this is the way that information graphics were most often produced in HTA at the time of the study, and little has changed at the time of writing this. Researchers must make the best use that they can of the standard graphing tools available in spreadsheet software such as Microsoft’s Excel or Open Office.

Using the capabilities of these tools as a starting point for what can be presented severely limits the possibilities of information presentation. It would be impossible to produce a GOFER or SOC display with the standard graphing tools available in any common spreadsheet software, and the same is true of the other graphics specified in Chapter 4. However, it is likely that such methods will continue to be used for convenience, and in some cases a simple bar chart may be all that is needed to present certain information.

Standard charts such as bar and pie charts have been subject to some research scrutiny in the past (Cleveland & McGill 1984; Elting et al. 1999; Feldman-Stewart, Brundage, & Zotov 2007). It is not impossible that new research questions can be formulated around these standard charts and graphs, but much has already been said about them, and their strengths and limitations.

7.2.2.2 Production by development of specialist software

A second way of producing information graphics is through the development of specialist software. This is the approach used to create graphical presentations such as forest plots in HTA reports. These are often produced with Excel add-ins, which augment the standard set of charts. Add-ins like this could be developed that would be able to display data in spreadsheets in particular ways, such as producing a GOFER or SOC display.

Alternatively, something like the GOFER display could be included in specialist systematic review software. A SOC display rendering system might be included in specialist modelling software, although the Markov models that are often used to inform NICE technology assessment reports tend to be developed in generic spreadsheet programs. A similar display might be included in discrete event simulation software such as Simul8 (2010), although the graphic would have to be adapted to display the results of this different kind of model.

A third specialist software option would be to produce standalone HTA visualisation software. This might allow systematic review data to be entered and viewed in various formats, before producing something like the GOFER
display. It could perhaps also import spreadsheets containing modelling data, producing outputs like \textit{soc} and others. This, of course, is the option that would require the most development work.

The process of producing add-ins or software would involve a team of programmers and testers, as in much software design, but would also need designers (as visual communication specialists) to control the appearance of the visual outputs in line with best information design practice.

Funding for such projects might come from commercial sources, if it could be demonstrated that there is a big enough potential audience to make returns possible. It should be noted that, while the original focus of these graphics was to present information in \textit{HTA}, substantial proportions of these audiences could be found in other areas of health research, or other fields entirely.

An alternative to a commercial model might be to produce open source software, perhaps as an output of a research project, which could eventually lead to methodological research outputs on the use of the software. However, the file serving costs of distributing such software, which could continue to be necessary long after the research work would be complete, do not fit well with this funding model.

\subsection*{7.2.2.3 Production by design on individual basis}

The third option for producing information graphics to display \textit{HTA} data would be to continue to use information designers to design individual information graphics, in the way that the prototypes in this thesis were created.

One advantage of this option is that each graphic produced could be changed to reflect the best method of presenting the information in question for that specific review. For example, if there were a large number of outcome measures, as in the Cochlear Implants review, the designer of the original \textit{gofer} display was able to use their design skills to show these clearly in a relatively small space. In another review, however, the area of the world might be very important, and the outcome measures less challenging to display. A skilled information designer could bring this information to the fore.

Also, in systematic reviews in \textit{HTA}, the included trials frequently do not report all their data in exactly the same way. The designer would be able to modify displays accordingly. For example, in the Alzheimer’s report \textit{gofer} graphic shown in Figure 7.1 – 1 (Bond et al. 2010), the trials included in the
review mostly reported mean age, but one reported the median. Some trials reported age range, some reported standard deviation, some reported standard error, and some reported none or all of these. While the SD values could be calculated from the SE values, the other values had to be displayed using different graphical forms. In the future, other data might emerge that would be problematic to represent in the format established by the GofEr displays produced so far.

An information designer would be able to respond to these challenges quickly, in an individual way. If software was used, a reviewer would have to request a software feature to deal with any presentation difficulty, and wait for an update to be produced by the team designing the software. In the time-pressured world of HTA research, the deadline set by the decision-making body might have passed by the time the researcher had access to a way of displaying their data.

There are also disadvantages in using a designer to produce individual representations, however. An unfamiliar graphical presentation requires a time investment on the part of the person using it for the first time. In the time-pressured world of HTA, this would have to be accounted for. However, the time-saving benefits of being able to return to a graphic at a later date may be able to outweigh this disadvantage.

Another potential disadvantage to individual production is that even if the designer makes extensive use of copy and paste to transfer numerical values into visual layout programs like Adobe’s Illustrator and InDesign, there will be an increased possibility of human error over using an automated software tool. This can be mitigated by using automated systems to transform data into the basic visual elements of a display, in a vector format, using programs like Adobe’s Flash, or the open source Processing software (Fry & Reas 2010). The raw visual elements produced by these can then be combined into a usable display with page layout software. This is the process that was used to produce the SOC display tested in Chapter 6.

This kind of semi-automation is not always appropriate. For example, it would not be worth programming an automatic system to transform 15 numerical values into a complex set of Sankey diagrams to display five trials for a GofEr display. In these situations, where copy and pasting of numerical values is necessary, the displays could be quickly checked against the raw numerical values by another researcher. For example, the nine-page GofEr display, produced for the Alzheimer’s report (Bond et al. 2010), which displayed
information on 44 trials, was checked in around an hour by a systematic reviewer. This revealed three instances of common human error, such as mistaking the order of values. This kind of checking process would be necessary whenever values are transferred from spreadsheets to visual layout software by the designer.

If information designers were used to create individual information presentations, they could be employed by several different organisations. They could be employed by the research teams that produce technology assessment reports, such as the university departments that provide assessment documents for NICE in the UK. They would then be responsible for presenting a range of data in HTA reports, across systematic reviewing and economic modelling.

Alternatively, information designers could be based centrally at decision-making bodies that commission reports. They would then be responsible for taking the raw data provided by the technology assessment teams, and displaying this to decision-makers, using a visual form, where appropriate. Lastly, the information designer could be employed by an external ‘information design company’ – closer to the design council’s preferred designer / client model (Design Council 2007).

The challenges of presenting health technology assessment are very different to those of logo or book design. Information design agencies are not common, and information designers with health specialisms even less so. To understand the challenges and complexities of the research data produced by health technology assessment, and therefore the needs of the decision-maker that commissions the assessment work, it would be better for specialist information designers to be available in-house. These designers are likely to have individual approaches to information visualisation, perhaps developing their own systems of categorising graphic techniques and information presentation elements.

### 7.2.3 Use of information graphics in HTA

Perhaps the most likely situation is that a combination of these three production methods will continue to be used, according to the complexity of the information to be presented, the available resources and skills, as well as which (or whether) tools are developed to automate the production of information graphics in HTA.
Some technology assessment reports are more straightforward than others. Those which have systematic reviews of a small number of included trials, and no complicating factors like sequential treatments or large numbers of patient subgroups, may contain a relatively small volume of data. While information graphics can still be used productively in these reports, to give decision-makers a sense of relative quantity, it may be that standard charts produced with spreadsheet software are all that is needed.

In reports with more complex systematic reviews, automated tools that produce displays like GoFéR would allow decision-makers to get a quick overview of the evidence. Likewise, when time is a key dimension of a report’s Markov modelling, an automated tool that produces something like SOC might be used. There are also likely to be other data that would benefit from presentation with a specialist graphical presentation technique, which could be produced using purpose-built software. For example, the other techniques mentioned in Chapter 4, when developed and tested, could prove useful for displaying other data.

However, there is a third level of complexity, in which individually designed information graphics would be even more beneficial than ones produced with specialist automated software. This might occur in the case of GoFer, for example, if a review had a large number of trials, multiple interventions, several subgroups, and the area of the world was a particularly important consideration. In situations like this, a well-trained and creative information designer may be able to produce the kind of graphical displays that can show the information that is needed for decision-making, even within such complex data.

The decision on which of these three methods to use for displaying data might also depend on the media available for presentation. If HTA data could be displayed using coloured, time-based or interactive media, more input from visual presentation specialists might be required.

The visual outputs from all three production methods could be thought of as information graphics that embody information communication assumptions that can be tested. However, in the first two production options, these assumptions are made in the software design, rather than as part of the individual graphics’ production process.

This means that the first two software-based options are more likely to be favoured in situations where data needs to be presented in a systematic
format in many different reports. This would only be appropriate where many different reports produce data which have similar ranges and levels of complexity.

The third method, of individual design, with customised automated elements as appropriate, will produce a larger number of testable visual presentation assumptions, leading to more research outputs. This option would therefore be the one that aligns most strongly with the needs of university-based research teams, such as those that provide technology assessment reports for NICE in the UK. In this system, as well as other HTA systems that used an individual design approach to information graphics, information design specialists would be required to produce the information graphics. However, they would have to work closely with health researchers, who would be essential to provide input in both development and evaluation of information graphics, leading to both design and research outputs.

To encourage the use of such techniques in health technology assessment, commissioning bodies should be encouraged to incorporate recommendations on the visual presentation of data in their documentation production guidelines. However, as David Sless notes, the only productive way of approaching guidelines on the use of information design is in terms of measuring visual communication. Specifying exactly which typefaces or type sizes to use limits creativity, and does not assist visual communication. Likewise, recommending specific ways of presenting information in graphical form should be avoided. However, the use of innovative visual communication methods and information design, by assessing speed, accuracy, behaviour or knowledge retention, should be encouraged.
7.3 Recommendations for future research

While each of the four studies presented in Chapters 3.1, 3.2, 5 and 6 have their own specific recommendations for future research, there are a few general comments that can be made here.

7.3.1 Developed information graphics in HTA

Graphics that have been developed to the point at which they prove useful to those testing them could be used in live situations. For example, the gofer and soc graphics could be included in reports produced for the NICE appraisal process in the UK.

The use of such graphics in live situations is likely to produce unforeseen issues, such as the quality of distribution media (printing, screen or projection), different needs of those that use the graphics, logistical or production timing problems, amongst others.

Monitoring studies will show how the information graphics are performing in practice. These could take the form of questionnaires aimed at decision-makers, or interviews with the bodies that commission technology assessment work.

7.3.2 New information graphics in HTA

There are also likely to be many other data that could be presented using information graphics in health technology assessment. Some possibilities are revealed in Chapter 4 in the other eight graphics detailed there that remain undeveloped and untested, but there will almost certainly be more. The development and testing of new information graphics should be encouraged.

The qualities of interactive and/or colour displays should not be overlooked. The two information graphics fully developed and evaluated in this thesis are suitable for inclusion in printed, monochrome reports, as this is the primary method of displaying information in the NICE appraisal process in the UK at the time of writing. However, enormous (and growing) numbers of
interactive information graphics are used in other areas, and could potentially provide benefits in HTA. Comparative studies of paper-based and interactive presentations might help to change this situation, as could comparative studies of monochrome and coloured information graphics.

Also, in response to the idea that design of information graphics is a creative process, and individual designers or design teams will produce different responses, it might be productive to test different responses to the same brief, or specification, against each other. This could take the form of testing different displays produced by different information designers or information design teams. This would enable an understanding of the effects of different visual hierarchy and/or style on the understanding of people using the graphics.

It would be interesting to test displays produced by information designers against those produced by researchers without design training. This would be similar to the comparative study of Gofér and the tabulated data in the report in Chapter 5. However, in this case the information designer had the advantage of seeing what the researcher had produced before designing their presentation.

### 7.3.3 Other audiences

Finally, the communication of information to a range of audiences is an important area to be addressed. This thesis has focussed on displaying HTA research outputs to experts in the field such as decision-makers and researchers. There is likely to be a role that information graphics can play in communicating the complex issues of health research to media organisations, the general public, and to the GPs and consultants that ultimately advise their patients on which treatments they should receive.