Chapter 6

Conclusion and critical reflection on the study

6.1 Introduction

In this chapter, the aim of the study, its purpose, design, methodology, and results and findings are summarized. The study is also evaluated in terms of its strengths and limitations and some recommendations for future research are suggested.

6.2 Summary of study

This study was conducted to investigate the effectiveness of, and differences between, visually locating symbols in alphabetically ordered layouts on the one hand and categorized layouts on the other. The participants were children at the beginning stages of acquiring literacy (Grades 1 to 3).

The 114 participants executed two computerized tests in which they were required to visually locate 36 animal symbols. The visual displays were either ordered alphabetically and colour-coded by initial letter, or arranged and colour-coded in subcategory groups. The order of presentation of the two tests was alternated. The participants also executed three computerized pre-tests before commencing the main tests. The pre-tests served to determine mouse control proficiency, basic alphabetical knowledge and ability to use the categories chosen for the tests. Data were automatically collected in a log file.

It was found that the participants located symbols faster and more accurately in a categorized layout compared to an alphabetically ordered layout, but with decreasing variation between the use of the two strategies as grade increased. However, variation in performance was found between the participants, both within the two tests as well as in the range of differences between the two tests.

It was also found that bottom-up perceptual factors influenced the participants in their rate of symbol location. Position in the display, size, colour and visual complexity were identified as bottom-up attention-drawing factors for the participants in this study while they were executing visual searches.

Young AAC users at the beginning stages of literacy acquisition may find the cognitive processing required for using alphabetically ordered displays costly for efficient use but colour-coded categorised visual displays within their categorization skills. However, the efficient use of alphabetically ordered displays increases as grade increases. Beyond Grade 3 the differences between the efficient use of these two organization methods for visual displays may no longer be significant.

Alphabetical order is a useful organizing strategy to aim for in AAC users because it can be applied across all visual displays. However, where literacy problems present in AAC users, it may be more suitable to provide message symbols organised in categorized displays.

6.3 Critical evaluation of the study

A critical evaluation of the study will be given in terms of the strengths of the study, the limitations to the study and the weaknesses of the study.

6.3.1 Strengths of the study

Strengths of the study are: (1) the cross-over counterbalance design; (2) the user-friendly computer interface; (3) appropriate materials and instruction; (4) the participants' independent control of the task; and (5) the position of the study as a bridge between visual cognitive science and AAC.

Firstly, the cross-over group design of this study added strength in terms of the validity of the results. The design sought to counterbalance the threats to the internal validity of the study caused by the interactions between aspects of the design (DePoy & Gitlin, 1994) which, in this case, was the order of presentation of the two tests. The results indicated that the ALP test took longer and was probably cognitively more demanding than the SUB test. Order of presentation was therefore indeed an important variable to consider. Statistical analysis indicated that there were no statistically significant differences between the groups in terms of order of presentation. In addition, the sample number (114) divided into two equivalent groups was large enough for the meaningful application of statistical procedures.

Secondly, the user-friendly, easily-operated computer interface was a successful method of presenting the test. All the participants were able to successfully work through the procedural aspects of the tests (even although they might not have successfully applied the available strategies for efficient search). Also, the use of computer logging allowed for objective measurement of the dependent variable.

Thirdly, the materials used and the instruction of the participants appeared well-suited to the study. The symbols used for the study were carefully selected during the development phase through pre-testing their familiarity, naming consistency, and categorization suitability for the age range of the participants. The instruction program for the participants and practice opportunities which were provided before the test to familiarize them with the two strategies of searching for symbols in a visual display appeared to be adequate and suitable. Only two participants failed to pass the pre-tests. This pre-testing of the skills required for the task also verified that the participants had the requisite skills for the task.

Fourthly, the participants could control the progress of the task. Only the time between activating the single target symbol and finding it in the visual display was measured. The time taken to activate the target symbol was not measured. This method resulted in the participants only progressing through the task if their attention was engaged, because they had to activate the next step in the procedure themselves. For methodologies where the appearance of the next target is unsolicited, unnecessary long times may have resulted before the participants reengaged their attention to the task.

Fifthly, the current study is positioned within the field of AAC, a field which has its roots in clinical and educational practice, as well as in the field of cognitive science, with its focus on theory development focus (Light & Lindsay, 1991). The study endeavoured to investigate principles of visual cognition in AAC use, thereby bringing together the disciplines of visual cognitive science and AAC. It attempted to align the task that the participants were required to do more closely to typical AAC use than typical visual search experimental tasks do. Appendix AB presents a detailed analysis indicating the similarities and differences between experimental research, typical AAC use and this study. This study is aligned with AAC graphic display usage primarily with respect to the visual characteristics of the symbols, the arrangement of the symbols within a grid, the colour cueing in the symbols and grid, the referential nature of the symbols, the use of a gloss and the direct selection of a target which remains available until located. It is, however, also aligned to experimental visual search primarily with respect to the non-contextual, non-functional use of single symbols that are exposed to the observer for a subsequent recognition match. There is very little similarity between experimental visual search research and typical AAC use, but this study has commonalities with both. This study may be useful in informing the AAC discipline concerning principles of AAC board design, as well as in informing cognitive science concerning the interaction between top-down task demands and bottom-up

influences, thereby bridging a gap between two disciplines that have seldom communicated with each other (Alant et al., 2006).

6.3.2 Limitations to this study

Limitations to this study were seen primarily in: (1) the use of a typical population during the experimental phase; (2) the non-contextual, non-functional single noun symbol use in the ALP and SUB tests; (3) the absence of practice and memory support in the test (which was a first exposure search only); (4) visual perception of the target before search; and (5) the measurement measure.

Firstly, although the use of typical participants in this study is a limitation in the applicability of the findings to the AAC population, it was considered the most appropriate methodology for this translational study where a sound understanding of the topic was required before it could be tested and analysed within an atypical population (Alant et al., 2006). In AAC it is often generally accepted to use typically developing children as a means to evaluate processes in children who do not present with confounding factors of sensorineural, cognitive, social, motor or emotional impairments (Wilkinson et al, 2006). The topic investigated in this study required this approach (Section 2.3.3 provides a more detailed discussion on this topic). Despite the acceptable practice in AAC research of using typical populations, it is acknowledged that not only are the results of this study based on the performance of typically developing children, but the literature review which supports this study is based on the performance of typical adults with intact visual systems. The study is therefore based in a population that is dissimilar to the population to which it is being applied. However, preliminary research has shown that the principles of experimental visual search may transcend across non-typical populations (Wilkinson et al., 2008).

Secondly, the use of non-contextual, non-functional use of single symbols for nouns in this study is mostly a non-typical use of AAC symbols (although people communicating with graphic symbols do sometimes use single symbols to generate messages). AAC use is by nature a purposeful, functional communication of a message which often requires a number of words of different grammatical classes strung together. Visual search performance may be different if applied to sentence generation rather than to searching for and selecting one symbol only.

Thirdly, an integral part of functional AAC use – but not required in this study – is the application of memory. Memory is required to know whether a symbol is present or absent

in a display, on which display to begin the search and where the symbol is located in the display. In typical AAC use, the user of the communication boards (displays) has usually had multiple exposures to the symbols. Memory storage of symbol location would almost certainly impact on the efficiency of performance in the visual search tasks of this study because practice may significantly reduce the demands of symbol search on working memory. In addition, this study investigated the rate and accuracy performance in first exposure to the symbols only. Search after repeat exposures may give different results. It may be that symbol categorisation variances between where users make their initial search and where they actually find them are rapidly adapted to, making subsequent searches more efficient. It may also be that the skill of searching by alphabetical order can improve rapidly with instruction and practice. It could even be that memory of symbol location is so influential that the search strategies are only minimally applied in subsequent exposures.

Fourthly, in typical AAC use, although there is visual search for each and every symbol selection, there is no prior perception of the target before a search begins. In visual search experiments, a target is presented and must then be searched for, with the perception of the target active as a mental representation. In AAC use, the target exists only as a concept in the mind of the user as a dormant mental code. In experimental visual search, as in this study, a target presented by the researcher initiates the search process. The visual perception of the target then resides in working memory, awaiting a recognition match during the search. In AAC use, the user initiates the target search on the basis of a message that needs to be communicated. A match in the visual display has to occur against a coded symbol pulled out of long-term memory storage. In typical AAC use there is no actual recognition match, so it is not a true visual search task.

And lastly, the selection time was measured in seconds, because The Grid™ software used in the study did not provide for smaller units of time. There was therefore no differentiation between selections made within 1.01 seconds or 1.99 seconds, which would have given a more detailed analysis. However, in most experimental visual search research, the response times for target locations are very quick, necessitating a measure within milliseconds, whereas in this study, with its heavy top-down demands, target selection times were generally much longer. Also, as mean times were considered in all analyses, rather than individual times, across 109 participants and 36 items, the mean times resulting from measuring in seconds could be expected to be close to the mean times resulting from measuring in milliseconds.

A weakness of this study was the integration of the pre-testing and testing and the procedural errors that resulted in some compromised data. The pre-testing and testing was conducted in the same session. The purpose of this procedure was to ease ethical considerations of not having children aware of failure to meet the selection criteria. However, this resulted in a great deal of unnecessary testing for the research team (19 additional participants), as well as unnecessary complications in the subsequent management of data. It was fortunate that the two sample groups remained balanced after the loss of participants who failed the selection criteria. Another weakness in this study was the 23.39% missing and compromised sound files required for verifying procedural integrity. The rating of the procedural integrity by an independent assessor also indicated some paraphrasing in the script while the research assistants were giving instructions to the participants. Although representing a weakness in a study, it is considered by the researcher not to have significantly influenced the results, due to the detailed and repetitive nature of the instruction.

6.4 Recommendations for further research

The results of this study revealed a variety of interesting trends, thereby raising many more questions that may be answered in subsequent research.

Application of a similar study conducted amongst children in higher grades. It could be informative to investigate if the differences between searching by alphabetical order and searching with a categorisation strategy in Grade 1 to 3 children, as noted in this study, would continue to decrease with respect to time and accuracy as grade increases. It could be that alphabetical order search may even become more efficient than categorization search as literacy competencies increase, or that individual preferences may emerge rather than strong group tendencies.

Application of a similar study conducted with people with disabilities. Although it has been shown that the principles of visual cognitive science are fairly consistent across many clinical conditions (Wilkinson et al., 2006; Hochstein et al., 2004), application of the principles of visual cognitive science to AAC user populations is still to be researched. It would be valuable to investigate to what degree the principles of visual cognitive science can be applied to these populations (Wilkinson & Jagaroo, 2004). In the case of people with cognitive disabilities it may even be that the differences in their performance on cognitive processing tasks lie more in differences in the sensory information they receive than in

cognitive mediation differences (Carlin et al, 2002). Due to the extensive language challenges often faced by young AAC users, and the meaningful nature of the symbols used in the tests, AAC user performances in alphabetic or category organised displays may appear very different compared to those described in this study with typically developing children.

A study of the impact of colour-coding on location rate and accuracy in visual search. Colour-coding was integrated with the organizational strategies of presenting the symbols in the displays in this study and therefore may have been influential on the results, although its specific influence could not be analysed separately from the influence of the layout design itself. Colour-coding is used a great deal in AAC intervention, but variably and with a paucity of research to support choices (Wilkinson, Carlin, & Jagaroo, 2006). Thistle and Wilkinson's (2009) study investigated colour-coded cell backgrounds, but there is still much to learn about their impact on visual search. Is there a difference between the impact of colour-coded cell backgrounds or colour-coded cell borders? Are brighter or more muted colour backgrounds more influential? Under what conditions are colour-codes distracting rather than helpful? How many colour groups would facilitate search, how large do they need to be and how must they be distributed to maximize visual search efficiency?

The influence of the gloss on location rate and accuracy. Future research could determine the influence of the gloss which is associated with the symbols in visual search tasks, and whether the presence of a gloss improves rate of location and accuracy.

The impact of practice on reducing location rates and increasing location accuracy. This study only investigated the impact of first exposure of a symbol on location rate and accuracy. It would also be interesting to investigate the impact of repeat exposures to reduce visual search times and increase location accuracy or to investigate how many repeat interactions on a symbol are required to approach a location rate and accuracy that no longer improves. It is important to establish whether the effect of bottom-up factors changes over time, practice, familiarity and learning (Thistle & Wilkinson, 2009). Uttal (1998) pointed out that serial processing can convert to parallel processing with increased experience, indicating the adaptability of the observer.

Can the skill of visual search be improved? In addition to visual search practice on a familiar display, research could seek to determine if there is also an impact on the skill of visual search in novel displays. Visual search performance can improve with experience (Baeck & Op de Beeck, 2010), but does practice only carry-over within a task, or across tasks as well?

The impact of individual search variables on location rate and accuracy. This study did not control for any of the search variables discussed in research question 2, yet some variables were found to have been influential on the results. Future studies might well venture to try and control for the impact of individual search variables on the process. The variable that has been investigated the most in an AAC context is colour. Size and visual complexity are variables that are well suited to further AAC symbol research, since they are characteristics of most AAC symbols and are controllable. This study indicated that they may be influential in typical AAC displays.

Do bottom-up influences increase or decrease as top-down requirements increase? This study indicated that bottom-up processes may be more influential when top-down requirements are less. Future studies could more formally determine the relationship between bottom-up influences and top-down requirements. Studies could investigate whether bottom-up influences are greater or lesser in randomly organized displays (where top-down task requirements are minimized) compared to organized displays, or in displays that have variable working memory demands.

Studies investigating the nature of mental representations. Research has not yet been able to identify the nature of mental representations of symbols, or the extent to which they are coded visually or semantically in the mind (Uttal, 1998). In AAC use, the form of the mental representations (which may vary across diagnostic populations and language development) could impact on search efficiencies. Some other methods of presenting a target symbol could be explored to add to the understanding of mental representations, such as: (1) an auditory presentation of the target symbol name, rather than a visual one (for example the word *dog* rather than the graphic). The word would have to be mentally translated from an auditory code into a visual code for a recognition match to occur; (2) an indirect prompting of the target symbol (for example a photograph of a dog, a phrase clue *The animal that barks* or a sound recording of a bark). The target would have no initial direct mental code, auditory or visual, to serve as the code for a recognition match; (3) a different visual representation to the target symbol in the display (for example the *dog* symbol used in the initial presentation is different to the one used on the display). The mental representation elicited on the initial presentation of the symbol would have to be matched against any possible representation of that symbol in the display; and (4) presentation of the target as a single symbol which has to be searched for in complex symbols (for example searching for a dog in a garden scene with a kennel and a dog beside it).

6.5 Summary

This study was designed and executed to investigate and compare the efficiency of visual search using alphabetical order and categorization search strategies in Grade 1 to 3. 114 participants executed two computerized tests. Results indicated that this age group was faster and more accurate using a categorization search strategy, but that the differences between the two tests decreased as grade increased. Perceptual features of the symbols were also found to have influenced the results. Reasons for these differences and implications of the findings for AAC use were discussed. This study, which was aligned to both experimental visual search in the field of cognitive science, as well as to the field of AAC research, fulfilled its initial objectives and revealed a number of questions for future research.