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**Self-Explanatory Objects:
An Investigation of Object-Based Help**

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Submitted for the degree of PhD. in Human-Computer Interaction,
The Open University, Milton Keynes,
December 1993.

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Self-Explanatory Objects: An Investigation of Object-Based Help

Abstract

The thesis describes an investigation of on-line help provision for computer systems that have graphical object-oriented interfaces. It concentrates on object-based help facilities and describes the development of a method for obtaining object-based help information and the identification of useful types of object-based help information. The thesis demonstrates that it is both possible and practical to obtain object-based help information from the code of an appropriately programmed main system, and it describes observational studies that showed the usefulness of some types of object-based help information.

The approach that was taken involved implementing two systems in object-oriented programming styles. Both systems have graphical object-oriented interfaces and object-based help facilities. The object-based help facilities provide information about the objects displayed by the interfaces when the display objects are indicated. The object-based help information is drawn from system objects which are coded components of the systems. This method is practical when there are one-to-one correspondences between display objects and the system objects that generate and maintain them. The term 'self-explanatory objects' denotes system objects that have been written to be used as a source of object-based help information in this way. The first system is a simple proof-of-concept prototype in the form of a noughts and crosses game.

The second system, a game of strategy called Partickles, includes both object-based and menu-based help.

The usage of Partickles' help facilities was investigated in a series of three successive studies conducted with a total of nineteen school students aged 12 to 18. Evidence from the studies has shown the usefulness of menu-based overviews and reference facilities, and of object-based help information that explains what display objects *would do* if activated in the current context. The results include suggestions for implementing help facilities based on self-explanatory objects, a set of guidelines for the provision of help in systems that have graphical object-oriented interfaces, a framework for the provision of object-based help and four types of information that can be used as a template for object-based help messages.

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Dedication

This thesis is dedicated to my mother,

Councillor Maggie Clark M.Phil,

with much love and gratitude.

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Chapter 1

Introduction

1.1 Introduction to the thesis

This thesis addresses the problem of providing suitable on-line help facilities and appropriate help information for systems that have graphical object-oriented interfaces. The aim of the thesis is to show that object-based help facilities can be suitable for systems that have graphical object-oriented interfaces, and that appropriate help information can be obtained from self-explanatory objects.

The thesis relates to three areas: graphical object-oriented interfaces, help provision and object-oriented programming. Graphical object-oriented interfaces enable human-computer interactions to be conducted through the medium of visually displayed objects. These objects show, or can be used to discover, what is happening in the interface, its structure and states, the options that are available and so on. On-line help facilities are subsidiary systems that supplement the information available from the interfaces of main systems, but it is not clear what forms of help provision are appropriate for main systems with graphical object-oriented interfaces. This is because the information supplied by graphical object-oriented interfaces may already meet many of the information requirements of users, and because users of graphical object-oriented interfaces may be accustomed to obtaining information through the observation and manipulation of display objects rather than the use of help facilities.

Object-based help is one type of help facility that may be suitable for systems that have graphical object-oriented interfaces. This type of help facility allows objects displayed by graphical object-oriented interfaces to be specified in order to obtain help information. For example, the selection of an object may produce help information about the object and/or access to further help information and facilities. Object-based help may be suitable for systems that have graphical object-oriented interfaces because it can be used to indicate the initial subjects and contexts of help enquiries in terms that are consistent with the object-orientation of graphical object-oriented interfaces, and in a manner which is consistent with the usage of graphical object-oriented interfaces.

Draper [1986] uses the term, *display objects*, to denote objects displayed by a graphical object-oriented interface, and the term, *system objects*, to refer to objects that are part of a program's code. Chapter 3 discusses the use of object-oriented programming styles to produce programs whose code contains system objects. When a system has been programmed in an object-oriented programming style its display objects can be generated and maintained by corresponding system objects and these system objects may be an appropriate source of help information regarding display objects. In this thesis, system objects that have been written to be used as a source of help information have been named, *self-explanatory objects*.

An investigation was conducted to determine whether self-explanatory objects are an appropriate source of help information for object-based help facilities, and whether object-based help is a suitable form of help facility for users of graphical object-oriented interfaces. This involved the implementation of two systems, programmed in object-oriented styles, that have graphical object-

oriented interfaces and object-based help facilities. Both systems contain self-explanatory objects which are used as a source of help information by object-based help facilities. An alternative approach to the implementation of self-explanatory objects was taken in each of the programs. In addition to its object-based help, the second program includes facilities that are extensions to object-based help, and menu-based help facilities that provide windows of general help information. A series of three studies with a total of nineteen subjects was conducted to see if these forms of help provision were used and useful. The studies showed that both the menu-based and object-based forms of help provision were used and useful, and suggested a number of conclusions regarding the suitability and appropriateness of these forms of help provision for systems that have graphical object-oriented interfaces.

1.2 The structure of the thesis

Chapter 1 introduces the thesis and outlines the approach that was taken. The problem is identified as the provision of suitable help facilities and appropriate help information for systems that have graphical object-oriented interfaces. The proposed solution involves the implementation of object-based help facilities which draw their information from self-explanatory objects. The chapter also contains simple examples of a graphical object-oriented interface and a self-explanatory object.

Chapter 2 describes the problem in more detail. It discusses issues relating to graphical object-oriented interfaces and help facilities, and outlines some of the work that has been done in these areas. The chapter also discusses the need for, and appropriateness of, help provision in systems that have graphical object-

oriented interfaces, and it considers whether object-based help facilities can meet these needs appropriately.

Chapter 3 contains details of some currently available systems that have object-based help facilities and a discussion of object-oriented programming. The discussion shows that when systems that have graphical object-oriented interfaces have been programmed in an object-oriented style it may be possible and appropriate to provide object-based help facilities that draw their information from self-explanatory objects.

Chapter 4 shows that it is possible to provide object-based help facilities that draw their information from self-explanatory objects. The chapter contains suggestions for implementing self-explanatory objects and refers to the programming of two systems: a noughts and crosses game and an original game called Partickles. Since Partickles provided the central activity in a series of studies its help facilities are described in detail in this chapter.

Chapters 5 to 9 concern the Partickles studies. Chapter 5 introduces the Partickles studies, presents overviews of the design and formats of the studies and also provides details of the subjects and sessions. The three studies - which were named the *pilot*, *core* and *video* studies - are described in Chapters 6, 7 and 8 respectively. Chapters 6, 7 and 8 describe and discuss the formats and results of each study. These chapters draw conclusions regarding the usage of the help facilities in Partickles taking the formats of the studies and the contexts of usage into consideration.

Chapter 9 summarises the results of all three studies in regard to the usage and usefulness of Partickles' help facilities. This chapter shows that it is appropriate

to provide object-based help facilities that draw their information from self-explanatory objects. The chapter also lists the main findings of the studies and discusses what has been learned in regard to the provision of help in systems that have graphical object-oriented interfaces.

Chapter 10 concludes the thesis with a summary of the work, discussions of its contributions and limitations, and suggestions for further work. The contributions described in this chapter include a set of general guidelines for the provision of help in systems that have graphical object-oriented interfaces, a framework for the provision of object-based help and a template for object-based help messages.

The appendices mainly relate to the studies and the study chapters. Appendix A includes the complete texts from the help facilities of Partickles version 3. Appendix B contains materials that were used in the studies. Appendix C provides extracts from the automatic (trace) records of three sessions which show the usage of Partickles' help facilities. Appendices D, E and F describe all the sessions individually and indicate the contexts in which Partickles' help facilities were used.

1.3 The approach

The approach that was taken was as follows:

1. Identify a potentially suitable form of help facility.
2. Investigate methods of implementing self-explanatory objects.
3. Identify some potentially appropriate help information.
4. Conduct studies to investigate the usage of this form of help provision.

Object-based help facilities were identified as being potentially suitable for systems that have graphical object-oriented interfaces. Object-based help is available in some commercially produced systems, but there has been a lack of research concerning its usefulness. The implementations described in this thesis demonstrate that object-based help can be suitable for systems that have graphical object-oriented interfaces, and the studies indicate the appropriateness of object-based help, and of alternative forms of help provision, for users of graphical object-oriented interfaces.

Two systems were implemented. The first system demonstrates that system objects can be used as a source of help information and that it is both possible and practical to access and present this information. The second system was used to explore an alternative approach to the implementation of self-explanatory objects, and it also provided the central activity in a series of three studies conducted to investigate the usage of its help facilities. The first system is a simple proof-of-concept prototype, based on a noughts and crosses (tic-tac-toe) game. The second system, Partickles, is an original game of strategy in the style of a board game. Three versions of Partickles were used in the studies.

The identification of potentially appropriate help information was an iterative process. The noughts and crosses program only supplies simple descriptive and prescriptive object-based help messages, but this was refined in Partickles - most notably with the provision of 'would do' help for the principal display objects. 'Would do' help information describes the current functionality of display objects - which is what they 'would do' next.

The main aim of the studies was to investigate whether Partickles' object-based help was used and useful. Partickles also provides menu-based help facilities

and facilities that are extensions to its object-based help, and these alternatives allowed subjects to demonstrate their preferences. The first study provided some results but was mainly used to test and refine the format of the studies. The second study provided results and raised a number of questions which were then examined in the third study. All the sessions contained an 'explore and practise' phase and a 'game playing' phase, and the domain established a general goal for sessions which was to beat the computer player. Apart from these broad constraints subjects were encouraged to demonstrate and express their preferences freely while observations were made of their progress and their usage of Partickles' help facilities. This allowed the usage of help facilities to be observed in the context of the usage of a graphical object-oriented interface, and helped to answer the question: "What sort of help provision is appropriate for a system that has a graphical object-oriented interface?" There were no set tasks that would allow the usage of help facilities to be compared on the basis of, for example, task completion time or speed of access at a keystroke level - though some experiments which involved observer interventions, changing the formats of the studies and reversioning Partickles were conducted during the studies.

The remainder of this chapter presents simplified examples of a graphical object-oriented interface and a self-explanatory object. The examples are intended to clarify these terms.

1.4 An example of a graphical object-oriented interface

The paradigmatic example of a graphical object-oriented interface is the Macintosh computer's *desktop* interface which contains pictures (icons) representing objects such as documents, folders and discs, and windows with

scroll bars and boxes for closing, zooming and sizing. Figure 1.1 shows a Macintosh-style computer interface:

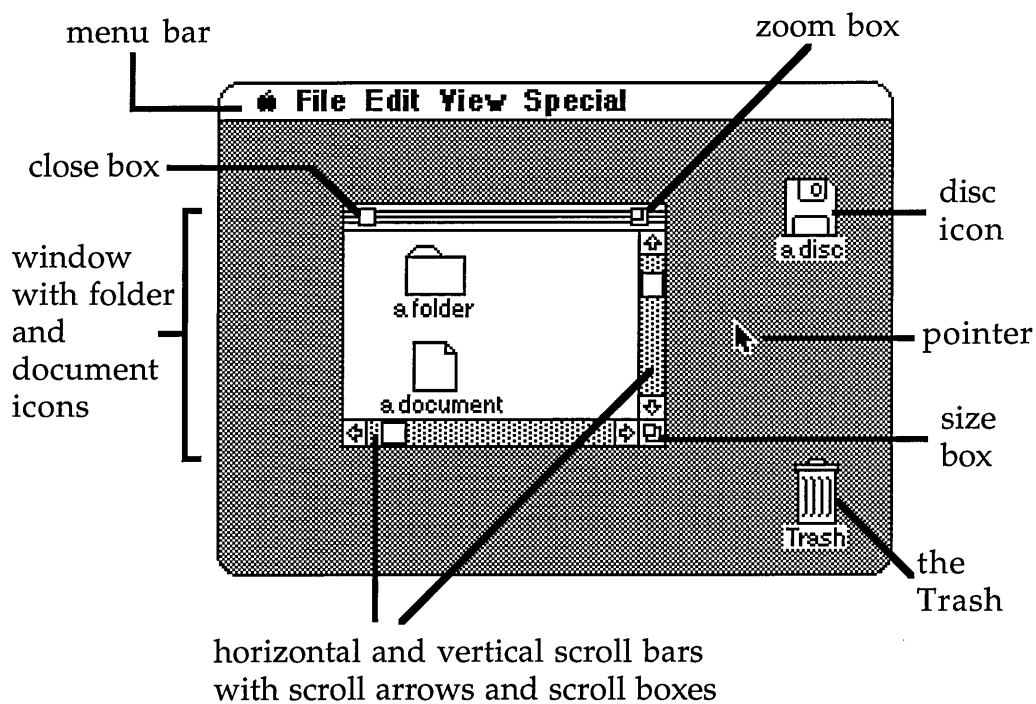


Figure 1.1 A Macintosh-style graphical object-oriented computer interface

The Macintosh desktop is an example of a WIMP interface. The term "WIMP" is an acronym listing some of the features of this sort of interface, namely: Windows, Icons, Mouse and Pull-down menus. Some types of WIMP interfaces have pop-up, instead of pull-down, menus. A mouse is one of a number of hardware devices that can be used to move a pointer around the screen and to indicate selections and issue commands with on/off buttons.

In Figure 1.1 the screen is divided into two areas: the upper menu bar with four words and an apple symbol - all of which provide access to pull-down menus - and the lower screen area (the 'desktop') which contains a number of display objects. Some of these objects are labelled, some are pictorial, some contain symbols and some (for example, the window and scroll bars) are composed of,

and/or contain, other objects. In spite of this fairly static description, graphical object-oriented interfaces of this kind are dynamic, interactive environments in which display objects fulfil the role of components in graphical dialogues. For example, double-clicking a disc icon issues the command: "open a window and display the disc's contents". Display objects may also be used without conscious attention to their role as dialogue components - a form of 'directness' in which users may feel that the display objects have replaced, or even become, the objects and operations they represent. For example, a user might tidy a window - moving, deleting and/or renaming icons - without considering that the window represents the contents of a disc which the system is updating.

Graphical object-oriented interfaces may include other information-providing features such as dialogue boxes, sound effects, error messages and history traces. Graphical object-oriented interfaces may be accompanied by facilities which are additional, optional and in many cases have their own interfaces. For example, tutorial and help facilities, and facilities for retrieving, locating and modifying information such as the Macintosh's Find File application (System 6) and spelling checkers in word processing programs. In some cases it is appropriate to distinguish between a main system with its interface and these associated systems, and consequently help facilities are sometimes referred to as "help systems".

1.5 An example of a self-explanatory object

The Macintosh-style interface shown in Figure 1.1 contains a window with a zoom box. Figure 1.2 provides an indication of some of the information and functions that could be included in the program code for a zoom box if it was implemented as a self-explanatory object:

```
name:      zoom box

data:      full_size (initially TRUE)

methods:   zoom_to_last_size
           zoom_to_full_size

code:      IF full_size (is TRUE)
           THEN zoom_to_last_size
                full_size = FALSE
           ELSE zoom_to_full_size
                full_size = TRUE
```

Figure 1.2 A simplified outline of a self-explanatory object

The pseudo-code presented in Figure 1.2 is intended to suggest the following:

.....**full_size** acts as a switch which may be either **TRUE** or **FALSE**. The first time that the zoom box object is accessed **full_size** is **TRUE** so the **zoom_to_last_size** method zooms the window to its last size and **full_size** is switched to **FALSE**. The next time that the zoom box object is accessed **full_size** is **FALSE** so the **zoom_to_full_size** method zooms the window to its full size and **full_size** is reset to **TRUE**.

The following information could be drawn from the zoom box self-explanatory object when **full_size** is **TRUE**:

drawn from a conveniently centralised source, but it could be extended to include an 'explain' method which would supply this information. Self-explanatory objects may provide an appropriate source of help information where they correspond with the display objects that users can see, where their functions correspond with the actions that users can cause them to perform and/or where they relate to concepts, processes and ideas that are recognisable and relevant to users.

1.6 Summary

This chapter has outlined the areas, aims and approach of this research. The problem that has been identified is that of providing suitable help facilities and appropriate help information for systems that have graphical object-oriented interfaces. The solution that is proposed involves the use of object-oriented programming styles to implement self-explanatory objects, and the provision of object-based help facilities that draw help information from self-explanatory objects.

The outline that has been presented in Chapter 1 is explained more fully in the chapters that follow. Chapter 2 contains further discussion of the problem and concentrates on graphical object-oriented interfaces and help facilities.

Chapter 2

The Problem

2.1 Introduction

The problem addressed in this thesis is that of providing suitable on-line help facilities and appropriate help information for systems that have graphical object-oriented interfaces. This chapter describes existing work and current issues related to graphical object-oriented interfaces and to help facilities. The chapter also considers whether users of graphical object-oriented interfaces need help, and some of the forms that this help provision might take.

2.2 Graphical object-oriented interfaces

This section illustrates one part of the problem with reference to work and issues related to graphical object-oriented interfaces. It begins with a definition of the term *graphical object-oriented interface*, then provides a short account of the origins and nature of WIMP interfaces. This is followed by discussions of issues that relate to the information provided by graphical object-oriented interfaces: the use of icons, labels and metaphors and the effect of direct manipulation. The examples of systems presented in this section concentrate on two systems that have WIMP interfaces: the Macintosh and the Star, and two systems that illustrate some of the issues described: The Alternate Reality Kit and The Rehearsal World. For completeness, brief reference is also made to visual programming, program visualisation and example-based programming and also to WYSIWYG ("What You See Is What You Get") interfaces.

The term *graphical object-oriented interfaces* has been used in this thesis to identify graphical user interfaces in which display objects are used for both input and output. Display objects (such as icons, windows and menu options) may be graphical in the sense that they are diagrammatic, tabular or pictorial, or they may simply constitute discrete screen areas - possibly differentiated from other areas by colour, borders, textual content and so on. Graphical object-oriented interfaces are object-oriented in the sense that the interfaces were conceived by their designers, and can be conceived by end-users, in terms of objects.

WIMP interfaces

An example of a Macintosh-style WIMP interface was presented in Chapter 1. The Macintosh was launched in 1984 and became the first commercially successful computer to incorporate a WIMP interface. The Xerox Corporation had marketed their Star computer three years earlier, but it was very highly priced at \$16,000. Both the Macintosh's and the Star's desktop interfaces were based on work done at the Xerox Palo Alto Research Center. Smith, Irby, Kimball & Verplank [1982] describe the development of, and principles behind, the Star user interface (which, at one point, they refer to as an "object-oriented interface"), and Palfreman & Swade's [1991] history of the development of computers and computing includes the origins of Apple Computers, who manufacture the Macintosh.

WIMP interfaces have become commonplace. Many microcomputers (such as the Commodore Amiga, the Atari ST and the Acorn Archimedes) have WIMP interfaces, Microsoft Windows is available for IBM PC computers and the Unix X-Windows system is available on a number of high-powered platforms such

as SUN and VAX computers. The features of WIMP interfaces may include: windows, scroll bars, pointers, icons and menus and the use of a mouse or comparable input device. In the Macintosh these features have become conventions which most Macintosh programs adhere to and (probably) most Macintosh users expect. The resulting uniformity across applications reduces the effort involved in learning to operate programs and transferring between programs.

Icons

When an interface is described as *iconic* the emphasis is placed on the design and interpretation of icons. O'Malley [1988] presents a detailed examination of graphical object-oriented interfaces, and iconic interfaces in particular, and she refers to experimental work done by Rogers [1988]. Some of the issues involved in the design of iconic interfaces which O'Malley discusses are: perception, representation (the use of symbols, depictions of referents, metaphors and so on), the functions of representations (such as identifying, indicating and classifying), discrimination between icons within groups and interactions involving icons.

Some of the decisions involved in the design of icons are listed below to indicate that compromises may have to be made. O'Malley makes specific reference to the trade-offs between consistency and naturalness. Such a trade-off might occur when, for example, users' expectations are derived from conflicting sources such as a metaphor and a convention. Compromises can result in situations where a second level of optional, additional information may be desirable:

- Which commands and domain elements are appropriate for iconic representation?

- What form/s should the representations take?
- Should the icon be idiosyncratic (like the Trash icon), part of a group (like Macintosh documents) and/or part of a metaphor (such as the desktop)?
- Do the icons still convey appropriate information when greyed and highlighted?
- Should the icons be labelled and if so will the labels identify the icons generically and/or individually?

Labels

Bewley, Roberts, Schroit & Verplank [1983] describe three of the many experiments conducted during the development of the Star user interface. In one of these experiments they compared four sets of icons using a number of name-to-icon matching and discrimination tests plus ratings supplied by subjects. One of the four sets of icons included labels which described the icons generically - for example: "printer", "directory" and "record". In this set icons were also labelled individually so that a label such as "Employees" could identify a member of the group of records. The tests showed that visual variety and labels were key features in the recognition of icons. The labelled set of icons was recognised more reliably than the other sets (largely because the labels identified the icons) but they took slightly longer to be recognised (possibly because subjects had more to read, but probably because this set provided the least visual variety). Labels for icons are relevant to the issue of help provision because they offer additional information in an alternative form. Bewley et al.'s conclusion was that, "once learned, there was little difference among the sets for recognition". The experiments indicated that labels can be a useful source of information while learning and this suggests

that, in some cases, they should be provided as optional, additional information for learners.

Metaphors

The Star user interface's desktop metaphor was adopted to provide a familiar conceptual model of the interface - so that users could conceive of their actions as analogous to using a desk. This model matched the intended role of the Star computer as an office information system, and it embodied a number of the design principles that were considered at the outset of the design process. These included: concreteness and visibility, seeing and pointing (instead of remembering and typing), WYSIWYG, universal commands and consistency. Smith et al. [1982] hoped the desktop metaphor would "make the electronic 'world' seem more familiar, less alien, and require less training". This suggests that analogies with 'known' concepts may be most useful during initial learning.

Direct manipulation

The term *direct manipulation* was coined by Shneiderman [1983], who identified the following characteristics of direct manipulation interfaces:

- continuous representation of object of interest
- physical actions instead of complex syntax
- reversible operations and immediate feedback.

O'Shea, O'Malley & Scanlon [1988] note that if a direct manipulation interface is designed appropriately then "the interface becomes transparent and no longer exists for the user. The (represented) world becomes, cognitively, directly present."

Hutchins, Hollan & Norman [1986] refer to direct manipulation in the following terms:

- *direct engagement* - where the user's intentions and goals can be expressed in terms of interface representations rather than through an intermediary language.
- *distance* - this is the gap between what users think and what they do and perceive. It relates to input: *the gulf of execution*, and output: *the gulf of evaluation*.
- *semantic directness* - the distance between the users' thinking and the forms of expression/interpretation.
- *articulatory directness* - the distance between the forms of expression/interpretation and what users have to do to execute a command and evaluate its execution.

The terms listed above indicate that directness is an effect experienced by users rather than a property of an interface. Nevertheless, interfaces can be designed to increase the likelihood that users will experience the effect of direct manipulation. Hutchins, Hollan & Norman [1986] mention that users can adapt their conceptualisations to make an interface more semantically direct. This indicates that interfaces designed to promote the effect of directness may be less direct for inexperienced users. Where this is the case, help facilities may reduce the time and attention spent exploring an interface by replacing experimentation with explanation, and this may assist inexperienced users to adapt their conceptualisations.

The Alternate Reality Kit

It has been suggested above that metaphors may only be useful for inexperienced users and that direct manipulation may only be direct for

experienced users. A combination of metaphor and direct manipulation might be suitable for both inexperienced and experienced users. An example of a direct manipulation system with a strong metaphor is the Alternate Reality Kit [Smith 1987]. This system, known as ARK, provides a physical world metaphor [O'Shea, O'Malley & Scanlon 1988] for a domain in which all display objects can experience forces and have a visual image, a location and a velocity. Physical laws can be represented as icons in the form of slider controls, launchers and on/off switches. The pointer is shaped like a hand which, when the mouse button is pressed, can grasp objects and operate controls. ARK allows simulated physical worlds to be created whose physical laws can be adjusted to allow comparative experimentation. A report on an experiment conducted using ARK is contained in Scanlon & Smith [1988]. Some of the switches in ARK resemble wall switches used for turning lights on and off. Verisimilitude has been achieved by depicting rectangular switch plates with bevelled edges and screw fasteners. As the ARK pointer is shaped like a hand, few users would need to learn how to operate these switches - ARK's physical world metaphor and support for direct manipulation makes this obvious. Some of the display objects in ARK have labels which can reduce the need for experimentation to discover the functionality of the interface. For example, in the case of a switch, the label may show the type of switch, "on/off", and the force it controls, "Magnetic Field" or "friction". Nevertheless, not all the objects in ARK are as comprehensible as its on/off switches. O'Malley [1988] writes, "No matter how well an iconic interface is designed, and no matter how 'direct' the interaction, there may still be circumstances where the user needs to have some sort of explanation of an object or event."

The Rehearsal World

The Rehearsal World is a system implemented by Gould & Finzer [1984]. Like the Alternate Reality Kit it was written in Smalltalk-80 - an object-oriented programming language which is discussed in Chapter 3. The Rehearsal World's help facilities are also described in Chapter 3. The Rehearsal World offers a graphical object-oriented programming environment in which, broadly speaking, objects can be described as *performers*, classes as *troupes*, the screen as a *stage*, messages as *cues*, programs as *productions* and so on. Menus are used to select troupes, performers and cues. When cues are selected performers demonstrate what they can do. Cues can be edited (by specifying parameters and writing scripts), performers can be made responsive (by becoming buttons) and performers can wait or perform backstage functions in the wings. New performers and scripts can be created by dropping through a trapdoor into Smalltalk. The Rehearsal World's theatre metaphor is extensively applied and well suited to object-orientation.

Program visualisation, visual programming and example-based programming

In the Rehearsal World, the selection of cues is a form of *programming with examples*, and the feedback provided by performers when cues are selected is a form of *program visualisation*. Both these features are also present in a system called Tinker [Lieberman 1984]. In an appendix to the Gould & Finzer paper Lieberman writes, "Tinker is similar in spirit to the Rehearsal World. Both try to make the programming process more accessible by providing immediate feedback to the programmer of each action taken."

'Visual programming' is a term applied when programs can be specified by means of graphical dialogues. National Instruments LabVIEW, which is described in Chapter 3, and Peridot [Myers 1987] are examples of systems with

visual programming environments. Lieberman [1984] warns that *programming with examples* is not the same as *programming by example* (where systems attempt to infer procedures from history traces). Visual programming, program visualisation and example-based programming are discussed by Myers [1986]. Programming with examples is a way of building a program with a kit of parts - which can match well with object-oriented environments - such as the Alternate Reality Kit. Tello [1989] comments, "In the ARK system ... a form of visual programming has been developed that allows simulated worlds with animated graphics representation to be developed and modified by a process of telling objects to 'swallow' other objects, in the sense of acquiring their methods."

WYSIWYG

The term, "WYSIWYG" relates the screen display (what you see) to printed output (what you get). The term is usually applied to text editors in which the screen display represents a sheet of paper. Smith et al. [1982] write, "The first powerful WYSIWYG editor was Bravo, an experimental editor developed for Alto at the Xerox Palo Alto Research Center... The text-editor aspects of Star were derived from Bravo". The significance of WYSIWYG is that it enables users to manipulate concrete representations and to avoid the mental computations involved in bridging the distance between the display and final output.

This section has discussed the first part of the problem. The second part concerns help facilities, and the next section considers some of the aspects of help provision and the issues that have been the subject of research into the provision of help.

2.3 Help Facilities

This section discusses some of the main types of help facility, categories of help information and issues related to the presentation of help. This is followed by an examination of help modes - which is the extent to which help facilities interrupt or run concurrently with main systems.

Types of help facility

Table 2.1, below, presents a taxonomy of types of help facility differentiated according to whether their information is presented **on-line** (by software) or **off-line** (by other means), and whether the information is **static** (its content is not changed by the help facility) or **dynamic** (the content can be constructed and/or adapted by the help facility):

off-line:	Hard-copy information such as: documentation, manuals and reference cards. Helpful human advisors (though some human help can be available on-line).
on-line/static:	On-line manuals, 'canned text' and user-editable help.
on-line/dynamic:	Modular help, context sensitive help, smart help, intelligent help and object-based help.

Table 2.1 Types of help facility

Some help researchers [such as: Houghton 1984, Duffy & Langston 1985 and Lee 1987] also consider tutorial facilities and/or error messages to be forms of help. Kearsley [1988] writes that, "Many help requests made by users (especially novices) are for information to correct errors. A well-designed help system will try to anticipate such errors and produce suitable guidance". Hildreth [1982] considers that help facilities *are* instructional facilities, but recommends

distinguishing them from intelligent help systems and error messages. The types of help facility included in Table 2.1 are described next.

Howard [1981], Borenstein [1985] and Carroll, Smith-Kerker, Ford & Mazur-Rimetz [1987] describe issues relating to writing documentation, and O'Malley, Smolensky, Bannon, Conway, Graham, Sokolov & Monty [1983] and Owen [1986] discuss the relative merits of on-line and off-line documentation. Trenner [1989] describes the EasyNet system where users can 'discuss' their queries with human helpers on-line. Bannon [1986] points out that human help is often sought in preference to on-line help. He also discusses human help available via 'hotlines' and he emphasises the value of human help obtained through social interactions.

On-line manuals are static in that they are not changed by software while the program is running (apart from, possibly, decompression or similar routines). One evocative term used to denote static, textual help information is that it consists of, "canned text". Duffy & Langston [1985] state that, "The kind of online assistance most widely available is the lower end of the continuum or static help, which in its most primitive form is simply an online manual accessible by keywords or menus", and they identify on-line manuals as being suitable for overviews and for reference, but limited in that the user cannot specify a help request or receive information relating to the current state of the user's activity. O'Malley et al. [1983] suggest user-editable, or extensible, help, "One proposal for improving both the quantity and quality of <on-line> system documentation is to transfer the bulk of this task from programmers and specialist documentation writers to the users themselves".

There are two senses in which the term 'modular help' may be used. The first relates to relatively small-scale components used to assemble/parse help messages. These modules have the advantage of reusability - for example: the text, "This is a ", need only appear in a program once, though it may be used in a variety of messages. The second way in which help can be described as modular involves larger components which may be semantically linked in a non-linear fashion in the form of a hypertext [Nelson 1981]. Hypertexts offer the opportunity for non-sequential browsing and for relating modules of information flexibly by manipulating reference pointers. The COUSIN system [Hayes & Szekely 1983] offers two types of help: a hypertext of static help frames, and dynamic frames of context sensitive help information. COUSIN's dynamic frames may include information about: the current state of the system, how it came to be in that state, what COUSIN expects the user to do next, what the user's options for action are, and links to frames within the static help hypertext.

The terms "context sensitive help", "smart help" and "intelligent help" are associated with the conditional selection/construction of help messages while a help system is active. These terms are not applied consistently in the literature, so the following descriptions are approximate. Context sensitivity relates to the state of the system at the time a help request is made and is used to select information that is relevant to the current context. Smart help is context sensitive and may be able to anticipate user requirements by making inferences based on session histories, system states and records of the preferences, actions and experience of users. Stanley [1987] writes that, "Smart help, as it is usually known, can simply be a more sophisticated version of one of the two existing approaches <on-line manuals and context-sensitive help>, but this technology also introduces the possibility of new mechanisms". Stanley describes a

prototype help system which uses artificial intelligence technology to answer, and learn answers to, user queries typed in a constrained form of natural language, but the system does not attempt to model the user's knowledge. Intelligent help systems attempt to infer the knowledge, needs and intentions of users.

The aim of the Esprit EUROHELP project (reported in: Sandberg, Breuker & Winkels [1988], Hartley & Pilkington [1987] and Hvelplund [1986]) was to establish a methodology for the provision of intelligent help systems. The project involved empirical and developmental research concerned with the production of menu-based, natural language intelligent help facilities for the Unix Vi text editor. The approach of the EUROHELP project was based on the premise that, "a help system should have the role of a human coach" [Breuker, Winkels & Sandberg 1987]. Suchman [1987] describes studies conducted with users of an intelligent help system attached to a photocopier. Her investigations concerned the mappings between the users' views of interactions and the system's representations (plans) of interactions. She observed that the system and its users did not have comparable access to the moment-by-moment contingencies that constitute the conditions of situated interaction. She points out that, "in the case of a computer-based coach the limits on the machine's access pose a difficult design problem", and refers to an example in which users selected the photocopier's help system to find out why a display had appeared. In this instance the help system provided information that explained the contents of the display rather than why the display had appeared. Suchman argues that the breakdown in communication occurred because the machine was following a predetermined plan consisting of series of steps whereas the users were responding flexibly to each new situation as they pursued their final goal.

The machine had assumed that the users were starting from scratch (a new plan) whereas they were actually attempting to continue a process (same goal). The machine could neither access nor interpret the users' perspective of their situation, and consequently it was unable to respond with an appropriate dialogue. Suchman concludes that, "there is a profound and persisting asymmetry in interaction between people and machines". Kammersgaard [1988] discusses four perspectives on the use of computers in human-computer interaction and concludes that although the dialogue partner perspective has gained widespread acceptance he finds its relevance "very limited".

An object-based help facility can be accessed by specifying objects in order to obtain help information about them. The term 'object-based help' refers to the ways in which the help facility is accessed and its information is organised. Object-based help facilities may be suitable for graphical object-oriented interfaces because both the help facilities and the interfaces are object-oriented, display objects constitute a visible 'index' of help information, and the help can be accessed in a manner that corresponds with the ways that the interfaces are used. Chapter 3 presents examples of systems that provide object-based help.

Categories of help information

The following list indicates some of the ways in which help information can be organised and indexed:

- by commands/facilities
- by display objects
- by tasks and topics
- as overviews
- by the amount/depth of explanation

- by user levels
- by problems

The list indicates the variety of types of help information. The first two categories describe the functionality of the system in terms of its components, but whereas commands and facilities usually act upon features of a domain, display objects may serve as dialogue components *and* as features of a domain. Information based on tasks and topics may relate to sequences/combinations of commands/facilities, to aspects of a domain and to the goals of users. Overviews may offer broader, more general and potentially less objective information, such as introductions, summaries and advice. The differences between descriptive and prescriptive information probably concern the style and role of the information rather than its content. Where a choice of the amount or depth of detail of help information is available (for example, a 'Short help/Long help' option) this may be based on the preferences, abilities and/or experience of users. Problems relate to goals that the user can have difficulty achieving and these may differ from error messages which relate to goals that the system cannot achieve. Information about problems - for example, 'common problems' categories, trouble-shooting advice and error messages - enable users to identify, avoid and/or deal with problems.

Duffy & Langston [1985] provide a broad definition of the purpose of a help system, "The general goal of a help system, regardless of application, should be to provide the typical user with all the information he or she needs to efficiently operate the system". Given the variety of types of help information it may be appropriate to provide several help facilities, or a help system that offers several categories of help information, to pursue this general goal. I. A. Clark [1980] presents a comprehensive list of "do's and don't's" for help

designers in which he comments that, "several separate HELPs may turn out to be unavoidable".

The presentation of help

The work described in this thesis concentrates on the choice of help facility and help information, rather than on its presentation. Nevertheless, presentation is an essential consideration in the design of help, and some of the issues that relate to this are listed in Table 2.2:

presentation of the facility:	Consistency with main interface; availability; responsiveness; ease of entry and exit; usability; use of windows, split screens, bubbles etc.; sharing/modifying the main interface.
presentation of the information:	amount, readability/accessibility, variety within and between forms of information, use of emphasis.

Table 2.2 Issues related to the presentation of help

The entries in Table 2.2 have been drawn from guidelines for the design of help presented by Trenner [1989], Kearsley [1988] and Lee [1987], and also from I. A. Clark's [1980] older, but still apposite, list of "do's and don't's". A discussion of these issues is contained in Clark [1990].

Borenstein [1986] conducted a comparative evaluation of different kinds of help system and concluded that, "Even for on-line help, good writing seems to be the most important part of helping the user, far more important than elaborate or sophisticated mechanisms". Houghton [1984] criticises help that consists of "solid blocks of text" and/or which is unnecessarily complex, while Cherry, Fryer, Steckham & Fischer [1988] suggest that condensed, sectioned and

tabular help might be more useful than narrative help. In addition to reducing and dividing help texts, the emphasis upon parts of help texts can be varied by: changes of form, highlighting, greying/shading, text styles (fonts, font sizes, capitalisation, underlining, italics etc.), the use of colours and of space. In addition to text, help information can be presented as: pictures, diagrams, tables, animation, demonstrations and simulations.

Lee [1987] describes a system called, simply, "?", whose help information is linked in a non-linear fashion by reference pointers like a hypertext, but which is not restricted to text. Lee describes "?" as a *hypermedia* system that, "makes extensive use of color bitmap graphics, movies and text highlighting to enhance visual impact". "?" is designed for use with graphical object-oriented interfaces and its default state is that of an icon which expands into a help window when the question mark key on the keyboard is pressed. "?" may, at the discretion of the main system, provide object-based help about the display object or screen area that the pointer was on at the time of the help request.

Help modes

Since help facilities are subsidiary systems, screens are of finite size and many main systems utilise the whole of a screen there is a problem with where to put help information. Another problem concerns interleaving the user/main system and user/help system interactions, particularly in regard to distinguishing help requests and help facility accesses from usage of a main system. Both problems relate to the issue of help modes - the extent to which help systems interrupt or run concurrently with main systems.

Help facilities may share a main system's interface - for example, by adding paragraphs to a scrolling window/screen of text. They may also modify the

main system's interface - for example, by highlighting or by running simulations. There may be spare space on a screen that help information can occupy, or an area that is dedicated to the display of additional information. In some cases it may be appropriate to temporarily split the screen to create an area for help. Help windows may be temporary or more permanent, and it may be possible to move them around the screen, close them and shrink them to an icon. Balloons (or bubbles) are a form of pop-up window that may convey information by the shape of their borders (which have tails for pointing at objects) and by their locations (situated next to objects of interest).

Some help facilities do not wait to be accessed. These may include help facilities that operate concurrently with their main systems, and intelligent help systems (and perhaps tutoring and error facilities) that intervene in, or interrupt, interactions. In some cases these facilities can be switched on and off. Accessing help can involve 'entering' a help mode and/or help facility before help information is obtained, or it may produce immediate help information. The help provided may be 'one-shot' (a single help message) or the start of a help dialogue or navigation of a help facility. Some forms of object-based help may allow display objects to be used for both accessing and indexing help information which means that the top level help 'menu' is permanently displayed in the form of display objects. In such cases a help mode may be invoked before the pointer is used to obtain help information, and the help mode may be indicated by a change in the pointer's shape.

Help modes are of particular relevance to the provision of object-based help in systems that have graphical object-oriented interfaces. This is partly because graphical object-oriented interfaces and windows of help information can occupy large amounts of screens. When a window of help information covers

part of a graphical object-oriented interface, the help information may relate to items hidden by the help window and it may be impossible to issue further help requests (issued by indicating/selecting display objects) if display objects are not visible. A help mode may also prevent, or alter, usage of a graphical object-oriented interface so that even if display objects are visible they may not be available for use. Help modes can interrupt the effect of direct manipulation described in section 2.2 - particularly where they contravene the "continuous representation of the object of interest" [Shneiderman 1983]. They also conflict with the goal of "modeless interaction" [Smith et al. 1982] that was pursued in the design of the Star user interface. Smith et al. comment that some of the problems associated with the use of modes in interfaces may be alleviated by providing a visible indication that a mode is active - such as by altering the shape of a pointer. Chapter 3 contains examples of systems that have object-based help facilities and describes some of the ways in which problems concerning help modes have been addressed in these systems.

2.4 Graphical object-oriented interfaces and help requirements

This section considers definitions of self-explanatory, self-explained and self-explanatory artefacts that relate to the visibility of graphical object-oriented interfaces and the extent to which these meet the information requirements of users. Some types of information that it may be appropriate to provide as help are identified, then the question of whether users of graphical object-oriented interfaces may be prepared to use help is examined. The section concludes by referring to the extensive help information provided with some currently available systems that have graphical object-oriented interfaces.

The definition of "self-explanatory" provided by Chambers English Dictionary is "*Obvious, bearing its meaning in its own face*". Since display objects in graphical object-oriented interfaces have faces (in the same sense that a playing card has a face), their graphical representations could be considered potentially self-explanatory. The visibility of a graphical object-oriented interface corresponds with the Latin origin of the word 'explain' which is: 'explanare' - to open out, spread out flat or make plain.

The Shorter Oxford English Dictionary defines "self-explained" as "*Explained by itself, understood without specific explanation*". This suggests that a graphical object-oriented interface might be considered self-explanatory if it could be understood without additional explanation. Users may be able to "understand" a graphical object-oriented interface by interpreting behaviour, representations, metaphors and labels as they use, experiment with and observe the interface - in which case it may only be appropriate to provide help as an optional alternative. Nevertheless, object-based help could be considered a way in which a display object can be *used* to obtain information about itself, particularly if the self-explanation originates from the same source as the display object rather than from an external source such as a help facility.

Suchman [1987] introduces two senses of the term "self-explanatory artifact". The first of these, "*that a self-explanatory artifact is one whose intended purpose is discoverable by the user*", is the sense in which the term "self-explanatory object" is used in this thesis. Suchman describes the second sense of the term self-explanatory artifact as follows, "*that an artifact might actually explain itself in something more like the sense that a human being does*". When this sense of the term is applied to the provision of additional

help information in computer systems it usually refers to intelligent help systems. The reason that this thesis does not pursue the intelligent help approach relates to the asymmetry between people and machines that was mentioned in section 2.3. Further discussions of fundamental problems associated with the development of intelligent computer systems are provided by Weizenbaum [1976], Winograd & Flores [1986], Dreyfus [1979] and Dreyfus & Dreyfus [1986].

O'Malley [1986] refers to, "Systems that bypass the need for formal 'help' by making the objects in the user's task environment 'visible'", but she notes that these systems may be limited in regard to the provision of information that relates to users' tasks, goals and learning requirements unless this is provided, as additional information, in the form of overviews. Overviews may be required (especially by beginners) because the information provided by graphical object-oriented interfaces is distributed - though this may be offset by the use of convention, metaphor and associations between display objects such as similarities of appearance and positional groupings. It may be appropriate to provide help information in the form of overviews for users of systems that have graphical object-oriented interfaces. It may also be appropriate to provide distributed help information to augment the distributed information provided by graphical object-oriented interfaces.

O'Malley [1986] discusses the desirability of integrating the sort of information usually supplied as overviews with direct manipulation interactions. This relates to the suitability of help facilities for systems that have graphical object-oriented interfaces. To be suitable a help facility must be used and useful, but users may prefer to maintain their direct engagement with an interface rather than seek help. Winograd & Flores

[1986] present a view that relates to the effect of directness. They refer to the work of the philosopher Martin Heidegger who argued that the separation of the perceiver from the perceived involves detached contemplation rather than concerned activity or practical involvement. Winograd & Flores state that, "Detached contemplation can be illuminating, but it also obscures the phenomena themselves by isolating and categorizing them". This view also pertains to the representations of information used by intelligent help systems since isolated and categorised representations are the only forms of information available to these systems. Winograd and Flores suggest that the use of representations is a capacity, but not the essence, of human thought which is concerned with the integration, rather than the separation, of phenomena and human experience and which relies on social contexts to give meaning to individual actions such as the use of representations.

Practical involvement may account for the effects of directness and transparency in interfaces where direct manipulation and familiarity reduce the need for detached contemplation. The amount of detached contemplation may be minimal - just sufficient to formulate and answer an enquiry - if the information is readily available. Such breakdowns in practical involvement occur naturally and frequently and may be resolved simply by glancing at another part of the interface, but where the practical involvement with an interface has not started (for beginners), or where a breakdown cannot be easily resolved by using the interface, help facilities can play a part in extending the illumination provided by detached contemplation. This accords with Winograd & Flores's recommendation that designers, "anticipate the forms of breakdown and provide a space of possibilities for action when they occur".

The time and effort required to obtain some forms of help may increase the extent of a breakdown in a direct manipulation interaction. The help information may, eventually, resolve the help enquiry that caused the breakdown, but by that time the process of obtaining help may have caused the interaction to break down completely. Overviews and navigable help facilities may be appropriate before an interaction has begun or when users have decided to interrupt an interaction, but at other times a help facility that minimises any increase in breakdowns may be more suitable. Object-based help facilities allow help to be obtained in a manner which is consistent with direct manipulation interactions, but to minimise breakdowns they also need to be quick and easy to access, use and exit.

This section has explored the question of whether users of graphical object-oriented interfaces need help. The visibility of graphical object-oriented interfaces may reduce the need for help, and the effect of direct manipulation may reduce the desire for help. Nevertheless, the extensive help facilities and documentation supplied with computers such as the Macintosh and Acorn Archimedes, and programs such as National Instruments LabVIEW and MacroMind Director (which are described in the next chapter), suggest that there is a trend toward supplying more, rather than less, help.

2.5 Summary

This chapter has concentrated on two areas of research: graphical object-oriented interfaces and help facilities. It has described some of the aspects of graphical object-oriented interfaces that provide information, such as icons, labels, metaphors and the effect of direct manipulation. The chapter has also referred to a number of issues - such as context sensitivity, modular help,

windows and hypertext - that are relevant to the provision of help in systems with graphical object-oriented interfaces.

The chapter has also considered whether object-based help facilities are potentially suitable for systems that have graphical object-oriented interfaces, and whether it may be appropriate to provide help information as overviews and as distributed information that augments the information provided by graphical object-oriented interfaces.

The problem addressed by this thesis involves the identification of a type of help facility that can be suitable, and help information that can be appropriate, for systems that have graphical object-oriented interfaces. The solution that is proposed involves the implementation and testing of object-based help facilities. The next chapter describes work related to two aspects of the proposed solution: object-based help facilities and object-oriented programming.

Chapter 3

Object-Based Help

3.1 Introduction

This chapter describes work related to object-based help facilities and to the programming of system objects. It describes a number of currently available object-based help facilities, then discusses object-oriented programming and the use of system objects as a source of help information. The next chapter will describe the implementation of two systems in which system objects are used as a source of help information.

3.2 Examples of object-based help facilities

The term *object-based help* is used here to refer to help facilities that provide information about display objects when the objects are specified. Object-based help is a way of accessing and indexing help information. Object-based help facilities interpret the selection/indication of a display object as a help request, they provide information about the object and may also provide access to more general information and other forms of help.

This section contains brief descriptions of seven systems that provide object-based help. All the systems described have WIMP interfaces. The descriptions show how the designers of these systems have addressed the problems that relate to help modes. At the end of the section the object-based help facilities are compared and discussed.

The Rehearsal World

This system was mentioned in Chapter 2. All of the help information in the Rehearsal World appears as text in a prompter's box which has a maximum message size of about five lines of ninety characters each. The prompter's box is a window that can be moved and/or erased, but it cannot be scrolled or resized. Its default position is at the centre of the bottom of the screen. In addition to displaying error messages and system status information, the prompter's box can contain what Gould & Finzer [1984] refer to as, "procedural help" and "descriptive help".

The procedural help appears when the onscreen HELP button is selected. The procedural information consists of suggestions, based on one previous activity, regarding something that the designer might like to do next, and a step-by-step guide for novices which introduces them to the mouse buttons and some of the control buttons.

The descriptive help can be edited in the prompter's box. Gould & Finzer [1984] write that:


"Almost every entity that can be seen on the screen is capable of self description. This is an important part of the Rehearsal World which makes it accessible to non-programmers. Obtaining a description of an entity is a two-step process. First one selects an entity using the Name Button of the mouse <the middle button of a three-button mouse>; this produces a text cursor <editable text box> showing an appropriate name. This name constitutes a small amount of descriptive help in itself. Further, if this name is then pasted <in> a help area, either in the prompter's box or in the HELP button of the control panel, the prompter's box will fill with text describing that entity."


The Rehearsal World is a programming environment, and its help facilities are intended for program designers rather than users of the programs/productions created in the Rehearsal World. Help requests can be interleaved with other actions and requested in a manner which is consistent with other actions. The design environment permits several windows to be displayed without overlapping (the screen has approximately 1000 x 800 pixels). Also, the HELP button is permanently displayed during designing and can be used to retrieve the prompter's box if it has been erased.

National Instruments LabVIEW

LabVIEW is a graphical programming system, and the version described here runs on the Macintosh. LabVIEW allows devices - such as thermocouples, multimeters and waveform generators - to be controlled, monitored and simulated. These devices are referred to as "instruments" in LabVIEW.

LabVIEW's help provision includes:

- A pointer shaped like a magnifying glass which can be used to select display objects and obtain information about them, related information and access to LabVIEW's navigable help facility.
- An alternative means of accessing LabVIEW's navigable help facility: via a "Help" option available from the "About LabVIEW" option in the  menu in the Macintosh menu bar.
- An 'Instrument Information' box for each instrument which provides: the instrument's filename, a user-editable description of the instrument and, if appropriate, information concerning faults.

The help provision described above is shown in Figures 3.1, 3.2 and 3.3. Other sources of information in LabVIEW include: its visually descriptive, object-oriented, direct manipulation interface; icons; hard copy documentation; error messages; and experimentation which can be undone with LabVIEW's undo and revert facilities. Figure 3.1 shows some of the initial help information presented by LabVIEW's help facility when the Help option is selected from the  menu:

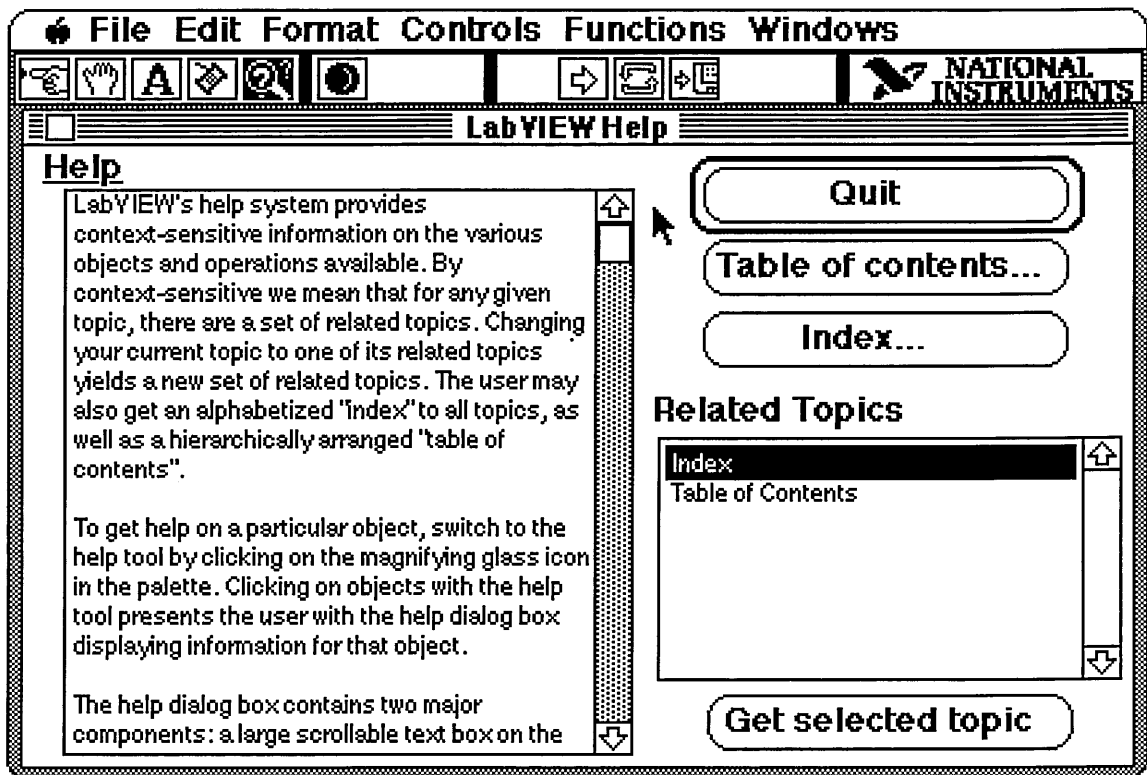


Figure 3.1 LabVIEW's help facility showing information about Help

In Figure 3.1 the white arrow with a black border situated beneath the "Fu" of the **Functions** menu option is the Go Button. When an instrument is functioning, the Go Button is replaced by an Active Instrument icon which depicts a black, 'active' arrow facing right. A third form of the icon shows the arrow torn in two - depicting a Broken Instrument. These three forms are an example of icons used to represent changed states and functionality. The Go Button icon indicates that an instrument is not operating and can be used to

start the instrument operating, the Active Instrument icon indicates that an instrument is operating and can be used to stop the instrument operating, and the Broken Instrument icon indicates that the instrument is non-operational. Figure 3.2, below, shows the help display that is presented when the magnifying glass pointer has been used to select the Active Instrument icon:

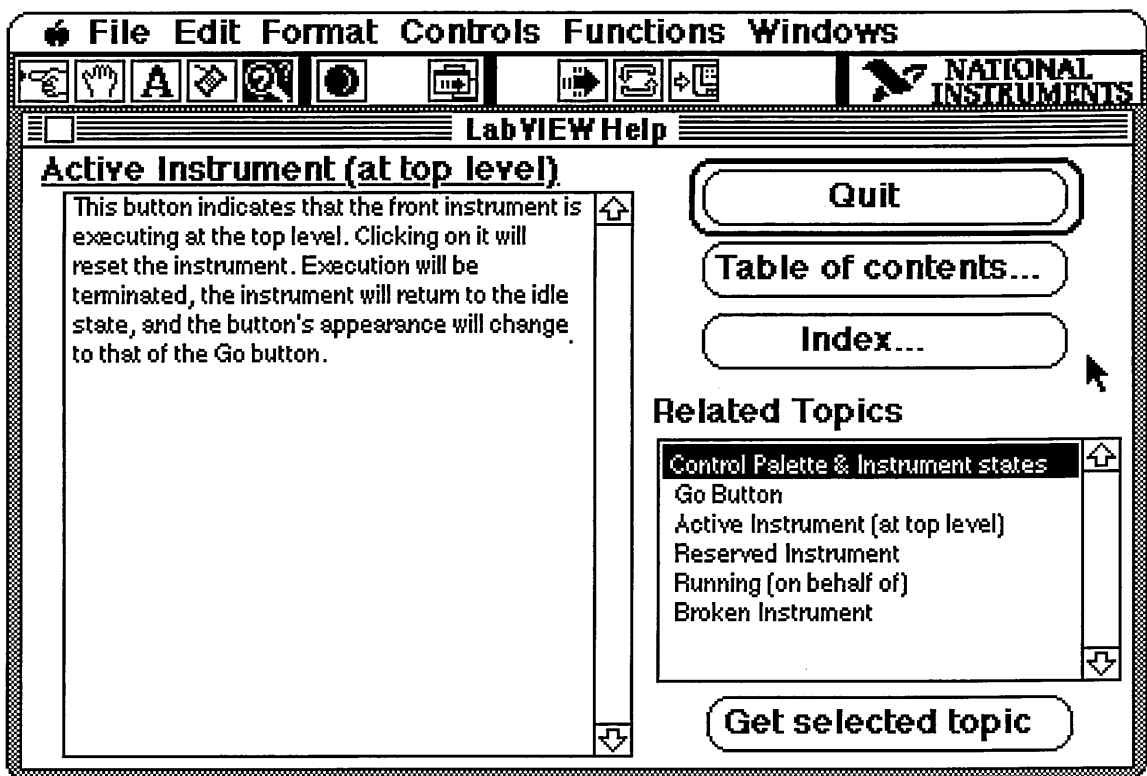


Figure 3.2 Object-based help regarding LabVIEW's 'Active Instrument' icon

The magnifying glass pointer is described in the help information as the "help tool", and its icon is situated in the "palette" beneath the "F" of the **Format** menu option. The procedure for obtaining object-based help in LabVIEW involves using the magnifying glass pointer to select a display object. This accesses the LabVIEW help facility shown in Figures 3.1 and 3.2 - but the information initially presented concerns the selected display object. A list of topics related to the selected display object may also be supplied. This flexibility has been achieved by indexing the help information in three ways:

sequentially, by display objects and as a hypertext of topics related to display objects.

Once the magnifying glass icon has been used to select a display object and the help facility has been accessed, the pointer reverts to the arrow shape. The help facility would have to be closed and the magnifying glass icon reselected before further object-based help could be accessed. The magnifying glass pointer places the system in a help mode which is ended by completing the help enquiry or changing pointer. Instruments cease functioning while the help facility is active. One of the limitations of LabVIEW's help facility is that its information consists entirely of text. Object-based help can be used to match display objects with their names and textual descriptions, but the reference to the "Go button" in Figure 3.2, and other textual references to graphical features contained in the help facility, may not be clear.

Each LabVIEW instrument has a 'front panel' which can display controls, inputs, outputs and other features of its functionality. The functions of an instrument are determined by its 'block diagram' which shows component instruments, linkages, program control structures and so on. Instruments are represented as icons in block diagrams, and visual programming in LabVIEW is achieved by creating and editing block diagrams. Every LabVIEW instrument has an associated 'Instrument Information' box which can be accessed by opening the instrument's front panel and selecting 'Get Info' from the File menu in the Macintosh menu bar. Instrument Information boxes could be considered a second form of object-based help in LabVIEW, but, unlike the main help facility, Instrument Information boxes contain descriptions of instruments that are user-editable - by users who have constructed/programmed their own instruments. Instrument Information boxes can be

obtained without interrupting an instrument that is functioning (though they may interrupt users by obscuring part of the screen), and they can also contain information about faults in the instrument. Figure 3.3 shows an Instrument Information box which describes a Waveform Calculator. The description which begins, "Computes waveforms and displays them...", in the central box is user-editable. The Instrument Information box contains information about a fault in the instrument (two components had not been linked with a wire), and was presented as an error message after an attempt had been made to start a broken instrument:

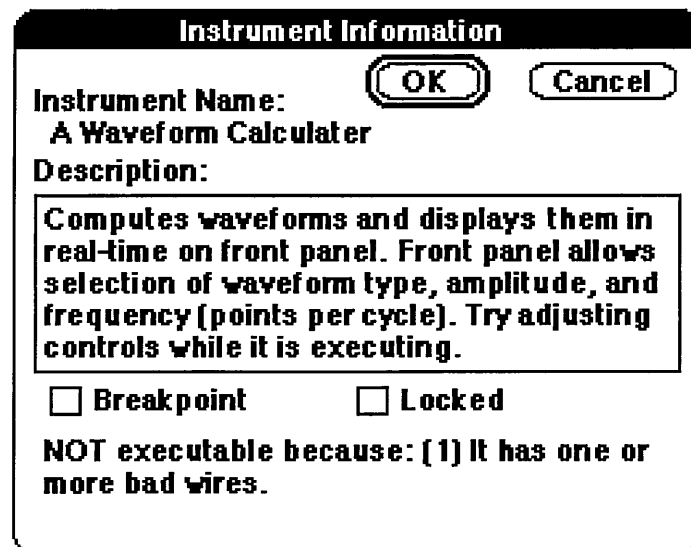



Figure 3.3 Editable help + error message for a LabVIEW instrument

Microsoft Word 4

Microsoft Word 4 is a word processing program, and the version described here runs on the Macintosh. Its help provision includes:

1. A main help facility in the form of an on-line manual that describes topics. The topics consist of mixed task and command related information. Users can browse through the manual sequentially or select from its alphabetically arranged index. The help facility is accessed via a Help button in the "About Microsoft Word" dialogue box which can be

obtained from the  menu in the Macintosh menu bar and via a Help option in the **Window** menu in the menu bar.

2. A context sensitive help facility obtained by pressing the command and question mark keys simultaneously (or the help key on an extended keyboard). The facility is used to access the main help facility - but it opens the main help facility's online manual at an appropriate page rather than merely presenting its index. This facility presents object-based help in one of two ways when the command + question mark keys (or help key) are (is) pressed:

- i) If a dialogue box is open the main help facility is accessed immediately and the topic that is presented relates to the open dialogue box.

- ii) If a dialogue box is not open the pointer's shape changes to that of a question mark. When the question mark pointer is used to select a menu option or a Microsoft Word 4 window the main help facility is accessed and the topic that is presented relates to the menu option or to windows generally.

The context sensitive help facility also supplies information concerning commands such as "Tab" and "Backspace" if these command keys are pressed when the question mark pointer is current.

3. Individual help facilities for some menu options. For example, a window of help information is available for both Microsoft Word 4's and the Macintosh desktop's Print commands. Microsoft Word 4 also has a facility for customising its menu options. This facility is presented in a dialogue box which lists all the menu options that are available and provides several controls including a Help button. The Help button can be used to obtain a brief description of each of the listed menu options.

The information in Microsoft Word 4's main help facility has been indexed by topics (in the main index) and by menu options (for context sensitive help). This is simpler than the arrangement of information in LabVIEW's main help facility, but a great deal of Microsoft Word 4's related information appears together in one topic and its scrollable texts are generally longer than LabVIEW's. Microsoft Word 4's main help facility also presents page numbers as pointers to further related information in the 'Reference to Microsoft Word' hard copy manual.

The context sensitive help facility in Microsoft Word 4 only supplies object-based help information for dialogue boxes, menu options and windows. It does not supply object-based help for all individual display objects. Selecting a zoom box (for example) with the question mark pointer produces help information about windows. This information includes a brief description of the location and function of zoom boxes, but it does not include a graphical representation of a zoom box. The question mark pointer creates a help mode which prevents menu options being used to issue commands, but the pointer reverts to its usual arrow/caret form after the help facility has been accessed and closed.

Macintosh system software version 7

The Macintosh desktop running under version 7 of the system software has two forms of object-based help: the Get Info facility (which was also available in previous versions of the desktop), and Balloon Help (new to system 7).

When desktop files, folders, applications and the Trash have been selected the 'Get Info' command in the **File** menu becomes available. This command can also be issued by pressing the command and "I" keys simultaneously. The Get Info command produces a window of help information, as Figure 3.4 shows:

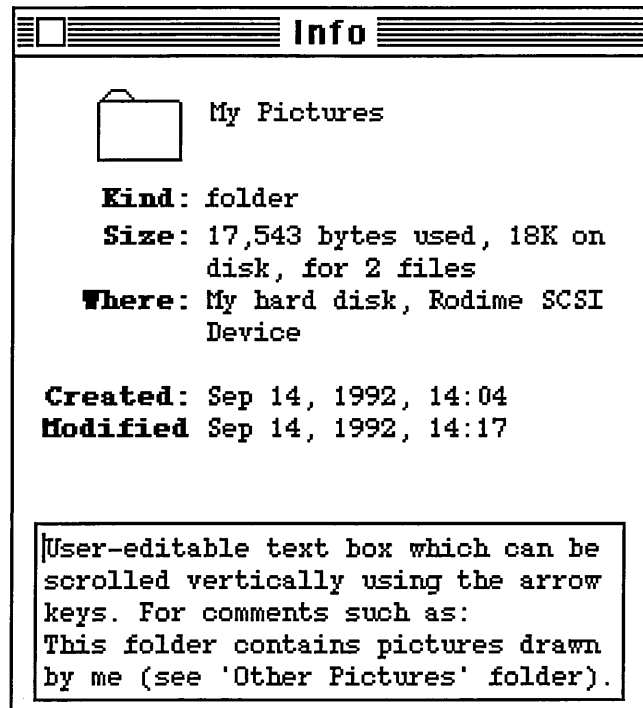


Figure 3.4 An Info window from the Get Info facility

Most of the desktop's Info windows have a user-editable text area, and this allows users to customise their files and/or provide information for other users - though few Macintosh applications seem to have taken advantage of this facility. Microsoft Word 4 is an exception, and most of the files supplied with Word 4 provide brief, descriptive information in the editable sections of their Info windows. For example, the Info window for the Microsoft Word 4 folder, "Getting Started Documents", contains the text, "Introductory documents described in the book 'Getting Started and Learning Word'."

Version 7 of the Macintosh system software provides a second form of object-based help for the desktop - its 'Balloon Help' facility. This facility can be switched on and off from a Balloon Help menu in, and towards the right of, the Macintosh menu bar. The menu's presence is indicated by an icon which shows a balloon shape containing a question mark. When it is on, the facility provides information about the display objects in the desktop whenever the

arrow pointer is placed over them; the instruction for using Balloon Help is, "point to items on the screen to see help balloons about them". Usage of the facility does not involve a help mode, and, since the balloons are of limited size, their presentation does not obscure much of the screen. Nevertheless, when the pointer is moved for a distance across a variety of display objects the flickering of balloons appearing and disappearing may be distracting. An example of Balloon Help information obtained for a zoom box is shown in Figure 3.5:

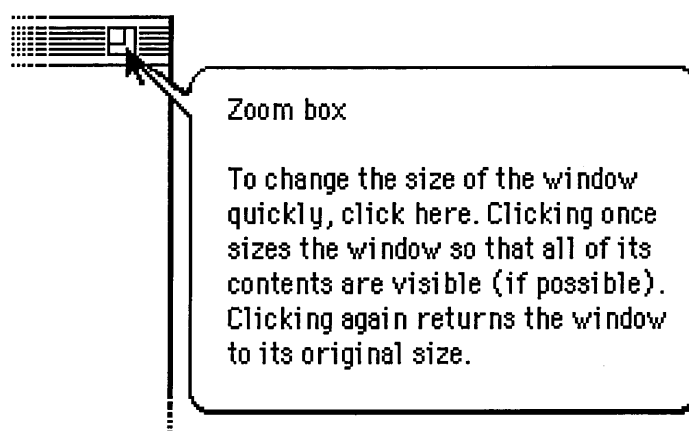


Figure 3.5 Balloon help for a zoom box

All display objects on the desktop can be described by Balloon Help, including menus and menu options. Applications may provide specific information for the Balloon Help facility (which is a Macintosh 'resource') to put in its balloons. The Balloon Help facility offers some context sensitivity - for example, "The Trash is bulging because there is something in it". Its main use is probably to acquaint beginners who are not familiar with WIMP systems with the features of the desktop, and to explain breakdowns such as the non-availability of options.

Acorn !Help and Color MacCheese


Like the Balloon Help in Macintosh System 7, both of these systems provide object-based help when the pointer passes over display objects. Acorn !Help is a utility supplied with the Acorn Archimedes computer, and Color MacCheese is a graphics editor program for the Macintosh. In both systems help information appears in a rectangular text window that can be moved and closed. The Acorn !Help window can also be sized, scrolled and collapsed to an icon, whereas the MacCheese help window has a fixed size of approximately six lines of forty-five characters per line and is available as a menu option.

Neither Acorn !Help nor the MacCheese object-based help facility interrupts the use or functioning of other programs/facilities. In the case of Macintosh System 7's Balloon Help, Acorn !Help and MacCheese the object-based help facility remains active until it is switched off, whereas in LabVIEW and Word 4 the object-based help facility has to be reselected for each new help enquiry. The option to have help windows that remain onscreen avoids the problem of balloons flickering on and off, but it does not place the information close to the point of interest as balloons do.

Acorn !Help can provide information about the Archimedes desktop and *any* application that supplies information in an appropriate form - such as the Acorn !Paint program. Acorn !Help can do this because the Archimedes, unlike the Macintosh, allows several programs to run simultaneously. The object-based help facility in MacCheese operates within one application, and is particularly useful for identifying the large number of editing tools available in the program. It can also supply information regarding menu options and open dialogue boxes. Some of MacCheese's help information is context sensitive -

for example, "Zoom Box - Click here to zoom the window to its maximum size", and, "Zoom Box - Click here to restore the window to its original size".

MacroMind Director

This is a program for creating animated displays and multimedia presentations. The version described here is version 0.93 for the Macintosh. MacroMind Director's help facility consists of a help window which can be accessed by a "Help..." command in the Macintosh's  menu or by selecting display objects, including menu options, with a question mark pointer. MacroMind have named their object-based help facility *object sensitive* help.


MacroMind Director's help information is divided into pages, and the pages are user-editable. There are three categories of pages: General, Windows and Lingo - though all three are part of a single, sequential database. The first General page, which is presented when the Help... command is selected from the  menu, contains information about the help system, while the other General pages contain information about keyboard equivalents to menu selections (shortcuts). The Windows pages correspond with display objects (including menu options). Lingo is the name of the language used for programming in MacroMind Director and the Lingo pages refer to parts of the language. The help pages may contain descriptive and prescriptive information, examples, shortcuts and a mixture of text and graphics. The information seems intended to be used solely for identification and reference; it is not task, tutorial or topic based - but general information is provided with the program by example files, a program that offers a 'tour' of MacroMind Director and hard copy manuals.

Figure 3.6 shows MacroMind Director's help window when the Play button display object has been selected with the question mark pointer:

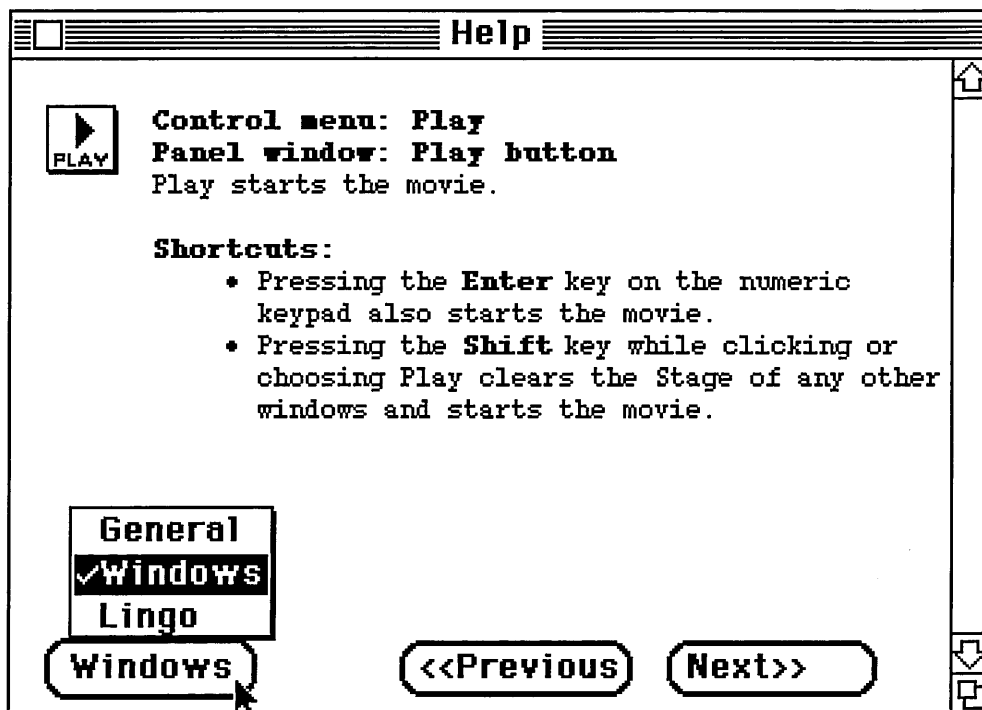


Figure 3.6 MacroMind Director's Object Sensitive™ Help

The help window contains a scroll bar for scrolling through long pages, buttons for moving to previous and next pages and a button which shows the current category and allows the user to move to the beginning of any of the three categories of pages. The navigation facilities in MacroMind Director's help facility are limited because object-based help is the principal means of accessing its information and the index for the help information is the main system's interface. This is unlikely to cause users difficulties because MacroMind Director incorporates some neat solutions to the problems related to help modes (which were discussed in Chapter 2). The help facility does not interrupt the functioning of the main system, and its help window can remain onscreen and respond to new help requests during editing and while an animation is playing. The help window can be moved and resized (vertically) to assist screen

organisation. The question mark pointer has a cross hair next to the question mark to allow selections to be made with precision. Changing to the question mark pointer represents entry to a help mode in which the next selection will be interpreted as a help request rather than interaction with the main system. The question mark pointer can be obtained by pressing the command and question mark keys simultaneously *before* selecting a display object - but it can also be obtained temporarily by holding down the Shift and Option keys *while* selecting a display object. In both cases the question mark pointer reverts to its previous pointer shape after the help facility has responded to the help request. Usage of the main system and help system can be mixed by holding down the Shift and Option keys to change a normal selection into a help request.

The seven systems that have been described in this section provide nine object-based help facilities. All of these facilities provide help information about display objects when the display objects are indicated, they all present their help in windows and, apart from Macintosh system 7's balloons, all the windows can be moved. Table 3.1 categorises the object-based help facilities according to the information/options they make available when accessed:

	entrance to navigable help facility		
	information about indicated object/s		one-shot help
The Rehearsal World	•		•
LabVIEW's help facility	•	•	
LabVIEW's Info boxes	•		•
Word 4's help facility	•	•	
System 7's Get Info boxes	•		•
System 7's Balloon Help	•		•
Acorn !Help	•		•
MacCheese	•		•
MacroMind Director	•	•	

Table 3.1 The types of information provision in the example systems

Table 3.2 categorises the object-based help facilities according to the methods used to access the facilities:

	help re. currently selected/active object/s	help pointer/mode	concurrent help	direct manipulation
The Rehearsal World				•
LabVIEW's help facility	•			
LabVIEW's Info boxes		•		
Word 4's help facility	•	•		
System 7's Get Info boxes		•		
System 7's Balloon Help			•	
Acorn !Help			•	
MacCheese			•	
MacroMind Director	•			

Table 3.2 Methods of accessing help in the example systems

This section concludes by referring to aspects of the object-based help facilities described in this section that relate to more general issues. This brief discussion has been divided into: pointers and help modes, context sensitivity and some general observations.

Three systems use help pointers to indicate a help mode and in two of these cases the pointer is shaped like a question mark. MacroMind Director's question mark pointer has cross-hairs which allows selections to be made with precision - providing that the user is aware that the cross next to the question mark serves this purpose. The Rehearsal World allows a direct manipulation method for obtaining help (by dragging) and this suggests possibilities for other direct manipulation methods. For example, an icon or pointer shaped like a supermarket labelling gun could stick help messages (rather than prices) on display objects, or display objects could be dragged to microscopes to view previously invisible labels.

There may be trade-offs involved in the choice between consistent information which may be used and reused for reference and context sensitive information which changes but may offer greater relevance and possibly brevity. The systems described in this section tend to employ context sensitivity to change the content of one-shot help and to select appropriate pages in on-line manuals - the contents of the on-line manuals are not changed. This may explain why there are many short pages in MacroMind Director's on-line manual.

MacroMind Director offers a thorough and principled approach to the provision of object-based help. The main means of accessing the information in its help facility is by selecting objects displayed by the main system's interface, and it offers temporary and more permanent help modes.

MacroMind Director also provides graphical help information (both pictorial and diagrammatic) to support its texts. MacroMind Director's help texts are user-editable, as are the texts in the Macintosh desktop's Get Info boxes and LabVIEW's Info boxes. LabVIEW and Microsoft Word 4 provide comprehensive navigation controls for their help facilities and Microsoft Word 4's help facility provides overviews of task and topic related help. A help facility may be non-intrusive if it operates concurrently with a main system and if there is room on the screen for a permanently displayed help window. Macintosh system 7's balloons obscure parts of the screen (since they appear next to the objects of interest) but this also emphasises their presence.

In addition to the proposal that object-based help facilities may be appropriate for systems that have graphical object-oriented interfaces, this thesis also contains suggestions for the implementation of object-based help. It is suggested that system objects in systems programmed in object-oriented styles can be used as a source of help information. The next section discusses some of the programming languages and programming styles which can be used to create program code that contains system objects, and discusses why these objects may be a suitable source of help information.

3.3 Object-oriented programming

Systems that have graphical object-oriented interfaces can be programmed in a variety of programming languages and programming styles but they are closely associated with object-oriented programming. Draper [1986] describes the twin aims of the developers of the Smalltalk language as being "to reconceive computation wholly in terms of objects and message passing, and to make the computation visible", and Cox [1986] comments that object-oriented

programming is "unusually suitable" for building iconic user interfaces. This section begins with a discussion of object-oriented programming languages and programming styles and then considers some of the reasons why the system objects used for object-oriented programming may provide an appropriate source of help information.

Programming languages

Object-oriented programming languages contain system objects which communicate with other objects by passing messages. An object may be characterised by its ability to contain *data* which is private to that object and *methods* which allow the object to perform operations and to send and respond to messages. One of the most widely known and influential object-oriented programming languages is Smalltalk [Goldberg & Robson 1983]. In 1983, version 2.0 of Smalltalk-80 became the first version of the language to be made commercially available and most of the references made to Smalltalk in this thesis apply to that version and later versions. Object-oriented programming in Smalltalk may involve the following features of objects:

- *abstraction* - objects are used to represent physical objects, processes, ideas and concepts. Abstraction relates to *what* an object represents rather than *how* it represents it.
- *encapsulation* - in addition to owning private data each object is responsible for responding appropriately to the messages it receives. Its data and methods are effectively hidden and are accessible only through its 'interface' which deals with sending and responding to messages.
- *inheritance* - objects are instances of classes which define the shared characteristics of the objects in that class. A class may be a part of a hierarchy of superclasses and subclasses in which each subclass is a more

specialised member of its superclass. Inheritance allows classes to be created by extending existing classes.

- *polymorphism* - this allows a generic message selector (the part of a message that specifies a command) to be sent to a number of objects to evoke responses individual to each object. For example, the messages: "aString print", "aNumber print" and "anImage print" all contain the polymorphic message selector "print" but the implementations of the methods for printing the aString, aNumber and anImage objects would differ. Polymorphism allows the behaviour of objects to be determined at an abstract level. For example, it is possible to determine that a number of graphics objects will respond to a "grow" message before writing, or considering, the code that will increase the sizes of circles, rectangles and so on.

Smalltalk, Simula and Eiffel are object-oriented programming languages. Many languages have been, and are being, extended or adapted to provide support for object-oriented programming and these include: CLOS, Loops and Flavors (which are based on Lisp), Object Pascal, Objective-C and C++. Detailed overviews of these languages are provided by Keefe [1986] and Tello [1989]. The C language [Kernighan & Richie 1978] has been retained as a subset of C++ [Stroustrup 1986]. C is a versatile, relatively low-level language which is widely used by commercial system developers; Stroustrup writes of "tens of thousands of programmers who know C". The advantages of C++ are that C is already well known and existing C source code can be compiled (with only minimal changes) by C++ compilers; it produces compiled code which executes rapidly; and, since C++ was developed by AT&T's Bell Laboratories who also originated C, it may come to be regarded (if it isn't already) as the 'standard' object-oriented version of C.

Object-oriented programming languages can be used to program in a variety of styles. Pinson & Wiener [1988] point out that, "The use of an OOP language does not guarantee that an object-oriented solution has been accomplished". Conversely, object-oriented programming does not require an object-oriented programming language. Spicer [1990] comments that, "good programmers have been using OOP techniques for years, even when they did not have OOP languages to back them up", and Duff & Howard [1990] write, "Yes, it is possible to write OOP code in C by extending the language somewhat and enforcing coding standards and self-discipline". The term *object-oriented programming styles* - used by O'Shea, O'Malley & Scanlon [1988] - implies that an object-oriented solution has been accomplished and it is a term that can be used independently of the language in which the solution was written.

Help information from objects

This subsection describes some research which indicates that system objects may be an appropriate source of help information. It refers to work by the following:

- Rich - who investigates the use of program code as a source of help information,
- Draper - who suggests that a form of object-based help can be used to access a system object in order to obtain information regarding a corresponding display object, and
- Cox, Gibson and Rosson & Alpert - who examine the types of information represented by system objects.

Rich [1982] points out that the use of program code as a source of information for on-line help offers the advantages of flexibility, ease of creation and

accuracy. She explored the issue of drawing help information from the code of a program in order to answer users' questions, and initially investigated a system called Scribe which is written in a language called Bliss, but decided that the most feasible approach involved coding systems in a style that was suitable for this form of information gathering. There were two main reasons given for this decision:

- " 1. Bliss allows unconstrained use of global variables and side effects...*
- 2. Bliss is not a typed language. This means that it is not possible to tell simply from looking at a piece of code what kind of object is being operated on..."*

Neither of these limitations applies to a system programmed in an object-oriented style whose data and variables are encapsulated in objects and classes, whose functionality is achieved through the message-passing interfaces of objects, and whose objects are recognisable as instances of classes. Rich's paper predates object-oriented languages such as Smalltalk-80 and C++, but the method of programming she recommends anticipates some of the advantages of an object-oriented programming style. For example, Rich writes that "it is important that the code be highly modular, each module corresponding to a comprehensible set of operations". Rich's recommendations have the following parallels with the use of system objects as a source of help information:

- using program code as a source of help information,
- programming systems in a style which makes this form of information-gathering possible,
- the use of modular code, and
- modules that are comprehensible to users.

Draper [1986] discusses the role of I/O (Input and Output) in computer systems, and while considering error messages and debugging aids he makes the following suggestion:

"A desirable facility would be to allow the user to point to a display object and ask where it came from. In a sense, this is a kind of 'help' request, but aimed at a display object rather than a system object ... This is based on a crude notion of a display 'object' originating at a statement."

Where the listings of objects (statements) are used as help information the information consists of raw, unmediated code which may not be meaningful to users who are unfamiliar with the language in which the system has been programmed. Nevertheless, Draper's suggestion contains three ideas that relate closely to the work described in this thesis:

- the distinction and correspondence between display and system objects,
- system objects used as help information, and
- object-based help as a means of accessing help information.

Rosson & Alpert [1990] suggest that "it may be more appropriate to consider the abstraction inherent in OOP as behavior, rather than data, abstraction". Gibson [1991] also focusses on the use of objects to represent behaviour in recommending "object behavior analysis" (OBA) as a means of mapping user requirements to object-oriented designs. She points out that people tend to identify the observable characteristics of objects first, then further distinguish the objects by their behaviour. One reason why objects may provide an appropriate source of help information is because objects can contain both data and methods. This allows information to be drawn from the objects that reflects both the observable characteristics of objects and the behaviour

associated with objects. This information may be appropriate as help if it relates to what users can see and to what users can do.

Cox [1990] describes the introduction of object-oriented programming as a *paradigm shift*. Cox writes that, "It is this increased emphasis on the relationship between consumers and suppliers of code that separates object-oriented and conventional programming". Rosson & Alpert [1990] are concerned with easing the process of design and improving the usability of the resulting system and they recommend achieving this by involving users in, or during, the design process - an approach that corresponds with the initial consideration of, and consultation with, users recommended by Gibson [1991]. Rosson & Alpert write that, "A designer who engages in interaction with users, with the goal of understanding how users understand the task domain, should be more likely to generate a design model based on the objects contained in users' conceptualization of the task. If successful, the designer will have created a design model that is object-oriented from the user's perspective". Where system objects correspond with aspects of users' conceptualisations of tasks, it may be appropriate to provide help information *about* system objects. As the previous paragraphs have indicated, this information can be obtained *from* system objects.

3.4 Summary

Object-based help may offer a means of accessing and indexing help information which is consistent with the forms, and usage, of graphical object-oriented interfaces. The Rehearsal World, Acorn !Help, Color MacCheese, Macintosh system 7's Balloon Help and MacroMind Director offer forms of object-based help which represent significant departures from the on-line

manual approach, and which have managed to reduce some of the problems associated with help modes. All nine of the object-based help facilities described in this chapter allow help information to be accessed by selecting and/or manipulating display objects. Two facilities require keyboard input to obtain help pointers, but none of the facilities require typed input - though three facilities allow their help texts to be created and/or edited. The facilities described in this chapter show that object-based help is not limited to supplying information about display objects, and that a main system may have more than one help facility and/or be supported by a variety of forms of information provision.

The section on object-oriented programming in this chapter referred to a number of object-oriented programming languages and to object-oriented programming styles. Object-oriented programming styles may be used to achieve object-oriented solutions irrespective of the language used. The use of system objects as a source of help information was considered and the following conclusions were drawn from work by Rich and Draper:

- Program code can be used as, and as a source of, help information.
- Object-based help can be used to access this information.
- System objects (or coded modules) can be used as a source of help information.
- Programs whose code is to be used as a source of help information should be programmed in a style that allows this.

In addition to the above, work by Gibson and Rosson & Alpert has suggested that system objects may be an appropriate source of help information because they can represent both the observable characteristics and behaviour of display objects - which corresponds with what users can see and do. Also, Cox and

Rosson & Alpert have indicated that system designers may try to create system objects that correspond with aspects of users' conceptualisations of tasks. Where this is the case system objects may be an appropriate subject for (as well as source of) help information.

Chapters 2 and 3 have examined the background and current context of the work described in this thesis. The next chapter describes two systems, implemented as part of this research, that provide object-based help drawn from self-explanatory objects.

Chapter 4

The Implementations

4.1 Introduction

Two systems were constructed to investigate ways of implementing self-explanatory objects, and help facilities based on self-explanatory objects. The first system, a noughts and crosses game, is a relatively simple program developed during initial investigations of object-oriented programming styles and object-based help. The second system, Partickles, is based on a more complex game of strategy; it contains several forms of help provision and the usage of its help facilities was investigated in three Partickles studies. The Partickles studies, which involved nineteen subjects, are introduced in the next chapter. This chapter describes the noughts and crosses and Partickles programs and discusses aspects of their implementations.

Throughout the thesis "Partickles" with a capital "P" refers to the Partickles system or to the game of Partickles, whereas "partickles" with a small "p" (except at the start of sentences) refers to the hexagonal playing pieces used in the game. In some places the names of features and facilities of Partickles have been presented in a non-serif font to aid readability. Also, the abbreviation SEO has been used in the thesis to shorten references to self-explanatory objects. Both the noughts and crosses program and Partickles were implemented on an Acorn Archimedes computer.

4.2 Noughts and crosses

The noughts and crosses game is shown in Figure 4.1:

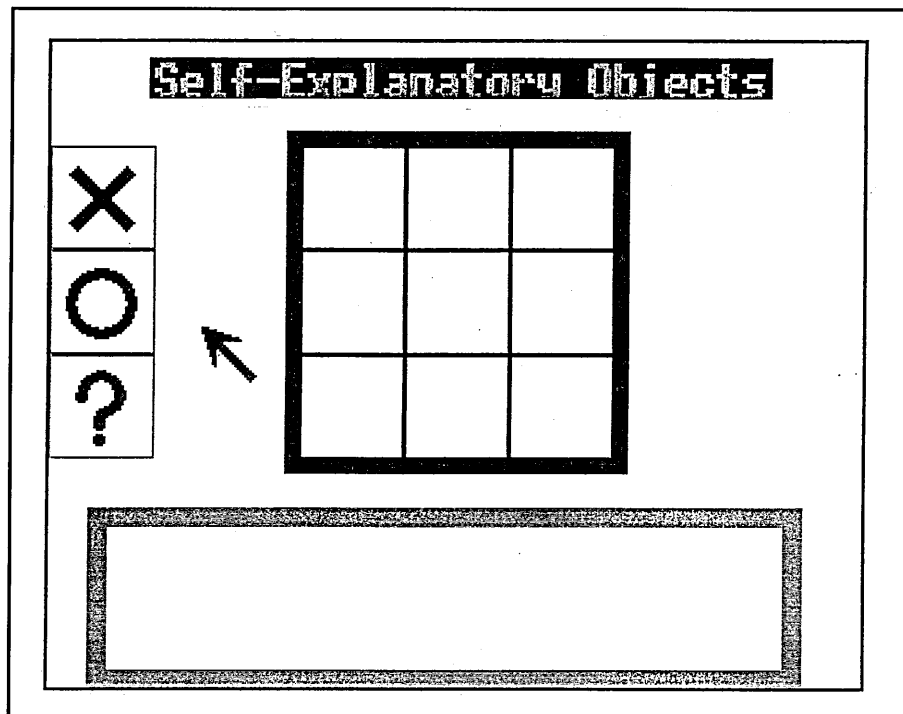


Figure 4.1 The noughts and crosses program before a game has begun

The noughts and crosses game offers a choice of two pointers: an arrow pointer for playing the game, and a question mark pointer for obtaining object-based help. In the course of a game players collect noughts and crosses from the menu boxes on the left of the screen and place them in the central grid using a mouse 'click, drag and release' procedure. If a nought or a cross is single-clicked in its menu box the computer player makes a move unless there are no places to fill or the game has already been won. When the question mark is single-clicked in its menu box the arrow pointer is exchanged for the question mark pointer.

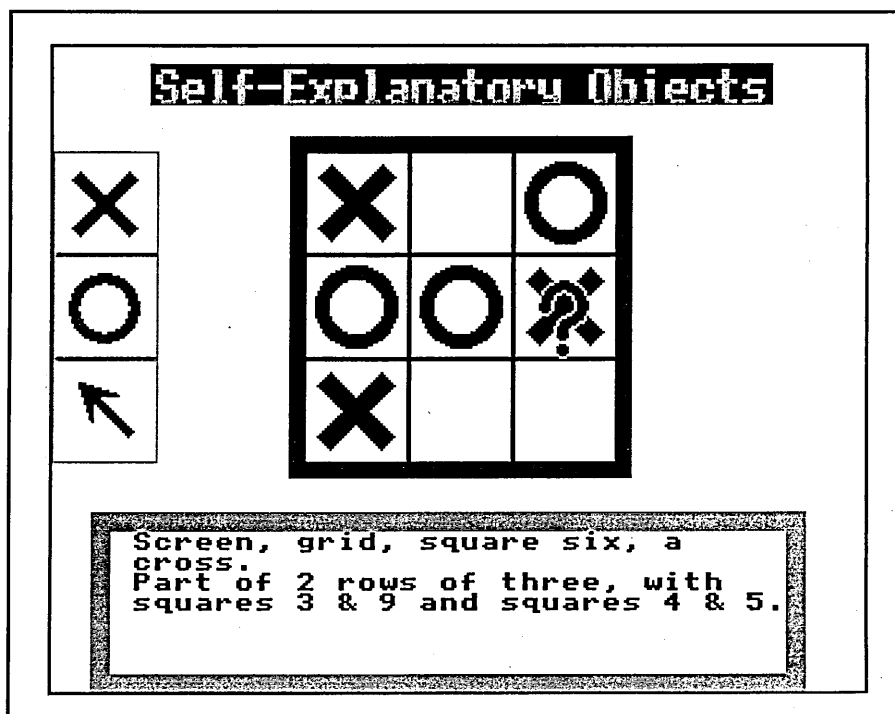


Figure 4.2 The noughts and crosses program's object-based help

In Figure 4.2 a game is in progress and the question mark pointer has been used to select a cross. The help facility has named all the objects beneath the pointer, and has also obtained information from the system object that organises rows of squares. The question mark pointer can be used to select any onscreen object or combination of overlapping objects. Textual information about the selected objects appears in the text box in the lower part of the screen, and, in this simple prototype, all objects under the question mark pointer are identified.

Three further examples of the program's object-based help information follow:

- If the question mark pointer was clicked on the empty square in the top row of the grid in Figure 4.2 the message would be:

"Screen, grid, square two. Strategic values for square 2: 6 for X, 8 for O."

In this example the help facility has obtained information concerning the strategic values of square 2 from the computer player system object.

- If the question mark pointer was clicked on the arrow in the menu box the message would be:

"Screen, buttons menu, arrow - use to select X, O or ?, or to clear a grid square."

This example briefly describes the general functionality of the arrow pointer and is phrased prescriptively.

- If the question mark pointer was clicked on the text box the message would be:

"Screen, text box - contains game information or self-explanations from objects."

This example briefly describes the general functionality of the text box and is phrased descriptively.

4.3 Programming noughts and crosses

The noughts and crosses program was implemented in Archimedes BASIC - a fast, powerful version of the language which offers facilities for structured and modular programming. The noughts and crosses game was chosen because it suited a graphical object-oriented interface, and BASIC was chosen to achieve a rapid implementation.

BASIC was used to create an object-oriented system within a 'shell'. Procedures serve as method primitives or, with local data, as objects. The objects communicate by passing messages to one another in strings. All objects are polled in sequence until the recipient of the most recent message recognises it and responds.

The following (slightly tidied) example is of the noughts and crosses program's squares object which manages the nine instances of grid squares and their contents. The object's five methods begin at line 1620 with a "Q" method which responds to queries from the help facility and which constitutes the object's self-explanatory capacity. A description of the code of the squares object follows Figure 4.3.

```

1540 DEFPROC squares
1550   IF dim% THEN 1570
1560     DIM sqr_obj$(9)
1570   IF init% THEN 1600
1580     FOR J%=1 TO 9: sqr_obj$(J%)="C": NEXT
1590     P%=-1: PROCstore("squares")
1600   IF FNmessage("squares") THEN PROCretrv("squares") ELSE ENDPROC
1610   OBJ%=0: REPEAT OBJ%=OBJ%+1: UNTIL OBJ%=10 OR
      FNmessage(STR$OBJ%)
1620   IF FNmessage("Q") ELSE 1670
1630     IF sqr_obj$(OBJ%)="X" THEN H$="o017 "+H$
1640     IF sqr_obj$(OBJ%)="O" THEN H$="o018 "+H$
1650     IF sqr_obj$(OBJ%)="C" THEN H$="o019 "+H$
1660     H$="o00"+STR$OBJ%+" "+H$: GOTO1740
1670   IF FNmessage("C") ELSE 1690
1680     PROCclear(OBJ%): sqr_obj$(OBJ%)="C": GOTO1740
1690   IF FNmessage("X") ELSE 1710
1700     PROCxshow(OBJ%): sqr_obj$(OBJ%)="X": GOTO1740
1710   IF FNmessage("O") ELSE 1730
1720     PROCoshow(OBJ%): sqr_obj$(OBJ%)="O": GOTO1740
1730   IF FNmessage("?") THEN N$="squares "+STR$OBJ%+" "+sqr_obj$(OBJ%)
1740   PROCstore("squares"): ENDPROC

```

Figure 4.3 The squares 'object' in the noughts and crosses program

Lines 1550 to 1590 are concerned with initialisation. Two global variables, `init%` and `dim%`, indicate when objects have been initialised and arrays have been

dimensioned. Arrays cannot be redimensioned in Archimedes BASIC, so two variables are needed to allow objects to be reinitialised without redimensioning arrays.

Line 1600 uses the FNmessage function to see if the highest priority message is for squares. If it is the object collects its private variables using PROCretrv, if not the procedure ends. All objects are able to use the global variables: J%, K%, L%, M%, N%, P%, A\$, B\$, C\$ and D\$ for their private data. PROCretrv retrieves the contents of these variables when an object is called, and PROCstore saves the contents of these variables when the object has completed its task/s. Squares only uses one of its private variables, J%, which is reset each time the procedure is called. Consequently the initialisation of P% in line 1590 is not needed and in fact was copied from another object in order to demonstrate initialisation of private variables. The OBJ% and sqr_obj\$() variables are also global but they are made effectively local by restricting their use.

Line 1610 checks the current message to see if it contains a parameter specifying a particular square (identified by the numbers 1 to 9).

Lines 1620 to 1730 check the message to see which method it applies to and then implement the appropriate method. The methods, and the letter codes used to select them, are as follows:

Qa query from the help facility regarding the contents of a specified square.

The method returns the appropriate code for a cross, nought or clear square in H\$ - the string used for sending replies to the help facility. Line 1660 indicates which square has been queried by placing its code in H\$.

C.....clears a specified square.

X.....places a cross in a specified square.

- Oplaces a nought in a specified square.
- ?answers a query from another object regarding the contents of a specified square. The method places the answer in N\$ - the string used for passing data/results between objects.

The self-explanatory component of the `squares` object responds to "Q" messages by placing codes in H\$ for the help facility to process. The help facility translates codes provided by self-explanatory objects into the names of display objects, and it can also supply additional information concerning general functionality for six types of display object. In the case of empty squares and squares containing noughts and crosses the help facility collects context sensitive, domain-related information from other objects as the examples in section 4.2 show. All the text that appears in object-based help messages is stored centrally with the help facility's data, though it would have been possible (and might be desirable for more complex systems) for self-explanatory objects to parse (or partially parse) their own object-based help messages.

Pinson & Wiener [1988] consider that, "OO languages must support encapsulation, abstraction, inheritance and polymorphism", while Duff & Howard [1990] write that, "There are three important features that distinguish OO languages from traditional programming languages: encapsulation, polymorphism and inheritance. To simulate OO, you need to map each of these into suitable mechanisms in the procedural language". The implementation of the noughts and crosses program emphasises encapsulation and abstraction rather than polymorphism and inheritance, but the implementation was not intended to simulate an object-oriented programming language, but instead to support an object-oriented programming style in which the system and its functionality can be considered in terms of objects and

message-passing. The remainder of this section considers the extent to which an object-oriented solution has been achieved with the noughts and crosses program.

The choice and use of objects (abstraction)

Work on the noughts and crosses program continued until examples of self-explanatory objects and an object-based help facility had been implemented. The resulting program is a hybrid, but if further work had been undertaken the system would have contained two types of object: those that generated and maintained display objects and those that received, processed and returned data. `Squares` is an example of the first type of object, and the help facility and computer player are examples of the second type of object.

The encapsulation of data

The encapsulation of data is effected by: a) restricting the use of global variables, b) sending messages requesting data between objects, and c) the `PROCretrv/PROCstore` mechanism which preserves the value of private variables and is part of the template for all the noughts and crosses program's objects. As the discussion of the `squares` object indicates, the `PROCretrv/PROCstore` mechanism enables all objects in the noughts and crosses program to use six integer variables and four string variables for their private data.

The association of data and methods with objects

This additional aspect of encapsulation allows objects to be thought of as discrete units with both tasks and the information to carry out those tasks. The `squares` object contains data regarding the contents of the nine

squares in `sqr_obj$()`, and it contains methods for changing the contents of the squares, updating its information and supplying the information when requested by other objects. By associating the methods for changing the contents of squares with the data regarding the contents of squares it was possible to tell `squares` what to do (for example, a "squares 5 O" message instructs `squares` to place a nought in the central square) and to rely on `squares` to keep the record of the contents of the squares up-to-date.

Communication between objects by message-passing

The encapsulation of the objects in the noughts and crosses program is further established by their ability to receive, respond to and send messages. Objects only respond to messages intended for them and are not used in any other way. The noughts and crosses program is too small to demonstrate the benefits of polymorphism for issuing generic commands, but there is some duplication in the names of commands in messages that objects can respond to. Seven objects respond to "Q" messages from the help facility, three objects provide different responses to "X" and to "O" messages and two respond to "?" messages which are requests for data.

The noughts and crosses program represents an initial investigation of object-oriented programming styles and the implementation of self-explanatory objects and object-based help. These investigations were extended with the second program, `Partickles`.

4.4 Partickles

Partickles is a computerised version of an original 'board-game' style of strategy game. The game and system were chosen because they suited a graphical object-oriented interface and an object-oriented programming style. A game was considered an appropriate vehicle for observing the use of help facilities in studies because of its potential to motivate and involve subjects for appropriate lengths of time, and because the broad goal of winning games does not restrict the use, or prescribe the choice, of help facilities. The advantages of using an original game in the studies were that all the subjects would be initially unfamiliar with the domain and that they would require information. The chapters which document the Partickles studies make occasional references to features of the game so the rules are outlined below.

The game of Partickles consists of two sides, red and blue, which compete to be the first to move all eleven of their playing pieces (partickles) into the opposite half of the game board. Each partickle can rotate (to change direction), move, combine with another partickle and/or perform a special 'effect' move. Two examples of effect moves are: 'push and move' or 'jump while moving'. At the start of games each partickle contains one coloured triangle (a part). When two partickles are combined (by moving one on top of the other) the combined partickle will contain both partickles' parts (up to a maximum of five). The number of places that a partickle may move during an effect move in one turn is the same as the the number of parts it contains. When partickles with different effects combine they may perform more complex effect moves, such as: 'push then jump while moving'. The colours of parts indicate the type of effect move a partickle can perform:

push	jump	step	resist	unpack (or swap)
green	orange	yellow	purple	white

A partickle containing a *push* part can push another partickle unless this contains a *resist* part. A partickle with a *jump* part can jump over other partickles. A partickle with a *step* part pauses, and can be rotated, after each step of a move of more than one place. A partickle containing an *unpack* part and at least one other part can separate into two or more partickles (unpacking) while moving. A *swap* move occurs when a partickle that contains an *unpack* part attempts an effect move onto a place occupied by another partickle of the same side; this results in the *unpack* part swapping with a part from the other partickle. The *unpack* effect plays a particularly significant role during end-games when combined partickles are unpacked in order to achieve the goal-state of eleven partickles situated in the opposite half of the board. Appendix A contains further information about the game of Partickles in the text from help/info menu option: Partickles rules.

Three versions of Partickles were produced during the course of the project, though the domain remained the same for all three versions. This chapter refers to some of the differences between the versions, but more detailed accounts of the changes, and the reasons for the changes, are presented in the method sections of the three chapters that describe the Partickles studies.

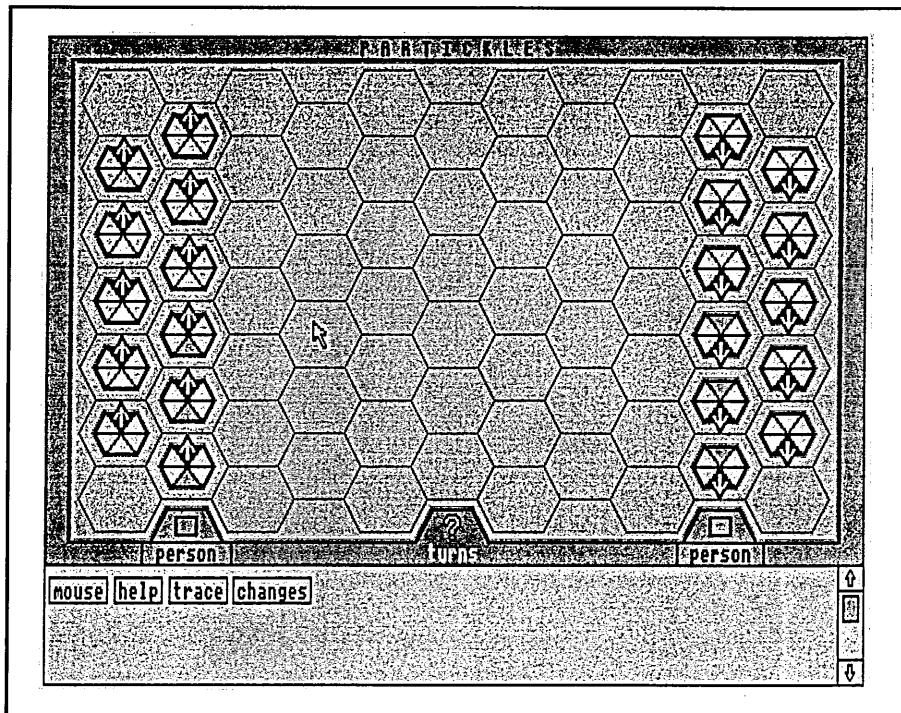


Figure 4.4 Partickles version 1 before a game has begun

Figure 4.4 shows a screen display which consists of two windows. The upper window contains the game board and game board frame, the hexagonal playing pieces and the arrow pointer. Six controls are located in the lower edge of the game board frame: two rectangular side-to-play boxes, two person/computer switches (both set to person), the automatic turn-taking on/off switch and the question pointer. The lower window contains a vertical scroll bar and four menu buttons: mouse, help, trace and changes.

Table 4.1 shows the options available from the menu buttons in version 1 of Partickles:

mouse	help	trace	changes
about mousing...	getting started...	show trace	demo-mode
which button...	Partickles rules...	full trace	sound
which pointer...	about the program...		reset
	suggestions...		icon bar
	status info...		

Table 4.1 Menu options in version 1 of Partickles

The mouse and help menu options provide access to Partickles' menu-based help. The menu-based help facilities and the trace facility are described later in this section. The changes menu contains options for starting computer versus computer demonstration games; turning the sound on and off; resetting the game board, closing help windows and setting switches and the pointer to their default state; and returning to the desktop (icon bar).

In versions 2 and 3 of Partickles some of the controls were removed from the lower edge of the game board frame and made into menu options. Figure 4.5 shows Partickles version 2:

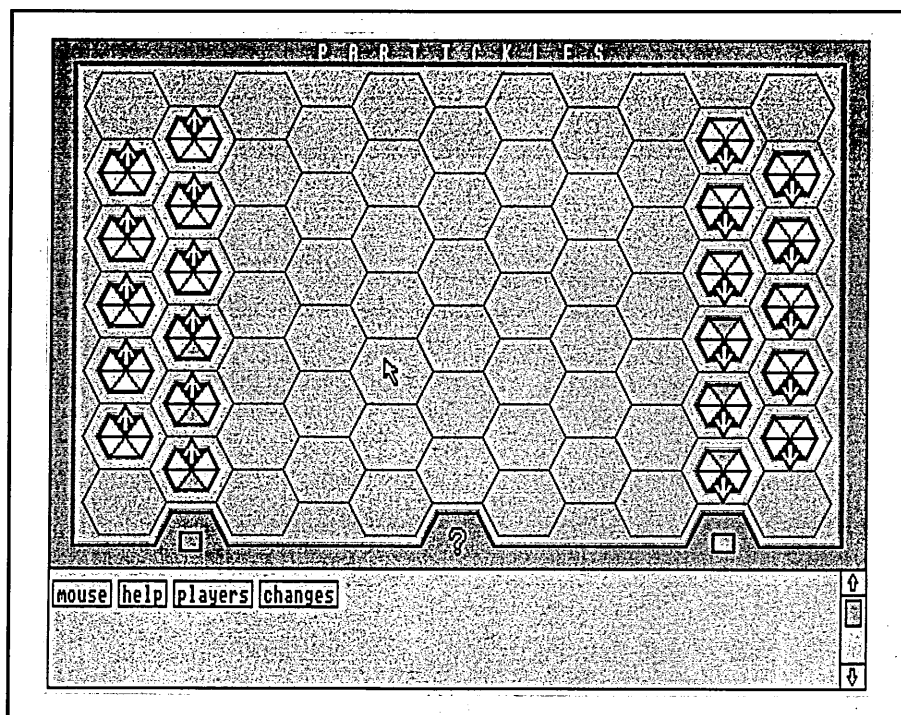


Figure 4.5 Partickles version 2 before a game has begun

Table 4.2 shows the menu options that are available in versions 2 and 3 of Partickles. The 'help' menu was renamed the 'info' menu in version 3.

mouse	help/info	players	changes
about mousing...	getting started...	person v person	demo-mode
which button...	Partickles rules...	person v computer	auto turns
which pointer...	about the program...	computer v person	trace
	suggestions...	computer v computer	sound
	status info...	random first turn	reset
			icon bar

Table 4.2 Menu options in versions 2 and 3 of Partickles

Details of the players and changes menu options (for Partickles version 3) are provided in the text of help/info menu option: about the program in Appendix A.

There is a choice of two pointers in Partickles: the arrow pointer and the question pointer (shaped like a question mark). These can be swapped at any

time by selecting the non-active pointer with the active pointer. The question pointer is only active in the upper window because it temporarily changes to the arrow when moved into other windows. The arrow pointer is the default (presented at the start of games) in versions 1 and 2 of Partickles, but the question pointer is the default pointer in version 3.

Partickles is operated entirely by means of a three button mouse. Most controls (such as scroll bars and side-to-play boxes) can be operated by any mouse button but when a pointer is placed on a partickle that is in a position/state to move:

- the left button makes the move (or provides object-based help)
- the middle button rotates the partickle
- the right button switches 'effect move' mode on or off

The type of pointer in use only affects the function of the left mouse button. The usual function of the arrow pointer + left mouse button is to select a partickle and start its move. Question pointer + left mouse button selections in the upper window provide object-based help information about the selected object or area. When object-based help is obtained for a partickle that is in a position/state to make a move a hot words box labelled **make move** appears next to the menu buttons in the lower window. Appendix A contains more information about the features, facilities and operation of Partickles in the text from help/info menu option: about the program. The remainder of this section describes Partickles' menu-based and SEO help facilities.

The menu-based help facilities

The mouse and help/info menu options produce windows of help information which, with the exception of help/info menu option: status info consist of canned text (and some graphics) in the on-line manual style. The

mouse and help/info menu options were intended to fully document the system and resemble 'traditional' menu-based help systems though the help/info menu options are indexed by the type of help they offer rather than by commands, topics or tasks. The texts of the mouse and help/info menu options are included in Appendix A.

The mouse menu options describe the usage of the mouse, its buttons and the two Partickles pointers. Most of the information in the which button and which pointer options is also provided by help/info options: getting started and about the program but the mouse menu isolates this information for clarity. The about mousing option concerns basic mouse usage and provides a general definition of screen objects. All three mouse menu options appear in non-scrolling windows similar to the one shown in Figure 4.6:

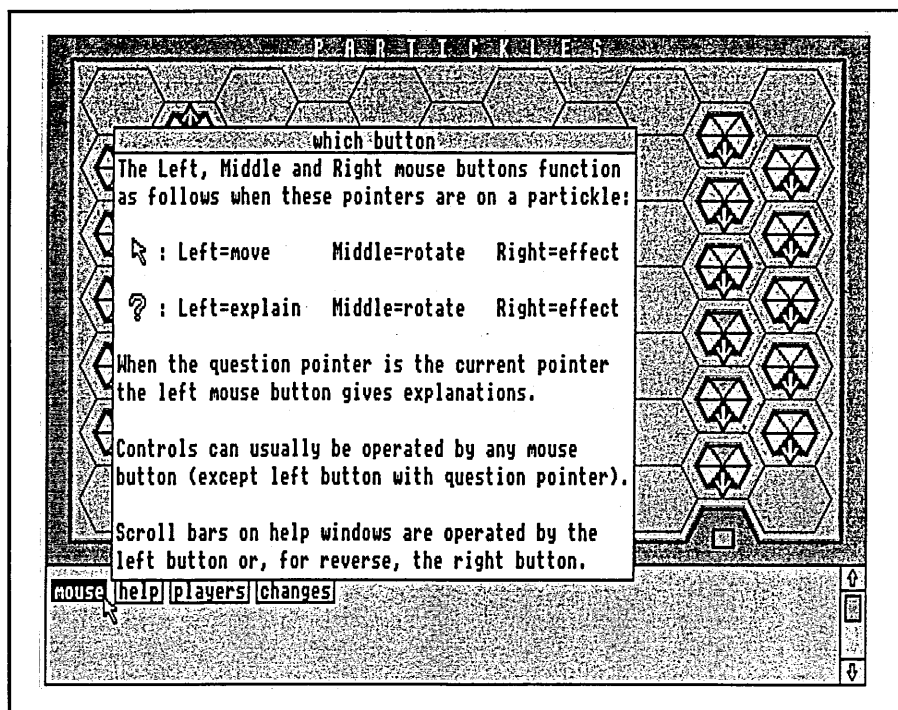


Figure 4.6 Mouse menu option: which button

Figure 4.7 shows a selection being made from the help menu in version 2 of Partickles:

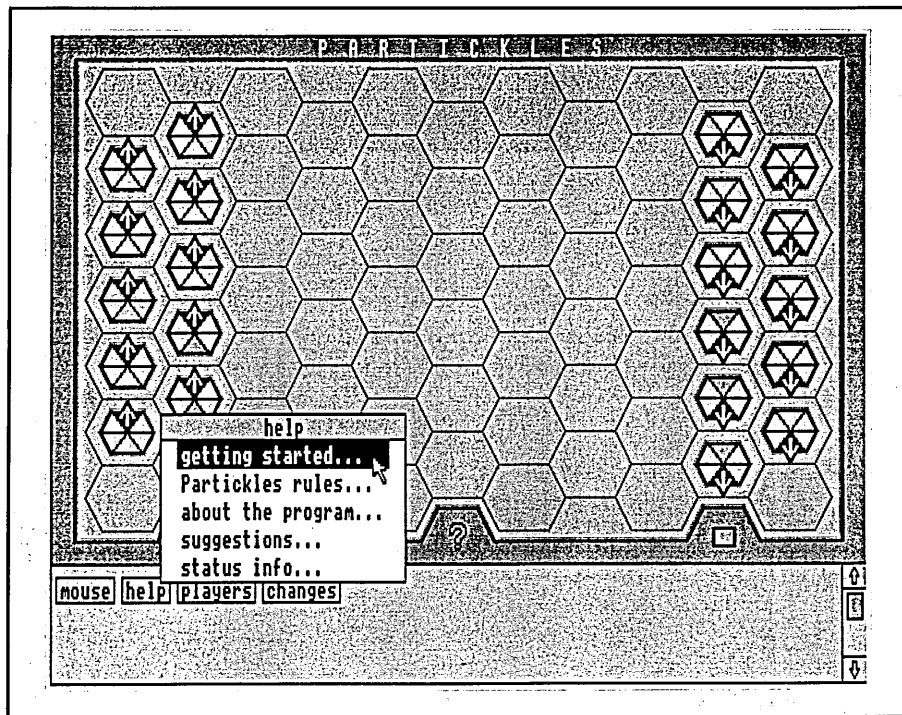


Figure 4.7 Selecting 'getting started' from the help menu

The contents of the help/info menu options are the same in all three versions of Partickles except where they describe or refer to facilities that have been changed by reversioning. The first four help/info options produce scrolling windows of canned text in the online manual style, such as the window shown in Figure 4.8:

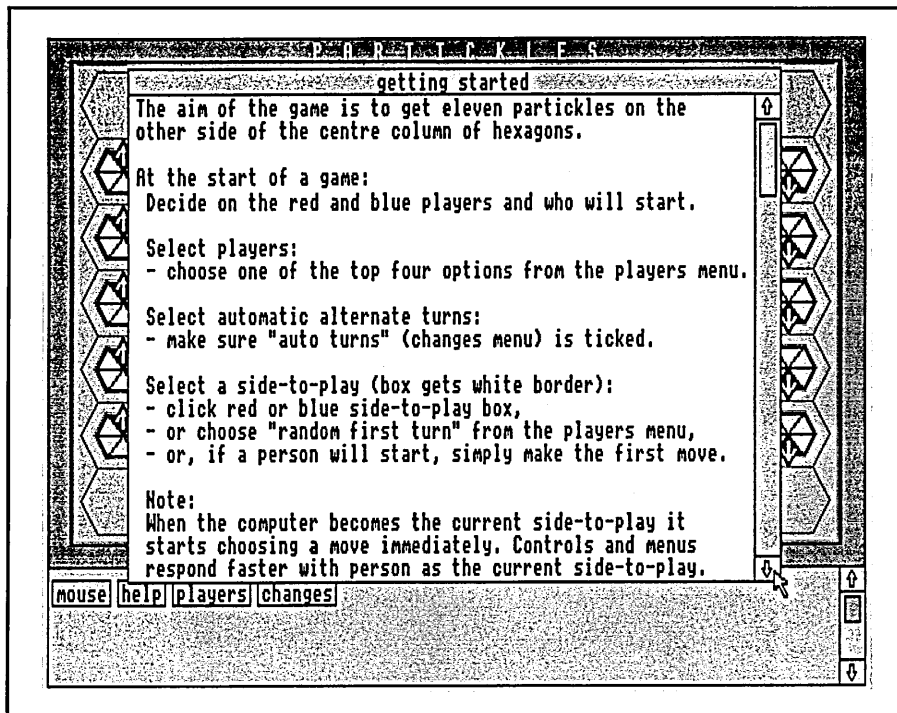


Figure 4.8 Help menu option: getting started

Help/info menu option: status info produces a non-scrolling window of tabular, context sensitive information:

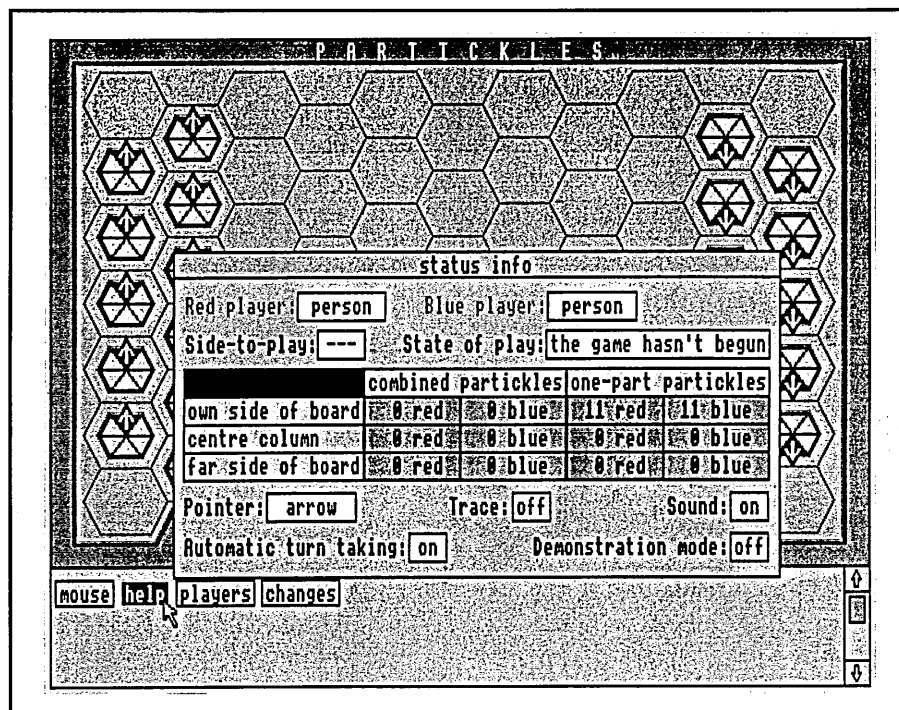


Figure 4.9 Help menu option: status info

The help/info menu provides a source of comprehensive information, an alternative to the object-based help facilities and, because it is divided into five parts, a means of identifying broad help requirements. The five help/info menu options are described individually below:

The **getting started** option consists of a mixture of domain and operational information. This is presented as a brief statement of the aim of the game, then three short sections containing information regarding setting up games and making moves plus a few trouble-shooting hints. The **getting started** option provides the minimal amount of information needed to learn to play quickly - and was intended to be sufficient as the sole source of formal help if its information is combined with an appropriate interpretation of the Partickles interface.

The **Partickles rules** option contains a detailed description of the domain. It was intended that subjects should be able to find all the information they needed to understand the game from **Partickles rules**. However, **Partickles rules** does not contain sufficient information to allow subjects to *play* the game because the option contains no operational information. The **Partickles rules** text is written as though it refers to a non-computerised version of the Partickles board game.

The **about the program** option contains a detailed description of the operational features of the interface, mouse and domain. It was intended that subjects should be able to find all the information they needed to operate the system from the **about the program** option. The only domain-related information appears in the first section, "Making a move", and refers to the step effect in order to describe multiple (i.e. more than one place) moves. The second

section, "Self-Explanatory Objects (SEO)", describes obtaining help with the question pointer and using the make move hot words box, but the move value hot words box and the effects SEO help facility are not documented in any of the help facilities. The third section, "Controls", describes all the controls (such as side-to-play boxes) in the upper and lower windows (including side-to-play boxes, scroll bars, menus and help windows), and also describes the players menu (or trace menu in version 1) and the changes menu and explains their options. The final section contains three brief hints relating to the sluggish response of the system while the computer player is choosing moves.

The suggestions option provides advice regarding activities and strategies. It consists of three sections: "Ideas", "Strategy" and "Program Behaviour". The Ideas section suggests eight activities which involve exploring the system and domain and also suggests avoiding the Strategy section until players have developed their own strategies. The Strategy section contains fifteen pieces of advice regarding strategies for playing the game. The Program Behaviour section contains two hints to help users cope with the sluggish response of the system while the computer player is choosing moves, plus a description of the demonstration game facility and a warning about closing help windows.

The status info option presents tabular, context-sensitive information regarding states of play and of the system. The information in status info shows the settings of controls and of the changes menu options - and two features which provide indications of the state of play. One of these, labelled "State of play", presents one of the following statements: "red's turn to move", "blue's turn to move", "the game hasn't begun", "a step partickle move", "effect move selected", "both sides have lost!", "the red side has won" or "the blue side has won". The other feature presents tabular information regarding the

distribution of partickles across the board as a means of comparing the progress of the two sides.

The SEO help facilities

The SEO help facilities can be grouped into three categories which are listed below and discussed more fully in the paragraphs that follow:

- object-based help - providing information about display objects when these are selected using the question pointer.
- hot words boxes - providing access to additional facilities after object-based help has been obtained.
- the trace facility - a dynamic description of interactions obtained by recording and parsing the activities of self-explanatory objects.

Object-based help is obtained by clicking partickles, controls or screen areas in the upper window with the left mouse button + question pointer. There are three sorts of object-based help: partickle SEO information, control SEO information and area SEO information. Object-based help is available for five controls and two screen areas (the game board and the game board frame) in version 1 of Partickles, but three of the controls were replaced by menu options in versions 2 and 3 of Partickles. Control SEO information can be seen in Figure 4.10:

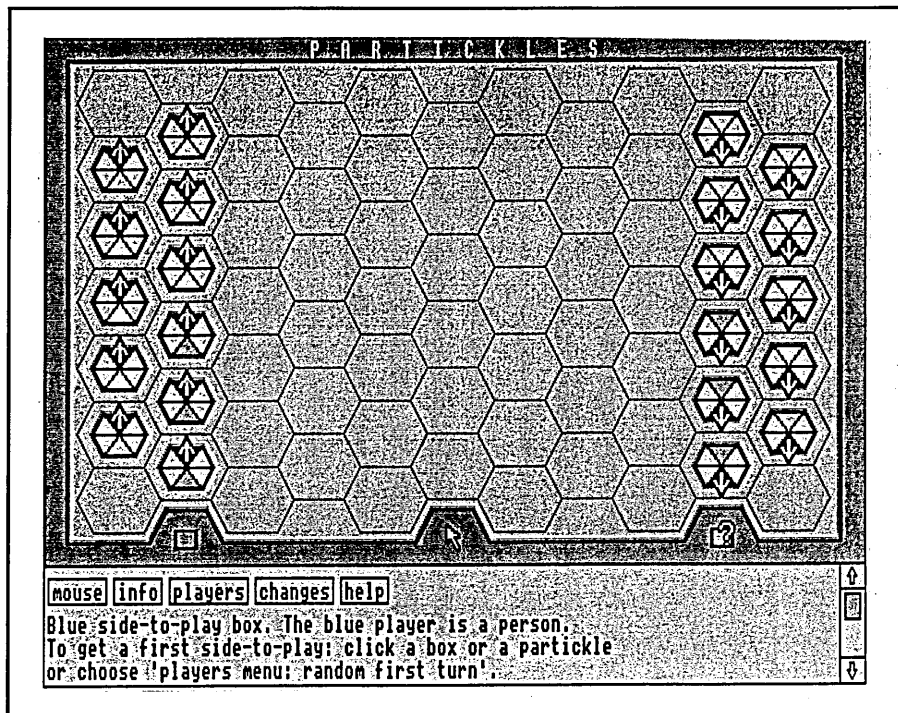


Figure 4.10 Control SEO information (Partickles version 3)

In Figure 4.10 control SEO information has been obtained for a side-to-play box. A game is not in progress so the control SEO information indicates how to obtain a first side-to-play. Once a side-to-play has been obtained control SEO information indicates which side is in play.

Particle SEO information is of two types: descriptive particle SEO information which describes the particle's side (red or blue), number of parts, the effect(s) it can perform and whether effect is on or off; and 'would do' particle SEO information which describes what a particle would do if it was made to move. In version 1 of Partickles both types of particle SEO information appear together in the lower window as shown in Figure 4.11:

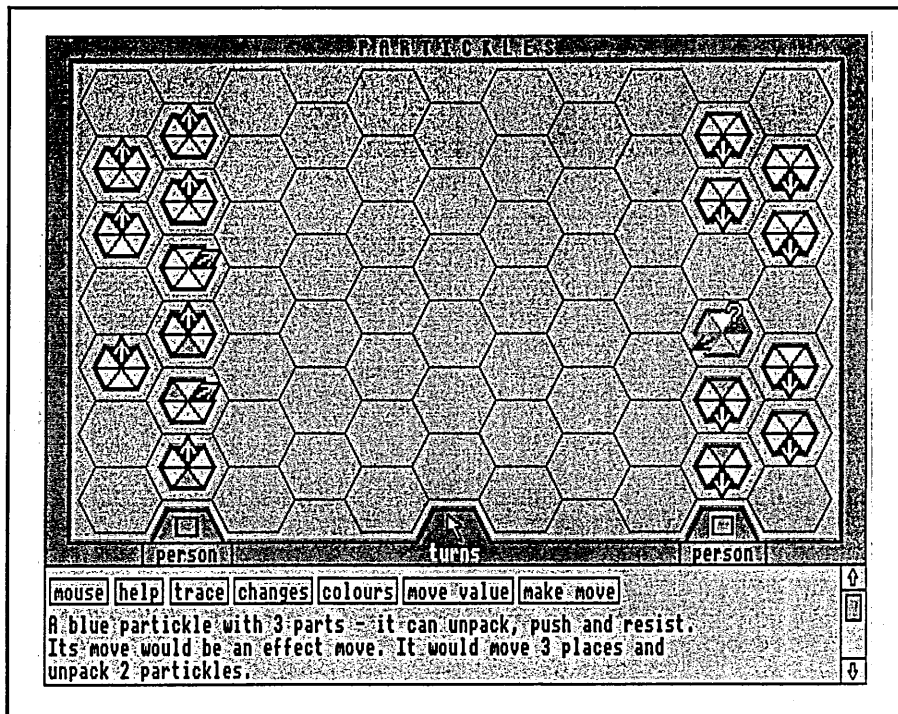


Figure 4.11 Partickle SEO information (Partickles version 1)

In version 2 the descriptive partickle SEO information is presented in a 'speech bubble' next to the partickle that has been selected while the 'would do' partickle SEO information remains in the lower window:

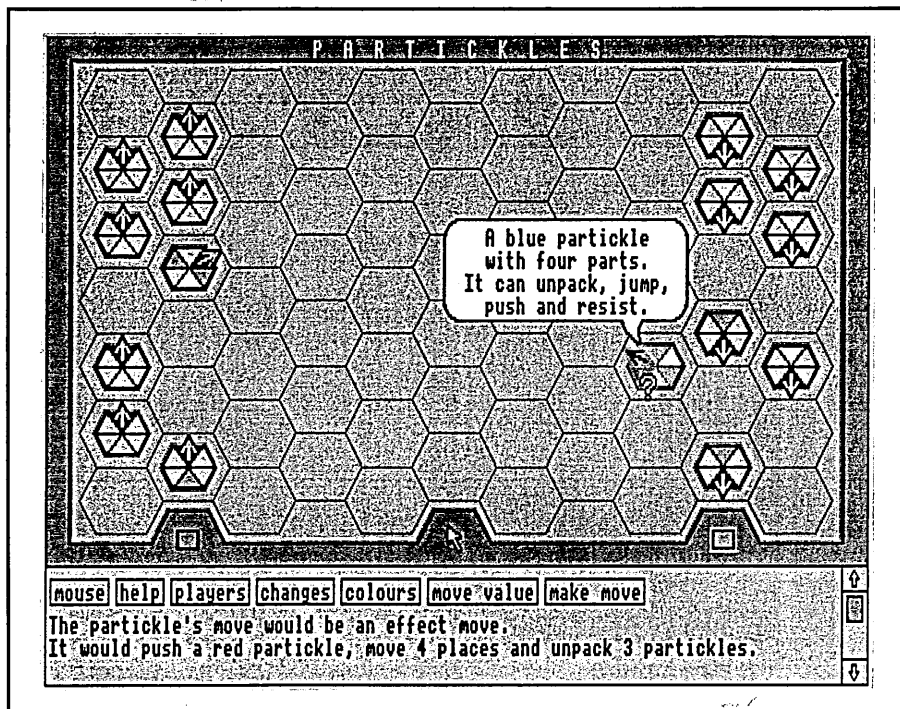


Figure 4.12 Partickle SEO information (Partickles version 2)

In version 3 the 'would do' partickle SEO information appears in the bubble and the descriptive partickle SEO information is presented in the lower window:

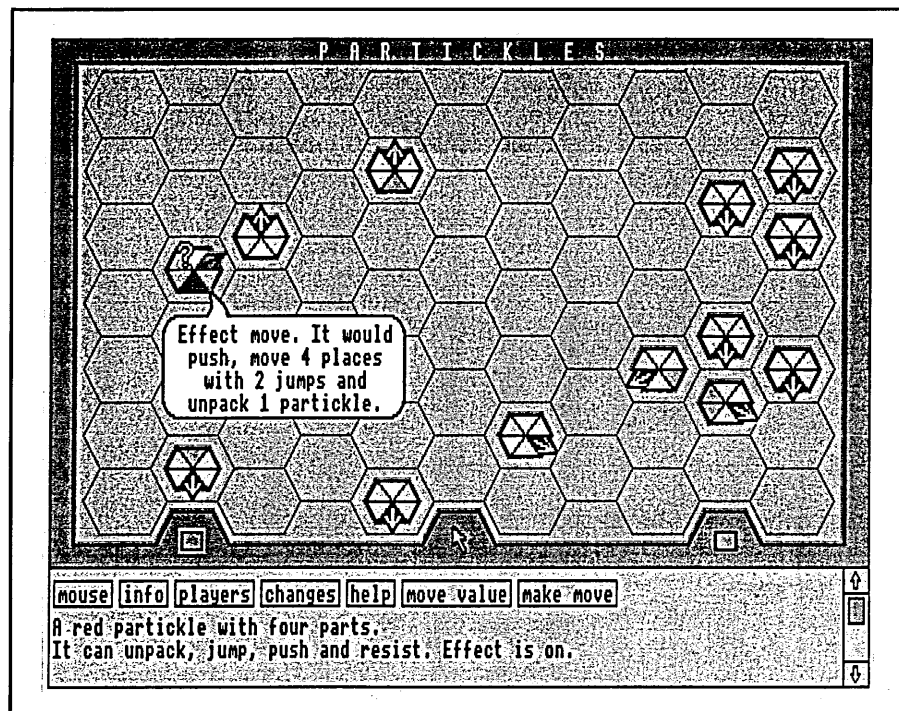


Figure 4.13 Partickle SEO information (Partickles version 3)

Hot words boxes appear to the right of the four permanent menu buttons in the lower window when partickle SEO information is obtained or, in version 3, when any object-based help is obtained. Many of the changes made to version 3 involve hot words boxes, but all three versions of Partickles contain a make move facility, a move value facility and an effects SEO help facility. These facilities are described next.

The make move facility can be used to start a move when the question pointer is current. The make move hot words box does not appear if the selected partickle is not in a position/state to make a move. SEO error messages are presented in the lower window if the make move hot words box is clicked but

the partickle cannot move because: it belongs to a side that is no longer the current side-to-play, or it is the computer player's turn to play, or the partickle SEO information no longer applies because partickles have been rotated and/or effect has been switched on or off. Figure 4.14 follows Figure 4.12 and shows what has happened as a result of selecting the make move hot words box:

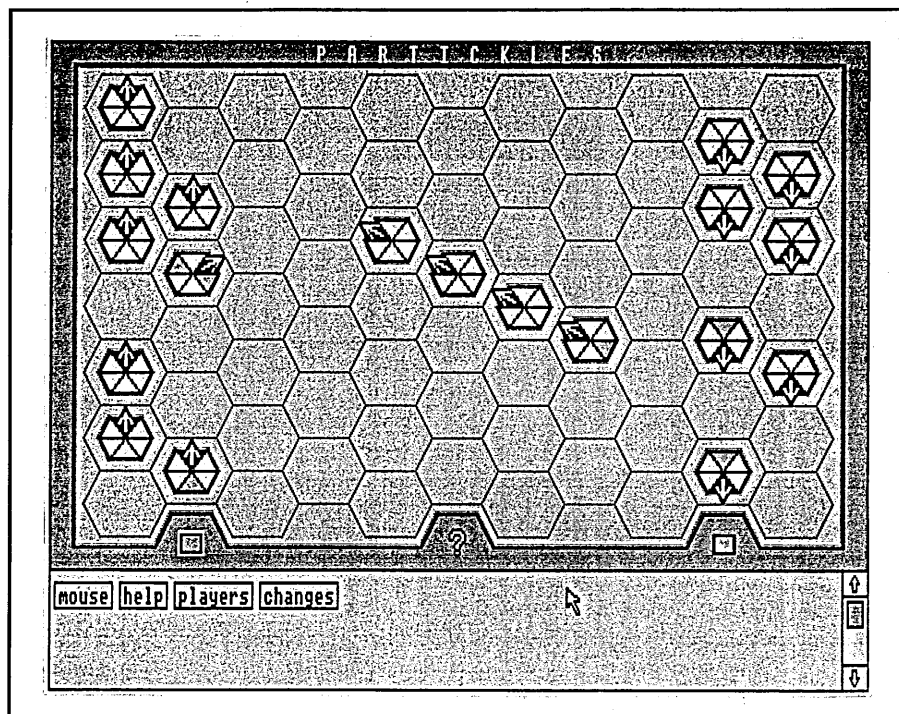


Figure 4.14 The use of make move (Particles version 2)

Figure 4.14 shows that the move described by the 'would do' partickle SEO information in Figure 4.12 has been made: the partickle has pushed a red partickle, moved four places and unpacked three partickles. The hot words boxes have been cleared leaving the arrow pointer at the make move hot words box's location. The current pointer is actually the question pointer which temporarily changes to the arrow (to show that object-based help is not available) when it leaves the upper window.

The move value hot words box is used to obtain and display the computer player's assessment (a numerical value) of the move described by 'would do' partickle SEO information. This facility can be used to obtain advice or to examine the computer player's strategy. Figure 4.15 follows Figure 4.12 and shows what has happened as a result of selecting the move value hot words box:

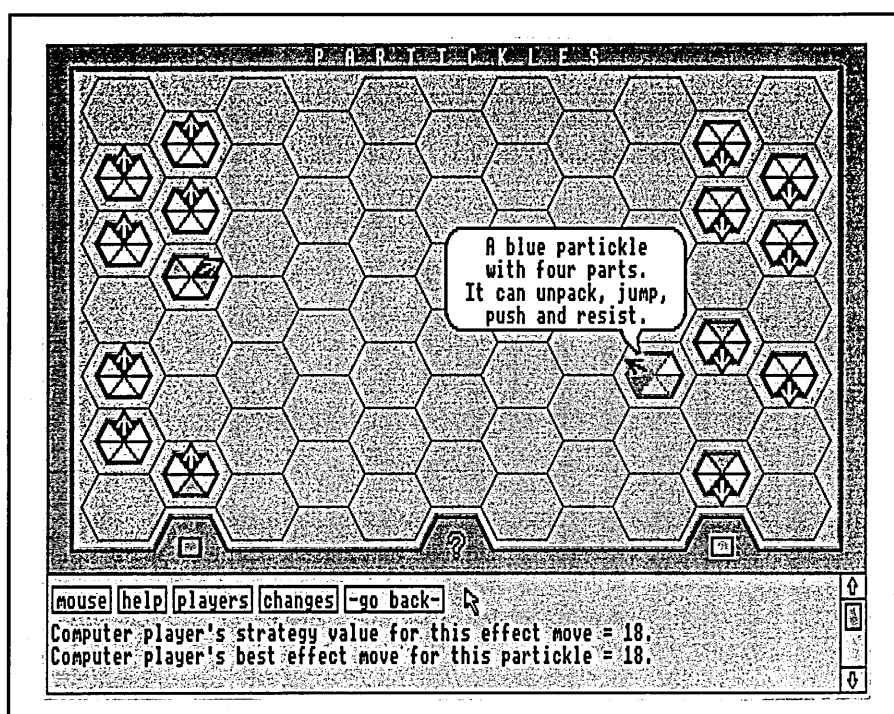


Figure 4.15 The use of move value (Partickles version 2)

In Figure 4.15 the move value facility has accessed the computer player object to obtain values for the current move (which, for the currently selected partickle, would be an effect move) and for the best effect move that the partickle could make. The 'better' moves are indicated by higher numerical values.

The effects SEO help facility is a form of hypertext containing information regarding effect moves. In versions 1 and 2 of Partickles the effects SEO help facility is accessed by a hot words box labelled colours but this name was

changed to effects in version 3. Figure 4.16 follows Figure 4.12 and shows what has happened as a result of selecting the colours hot words box:

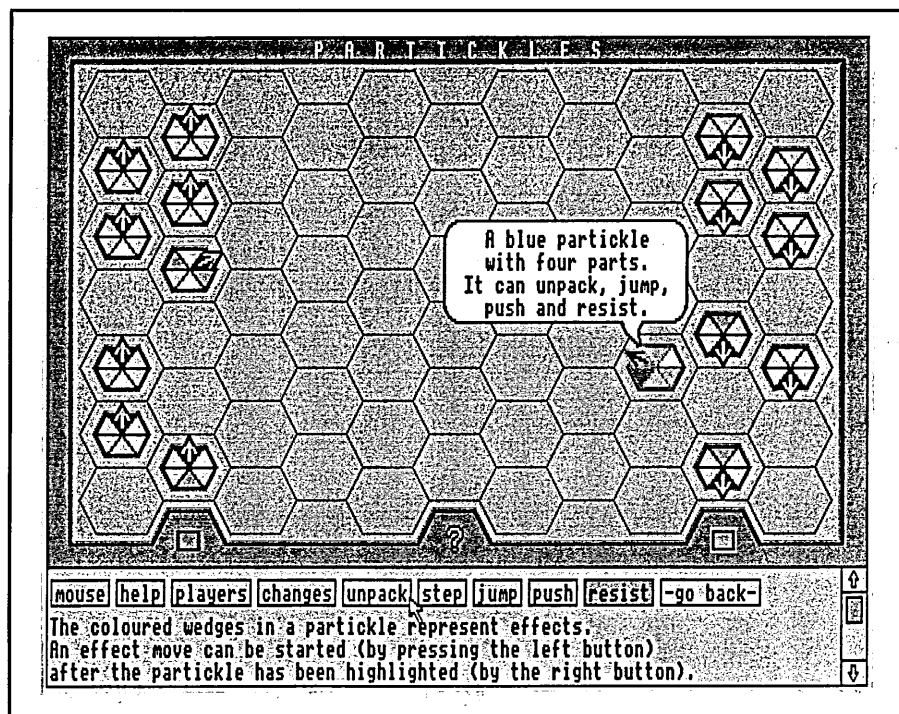


Figure 4.16 The effects SEO help facility (Partickles version 2)

In Figure 4.16 the effects SEO help facility has been accessed and has displayed a brief paragraph about effects in the lower window, a -go back- box and the top level index of five coloured hot words boxes labelled with the names of effects: unpack, step, jump, push and resist. The five hot words boxes are coloured to match the coloured triangles that represent effects in partickles. Selecting these hot words boxes produces information describing the corresponding effect, plus a -go back- hot words box and, in the case of the unpack hot words box two further hot words boxes: ...unpack and swap, and for the step hot words box an additional ...step hot words box. Subjects are able to navigate the effects SEO help facility by selecting hot words boxes. Figure 4.17 follows Figure 4.16 and shows what has happened as a result of selecting the unpack hot words box:

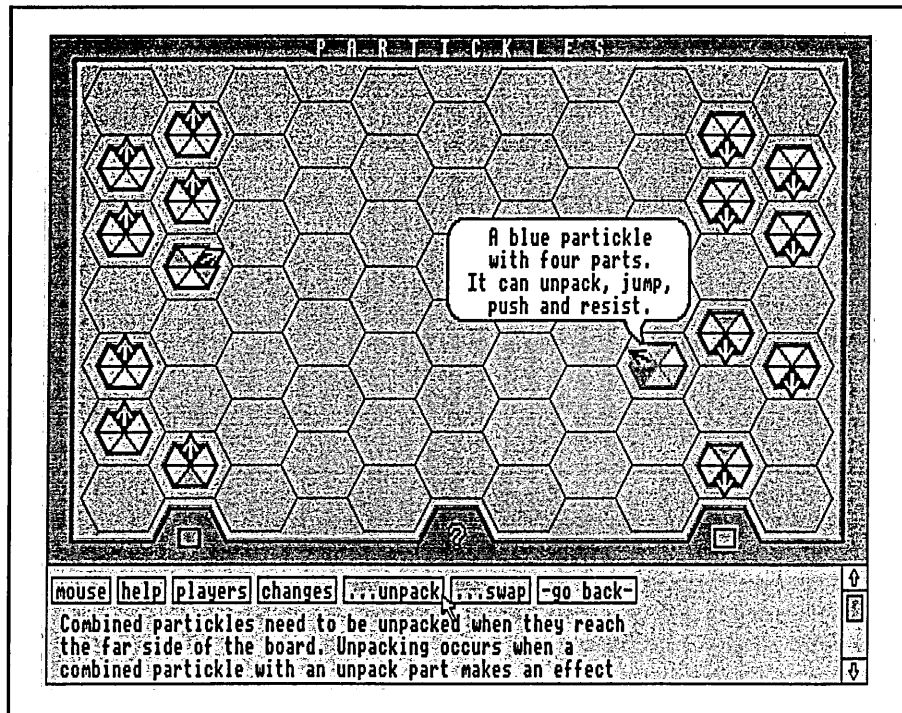


Figure 4.17 The effects SEO help facility's unpack option

Figure 4.17 shows that selecting unpack has produced information about unpacking in the lower window, two further hot words boxes related to unpacking and a -go back- box.

Version 3 of Partickles contains an extended SEO help facility accessed by a help hot words box. The help hot words box appears in place of colours when particle SEO information is obtained, and also appears when control or area SEO information is obtained (Figure 4.10). Figure 4.18 (which follows Figure 4.13) shows what happens when help is selected:

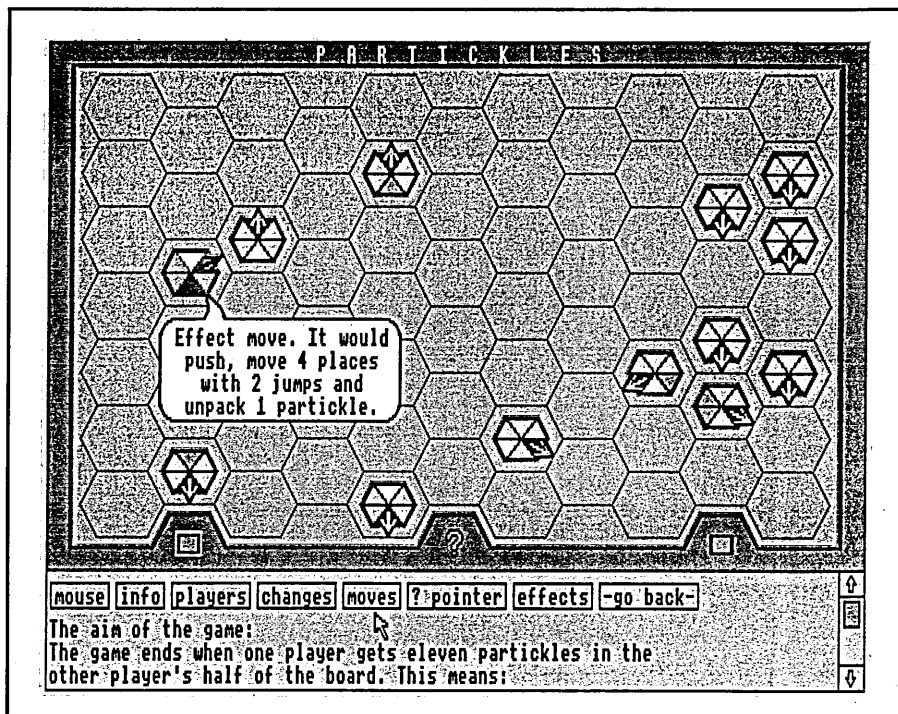


Figure 4.18 The extended SEO help facility (Partickles version 3)

As Figure 4.18 shows, selecting the help hot words box provides information regarding the aim of the game and three hot words boxes: moves, ? pointer and effects. The moves and ? pointer options provide paragraphs of information in the lower window relating to making moves and to object-based help. The effects hot words box provides access to the effects SEO help facility. The content and navigation of the effects SEO help facility is the same for all three versions of Partickles. All the information in the effects SEO help facility is identical to parts of the information provided in help menu options: getting started and Partickles rules and this is indicated in Appendix A. The texts provided by the help, moves and ? pointer hot words boxes are also included in Appendix A.

The trace facility displays its information in the lower window and is updated after every significant action/selection. In version 1 of Partickles there are two trace options: show trace which switches the trace on or off, and full trace

which toggles between the parsed and unparsed formats. In versions 2 and 3 of Partickles trace is a changes menu option and only the parsed format of the trace is available. Trace information is temporarily removed from the lower window to make way for other SEO help information, but it is replaced when this is cleared. Figure 4.19 shows an example of the parsed output from the trace facility in version 1 of Partickles:

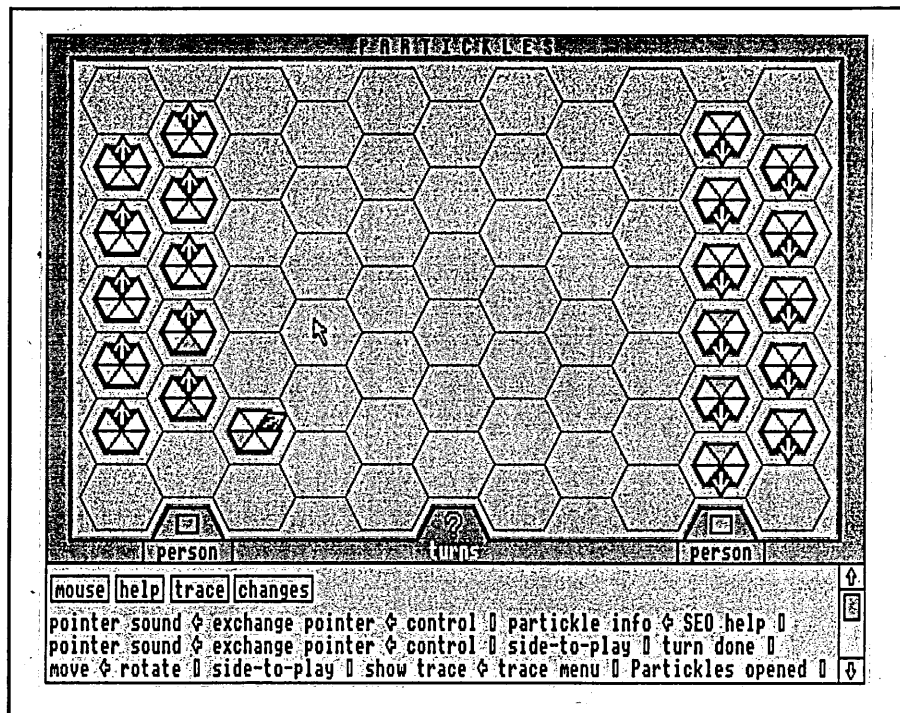


Figure 4.19 The trace facility

In Figure 4.19 the most recent action is shown on the left of the top line in the lower window beneath the menu buttons. Reading from the bottom right: after opening Partickles the trace facility was switched on, a particle was rotated (which automatically selected a side-to-play) and a move was made, the pointer was exchanged and particle SEO information was obtained, then the pointer was changed back to the arrow.

The function names and arguments used by `trace` are stored in a compact, coded form which can be saved as a file. Each of these 'trace records' contains details of a complete session with Partickles and when parsed by a decoder program produces an output similar to that of the `trace` facility. Annotated extracts from three parsed trace records are provided in Appendix C.

The next section discusses the programming of Partickles and describes the implementation of its SEO help facilities.

4.5 Programming Partickles

Partickles is written in C within the Archimedes multi-tasking WIMP environment. The reasons for choosing C and the Archimedes were as follows:

- C is commonly used in commercial system development - including systems with graphical object-oriented interfaces - so the solutions described in this section have direct, current relevance.
- C can be compared with, and in some respects can simulate, its object-oriented relative, C++.
- The Archimedes was preferred because it is fast, has a high resolution, colour bit-mapped display, a largely familiar operating system and because it is commonly used in British schools (where the Partickles studies were to be undertaken).
- The Archimedes has a well supported C interface to its WIMP environment.
- At the time of programming, resources and the availability of products restricted the choice of other systems and languages.

Early attempts to code Partickles in a object-oriented style involved using C functions as the units of modularity. This would have produced a system programmed in a similar style to that of the noughts and crosses program but which used function calls and their arguments directly instead of messages in strings and which used the local data in functions for private data since this was capable of preserving its values between calls. Eventually a solution was developed in which objects are represented by data structures whose parts imply the functionality that can be applied to them and/or which can be associated with methods.

Duff & Howard [1990] describe a number of mechanisms which can be used for object-oriented programming in C. These mechanisms are intended to simulate, and provide support for, encapsulation, polymorphism and inheritance, and, like the Partickles' solution, they involve the use of the C data type *structure* to specify an object type (which in C++ can be specified by the data type *class*). The mechanisms that Duff & Howard describe are intended to encourage the development and use of reusable software components as well as to provide a staged introduction to object-oriented programming. Duff & Howard's techniques for linking methods with data and for providing polymorphism and inheritance involve the use of a "sendMessage" function and lookup tables to match functions with objects. In Partickles, where there is no need to support polymorphism and inheritance, it is possible to regard direct function calls as message-sending providing that the programmer only specifies calls to appropriate functions. Some encapsulation of objects in C can be provided by the use of structures to group data types, but these structures do not contain private data and cannot specify member functions like those of C++. Consequently, the object-oriented techniques employed in Partickles and suggested by Duff & Howard require a conscientious object-oriented approach

on the part of the programmer in regard to encapsulation and also the choice of objects (abstraction). The remainder of this section concentrates on the coding of the SEO help facilities.

Figure 4.20 shows the `particle_info` data structure that represents particles. Descriptions of its data components and their expected values are shown as comments within `/*...*/` delimiters:

```
typedef struct {
    int partno,          /* particle                (0-21) */
        loc,            /* location of particle    (0-71) */
        dir;           /* orientation              (0-5) */
    BOOL effecton,     /* NB. switching off ends step move (T/F) */
        present;      /* if false (absent) has been combined (T/F) */
    int side,          /* side (red/blue)         (0-1) */
        stepping,     /* decs thru stepmove from combno (5-1) or (0) */
        combno,       /* number of particles in combination (1-5) */
        unpack,       /* no. of this effect type in comb (0-1) */
        step,         /* "                        (0-2) */
        jump,         /* "                        (0-2) */
        push,         /* "                        (0-3) */
        resist;      /* "                        (0-3) */
} particle_info;
```

Figure 4.20 The C structure that represents particles as objects

One advantage of using a data structure to represent objects is that each variable in the structure can be associated with a method that changes the variable's value. For example, the `dir` variable in the `particle_info` structure can be associated with a "rotate" method that changes the particle's direction. The self-explanatory capabilities of the particle objects are implemented by associating a `seo_particle` function with instances of the `particle_info` structure. Figure 4.21 shows how the `seo_particle` function uses information

from partickle objects to build a description of the general functionality of partickles and their states (effect on or off, and whether stepping during a step move). The text used for the help message is shown in bold for clarity:

```
static void seo_partickle(int partickle)
{
    int temp, count, line = 0;
    char nos[5][6] = {"one","two","three","four","five"};
    BOOL canmove = TRUE;
    partickle_info hpi;
    single_move_info hsm;
    effect_move_info hem;
    message();

    hide_hotbox();
    hpi = get_partickle_info(partickle);
    if (!bubble) canmove = bubble_show(hpi);
    else if (hpi.effecton) {
        hem = get_effect_move(hpi);
        if ((hem.move_places == 0) && !hem.swap) canmove = FALSE;
    }
    else {
        hsm = get_single_move(hpi);
        if (hsm.move_places == 0) canmove = FALSE;
    }

    if (hpi.partno <= 10) strcpy(helpstring[line], "A red");
    else strcpy(helpstring[line], "A blue");
    strcat(helpstring[line], " partickle with ");
    strcat(helpstring[line], nos[hpi.combno-1]);
    strcat(helpstring[line], " part");
    if (hpi.combno > 1) strcat(helpstring[line], "s");
    strcat(helpstring[line], ".");

    temp = 0;
    if (hpi.unpack) ++temp;
    if (hpi.step) ++temp;
```

```
if (hpi.jump) ++temp;
if (hpi.push) ++temp;
if (hpi.resist) ++temp;

++line;
strcpy(helpstring[line], "It can ");
for (count = 1; count <= temp; count++) {
    if (hpi.unpack) {hpi.unpack = 0; strcat(helpstring[line], "unpack");}
    else if (hpi.step) {hpi.step = 0; strcat(helpstring[line], "step");}
    else if (hpi.jump) {hpi.jump = 0; strcat(helpstring[line], "jump");}
    else if (hpi.push) {hpi.push = 0; strcat(helpstring[line], "push");}
    else if (hpi.resist) {hpi.resist = 0; strcat(helpstring[line], "resist");}
    if (count == temp) strcat(helpstring[line], ". Effect is ");
    else if (count == (temp-1)) strcat(helpstring[line], " and ");
    else strcat(helpstring[line], ", ");
}
if (hpi.effecton) strcat(helpstring[line], "on.");
else strcat(helpstring[line], "off.");

++line;
if (hpi.stepping && (hpi.combno > 1)) {
    strcpy(helpstring[line], "It can step ");
    strcat(helpstring[line], nos[hpi.stepping-1]);
    if (hpi.stepping < hpi.combno) strcat(helpstring[line], " more");
    strcat(helpstring[line], " place");
    if (hpi.stepping > 1) strcat(helpstring[line], "s");
    strcat(helpstring[line], ".");
}

show_hotbox("help");
show_hotbox("move value");
if (canmove) show_hotbox("make move");
box[0] = 1;
box[1] = partickle;
box[2] = hpi.dir;
```

```
    box[3] = hpi.effecton;  
    box[4] = 2;  
}
```

Figure 4.21 The `seo_partickle` function - providing descriptive help

The example in Figure 4.21 is taken from Partickles version 3. The help request (clicking on an icon with the left mouse button + question pointer) is passed to the `seo_help` function which identifies the icon as a particle and then calls `seo_partickle` with an integer parameter indicating which particle has been selected. The `seo_partickle` function obtains the relevant, up-to-date `particle_info` structure by calling `get_particle_info` and it names the particle object that is returned "hpi". The help messages built by the `seo_partickle` function are based on the information in `hpi` and constitute the self-explanations of particle objects.

The last lines of the `seo_partickle` function in Figure 4.21 show the calls and assignments that provide hot words boxes when object-based help is obtained. When a hot words box is selected the event handler for the lower window transfers calls to a `seo_hotbox` function. When the make move hot words box is selected `seo_hotbox` checks the values of the array `box` (elements 1, 2 and 3) and uses these and other variables to see if the particle's state has remained unchanged and the system state still permits a move. If this is the case the move is made - if not one of six SEO error messages are displayed, such as, "Cannot make the described move because the particle has been rotated". When the move value hot words box is selected the `seo_hotbox` function obtains information from the computer player. The computer player's assessment of a move is an object: the data structure, `dir_val`. This contains a value for a move made in the current direction that the particle is facing, the current direction, the value of the best move that the particle can make and

the direction in which the best move would be made. When hot words boxes belonging to the effects SEO help facility or extended SEO help facility are selected the `seo_hotbox` function changes the information presented in the lower window and presents a new selection of hot words boxes.

The first part of the `seo_partickle` function in Figure 4.21 shows a `message()` call which tells the trace facility that the function is in use. A call to the `message` function is included with all the functions that are potentially meaningful to users. The `message` function stores references to functions as they are called. The references are stored in two forms. One of these is a series of six byte entries comprising a trace record. The six bytes hold values for hours, minutes and seconds, a number representing the function, an argument (optional) that the function has received and a zero terminator. At the end of a Partickles session the trace record can be saved to disc for later parsing by a separate trace decoder program. The trace records provide details of entire interactions. The second form in which references to function calls are stored is in a parsed form as strings. These strings are output in the lower window whenever the trace facility is switched on. The call to the `message` function could have included arguments to identify the calling function. Instead, `message` uses `setjmp` (a library function) and some arithmetic to find out where the details of the function called prior to `message` are located on the function calling stack. It then reads the function name and some of its arguments and variables directly from memory. A look-up table is used to convert these details into a number (for the trace record) and the parsed form of the information (for the trace facility). For example, the function name `seo_partickle` would be given the number 40 and translated into "partickle info". The reason why the function calling stack is examined is to show that the program can provide dynamic information by capturing its own function calls (the Partickles

equivalent of message-passing). Trace is regarded as a SEO facility because reading Particles' function-calling stack is an attempt to simulate intercepting message-passing in a more object-oriented programming language.

The `seo_particle` function in Figure 4.21 also uses instances of structures called `single_move_info` and `effect_move_info` whose declarations are shown below:

```
typedef struct {
    int particle,           /* particle                (0-21) */
        start,            /* start location of particle (0-71) */
        dest,            /* final location of particle (0-71) */
        move_places;     /* number of places moved   (0-1) */
    BOOL combine;         /* did it combine           (T/F) */
    particle_info comb_part; /* particle combined with */
} single_move_info;

typedef struct {
    int particle,           /* particle                (0-21) */
        start,            /* start location of particle (0-71) */
        dest,            /* final location of particle (0-71) */
        move_places,     /* number of places moved   (0-5) */
        jump,            /* number of particles/places jumped (0-4) */
        jumpplaces[4],   /* positions of jumped particles (0-71) */
        unpack,          /* number of particles unpacked (0-4) */
        unpackageff[4],  /* unpackagee effect types (UNPACK-RESIST) */
        unpackagepos[4], /* unpacked particle positions (0-71) */
        swappart,        /* particle unpack swaps into (0-21) */
        swapeffect;     /* swapee effect type (UNPACK-RESIST) */
    BOOL swap,          /* was a swap made          (T/F) */
        push,           /* was a particle successfully pushed (T/F) */
        ownside;       /* pushed particle: same side or not (T/F) */
    int pushpart,       /* pushed particle          (0-21) */
        startpush,     /* start location of pushed particle (0-71) */
        destpush;     /* final location of pushed particle (0-71) */
} effect_move_info;
```

Figure 4.22 The `single_move_info` and `effect_move_info` structures

The structures shown in Figure 4.22 are used to see if a partickle can make a move. Instances of the `single_move_info` and `effect_move_info` structures are objects in the same sense that instances of the `partickle_info` structure are objects, but unlike the `partickle` objects they do not have corresponding display objects. The `single_move_info` and `effect_move_info` structures represent *moves* and hence constitute behavioural abstraction. This form of abstraction in object-oriented programming was discussed in Chapter 3 with reference to work by Gibson who advises that a basic rule learned by every successful object-oriented developer is, "Focus on behavior and group by behavior". Though the move objects represent actions rather than concrete objects the concept of a move is one that users can recognise and in Partickles it is expressed as help information that describes what partickles 'would do'. 'Would do' partickle SEO information is drawn from instances of the `single_move_info` and `effect_move_info` structures by a function similar to the `seo_partickle` function shown in Figure 4.21.

4.6 Discussion

This chapter has described two systems. The noughts and crosses program was a relatively simple first investigation of object-oriented programming, self-explanatory objects and object-based help. It incorporates mechanisms that demonstrate how a modular style of programming using a procedural language can be extended in the direction of an object-oriented style of programming. Though the 'objects' in the noughts and crosses program are built within BASIC's procedures they function by passing messages in strings, they contain private data and they encapsulate both data and methods. Some of the noughts and crosses' objects are provided with a self-explanatory capability

in the form of methods that supply the help facility with coded identifiers in response to "Q" messages. The object-based help facility that parses, supplements and in some cases requests additional data is primitive and the information it presents consists mainly of the names of display objects and comments supplied by the help system designer regarding their general functionality.

The investigations of object-oriented programming and self-explanatory objects in Partickles concentrated upon the representation of partickles playing pieces as system objects by data structures. The method of object-oriented programming using C suggested by Duff & Howard [1990] also involves the use of data structures to represent objects. The objects in the noughts and crosses program largely correspond with display objects or fulfil data-processing functions, but in Partickles the abstraction represented by the move objects relates to behaviour rather than to the visible characteristics of display objects. The partickle objects are used as a source of descriptive partickle SEO information concerning the names, states and (a selection from) the general functionality of partickles. This information includes descriptions of what users can see. The move objects are used as a source of 'would do' partickle SEO information concerning the current functionality of partickles. This information describes what partickles would do and hence relates directly to what users can do.

Neither system described in this chapter represents a polished example of object-oriented programming. The systems were used to investigate object-oriented programming and, in Partickles, this resulted in a solution which is similar to that suggested by Duff & Howard [1990], and which includes the use of objects to represent behaviour. Duff & Howard state that, "Object-oriented

techniques can and should be considered separate from object-oriented languages". Neither of the systems described in this chapter was programmed in an object-oriented language. This allowed a solution to be developed in C - a language which is widely used for commercial development - and it focussed attention on the style of programming rather than the language.

The usage of Partickles' help facilities was investigated in a series of three successive studies, and, in its role as a study tool, Partickles provided a game and a computer player opponent to motivate and occupy subjects, and a trace record facility to store details of interactions during sessions. Partickles contains menu-based help facilities divided into a number of categories to assist the interpretation of help requests, and SEO help facilities which are described below:

- object-based help
.....obtained using a question mark pointer. Object-based help is available for two screen areas, some controls and all partickles in the upper game board window. During the studies the object-based help information supplied by Partickles was used to investigate some of the types of information that can be appropriate for object-based help in systems that have graphical object-oriented interfaces.
- extensions to object-based help
.....obtained by selecting hot words boxes after object-based help has been obtained, and comprising: the make move, move value and effects/extended SEO help facilities. These facilities were designed to investigate the extensibility of object-based help, and the usefulness of supplying additional information/facilities once an initial help request has established the context of an enquiry.
- dynamic help based on objects

.....obtained by switching on the trace facility from a menu. This facility was included to investigate the premise that if a system is programmed in terms of objects that are meaningful to users, then information concerning the operation of the system might be both comprehensible and useful to them.

The Partickles studies are introduced and then described in the next four chapters, and the results of the studies are presented in Chapter 9.

Chapter 5

Introduction to the Studies

5.1 Introduction

The purpose of the Partickles studies was to investigate the utility of object-based help facilities and of object-based help information drawn from self-explanatory objects. The studies were designed to produce examples of the use of Partickles' help facilities so that the usage could be discussed, comparisons made and conclusions drawn. This chapter discusses the design of the studies, describes the materials and procedure that were used, and provides details of the subjects and the sessions.

There were three Partickles studies: the pilot study, the core study and the video study. All three studies produced data concerning the use of the help facilities in Partickles. The pilot study was used to focus the aims and improve the format of subsequent studies. The core study raised a number of questions in regard to the use of the help facilities in Partickles and the formats of the studies. The video study was used to examine and extend the findings, and to test the formats, of the other two studies.

The subjects of all three studies were school students and the studies were conducted in a school. All sessions of the studies were observed by myself. There were 9 pilot study sessions, 6 core study sessions and 3 video study sessions. These involved: 7 subjects in the pilot study (two of whom returned

for second sessions), 6 subjects in the core study and 6 subjects in the video study.

The "Method" sections of Chapters 6, 7 and 8 describe the formats of the three studies and discuss the differences between the formats. The main differences between the studies were as follows:

- Some aspects of Partickles' help facilities were modified.
- The pilot study subjects were aged 12 to 14 whereas the core and video study subjects were aged 16 to 18.
- Subjects were studied individually in the pilot and core studies but in pairs in the video study.
- The tape recorder used in the pilot and core studies was replaced by a video tape recorder in the video study.
- The formats of the pilot and core studies were similar but the video study differed - largely because the subjects were in pairs, but also so that an alternative format could be used for comparisons.

5.2 Design

The Partickles studies were a means of gathering evidence concerning the following:

- the problem of providing appropriate on-line help for systems that have graphical object-oriented interfaces, and
- the proposed solution of providing object-based help facilities that draw help information from self-explanatory objects.

In Chapter 1 it was suggested that the information supplied by graphical object-oriented interfaces may already meet many of the information requirements of

users, and that users of graphical object-oriented interfaces may be accustomed to obtaining information through the observation and manipulation of display objects rather than the use of help facilities. Nevertheless, users of graphical object-oriented interfaces might use help because the interfaces do not fulfil all their information requirements or because they consider that the help fulfils some of their information requirements more appropriately than the interface. The appropriateness of help provision for a system that has a graphical object-oriented interface can be investigated by monitoring usage and assessing whether subjects' preferences indicate that they found the help useful. Borenstein [1985] writes that: "Objective measurements of these preferences are possible through monitoring the actual use of help systems when several alternatives are available, though it must be ensured that the users are fully aware of all the available alternatives". Partickles provides a graphical object-oriented interface and a choice of help facilities, and the Partickles studies were designed to provide evidence of subjects' preferences regarding these alternative sources of information.

Borenstein [1985], Cherry et al. [1988], Carroll & Aaronson [1988] and Magers [1983] conducted studies which related the effectiveness of help provision to subjects' progress in performing tasks. The tasks required the use of help for their successful completion. Kearsley [1988] writes that, "With respect to effectiveness measures, total or average task-completion time seems to be the most commonly used performance dimension". The use of tasks in studies is a way of generating help requirements so that help usage can be assessed, but it may also prescribe help requirements. The subjects of the Partickles studies were given a broader task, namely, learning to play the Partickles game and to operate the system. This task generated a variety of help requirements, and it

provided data concerning help requirements in addition to data concerning help usage.

The principal objective measure of the appropriateness of Partickles' help facilities was the extent to which these were used. Repeated and/or lengthy usage of help facilities indicated that subjects considered that the help they provided was appropriate. The comments made by subjects during and after their usage of Partickles provided an additional, but subjective, source of data concerning their preferences.

Chapters 6, 7 and 8 document, and present the findings of, the three Partickles studies and in Chapter 9 Partickles' help facilities are discussed individually in the light of these studies. These chapters were constructed to answer two basic questions: "Was it used?" and "Was it useful?" The first question is answered by examining details of usage, the second by looking for repeated and/or extensive usage, noting subjects' reactions, comments and progress and assessing whether the use of Partickles' help facilities met subjects' apparent needs.

5.3 Materials

The Partickles program provided the main activity of the sessions. Information about the conduct of sessions was contained in subjects' guidelines, observer's guidelines and record sheets. Data was recorded on record sheets and blank sheets (in the form of the observer's written records and notes), on checklists (completed by the video study subjects), as audio or video recordings and as machine-readable, time-stamped trace records of subjects' interactions with Partickles. These materials and their functions are described below:

- Subjects' Guidelines

.....briefly described the session procedure and explained the observer's and subjects' roles. The explanations were intended to: a) empower the observer to organise the session, to intervene and to reject questions and, b) to encourage subjects to make comments and to confine their activities to using the mouse. The subjects' guidelines are included in Appendix B.

- Observer's Guidelines

.....was divided into sections relating to the beginning and end of sessions and to the phases of sessions. It instructed the observer in regard to setting up and using equipment and loading, starting and resetting software; it contained the instructions and introductions that the observer read to subjects and it indicated when and where details of subjects and observations of the interactions should be recorded. There were two versions of the observer's guidelines. The pilot and core study version contained suggested procedures for intervening, briefing subjects and managing transitions between phases of sessions, but by the time the video study version was constructed these were no longer needed. The observer's guidelines are included in Appendix B.

- Record Sheet

.....was used to record subject and session details, the timings of phases of sessions and observations (the observer's notes). There were three versions of the record sheet and two of these have been included in Appendix B. The pilot and core study versions, which were similar, contained a list of eight items that subjects were required to have noticed before they played Partickles. The items were ticked as subjects encountered them. A blank sheet of paper was attached to the first version of the record sheet for noting observations and the times of

observations, but the second version (used in the last pilot study session and all the core study sessions) contained spaces in the appropriate sections for noting observations and times, and additional blank sheets were appended if necessary. At the end of the pilot and core study sessions subjects were asked if they would be prepared to return for another session with Partickles, and their replies were noted at the start of the record sheets. The video study version of the record sheet contained short sections for noting the times of phase and for brief comments. The video study did not allow time for noting observations in detail, so the observer's notes for the video study sessions were made on blank sheets during initial viewing of the video recordings. The final section of the video study version of the record sheet listed five questions that subjects were asked at the end of sessions.

- The Partickles Program

.....as described in Chapter 4. The computer used was an Acorn Archimedes or A3000 with a colour display, sound and a three-button mouse. Subjects interacted with Partickles solely by means of the mouse.

- Trace Record of Partickles usage

.....was a record, saved as a file, of subjects' selections and system responses during a session. Once decoded the trace record was similar to the output from the trace facility, but each trace record entry was presented, with the time of the entry, on a separate line. The trace records provided detailed session histories to which the other forms of data could be related. Sample parts of three annotated trace records are provided in Appendix C.

- Audio Cassette Tape Recorder (pilot and core studies)
.....recorded everything spoken by the observer and subjects. The audio recordings were used to help verify the results presented in the Partickles studies chapters and some comments and dialogue have been included in the session details presented in Appendices D and E.
- Video Tape Recorder (video study)
.....a VHS video tape recorder was used in the video studies in place of the audio tape recorder. It recorded sound and hence fulfilled the role of audio tape recorder and additionally showed what happened on, and in front of, the computer screen.
- Checklists (video study)
.....two checklists, A and B, replaced and extended the eight items listed in the record sheets of the first two studies. The observer had used that list to tick off items that did not need to be included in the observer briefing. The new checklists took the form of lists of exercises for subjects to complete and were intended to replace the observer briefing and to encourage dialogue and collaboration. Checklists A and B are included in Appendix B.

The remainder of this section concerns a program called "Intro". All the Partickles study subjects completed a series of exercises presented by Intro at the start of their sessions. Intro was developed to test subjects' colour vision and literacy, to obtain information about their previous experience and to provide practice with using and changing pointers. The information obtained with Intro is presented in section 5.5. The same version of Intro was used for all sessions of the Partickles studies and it ran on the same computers as Partickles. Figures 5.1, 5.2 and 5.3 show the Intro program in use:

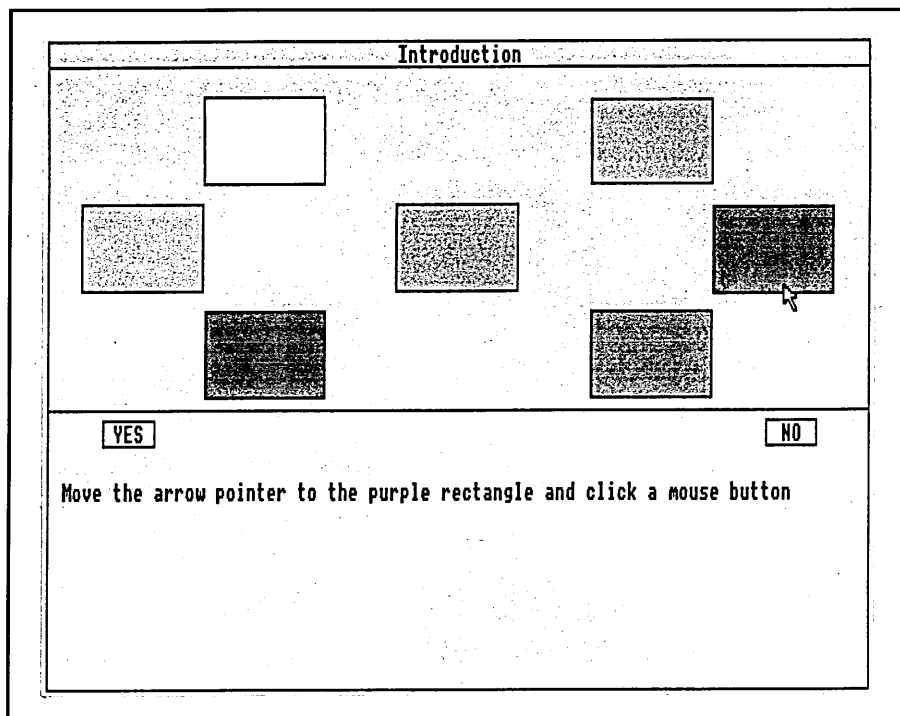


Figure 5.1 The Intro program: colour vision, mouse usage and screen-reading

Figure 5.1 shows the first Intro exercise in which subjects were asked to identify each of the main colours used in Partickles by matching the name of the colour to a coloured rectangle on the screen.

Figure 5.2 (below) shows the second Intro exercise which consisted of four questions regarding subjects' previous computer and domain experience. The questions were answered by clicking "YES" or "NO" boxes.

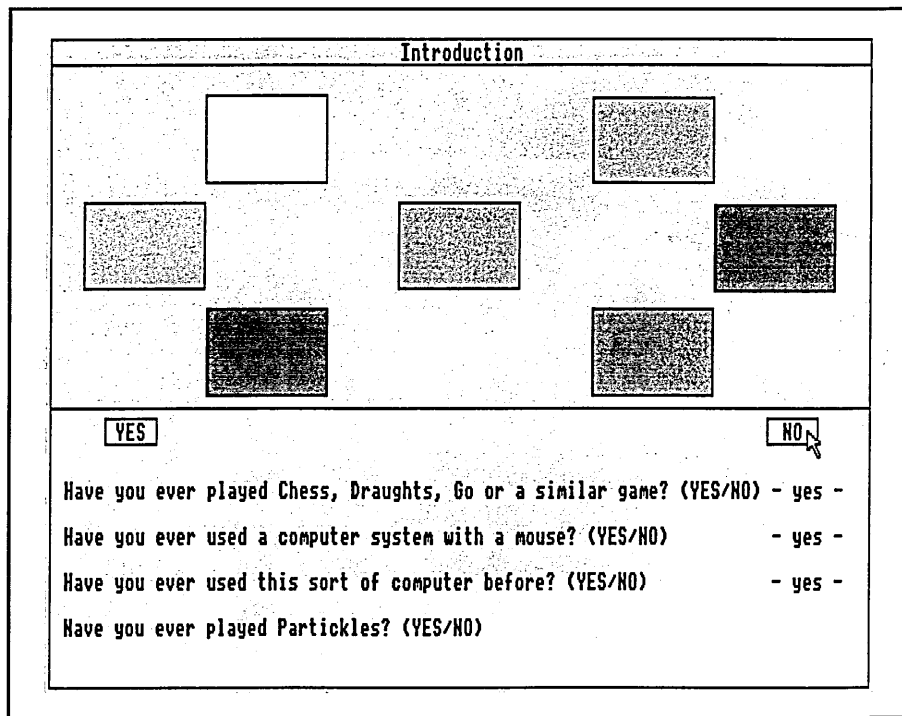


Figure 5.2 The Intro program: previous experience

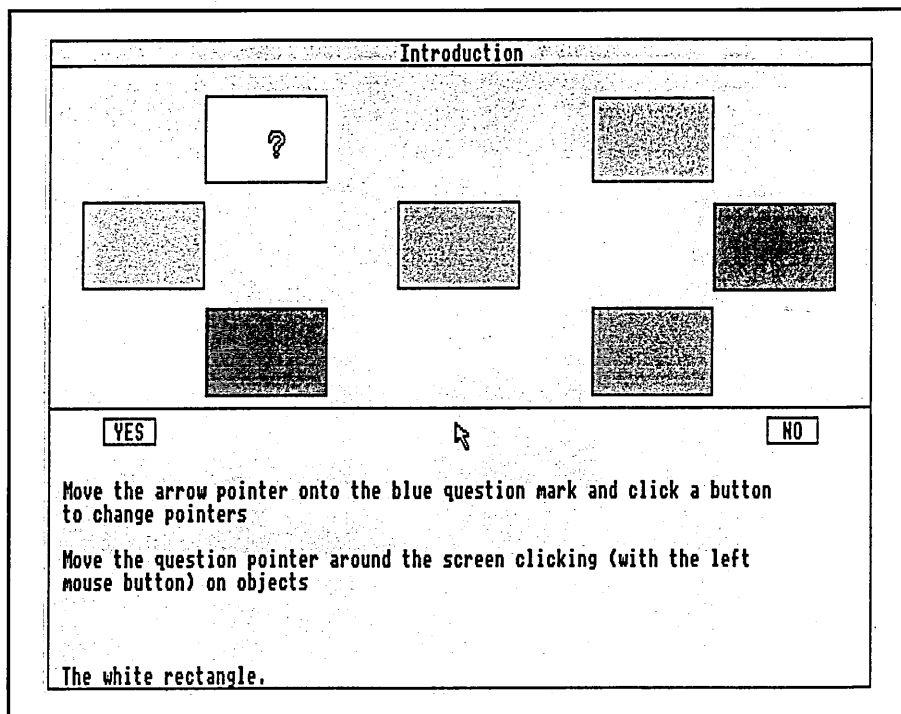


Figure 5.3 The Intro program: changing pointers and object-based help

Figure 5.3 shows the final Intro exercise in which subjects were asked to change pointers and then to click on screen objects. This was essential practice because,

in versions 1 and 2 of Partickles, the pointer *had* to be changed before SEO help facilities could be accessed. After clicking eight times on screen objects an "END" box appeared, with the instruction: "Click on the END box when ready to end".

The record sheets (included in Appendix B) contained lists corresponding to the exercises presented by the Intro program, and show the exact wording of the exercises. The video study version of the record sheet contained two Intro sections: one for each subject of the pair.

5.4 Procedure

In all three studies the session procedures followed the plans detailed in the observer's guidelines. Sessions were divided into phases, and each phase was preceded by an introduction (contained in the observer's guidelines) read aloud by the observer.

The procedure of the pilot and core studies was as follows:

- Introduction to the session read to subject.
- **Intro phase** with the Intro program.
- Subject's guidelines read by subject.
- **Explore and Practise phase** with Partickles.
- Observer briefing.
- **Game Playing phase** with Partickles.
- Informal debriefing.

During the Intro phase the observer filled in the Intro section of the record sheet. After the Intro phase the observer noted the time and date of the session

and details of the subject. The subject's guidelines briefly listed the three phases of the session and mentioned the informal debriefing. During the explore and practise phase the observer noted observations in the "explore and practise" section of the record sheet and ticked the listed activities as the subject encountered them. The explore and practise phase ended when all the listed activities had been completed, or if too much time had been spent on this phase, or if the subject wanted to begin game playing. The observer briefing at the end of the explore and practise phase involved the observer demonstrating, or guiding the subject through, any of the listed activities that the subject had not tried during the explore and practise phase. During the game playing phase the observer noted observations regarding the subject's progress and any interesting activities and comments. The observer sometimes intervened during this phase - to ask about particular incidents or to remind subjects of alternative sources of information. The observer's guidelines only suggested one question for the informal debriefing: "Would you be prepared to come back for another session with Partickles?", but the debriefing was also an opportunity to discuss the subject's progress, particular episodes and so on. This session procedure was also used on the two occasions in the pilot study when subjects returned for second sessions but the introductions to the phases and the observer briefings were kept brief so that the game playing could continue as soon as possible.

The procedure of the video study was as follows:

- Introduction to the session read to the subjects.
- **Intro phase** (+ subjects' guidelines)..... with the Intro program.
- **Explore and Practise phase** with Partickles.
- **Checklist phase** with Partickles.
- **Game Playing phase** with Partickles.

- Questions.

During the Intro phase one subject completed the Intro program's exercises while the other read the subjects' guidelines, then the subjects changed roles. Each subject was allowed five minutes for exploring and practising while the other subject watched. This length of time was chosen after consideration of the total length of the phase and the attention span of the potentially passive non-mouse user. During the checklist phase one subject used the mouse while the other read and ticked exercises from checklist A. When the checklist was complete the subjects changed roles and completed checklist B. In the game playing phase the subjects played jointly against the computer player for at least one game, and the use of the mouse was swapped after each game. The subjects' and observer's guidelines also referred to the possibility that in later games the subjects might play against one another and/or use either the question pointer with SEO help facilities or the arrow pointer with menu helps. The video study record sheet (included in Appendix B) contained the five questions that the subjects were asked in all the video sessions. The record-keeping tasks of the observer in the video study were similar to those of the pilot and core studies, but observer interventions were minimised during the game playing phase and the observer's notes were written after an initial examination of the video recording.

5.5 The Subjects

There were nineteen subjects in the Partickles studies and they have been coded alphabetically to match the chronological order of their initial sessions. The selection of subjects was made by their class teachers. The pilot study and

core study subjects were from computer studies classes, and the video study subjects were from vocational studies classes.

subject code	A	B	C	D	E	F	G
age	13	12	13	14	12	13	14
gender	F	M	F	M	M	F	M
L/R handed	R	R	R	R	R	R	R
colour vision	ok	ok	ok	ok	ok	ok	ok

Table 5.1 Details of the pilot study subjects

subject code	H	I	J	K	L	M
age	16	16	17	16	17	17
gender	M	M	M	M	M	M
L/R handed	R	R	R	R	R	R
colour vision	ok	ok	ok	ok	ok	ok

Table 5.2 Details of the core study subjects

subject code	N	O	P	Q	R	S
age	16	16	18	18	18	18
gender	M	M	F	F	F	F
L/R handed	R	L	R	L	R	R
colour vision	ok	ok	ok	ok	ok	ok

Table 5.3 Details of the video study subjects (studied in pairs)

The video study subjects were asked whether they were left or right handed prior to using the Intro program, so that they and their partner could be seated appropriately - and, conveniently, two of the video study subjects were left-handed. All the other Partickles studies subjects were right handed. Prior to the

studies a user with limited ability to distinguish between reds and greens (the commonest form of colour blindness) tested Partickles and he was able to identify all its colours. The Intro program presented the main Partickles' colours in rectangles and asked subjects to match each of these with its name. All of the Partickles studies subjects matched the colours successfully. Intro also functioned as a literacy/screen-reading test since subjects could not complete the exercises if they couldn't read the instructions. Only one subject, subject G, had difficulty with reading from the screen, and this problem was first noticed in the Intro phase of session P7 in which the two question pointer exercises were misread as follows:

- The first exercise instruction referred to the "blue question mark" which subject G interpreted as 'blue rectangle' until the observer asked him to read the exercise out loud.
- For a while the subject did not notice that the second exercise instruction specified "the left mouse button" until he had reread the instruction.

The utility of Partickles' help texts was dependent upon subjects' abilities to read them, so it was useful that the Intro phase revealed subject G's difficulties early in the session. The Intro program also contained four questions that investigated subjects' previous computer and domain experience. The questions are shown in the Intro sections of the record sheets in Appendix B. Only two subjects in the studies claimed no previous experience of strategy games like Chess, Draughts and Go, three subjects claimed no experience of computer systems that had a mouse and five subjects claimed no experience with the type of computer (Acorn Archimedes or A3000) used in the studies. The fourth question was included as a reminder that the Partickles program constituted the main activity of the sessions. Subjects' answers, which were either 'Yes' or 'No', are presented in Tables 5.4, 5.5 and 5.6:

subject code	A	B	C	D	E	F	G
domain experience	N	Y	Y	Y	Y	Y	N
computer experience	N	N	N	Y	Y	Y	Y
system experience	N	N	N	Y	Y	N	Y
Partickles experience	N	N	N	N	N	N	N

Table 5.4 Previous knowledge of the pilot study subjects

Pilot study subjects A and B returned for second sessions with Partickles and were able to answer "Yes" to all four Intro questions at the start of their second sessions.

subject code	H	I	J	K	L	M
domain experience	Y	Y	Y	Y	Y	Y
computer experience	Y	Y	Y	Y	Y	Y
system experience	Y	Y	Y	Y	Y	Y
Partickles experience	N	N	N	N	N	N

Table 5.5 Previous knowledge of the core study subjects

subject code	N	O	P	Q	R	S
domain experience	Y	Y	Y	Y	Y	Y
computer experience	Y	Y	Y	Y	Y	Y
system experience	Y	N	Y	Y	Y	Y
Partickles experience	N	N	N	N	N	N

Table 5.6 Previous knowledge of the video study subjects

All the core and video study subjects (who were older than the pilot study subjects) answered "Yes" to the first three questions - with one exception:

subject O who claimed no previous experience with the type of computer used in the studies. However, subject O was seen playing computer games on that type of computer twice: the first occasion was two days after his session and the second was five days after that. This suggests that subject O may have made a mistake or may have interpreted the question differently from the other subjects.

5.6 The Sessions

The pilot study was the first Partickles study and this was followed by the core study and then the video study. The session codes reflect the chronological order in which sessions were conducted with the exceptions of pilot study sessions P1b and P2b. Both of these second sessions were conducted three days after the initial sessions P1a and P2a. The chronological order of the pilot study sessions was: P1a, P2a, P3, P4, P2b, P1b, P5, P6 then P7.

subject code	A		B		C	D	E	F	G
session code	P1a	P1b	P2a	P2b	P3	P4	P5	P6	P7

Table 5.7 Pilot study subject and session codes

subject code	H	I	J	K	L	M
session code	C1	C2	C3	C4	C5	C6

Table 5.8 Core study subject and session codes

subject code	N	O	P	Q	R	S
session code	V1		V2		V3	

Table 5.9 Video study subject and session codes

The video study subjects were studied in pairs, and they were all pairs of friends. Prior to the video study an additional session, the video pilot, was conducted to explore the possibilities of sessions using two subjects, a video camera, checklist exercises and constraints on the use of help facilities and pointers. Version 2 of Partickles was used in this session and two subjects from the core study, subject H and subject I, played five games jointly against the computer player. They lost the fourth game (probably due to a lapse in concentration caused by over-confidence) but they won all the others. This shows that these subjects had progressed beyond the initial game learning stage, but they made limited use of Partickles' help facilities during the session. Some details from the video pilot session are reported in Chapter 9 in respect of the usage of particular facilities, but the video pilot's main aim was to trial and practice a modified session format in preparation for the video study.

The next three chapters document and present the findings of the pilot, core and video studies respectively.

Chapter 6

The Pilot Study

6.1 Introduction

The pilot study was the first Partickles study. It consisted of nine sessions with seven subjects studied individually, as follows:

subject code	A		B		C	D	E	F	G
session code	P1a	P1b	P2a	P2b	P3	P4	P5	P6	P7

Table 6.1 Pilot study subjects and sessions

Subjects A and B returned for second sessions with Partickles. The pilot study subjects were aged from twelve to fourteen and the pilot study sessions took place in a relatively isolated corner of a 'fairly quiet' school classroom. The pilot study sessions are described individually in Appendix D.

The pilot study had two main aims:

- to investigate the usage of Partickles' help facilities, and
- to examine and iteratively redesign the study in order to focus the aims and develop the format of subsequent studies.

The preferences (see section 2 of Chapter 5) of the pilot study subjects in regard to the sources of information that they found most useful were less clear than those of the subjects in the core and video studies. This was largely due to improvements in the formats of the later studies suggested by

the pilot study. One of the changes made to the formats of the later studies was that older subjects with greater computer experience were used. The pilot study was the only source of information regarding younger subjects with less computer experience. This proved interesting because the older, more experienced subjects made greater initial use of help facilities to gain general introductory information, and useful because the contrast in the results obtained by varying the ages and computer experience of subjects suggested a distinction between the usage of help facilities to obtain general introductory information and usage for reference in regard to specific enquiries.

6.2 Method

Design

During the course of the pilot study it became clear that the main areas of interest were: the frequency and forms of use of object-based help; the frequency, amount of use and choice of menu-based help options; the use, particularly the navigation, of the effects SEO help facility; and the variance of help usage as subjects gained experience and knowledge. Consequently observations regarding subjects' progress and problems were noted and particular attention was paid to the usage of the menu-based help facilities, to pointer changes and to actions when the question pointer was current.

Materials

The materials used in the pilot study were described in Chapters 4 and 5. A second version of the record sheet was introduced in session P7 - the final pilot study session - and was also used throughout the core study. There were only minor differences between the first and second versions, and these were

introduced to accommodate changes in the Partickles program and to make note-taking easier.

Partickles version 1 was used during most of the pilot study but in the final three sessions (P5, P6 and P7) the following modifications were introduced:

- The interface was simplified by replacing the trace menu and the auto and person/computer controls with additional changes menu options and a new players menu.
- The colours, move value and make move hot words boxes were made more visible against the grey background by colouring these light blue instead of grey.
- By session P7 some of the descriptive partickle SEO information had been moved from the lower window to a 'bubble' that appeared in the upper game board window next to the partickle that was being described.

Data from the pilot study sessions was collected in the form of machine-readable, time-stamped trace records of subjects' interactions with Partickles, audio tape recordings and the observer's notes written during sessions.

Procedure

The procedure of the pilot study sessions followed the plan detailed in the observer's guidelines as described in Chapter 5. Briefly, the phases of each session were as follows:

- Intro phase
- Explore and Practise phase - followed by the observer briefing
- Game Playing phase - followed by the informal debriefing

In Table 6.2 below timings are presented as hours: minutes. The length of time spent using Partickles includes the explore and practise phase, the observer briefing and the game playing phase, but does not include the Intro phase or the debriefing.

subject code	A		B		C	D	E	F	G
session code	P1a	P1b	P2a	P2b	P3	P4	P5	P6	P7
length of session	0:46	0:59	0:52	0:35	0:48	0:57	0:51	0:56	1:27
time with Partickles	0:40	0:56	0:45	0:31	0:42	0:51	0:43	0:47	1:20

Table 6.2 Duration of the pilot study sessions

6.3 Results

This section documents the usage of Partickles' help facilities during the pilot study sessions. These results are discussed in the next section.

None of the pilot study subjects beat the computer player in any of their games. One reason for this could be the brevity of the sessions - only one of which lasted longer than an hour. This was session P7 where the subject had difficulty reading the help information and using the mouse. If second sessions are considered as continuations of first sessions then subjects A and B spent over an hour using Partickles without achieving wins, though they both continued to make progress in their second sessions. Table 6.3 shows the number of games that subjects played against the computer.

subject code	A		B		C	D	E	F	G
session code	P1a	P1b	P2a	P2b	P3	P4	P5	P6	P7
games played	2	4	2	3	4	4	2	2	11

Table 6.3 Number of games played by pilot study subjects

When the Partickles' screen appeared subjects were told: "Please start". Their very first actions on encountering Partickles were as follows:

subject A: rotated partickle

subject B: moved partickle

subject C: clicked side-to-play box

subject D: selected help menu option: Partickles rules

subject E: moved partickle

subject F: moved partickle

subject G: changed pointers

Four of the seven pilot study subjects began by manipulating partickles and one subject clicked on a side-to-play control and then moved a partickle. These five subjects chose immediate involvement with the domain. Two subjects (D and G) read menu-based help options before they manipulated partickles.

All the pilot study subjects manipulated partickles while they were obtaining introductory information during the explore and practise phases. Subjects D and G spent most of their explore and practise phases exploring the interface and using help facilities. Three subjects made moves for lengthy initial periods - subject B for 15 minutes, subject C for 17 minutes and subject F for 13 minutes - and gradually expanded their knowledge of the types of possible moves. Two subjects also spent lengthy initial periods making moves - subject A for 12 and a half minutes and subject E for 15 minutes - but they made little progress:

partly because they were unaware of essential elements of move making and possibly because they were overly cautious.

The pilot study subjects made less use of the Partickles help facilities than the core and video study subjects. All the pilot study subjects used some of the help facilities but none of the subjects accessed every help menu option. Subject B did not access any of the help facilities during the explore and practise phase and subjects C, E and F did not use help facilities during the game playing phase.

Object-based help

Table 6.4 shows the numbers of partickle and control SEO information accesses made by pilot study subjects during the explore and practise and game playing phases:

subject code	A		B		C	D	E	F	G
	P1a	P1b	P2a	P2b	P3	P4	P5	P6	P7
no. of partickle SEO infos	0	16	0	5	12	5	7	8	6
no. of control SEO infos	0	0	0	0	12	0	5	0	1

Table 6.4 Details of the use of object-based help in the pilot study

All the pilot study subjects obtained partickle SEO information, and three of the subjects obtained control SEO information. Object-based help tended to be accessed in 'groups' of several, successive SEO information accesses. Table 6.5 gives an impression of the grouping of object-based help accesses in the pilot study. Groups are defined as sequences of object-based help accesses that were not separated by changes of pointer or the use of other, attention-diverting

facilities. The "—" symbol used in this table, and subsequent tables, indicates cases where categories do not apply.

session code	P1a	P1b	P2a	P2b	P3	P4	P5	P6	P7
object-based help	no	yes	no	yes	yes	yes	yes	yes	yes
grouped accesses	—	16	—	5	22	4	10	6	0
number of groups	—	1	—	1	4	1	2	1	0
single accesses	—	0	—	0	2	1	2	2	6

Table 6.5 The 'grouping' of object-based help accesses in the pilot study

The trace records for sessions P1b, P2b and P4 showed that partickles were rotated, and/or effect move mode was switched on/off, during sequences of partickle SEO information accesses. This evidence suggests that subjects A, B and D used 'would do' partickle SEO information to investigate what partickles would do. Nevertheless, the pilot study provided limited evidence of the use of 'would do' partickle SEO information and the potential significance of 'would do' help was not identified during this study.

Extensions to object-based help

Only two pilot study subjects selected hot words boxes to access the facilities that were provided as extensions to object-based help. Table 6.6 shows the number of times that these facilities were accessed during the explore and practise and game playing phases:

	make move	move value	effects SEO help facility
subject F	0	2	1
subject G	2	3	2

Table 6.6 Usage of extensions to object-based help in the pilot study

Most of the hot words box accesses were made during initial investigations of the hot words boxes, though subject G's three move value selections were probably all mistakes. All the pilot study subjects used the arrow pointer to make all their moves - apart from the two occasions when subject G selected make move. There is slight evidence to suggest that subject G attempted to combine obtaining partickle SEO information with the use of the make move facility on one occasion, though he failed to do so. The second time that subject G accessed the effects SEO help facility he seemed to seek and find specific information successfully.

Menu-based help

Table 6.7 shows the numbers of mouse menu options (0-3) and help menu options (0-5) that were accessed by pilot study subjects during the explore and practise and game playing phases. The table also indicates whether help menu options were accessed during the game playing phase, and whether the two help menu options: Partickles rules and getting started were the help menu options that subjects accessed most and/or spent most time reading.

subject code	A		B		C	D	E	F	G
	P1a	P1b	P2a	P2b	P3	P4	P5	P6	P7
mouse menu options seen	0	0	0	0	0	2	0	0	3
help menu options seen	2	0	1	2	0	2	1	0	2
help menu in game phase	no	—	yes	yes	—	yes	no	—	yes
mainly P rules or g started	yes	—	yes	no	—	yes	yes	—	yes

Table 6.7 Menu-based help options accessed in the pilot study

Mouse menu options were used by subjects D and G, but all the subjects except D had difficulty with, or spent a relatively long time learning, basic particle moves and mouse button functionality. There was little need for the information in the mouse menu options after the explore and practise phase and the observer briefing - though subject G did use the mouse menu later in his session for a recap. Subjects B, C and F seemed to learn the functionality of the mouse by experimentation.

Subjects C and F did not access any of the menu-based help options during their sessions, though they both obtained particle SEO information. Subject D and subject G accessed help menu options early in their sessions to obtain introductory information and subjects A, B, D and E used help menu options in respect to specific problems or areas of interest. However, none of the menu-based help options were used frequently or at length and none of the subjects accessed help menu options: about the program or status info. Table 6.8 shows the menu-based help options that were accessed and the amounts of time that each of their windows were onscreen. There were four Partickles rules accesses in session P2a but three of these occurred within a two minute period and have been counted as a single access.

session	help menu accesses	mouse menu accesses
P1a	getting started: 47 seconds suggestions: 32 seconds	—
P1b	—	—
P2a	Partickles rules: 94 seconds Partickles rules: 35 seconds	—
P2b	Partickles rules: 74 seconds suggestions: 156 seconds	—
P3	—	—
P4	Partickles rules: 65 seconds suggestions: 48 seconds	which button: 41 seconds which pointer: 20 seconds which button: 27 seconds
P5	Partickles rules: 48 seconds	—
P6	—	—
P7	getting started: 115 seconds Partickles rules: 21 seconds	which button: 13 seconds which pointer: 7 seconds about mousing: 11 seconds

Table 6.8 Menu-based help option accesses in the pilot study

6.4 Conclusions

None of the pilot subjects won a game against the computer player and this meant that only the initial stage of learning Partickles had been observed. This was attributed to either: the age of the pilot study subjects, their limited computer experience and/or the brevity of sessions. Longer sessions and older subjects with greater computer experience were tried in later studies to see if subjects would progress beyond the initial stage of learning Partickles.

The two subjects who did most information gathering before moving partickles were the two who had most previous experience with computers.

This suggests that inexperience resulted in a more direct approach in tackling an unfamiliar interface. The contrast in the initial approaches of the pilot study subjects and of the older, more experienced, subjects of the later studies suggests this point even more strongly.

Most of the object-based help accesses in the pilot study occurred in groups. This seems a reasonable strategy when most descriptive and 'would do' partickle SEO information is unfamiliar to users, and also when particular partickles are being manipulated to see what they 'would do' in varied states. As the pilot study subjects did not progress beyond the initial stage of learning Partickles, the grouping of object-based help accesses (shown in Table 6.5) constituted part of their initial information-gathering and may have been used to aggregate introductory overviews. This conclusion was supported by some of the core study's results. There were insufficient object-based help accesses in the pilot study to support further conclusions concerning its usefulness.

Only two subjects accessed mouse menu options, though all the subjects except subject D might have found this facility useful. When subjects were in difficulties because they were unaware of the functionality of the mouse buttons they also tended to be unaware that this was the source of their difficulties and that, consequently, the mouse menu contained potentially helpful information. Subject E provided the most extreme example of this sort of difficulty by only using the left mouse button for the first 15 minutes of his session with Partickles.

Partickles rules was used more than any other help menu option in the pilot study, and there is evidence that two of the four subjects who accessed Partickles rules found it useful. One subject failed to resolve an enquiry using

Partickles rules and another only looked at the option briefly, but subject D used Partickles rules to obtain introductory information and subject B accessed it three times successfully for reference and on two of these occasions also seemed to be obtaining general introductory information. Help menu option: getting started was accessed twice: once successfully for reference and once to obtain general information, so this option also proved useful. Help menu option: suggestions was accessed three times, but in all three cases its information (which concerned strategies and activities) was inappropriate for subjects who were still learning about making moves.

The changes made to Partickles during the pilot study were intended to simplify the interface and to make some of the SEO help facilities more noticeable and memorable. There were no significant alterations made to the content of the SEO help facilities between versions 1 and 2, and it is not clear whether the results obtained from the last three pilot study sessions were affected by the changes that were made to Partickles. However, in the last two sessions subjects F and G both set up and started their first games for themselves (the only pilot study subjects who did this) which suggests that the interface had been simplified. Also, subjects F and G were the only pilot study subjects who selected hot words boxes, and this was after the hot words boxes had been coloured light blue to make them more noticeable. One reason why the numbers of object-based help accesses were limited in the pilot study could be that the partickle SEO information provided too much text with insufficient variation and lack of prominence. The presentation of partickle SEO information was changed (with the introduction of help in bubbles) for session P7, but the effects of this change did not become apparent until the next study.

None of the pilot study subjects investigated all the help facilities and options that were available, and the evidence concerning some help facilities (such as the extensions to object-based help) was limited. The pilot study provided evidence concerning the grouping of object-based help accesses and the direct initial approach used by subjects with limited experience of computers. The extent to which object-based help (accessed in groups) and help menu options: Partickles rules and getting started were used indicates that some pilot study subjects considered that these forms of help provision were useful.

The pilot study had been used to fine-tune the materials, to practice the procedure and to focus observations for the next Partickles study. The study also showed that another study was needed to provide examples of progress beyond the initial stage of learning Partickles and to provide further examples of the use of Partickles' help facilities. The next Partickles study was the core study which is described in Chapter 7.

Chapter 7

The Core Study

7.1 Introduction

The core study was the second Partickles study. It consisted of six sessions with individual subjects studied in each session as follows:

subject code	H	I	J	K	L	M
session code	C1	C2	C3	C4	C5	C6

Table 7.1 Core study subjects and sessions

The core study sessions took place in a relatively isolated corner of a 'fairly quiet' classroom and the core study subjects were all sixteen or seventeen years old. The core study sessions are described individually in Appendix E. The core study subjects were older and had greater computer experience than the pilot study subjects and, on average, the core study sessions were longer than the pilot study sessions. These changes were introduced so that the core study results could show the usage of Partickles' help facilities as subjects progressed beyond the initial stages of learning Partickles.

Partickles version 2 was used in the core study. This version was developed during the final sessions of the pilot study. In version 2 the partickle SEO information was divided and the descriptive partickle SEO information was prominently displayed in 'speech bubbles'. The bubbles were intended to make this part of the object-based help more noticeable and hence encourage usage if

subjects found its information useful. When a partickle was selected with the question pointer and left mouse button a bubble appeared next to it. The bubble's 'tail' pointed to the partickle that the partickle SEO information referred to, which was a potentially useful reminder, and the bubble information was situated conveniently close to the item (partickle) of interest, but the bubbles were intrusive because they appeared in, and partially obscured, the upper game board window. Figure 4.12 in Chapter 4 shows how the partickle SEO information was presented in version 2. The division of partickle SEO information into two smaller sections, with descriptive partickle SEO information in bubbles and 'would do' partickle SEO information in the lower window, may have made the text easier for subjects to assimilate and it also allowed some discrimination between results regarding the usage of 'would do' and descriptive partickle SEO information.

7.2 Method

Design

The aim of the core study was to investigate the use of the help facilities in Partickles. Experience in conducting the pilot study had suggested that this involved focussing on the following features of sessions:

- The frequency and forms of use of object-based help.
- The use, particularly the navigation, of the effects SEO help facility.
- The use of other SEO help facilities.
- The amount of use and choice of menu-based help options.
- The use of the system as a source of 'help' information.
- The influence of observer interventions (whether reminders of alternatives were construed as advice).

- Changes of help usage between phases of the sessions.
- Variations in help usage as subjects gained experience and knowledge.
- Progress in learning.
- Success in games.
- Particular problems and events.
- Subjects' reactions/comments.

Materials

The materials used in the core study were identical to those used in the pilot study with two exceptions:

- The record sheet (included in Appendix B) was streamlined to make notetaking easier.
- All the core study sessions used Partickles version 2 - which differed from version 1 in having an interface with fewer controls, a players menu instead of a trace menu, bubble help incorporating descriptive partickle SEO information and some brighter coloured hot words boxes. There were no changes made in the content of the SEO help information between version 1 and version 2.

The details of the core study sessions were recorded in the form of machine-readable, time-stamped trace records of subjects' interactions with Partickles, audio tape recordings and the observer's notes written during sessions.

Procedure

The core study procedure was the same as that of the pilot study. Briefly, this consisted of: the Intro program, the explore and practise phase, the observer briefing, the game playing phase and the informal debriefing.

In Table 7.2 below the session timings are presented as hours: minutes. The length of time spent using Partickles includes the explore and practise phase, the observer briefing and the game playing phase, but does not include the Intro phase or the debriefing.

subject code	H	I	J	K	L	M
session code	C1	C2	C3	C4	C5	C6
length of session	0:49	0:45	1:17	1:44	0:45	1:51
time with Partickles	0:45	0:39	1:13	1:38	0:41	1:45

Table 7.2 Duration of the core study sessions

The length of the core study sessions was determined by the availability of subjects, but on average the core study sessions were seventeen and a half minutes longer than those of the pilot study.

7.3 Results

This section documents the usage of Partickles' help facilities during the core study sessions. These results are discussed in the next section.

Table 7.3 shows the number and results of games that subjects played against the computer player:

subject code	H	I	J	K	L	M
session code	C1	C2	C3	C4	C5	C6
games played	1	1	5	12	3	12
wins by subject	0	1	1	2	0	5
wins by computer	1	0	4	10	3	7

Table 7.3 Progress in games by core study subjects

Only two subjects failed to beat the computer - and in both cases the subjects had less than three quarters of an hour with Partickles. Subject H would almost certainly have won a further game against the computer if there had been time - and he did play and win a 'next game' in the video pilot session (described in Chapter 5), though on that occasion he was playing jointly with subject I against the computer. The core study subjects played a total of 34 games between them and achieved 9 wins. Subject J won the fourth game he played, subject K won the fifth and twelfth games and subject M won the fourth, eighth, tenth, eleventh and twelfth games. The fact that four core study subjects won games provides a crude, but objective, indicator of the helpfulness of the information-providing facilities and features of Partickles by showing that the information necessary for subjects to be able to play Partickles was available in the system.

The one point at which subjects' performances in all sessions can be compared directly is that of their initial actions when first presented with the Partickles program. Their explorations of Partickles began as follows:

subject H: selected help menu: getting started

subject I: selected help menu: getting started

subject J: selected help menu: getting started

subject K: glanced at all 4 menus then selected help menu: getting started

subject L: selected help menu: getting started

subject M: selected help menu: about the program

There was considerable uniformity in the initial behaviour of the core study subjects. All six of the subjects began by selecting a help menu option and five of them chose help menu option: getting started as their first selection. Most of the pilot study subjects did not begin their sessions by reading help texts. The initial reading of help texts by the core study subjects suggests that these subjects, who were older than the pilot study subjects and had more experience with computers, felt that 'examining the documentation' was an appropriate initial strategy for dealing with an unfamiliar computer system. The core study subjects' extensive initial usage of the help menu texts was a surprise, and resulted in the broad finding that the information in the help menu options was accessed to gain an introduction to the system and for later reference in regard to specific enquiries. The only exception to this finding occurred in session C5 where subject L, who did not use SEO help facilities, used three help menu options and two mouse menu options to obtain a second 'introduction' during the game playing phase. The second introduction occurred after the first two games when subject L was aware that there was only enough time for one more game and that he did not know enough to win. He knew that he needed to find out how to unpack partickles and he found this information in help menu option: Partickles rules, but he also spent sufficient time with a sufficient variety of options to indicate that he was extending and/or revising his general impression of the game.

All the core study subjects restricted themselves to using menus during the explore and practise phase - with the exception of subject H who obtained object-based help five times contiguously (partickle SEO information four times

and control SEO information once) and clicked on the colours and move value hot words boxes in addition to reading help menu options. Subject J was the only core study subject who accessed mouse menu options during the explore and practise phase. None of the core study subjects manipulated partickles until they were ready to begin game playing.

Variations in the lengths of games can be attributed to: the amount of time that individual moves were considered, the complexity of games and, to a lesser extent, the time spent using help facilities. All subjects set themselves the goal of beating the computer player, but their interpretations of this goal and the ways they attempted to achieve it differed. It can be surmised that subjects H and I tried to win their first games and hence used help freely whereas subjects L and M aimed to achieve eventual wins with minimal use of help facilities. Subject J made moderate use of the Partickles help facilities and subject K made minimal use of the Partickles help facilities until he reached a point where he seemed to be aware that he was not making progress and he commented: "Seems to be getting harder". From that point, after an observer demonstration, subject K began to make extensive use of partickle SEO information.

There were more observer interventions in the core study than in the pilot study since the observer was better able to assess the points at which subjects would fail to 'discover' facilities unaided. The observer interventions tended to involve reminders concerning SEO help facilities or the availability of help facilities generally, and many observer interventions took the form of improvised experiments. For example, the observer's notes (with its abbreviations expanded) for session C2 state:

The subject is using partickle SEO information a lot, but only for descriptive information. He is using help menu options to map the colours in partickles to their effects. Tried an experiment at 12.44: told him about navigating the effects SEO help facility to get colour-effect mapping information. Will he use it? At 12.51 he obtained partickle SEO information then used the effects SEO help facility - navigating as far as colours: unpack - to find out how to unpack a partickle containing 5 parts.

Reminders of this kind were made to obtain information about subjects' preferences and about the effects of changes if subjects chose to change their behaviour. In the above example the alternatives were the effects SEO help facility (accessed via the colours hot word box) and help menu option: Partickles rules which the subject was already using. The result of the experiment was that seven minutes after the effects SEO help facility had been demonstrated the subject used it in preference to help menu option: Partickles rules. Once the subject had confirmed his preference by using the effects SEO help facility a second time it seemed reasonable to conclude that he had found this facility useful.

Object-based help

Table 7.4 shows the numbers of partickle and control SEO information accesses made by core study subjects during the explore and practise and game playing phases:

subject code	H	I	J	K	L	M
session code	C1	C2	C3	C4	C5	C6
no. of partickle SEO infos	31	46	18	72	0	13
no. of control SEO infos	1	0	0	0	0	0

Table 7.4 Details of the use of object-based help in the core study

Although control SEO information was only obtained once, all the core study subjects except subject L used partickle SEO information. The numbers of partickle SEO information accesses suggest that the subjects found this facility useful. Subject H used it prior to the observer briefing, subjects I and J used it after the observer briefing and subjects K and M used partickle SEO information after additional prompting. Most of the moves made by the core study subjects were made using the arrow pointer. This meant that when subjects were using the question pointer to obtain object-based help during games they had to change to the question pointer first and change back to the arrow pointer before making a move. This indicates that the subjects found partickle SEO information sufficiently useful to compensate for the inconvenience of this procedure.

Most of the partickle SEO information accesses occurred during the early stages of game playing, and most were made discretely and for specific reference. This differs from the 'grouping' of partickle SEO information accesses that was observed in the pilot study, though there was some evidence of grouping in core study sessions C1, C2 and C6. On these occasions, the subjects' initial use of partickle SEO information extended into contiguous phases which were apparently used to supplement introductory information by providing overviews regarding the states and functionality of partickles.

The trace record entries for sessions C1, C4 and C6 show that partickles were rotated, and/or effect move mode was switched on/off, during sequences of partickle SEO information accesses. This suggests that subjects H, K and M used 'would do' partickle SEO information to investigate what partickles would do. The trace record entries for session C6 suggest that eleven of subject M's partickle SEO information accesses were made to obtain 'would do' information (the other two partickle SEO information accesses in session C6 were made in order to use the extensions to object-based help). The trace record entries for sessions C1 and C4 suggest that subjects H and K used both descriptive and 'would do' partickle SEO information, and the numbers of partickle SEO information accesses in these sessions indicate that subjects H and K considered that both types of partickle SEO information were useful.

In sessions C2 and C3 there was no evidence that subjects I and J used 'would do' partickle SEO information, and this suggests that these subjects used the descriptive partickle SEO information in bubbles. Appendix E contains two comments made by subject I, and two references to the observer's notes for subject J's session, which also indicate that descriptive partickle SEO information was used. The 46 partickle SEO information accesses in session C2 and the 18 partickle SEO information accesses in session C3 indicate that subjects I and J considered that descriptive partickle SEO information was useful.

Extensions to object-based help

The facilities provided as extensions to object-based help were used very little - with the exception of make move in session C4. Table 7.5 shows the number of times that these facilities were accessed during the explore and practise and game playing phases:

subject	session	make move	move value	effects SEO help facility
H	C1	0	1	5
I	C2	1	0	2
J	C3	2	0	1
K	C4	44	0	1
L	C5	0	0	0
M	C6	0	0	2

Table 7.5 Usage of extensions to object-based help in the core study

None of the core study subjects used the **make move** facility without observer guidance and even when **make move** was tried the subjects quickly reverted to using the arrow pointer to make moves. With the exception of the last three games of subject K's session all the subjects used the arrow pointer, almost exclusively, to make moves. Subject K made moves using the arrow pointer for nine games, then, after an observer demonstration, he used **make move** in his last three games. He used **make move** 25 times in the tenth game, 16 times in the eleventh game and 3 times in the twelfth game. The only time that **move value** was accessed in the core study occurred when subject H was exploring the functions of several facilities in the explore and practise phase.

The **effects SEO help facility** received very little use. Subjects H and J clicked the colours hot words box which provides entrance to the **effects SEO help facility** and they studied the information presented by the five hot words boxes that appear when colours is clicked, but they did not navigate further. Subjects I, K and M navigated the **effects SEO help facility** for reference in regard to specific enquiries on four occasions, and on three of these occasions seemed to find the information they were seeking. Subject I had been using help menu option: **Partickles rules** as a source of information concerning effects, but after

the observer pointed out, and demonstrated, that the same information was contained in the effects SEO help facility, subject I used the effects SEO help facility on two occasions instead of using Partickles rules.

Menu-based help

Table 7.6 shows the numbers of mouse menu options (0-3) and help menu options (0-5) that were accessed by core study subjects during the explore and practise and game playing phases. The table also indicates whether help menu options were accessed during the game playing phase, and whether help menu options: Partickles rules and getting started were the help menu options that subjects accessed most and/or spent most time reading.

subject code	H	I	J	K	L	M
session code	C1	C2	C3	C4	C5	C6
mouse menu options seen	0	1	3	0	3	1
help menu options seen	5	3	5	3	5	5
help menu in game phase	yes	yes	yes	yes	yes	yes
mainly P rules or g started	yes	yes	yes	yes	yes	yes

Table 7.6 Menu-based help options accessed in the core study

Mouse menu options were accessed in four sessions. All the core study subjects were experienced computer users and only subject J accessed mouse menu options during the explore and practise phase. Mouse menu options were accessed by subjects I, L and M during the game playing phase for reference regarding mouse button functionality. Subject L accessed mouse menu option: which button twice and looked at the other two mouse menu options during his second period of obtaining introductory information. Subject M was the only core study subject who had difficulties in using the mouse. He did not use

the right (effect on/off) mouse button at all during his first game - and when questioned it turned out that he was accustomed to using a two-button mouse. The observer had demonstrated mouse menu option: which button during the observer briefing and subject M accessed it 10 minutes later during the third game while he was clarifying procedures for making effect moves.

All the subjects used help menu options for initial learning during the explore and practise phase and for occasional reference during the game playing phase. All the subjects made more use of help menu options: Partickles rules and getting started than the other help menu options. Partickles rules was used for reference particularly in regard to: 1) matching the coloured parts in partickles to the effects that these represented, and 2) discovering what the various effects could do or finding out which effect performed a desired function. Table 7.7 shows whether help menu options were accessed during the explore and practise phase and the number of accesses made during the game playing phase. Subject L's second period of introductory information gathering in session C5 is shown in brackets.

session	explore and practise phase	game playing phase
C1	all 5 - mainly getting started and Partickles rules	Partickles rules 5 times
C2	getting started, Partickles rules and suggestions	Partickles rules 3 times
C3	all 5 - mainly getting started, Partickles rules, about the program and suggestions	Partickles rules 2 times getting started once
C4	getting started, suggestions and Partickles rules	Partickles rules 3 times getting started once
C5	all 5 help menu options	Partickles rules once getting started once (about the program, getting started and Partickles rules)
C6	mainly Partickles rules and getting started, also about the program and status info	status info twice suggestions twice

Table 7.7 Help menu accesses in the core study

7.4 Conclusions

The core study provided evidence of the usefulness of both menu-based help (in six sessions) and object-based help (in five sessions) which suggests that users may wish to use a combination of help facilities and/or a variety of types of help information. The core study showed the usefulness of partickle SEO information and provided evidence concerning the usefulness of descriptive partickle SEO information, but the evidence concerning the usefulness of 'would do' partickle SEO information was less clear. The most used, and useful, menu-based help options were Partickles rules and getting started. Help facilities were used to obtain general introductory information and for later reference in regard to specific enquiries. Most of the pilot study subjects began their sessions

with Partickles by selecting screen objects, especially partickles, whereas all the core study subjects began by selecting help menu options. This may have been because the core study subjects were older and had more computer experience than the pilot study subjects. The core study subjects progressed beyond the initial stages of learning Partickles. Four subjects achieved wins, and a fifth subject (subject H) learned to play competently. Their progress showed that the usage of Partickles' help facilities varied as the subjects gained experience, and that the information needed to learn to play Partickles was provided by the system.

The remainder of this section has been divided into two parts: further points regarding some of the core study's findings, and some questions and reservations raised by the core study. The further points are outlined below and discussed in the paragraphs that follow:

- There is additional evidence of the usefulness of partickle SEO information.
- One subject used partickle SEO information repeatedly as an alternative to remembering its information.
- In two sessions the frequency with which partickle SEO information was used diminished.
- The usage of menu-based help also decreased during the course of sessions.

There was greater use of object-based help in the core study than in the pilot study. This may be partly attributable to the presentation of descriptive partickle SEO information in 'bubbles'. The clearest example of the usefulness of partickle SEO information was provided by subject K in session C4 after he had changed his learning strategy to include SEO help facilities. Subject K provided evidence

of rapid improvement using partickle SEO information after a contrasting period of minimal progress in which partickle SEO information had not been used. Subjects H and I used partickle SEO information extensively and they both learned to play competently relatively quickly. Subject M obtained 'would do' partickle SEO information during a contiguous phase of object-based help accesses, and his continued use of this facility during this episode suggests that it was providing useful information in the form of an overview regarding the states and functionality of partickles. Subject J obtained descriptive partickle SEO information 18 times which was sufficient to enable him to learn to match the colours in partickles to the effects they represented. Appendix C contains extracts from the trace records of two core study sessions. One of these trace records shows the use of descriptive partickle SEO information (in subject I's session) and the other shows the use of 'would do' partickle SEO information (in part of subject K's session).

Subject I obtained partickle SEO information more often in a single game than any other core study subject and in the video pilot session which followed the core study, in which he also obtained partickle SEO information frequently, he commented: "I can never remember what the colours are". This example indicates that subject I found obtaining partickle SEO information preferable to memorising the colour-to-effect mappings. This raised the question of whether subjects might use some parts of help information for repeated reference in order to save them the effort of remembering its information.

In the two sessions where partickle SEO information was used fairly frequently over a period of several games the frequency diminished as subjects gained knowledge and experience. In session C3 subject J accessed partickle SEO information 13 times during the twelve and a half minutes of the first game and

8 of these accesses occurred in the first five minutes. The subject obtained partickle SEO information twice in the second game, once before the third game and twice during the third game, but he used no help facilities in the subsequent games. In session C4 subject K began to use partickle SEO information frequently after the ninth game. He accessed partickle SEO information thirty-nine times in the tenth game, twenty-four times in the eleventh game and nine times in the twelfth game. In both session C3 and session C4 the decreasing usage of partickle SEO information coincided with improvements in the subjects' play which led to victories over the computer player. This suggests that partickle SEO information performed a useful function but was no longer needed once the subjects had assimilated its information. At the end of session C6 the observer had the following discussion with subject M:

Obsv: "You didn't actually use, um, these things very much. You seemed to prefer to spend most of your time actually using... playing the game moving partickles..."

Subj: "Um, I mean if you know what happens to it then..."

Obsv: "Yup. So you don't need the question mark pointer if you know what's going to happen."

Subj: "Yeh."

The usage of menu-based help options during sessions can be divided into fairly intensive initial usage to obtain introductory overviews and occasional accesses later on for reference. Subject L also used menu-based help options to obtain a second 'introduction' during the game playing phase, but apart from this exception the menu-based help options were generally used less frequently and for shorter periods in the later stages of sessions. Table 7.8 shows the total amounts of time that help menu options were onscreen during three periods of sessions: the explore and practise phase and the first and second halves of

the game playing phase. In sessions C3, C5 and C6 subjects began game-playing during the explore and practise phases - but in Table 7.8 their explore and practise phases are assumed to have ended with the start of their first games. The length of the game playing phases has been divided into two equal periods to show the variance of help menu option usage over time. Subject L's second introduction has not been included in the table, but this included three help menu option accesses which lasted for a total of 3 minutes and 12 seconds in the second half of the game playing phase. Table 7.8 shows that the usage of help menu options decreased during the course of sessions.

session	explore and practise phase	1st half of game playing phase	2nd half of game playing phase
C1	8 mins 48 secs	6 mins 26 secs	1 min 33 secs
C2	8 mins 31 secs	2 mins 22 secs	0 mins 0 secs
C3	12 mins 59 secs	0 mins 15 secs	0 mins 58 secs
C4	4 mins 30 secs	3 mins 26 secs	0 mins 43 secs
C5	11 mins 17 secs	0 mins 0 secs	1 min 9 secs
C6	4 mins 26 secs	1 min 31 secs	1 min 7 secs

Table 7.8 Durations of help menu option accesses in the core study

The core study raised a number of questions and reservations in regard to its findings and format. These are summarised below and discussed more fully in the paragraphs that follow:

- More variety amongst subjects would have broadened the potential applicability of the results.
- There was too little evidence concerning 'would do' participle SEO information.
- Subjects may have been influenced to use object-based help by the observer.

- Subjects may have been influenced against using the question pointer because the arrow pointer was the default pointer.
- Subjects' preferences and practices may have been based on their initial choices and/or affected by the names of facilities.

As the core study subjects were male and they were drawn from a computer studies class, they were not a representative sample of users of graphical object-oriented interfaces. The pilot study subjects had been younger and of both sexes, but the findings of the core study might have been more convincing if there had been more variety in the subjects chosen.

One of the reasons why some core study subjects used descriptive partickle SEO information was to identify the effects that the coloured triangles in partickles represented. It could be considered that this help requirement was caused by a limitation in the representation of partickles, though many board games use forms of representation which do not directly indicate the functions of their playing pieces - and there is a direct parallel between the playing pieces used in Partickles and in the Trivial Pursuit board game by Horn Abbot International Ltd. Compensating for the limitations of an interface may not be a sufficiently strong reason for providing object-based help because it may be more appropriate to improve the interface instead. Behavioural, rather than descriptive, information such as 'would do' help information may provide an alternative, and perhaps more significant, contribution towards system development and help system research, but the core study did not provide a great deal of clear evidence in regard to the usage of 'would do' help.

The Intro program introduced subjects to changing pointers and obtaining object-based help. Only one of the core study subjects obtained object-based help

before it had been demonstrated in the observer briefing at the end of the explore and practise phase. One subject did not use object-based help at all, while two required additional observer demonstrations before they began to use object-based help. Although the observer intervened to suggest alternatives his interventions may have implied that he was suggesting a 'better' alternative. However, some observer interventions were ignored and some of the suggested alternatives were tried and then dismissed. A potential weakness of Partickles version 2 could be that its object-based help facility was not easy to discover. The five core study subjects who discovered, and/or were shown, object-based help used it repeatedly. This suggests that they chose to use object-based help, but, because their choices may have been influenced by observer interventions, more convincing evidence was needed.

Subject K was the only subject who combined his usage of object-based help with the make move hot words box. It is not clear why the other subjects changed to the arrow pointer to make moves after using the question pointer to obtain partickle SEO information. It is not very convenient to use the question pointer and make move hot words box to make moves, but it is less awkward than changing from the question pointer to the arrow pointer. This awkwardness may have prejudiced subjects against the use of object-based help and may have encouraged the grouping of object-based help accesses. Subjects might have resisted using the make move hot words box because they had already become accustomed to using the arrow pointer before make move was demonstrated to them. This suggests that if subjects became accustomed to using the question pointer first they might show a similar resistance to changing to the arrow pointer.

Subjects' initial and continued use of the arrow pointer raised the question of the extent to which their initial practices became habitual. All the subjects began their sessions by reading help menu options and later they all used help menu options during the game playing phase. Some of the names of the Partickles help facilities may have had associations that altered subjects' assessments of the significance of these help facilities. For example, five of the six subjects began by selecting the menu labelled "help" which suggests that this word had a very strong appeal. The label "getting started" successfully achieved its purpose of attracting beginner learners to help menu option: getting started. However, it was assumed that the label "Partickles rules" would have little appeal to subjects but it turned out that Partickles rules was used far more than any other help menu option. These considerations raised the question of whether changing some of these labels would affect subjects' preferences.

The core study provided a 'core' of examples of the usage of Partickles' help facilities, and it raised a number of questions related to its format and findings. A further study was devised to investigate these questions and this is described in the next chapter.

Chapter 8

The Video Study

8.1 Introduction

The video study was the third and final Partickles study. It consisted of three sessions with six subjects studied in pairs as follows:

subject code	N	O	P	Q	R	S
session code	V1		V2		V3	

Table 8.1 Video study subjects and sessions

The video study sessions were conducted in an empty classroom. Two of the video study subjects were male and four of the subjects were female. The male subjects (N and O) were both aged 16 and the female subjects were all aged 18. The video study sessions are described individually in Appendix F.

The differences between the format of the video study and those of previous studies are described and discussed in the next section. These modifications were introduced to test the formats of the earlier studies, to examine and extend their findings and to address the reservations and questions (described in Chapter 7) that the core study had raised.

8.2 Method

Design

The video study used the third version of Partickles. In version 3 the question pointer was made the default pointer to see whether users would *opt out* of using object-based help rather than having to *opt in* - and the effects SEO help facility was extended to cover the essential details for getting started to provide an alternative to menu-based help for introductory overviews. The positions of descriptive and 'would do' partickle SEO information were reversed to provide more information about the usage of 'would do' partickle SEO information. Also, the names of some facilities were changed in version 3 in order to investigate whether these had affected subjects' preferences in previous studies.

The video study subjects were studied in pairs so that their conversations could inform assumptions regarding their thinking and provide evidence of the use of 'would do' partickle SEO information. The checklist phase was intended to reduce the observer's input and to encourage communication between subjects. The video camera recorded subjects' conversations and showed what happened on, and in front of, the computer screen. The visual record of the system's activities, mouse pointer usage and the occasional hand gesture in front of the screen supplemented the trace and audio data and helped resolve spoken elliptical references.

The main differences between the format of the video study and the formats of the previous studies are listed in Table 8.2. The right hand column of the table outlines the aims of these modifications.

changes	aims
The subjects were studied in pairs.	...so their conversations could be used as a source of evidence.
The subjects were drawn from vocational studies classes rather than computer studies classes.	...to provide more variety amongst the subjects of the studies.
There were more female subjects than male subjects.	...also to provide more variety amongst the subjects of the studies.
Partickles version 3 was used.	...to examine: the usage of 'would do' help and of an alternative source of introductory information, and the influence of the default pointer and of the names of some facilities.
A video tape recorder was used instead of an audio tape recorder.	...to compare means of recording data.
The time available for the explore and practise phase was limited to five minutes per subject.	...to accommodate the checklist phase, and investigate the appropriateness of tighter time constraints.
A checklist phase replaced the observer briefing at the end of the explore and practise phase.	...to reduce/replace observer interventions in order to assess their effect in previous studies.
The observer had the option to constrain the usage of some Partickles facilities during games.	...to trial a within-subjects approach to examining usage.
Specific questions were asked at the end of the session in place of the informal debriefing.	...to trial a questionnaire approach to obtaining subjects' opinions.

Table 8.2 Details of the modified format used for the video study

Materials

In addition to the video recorder and Partickles version 3 the materials used in the video study differed from those used in pilot study as follows:

- The subjects' and observer's guidelines and the record sheet were altered to accommodate sessions with two subjects and other alterations to the study format.
- Checklists A and B were introduced. These took the form of lists of exercises for subjects to complete.

Checklists A and B and the video study versions of the subjects' guidelines, observer's guidelines and record sheet are all included in Appendix B. The differences between Partickles version 2 which was used in the core study and Partickles version 3 were as follows:

- The name of the help menu was changed from "help" to "info".
- The "colours" hot words box that had provided access to the effects SEO help facility was renamed "effects" and included in an extended SEO help facility.
- The extended SEO help facility was accessed by a help hot words box which became available after every object-based help access (see Figures 4.10, 4.13 and 4.18 in Chapter 4). Clicking help produced three options: moves (information about making moves), ? pointer (information about object-based help) and effects (which accessed the same effects SEO help facility as colours in version 2). The information presented by these options is included in Appendix A.
- The question pointer was made the default pointer instead of the arrow pointer. In version 3 the question pointer, rather than the arrow pointer, was automatically selected when the program was first run and when

games were reset, but the arrow pointer remained available as an option. The descriptions of pointer usage in the menu-based help options remained largely unchanged and still tended to imply that the arrow pointer was the program's principal pointer.

- In version 2 of Partickles the partickle SEO information had been divided so that the descriptive partickle SEO information appeared in bubbles in the main game window and the 'would do' partickle SEO information appeared in the lower window (see Figure 4.12 in Chapter 4). In version 3 the places where these two forms of information appeared were reversed so that the 'would do' information appeared more prominently in bubbles (see Figure 4.13 in Chapter 4). This involved altering the parsing of this information but the only alterations to its content involved removing (to fit in the bubbles) the information that stated whether a pushed partickle was a red or a blue partickle and, more significantly, adding in the lower window information that reflected the current state of a step partickle during a multiple step effect move - for example: "It can step 3 more places".

Some of the modifications made to Partickles affect the terminology used to describe help facility usage. The term 'info menu' refers to the same facility as 'help menu' in the previous studies. In version 3 of Partickles the help hot words box replaced the colours hot words box and also appeared whenever object-based help was obtained. The effects SEO help facility was not changed but in version 3 of Partickles it became one of three options within an extended SEO help facility. The other options in the extended SEO help facility were accessed by the new moves and ? pointer hot words boxes.

The details of the video study sessions were recorded in the form of machine-readable, time-stamped trace records of subjects' interactions with Partickles and VHS video tape recordings. The complexity of the video study procedure meant that the observer was often too busy organising sessions to observe them. Consequently the observer's notes for the video sessions comprise brief notes taken during the sessions and longer reports written shortly after each session upon a first examination of the video tapes.

Procedure

The procedure of the video study followed the plan detailed in the observer's guidelines which is described in Chapter 5. It consisted of the following phases:

- Intro phase
.....with each subject in turn while the other subject read the subjects' guidelines.
- Explore and Practise phase
.....five minutes each.
- Checklist phase with Partickles
.....one subject used the mouse while the other read and ticked exercises from checklist A, then the subjects changed roles and completed checklist B.
- Game Playing phase with Partickles
.....the subjects began by playing jointly against the computer player and swapped the mouse after each game. In later games the observer could suggest that the subjects played against each other and/or could limit them to using only: a) the question pointer and SEO facilities or b) the arrow pointer with menu-based help.
- Questions phase
.....the subjects were asked five questions from the observer's guidelines.

In Table 8.3 below the session timings are presented as hours: minutes and the length of time spent using Partickles includes everything that happened after the Intro phase and before the questions phase.

subject code	N	O	P	Q	R	S
session code	V1		V2		V3	
length of session	1:29		1:35		1:29	
time with Partickles	1:20		1:28		1:22	

Table 8.3 Duration of the video study sessions

Since the two previous studies had indicated that longer sessions were preferable and because, in some respects, the time was divided between the two subjects, approximately one and a half hours was allowed for each of the video sessions.

8.3 Results

This section documents the usage of Partickles' help facilities during the video study sessions. The results are discussed in the next section.

Table 8.4 shows the number and results of games that subjects played against the computer player.

subject code	N	O	P	Q	R	S
session code	V1		V2		V3	
games played v computer	2		3		1	
wins by subjects	1		3		0	
wins by computer	1		0		1	

Table 8.4 Progress in games by video study subjects

In session V1 the subjects progressed from an initial defeat to a victory in their second game. In session V2 the subjects' progress was quick and thorough and enabled them to win all their games against the computer player, but in session V3 the subjects made limited progress and lost the only game they played. It was concluded that the pairing of the session V3 subjects and the allocation of roles were the causes of their lack of progress. In addition to the games shown in Table 8.4 there was a fourth game in session V2 in which the subjects played against one another. This game, and the third game in which the observer limited the session V2 subjects to using the arrow pointer and menu-based help, are discussed later.

As the video study sessions involved pairs of subjects working together the usage of Partickles' help facilities relates to the effectiveness of their collaboration. The following overviews of the video study partnerships refer to some of the details of sessions described in Appendix F.

- In session V1 the subjects differed in their learning strategies - with subject N apparently favouring reference and menu-based help while subject O seemed to prefer experimentation and object-based help. Subject N developed an early misconception about the game that became established as one of the pair's playing strategies. He seemed to be the more dominant subject, so the misconception was not questioned

and was probably reinforced by subject Q's implied approval. However, both subjects contributed ideas and strategies.

- In session V2 neither of the subjects was dominant and both learned efficiently and rapidly. Subject Q quickly developed a thorough understanding of the system in its own terms while subject P also contributed imaginative ideas and theories, but their abilities seemed to complement one another and allow rapid progress and consolidation. They communicated effectively and are the only pair who consistently checked that the other had read sections of help texts before scrolling/moving on. They won all three of their games against the computer and when they played a game against one another (rather than jointly against the computer player) they seemed to contrive what was virtually a draw - partly by collaborating in their continued learning of game strategies.
- In session V3 one of the subjects, subject R, was an unskillful mouse user and lacked confidence but appeared on occasions to have a clearer impression of the game than her partner. The other subject, subject S, was a more able mouse user but thoroughly dominated the partnership and introduced some debilitating misconceptions into their joint playing strategy. Subject R was the mouse user during the pair's one and only game. Subject S frequently told subject R what to do and at one point even seized control of the mouse - which was readily relinquished. Subject S did not gain sufficient experience of playing the game or feedback from subject R to allow her to dispel her misconceptions. They might have made better progress if, in a second game, subject S had used the mouse while subject R observed and made suggestions.

Only the initial action of the first subject to use Partickles from each pair can be compared with the initial actions of subjects from previous studies. This is because the second subject of each pair had already spent five minutes observing their partner exploring Partickles; they may have contributed to this exploration verbally and they may have been left with a system which was not in its initial state. The initial actions/selections of the first subjects in the video sessions were as follows:

- subject N (session V1): selected info menu option: Partickles rules
- subject P (session V2): selected info menu option: Partickles rules
- subject R (session V3): selected info menu option: getting started

In all three video sessions the first action of the first subject of each pair was to access an info menu option. This corresponds with the initial actions of the core study subjects and differs from the majority of initial actions of the pilot study subjects. When subjects O and S began their parts of the explore and practise phase the info menu option: Partickles rules window was already open. Subject O's first action, which was selecting the players menu, closed the open window. Subject Q also began by selecting the players menu and subject S's first action was to continue scrolling through Partickles rules.

Subjects N and P spent their explore and practise periods reading info menu option: Partickles rules. Subject R opened and looked briefly at all five info menu options then looked at the players and changes menus before opening Partickles rules. Subject S continued reading the Partickles rules option that subject R had accessed, then looked at all four menus and selected one info menu option and all three mouse menu options. Subject Q also looked at all four menus and selected one mouse menu option and two info menu options. Subject O was the only video study subject who did not access a menu-based

help option in the explore and practise phase. He tried some players menu options then obtained area SEO information by clicking with the question pointer on the game board. This produced a help hot words box which the subject selected. He might have proceeded to obtain partickle SEO information or to access some of the extended SEO help facility's options, but subject N said: "Try changes" and so subject O accessed the changes menu, selected the demo-mode option and the subjects spent the last two minutes of the explore and practise phase watching a computer versus computer demonstration game.

The checklists were an extension of, and replacement for, the observer briefings of previous studies. The checklist phase provided awareness of the existence of facilities and some practice with them. There were many observer interventions during this phase arising, mainly, when subjects tended to tick exercises that were incorrect/incomplete and when subjects did not know if they had completed an exercise successfully. These interventions are described in Appendix F.

Only one observer intervention occurred during a game playing phase. This was at the beginning of session V2 when the observer pointed out the make move hot words box. It is possible that without this intervention the subjects in session V2 might have become accustomed to changing to the arrow pointer in order to make moves as the majority of the core study subjects had done, though they might also have discovered make move without assistance - as occurred in sessions V1 and V3. It is not likely that the observer intervention prejudiced these subjects in favour of using make move since they decided not to use it for making multiple step effect moves. The observer intervened on this occasion because he had allowed the subjects to hurry through the checklist phase and as a result they had not had time to familiarise themselves

with the make move facility. The advantage of hurrying through the initial stages of session V2 was that it allowed a total of four games to be played and allowed the introduction of experimental constraints in the last two games.

Object-based help

Table 8.5 shows the numbers of partickle and control SEO information accesses made by the video study subjects during the explore and practise and game playing phases:

subject code	N	O	P	Q	R	S
session code	V1		V2		V3	
no. of partickle SEO infos	114		113		205	
no. of control SEO infos	0		1		2	

Table 8.5 Details of the use of object-based help in the video study

Although there was little use of control SEO information in the video study the large numbers of partickle SEO information accesses indicate that the subjects considered that this form of help provision was appropriate. Subjects' comments showed that they were using partickle SEO information to confirm partickle moves and to specify moves for the purpose of collaboration. Their comments and the number of 'spare' partickle SEO information accesses showed that partickle SEO information was being used to investigate alternative moves. 'Spare' partickle SEO information accesses were those which were not immediately followed by a move and they totalled: 21 in session V1, 45 in session V2 and 115 in session V3. All three of these figures indicate the usefulness of partickle SEO information, and the variation between these figures is discussed in the next paragraph.

In session V1 the subjects' tended to choose moves before obtaining partickle SEO information and to proceed with the move even if the 'would do' partickle SEO information conflicted with their prediction. This behaviour can be attributed to the subjects' reluctance to re-examine decisions once opinions had been expressed. The session V3 figure for 'spare' partickle SEO information accesses indicates that these subjects had difficulty in choosing moves, but the figure for session V2 shows that 'would do' partickle SEO information was useful for investigating alternative moves and was a prominent part of the successful learning and playing strategies of the session V2 subjects.

In session V2 subject P referred aloud to the descriptive partickle SEO information in the lower window. There is no evidence from the video study to indicate that the descriptive partickle SEO information was used (rather than merely noticed) in any of the sessions. In sessions V1 and V3 the subjects used the effects SEO help facility to obtain descriptive information about partickles which suggests that they were not using the descriptive partickle SEO information.

Extensions to object-based help

The video study results confirmed the core study findings that the facilities provided as extensions to object-based help were used very little - with the exception of make move. Table 8.6 shows the number of times that these facilities were accessed during the explore and practise and game playing phases:

facilities based on hot words boxes	session V1	session V2	session V3
effects SEO help facility	4	3	22
moves	1	1	1
? pointer	0	0	1
move value	5	0	2
make move	93	68	90

Table 8.6 Usage of extensions to object-based help in the video study

The proportionately large number of times that the effects SEO help facility was accessed in session V3 resulted from the misconception (referred to in Appendix F as the 'effect mode error') that the procedure required to make effect moves involved selecting the effects SEO help facility's hot words boxes. This confusion contributed to the subjects' lack of playing success and negates any beneficial aspects of the effects SEO help facility in this session - since the subjects would have made more progress if this facility had been absent. The effects SEO help facility was navigated twice in session V1 and twice in session V2. Both sessions provided evidence that the subjects successfully located the information they were seeking the second time they navigated the effects SEO help facility. The effects SEO help facility was also accessed, but not navigated, twice in session V1. On these occasions, and also the first time that the effects SEO help facility was accessed in session V2, the subjects studied the five coloured hot words boxes whose labels and colours indicate the mappings between partickle colours and partickle effects.

The extended SEO help facility in Partickles version 3 included the moves and ? pointer hot words boxes in addition to the effects SEO help facility. The moves option was read in sessions V2 and V3 and part-read in session V1. The

? pointer option was only accessed in session V3 and it was not read completely during this one access.

The move value facility was accessed five times in session V1 and twice in session V3. In session V1 all the move value accesses were made when the make move hot words box was not available and were probably attempts to make moves. In session V3 both move value accesses occurred when the effect mode error was confusing subjects and they were investigating all the SEO facilities.

The question pointer was used with the make move hot words box to make all the moves in sessions V1 and V3 and almost all moves in the first two games of session V2. Pointer usage during the third and fourth games of session V2 is discussed in the next paragraph. There were occasions in all three sessions when subjects changed to the arrow pointer and were told to change back to the question pointer by their partner. These statements and the usage of the question pointer indicate a preference for the question pointer. Nevertheless, the question pointer may have been preferred because it was familiar (as the default pointer) as well as because it was useful. Subjects who were advising (rather than using the mouse) required familiar states and familiar facilities as the starting points for their suggestions. If subjects had not found the question pointer useful they could have chosen to use the arrow pointer. This happened in session V2 when the subjects discovered that the question pointer was awkward to use for multiple step effect moves and chose to use the arrow pointer instead. This shows that the video study version of Partickles offered a genuine alternative in regard to pointer usage and supports the conclusion that the video subjects preferred the question pointer. Also, the default arrow pointer was exchanged for the question pointer in previous studies more

frequently than the question pointer was exchanged for the arrow pointer in the video study.

The observer used the third and fourth games of session V2 to gain further insights into the subjects' use of pointers. For the third game the subjects were asked to use only the arrow pointer and menu-based help. The subjects chose to continue using the arrow pointer in their fourth game, and no help facilities were used in either the third or the fourth games. The subjects' comments when asked not to use the question pointer: "That's not too bad 'cos we know what we're doing with it now", and when they had used the arrow pointer for most of two games: "It's actually easier without the question mark, once you've got used to it" confirmed that the question pointer was useful while subjects were learning the game but was less convenient than the arrow pointer once subjects were familiar with the game.

At one point in the second game of session V2 the following SEO error message appeared: "Cannot make the described move because another partickle has been highlighted". The subjects read the message, unhighlighted the partickle and then made the move successfully. In session V3 there were two SEO error messages: "Can't make the described move because the red side is no longer in play" and a similar message relating to the blue side. In both cases the messages were read, understood and acted upon successfully.

Menu-based help

Table 8.7 shows the numbers of mouse menu options (0-3) and info menu options (0-5) that were accessed by video study subjects during the explore and practise and game playing phases. The table also indicates whether info menu options were accessed during the game playing phase, and whether info menu

options: Partickles rules and getting started were the info menu options that subjects accessed most and/or spent most time reading.

subject code	N	O	P	Q	R	S
session code	V1		V2		V3	
mouse menu options seen	0		1		3	
info menu options seen	1		3		5	
info menu in game phase	no		no		yes	
mainly P rules or g started	yes		yes		yes	

Table 8.7 Menu-based help options accessed in the video study

One mouse menu option was read in session V2 and all three options were read in session V3. These were the only times that the mouse menu options were accessed in the video study and all four accesses occurred during explore and practise phases.

The pilot and core studies showed that the help menu was used to gain introductory overviews and for reference in regard to specific enquiries. In the video study the subjects were allowed less time in the explore and practise phase for gaining introductory overviews, but these overviews were supplemented by the experience subjects gained during the checklist phase. Table 8.8 shows all the info menu option accesses in the video study apart from options that were accessed by mistake or options that were reaccessed after being accidentally closed:

session	explore and practise phase	checklist phase	game playing phase
V1	Partickles rules	Partickles rules & getting started	—
V2	Partickles rules, suggestions and getting started	getting started	—
V3	all 5 info menu options - mainly Partickles rules. Also status info again.	getting started	getting started, Partickles rules, status info and Partickles rules

Table 8.8 Info menu accesses in the video study

Info menu option: Partickles rules was examined more thoroughly than any other info menu options in the explore and practise phases of all three sessions. In session V2 the subjects also skimmed through info menu option: suggestions and were beginning to read info menu option: getting started when the explore and practise phase ended. In session V3 the subjects glanced at all five info menu options then looked through all the Partickles rules information and after this had a second glance at info menu option: status info.

In the checklist phase some of the exercises required subjects to access info menu options and on one occasion subject O accessed info menu option: Partickles rules because he thought this was required. Apart from these accesses info menu options were used for reference during the checklist phase on two occasions in session V1 and on one occasion in session V3. In session V1 info menu options: Partickles rules and getting started were accessed for reference but in both cases these accesses were unsuccessful and the subjects solved their problems using SEO facilities. In session V3 the subjects solved their enquiry by combining information from info menu option: getting started with 'would do'

partickle SEO information. In session V2 subject P accessed info menu option: getting started at the end of the checklist phase which was the appropriate time to be considering getting started, but subject Q persuaded subject P that they didn't need to read any more about starting a game.

During the game playing phases of sessions V1 and V2 SEO help facilities were accessed and menu-based help was not. This suggests that SEO help facilities were preferred to menu-based help for reference in these sessions. In the course of session V3 the subjects accessed all the Partickles help facilities which can be seen as symptomatic of the widespread difficulties that this pair experienced. Info menu options were accessed on three occasions during the game playing phase of session V3. One of these occasions demonstrated successful use of the info menu options, though the success was limited to narrowing the subjects' field of enquiry. On the second occasion the subjects were confused by reading info menu information out of context and on the third occasion the subjects chose inappropriate info menu options and later found the information they were seeking in the effects SEO help facility.

8.4 Conclusions

The video study explored a number of factors that may have influenced results from previous studies and it added to the findings of previous studies - most notably in regard to the use and usefulness of 'would do' partickle SEO information. The video study conclusions have been divided into two parts that relate to the format of the studies and to the usage of Partickles' help facilities.

Conclusions regarding the study format

The conclusions that relate to the format of the video study (and to the formats of previous studies) are summarised below and discussed more fully in the paragraphs that follow:

- Consistency in the length of sessions and phases of sessions was not needed.
- Labelling facilities with the word "help" did not appear to significantly affect subjects' preferences, but accessing the effects SEO help facility with a hot words box labelled "effects" rather than "colours" may have introduced confusion.
- The video recorder contributed more useful data than the audio tape recorder that was used in previous studies.
- The format of the video study provided a control condition which indicates that observer interventions in previous studies had not influenced subjects to use object-based help.
- The checklists stimulated dialogue and cooperation between subjects and they assisted in minimising observer interventions during game playing, but they could not be completed without the observer's supervision.
- Subjects did not have enough time to consider their answers in the questions phase. Their conversations, and the informal debriefings with the observer in previous studies, provided a greater number of useful comments. The dialogue between pairs in the video study also provided useful comments, but some of the preferences observed in the video study may have been compromised by the effects of collaboration.

There was found to be no advantage in making the length of sessions and of the explore and practise phases consistent since the Partickles studies were

designed to investigate usage rather than compare subjects. The length of the video sessions (approximately one and a half hours) seemed adequate for session V1, generous for session V2 and insufficient for session V3. Limiting the time allowed for the explore and practise phase restricted the data regarding subjects' preferences in seeking introductory information and two subjects spent their entire explore and practise periods reading info menu option: Partickles rules. It appears that, given suitably long sessions, the heuristic approach to timing phases of sessions used in the pilot and core studies was more appropriate than aiming for consistent timings across sessions.

Some of the pilot study subjects and all of the core study subjects obtained most of their initial introductory information about Partickles from the help menu. The word "help" has many associations which may have influenced subjects' initial selections and subsequent use of this option. A simple experiment was undertaken in the video study: the word "help" was replaced by the word "info". It was found that the substitution made no apparent difference; the video study subjects' initial use of the info menu was very similar to the core study subjects' initial use of the help menu. In the video study version of Partickles the word "help" was used to label the hot word box that accessed the extended SEO help facility. The extended SEO help facility was accessed more frequently in the video study than the effects SEO help facility had been accessed in previous studies, but it was also available more frequently. Changing the label of the hot words box that accessed the effects SEO help facility from "colours" to "effects" may have been partly responsible for the confusion that arose regarding this facility because "effects" can be interpreted as relating to actions (effect moves) and some video study subjects thought that the effects SEO help facility could be used to specify effect moves.

The video recorder used in the video study provided more data than the tape recorder used in the first two studies, though both were used to supplement the trace records of sessions. The video tape allowed subjects' comments to be linked with their actions more accurately, it showed that subjects gestured with their hands and with the pointer and it showed selections that they almost made and that they tried, but failed, to make. The video tape also recorded subjects' interactions with Partickles in a form which is accessible to people who are unfamiliar with the work of this project. The video camera was an improvement in the format of the Partickles studies, but it was intrusive: affecting subjects' seating positions, requiring adjustment and diverting the observer's attention.

The video study was designed to avoid the need for observer interventions in the game playing phases by replacing the observer briefing with a more thorough introduction to the system (the checklists), and by making the question pointer the default pointer in version 3 of Partickles so that SEO facilities were easier to discover. Only one observer intervention was made in the game playing phases of the video study - a reminder concerning the make move facility - but there was far greater usage of make move, and SEO facilities generally, in the video study than in either of the previous studies. This indicates that the observer interventions in the pilot and core studies had not significantly affected subjects' preferences.

Checklists A and B are included in Appendix B. Some checklist exercises did not specify how to achieve what was required and/or indicate how to recognise their successful completion and consequently the observer had to compensate for their deficiencies. All the observer interventions during the checklist phases are described in Appendix F, and the descriptions show that the

interventions were unlikely to have contributed any bias. The checklist phases fulfilled their function of completing the subjects' introductions to Partickles and reducing the need for observer interventions during game playing phases. The checklists also encouraged dialogue between subjects. Prior to the checklist phases there were only two utterances by each subject in session V1 and one quick question and answer in session V3, though there was plenty of conversation in session V2 when the subjects were not reading. The checklists required the subjects to instruct each other and this made conversation mandatory and established normative communication for game playing.

The questions asked in the questions phase of the video study can be found in the video study version of the observer's guidelines in Appendix B. All three pairs of subjects thought Partickles was "good" and were prepared to return for additional sessions. The answers that the session V1 subjects gave are reported in Appendix F. In session V2 subject Q said she preferred the question pointer + make move mode to the arrow pointer because: "It's far more user friendly", and the subjects in session V3 commented that information was needed more while playing than at the beginning of the session. Subjects might have provided more thoughtful answers if they had been given more time and a written questionnaire. The answers might have taken a more useful form if rating scales had been used. Nevertheless, the Partickles studies were constructed to obtain objective evidence of subjects' preferences from examples of usage rather than subjective evidence based on subjects' opinions. In the pilot and core studies the most useful comments were either volunteered or occurred in the course of conversations with the observer. In these studies the subjects were studied individually and they sat next to the observer which made it easier for the observer to manoeuvre conversations into relevant areas and to ask for clarifications of comments. In the video study subjects were

studied in pairs so that their conversations during the course of sessions could be observed - and this aspect of the video study yielded many useful comments. For example, some of the comments showed that subjects who were looking at help information were actually reading it while others proved that 'would do' partickle SEO information was being used. To some extent, most notably in session V3, the pairs made slower progress than single users, and misconceptions, once expressed, became firmly established. Misconceptions were difficult to displace because subjects tended not to voice reservations concerning matters they had agreed upon. Also, operating the program by negotiation tended to be slow and inefficient. These points suggest that the studies might have been improved if, for each version of Partickles, a mixture of individual users and pairs of users had been studied.

Conclusions regarding the usage of help

The conclusions that relate to the usage of Partickles' help facilities are summarised below and discussed more fully in the paragraphs that follow:

- The core study showed that descriptive partickle SEO information was used and useful and the video study showed that 'would do' partickle SEO information was used and useful.
- Subjects in all three studies initially chose to use, and continued to use, the default pointer. The question pointer was used extensively in the video study. It was most useful during the initial stages of learning, after which the arrow pointer was more convenient.
- Some facilities based on hot words boxes were used little, but make move was used extensively in the video study.
- There was more usage of the effects SEO help facility in the video study than in previous studies (though in some cases its role was

misinterpreted) which suggests that a less confusing version of this facility might be useful.

- The only mouse menu information that the video study subjects needed was also available from other sources.
- Menu-based help was used to obtain introductory information in both the core and video studies. The effects SEO help facility was used more frequently and more successfully than info menu options for reference in the video study.

The core study showed that descriptive partickle SEO information was used and useful, but it provided only limited evidence that 'would do' partickle SEO information was used. For the video study the 'would do' partickle SEO information was displayed prominently in bubbles in the upper window in place of the descriptive partickle SEO information. This resulted in the finding that, in the video study, 'would do' partickle SEO information was used and useful while descriptive partickle SEO information was little used. Exchanging the emphasis from descriptive partickle SEO information in version 2 of Partickles to 'would do' partickle SEO information in version 3 provided evidence that both types of information were useful.

Making the question pointer the default pointer in version 3 of Partickles resulted in the finding that almost all the subjects in the Partickles studies initially chose to use, and then continued to use, the default pointer. In the pilot and core studies the subjects began by using the arrow pointer and continued to use it, while in the video study the subjects started with the question pointer and continued to use that. The arrow pointer offered the advantage of one-shot move making, which suggests that subjects who used the less convenient two-shot method of move making (with the question

pointer and make move hot words box) found that object-based help compensated for the inconvenience. Comments made by the video study subjects confirmed this. For example, when subject O changed pointers his partner, subject N, responded by saying: "I think we need the question mark not the arrow". In session V2 when subject P asked: "It moved - why did it do that?" subject Q replied: "Go get your question mark." and in session V3 when subject R changed to the arrow pointer subject S responded: "No, you don't have to change that". Some of the Partickles studies' results show that help facility usage decreased as subjects gained knowledge and experience. Consequently the advantages of object-based help could be expected to diminish over time to the point where the arrow pointer was preferred even if the question pointer had been preferred earlier. This was demonstrated in session C4 in which subject K's use of the question pointer in the last three games of the session gradually diminished, and session V2 in which the subjects, having been asked not to use the question pointer for their third game, chose to retain the arrow pointer for their fourth. These sessions, and those where the arrow pointer had been the default and question pointer usage decreased over time, indicate that the question pointer was more useful than the arrow pointer for learning. The use of the arrow pointer for multiple step effect moves in session V2 shows that the alternative one-shot approach was sufficiently prominent for the video study subjects to have demonstrated a preference for object-based help.

The make move hot words box was used frequently in spite of the inconvenience of the double selection process that this entailed. The inconvenience was recognised by the session V2 subjects who developed the practice of changing to the arrow pointer to avoid the repeated effort of shuttling the pointer between partickles and the make move hot words box

during multiple step effect moves. There is no evidence that the `move value` facility was accessed in order to use its information in any of the video sessions. The `moves` information in the `extended SEO help facility` was only accessed once in each session but this may have been sufficient for subjects to assimilate its brief information. Only part of the information produced by the `moves` option was read in session V1 and this did not prove useful though some of its information was relevant at that time. The `moves` facility may have contributed to the successful learning strategies of the subjects in session V2, but it did not remedy the unsuccessful learning strategies of the subjects in session V3.

In version 3 of Partickles the `effects SEO help facility` was one option within the `extended SEO help facility` (accessed via the help hot words box). This increased the availability of the `effects SEO help facility` as an option, but it also added an additional level of options to be navigated and increased the number of options that could be confused. The `effects SEO help facility` was used very little in the core study. In the first two video sessions the `effects SEO help facility` was used more frequently than in the core study but this could be because the video study version of Partickles made this option available more frequently. In the third video session the `effects SEO help facility` was accessed 22 times - not because it was useful, but because the session V3 subjects did not understand its function. The misconception concerning the `effects SEO help facility` that arose in session V3 (and once briefly in session V2) is described in Appendix F. Apart from session V3 the `effects SEO help facility` was not used a great deal in the video study and one of the main reasons for this is that the video subjects, like the core study subjects, had used menu-based help to obtain introductory information. Experiment and observation, the computer player and 'would do' partickle SEO information seemed to supply most of the video

subjects' reference needs. However, in sessions V1 and V2 the subjects accessed the effects SEO help facility for reference during game playing and did not access menu-based help options - which suggests that a less confusing version of the effects SEO help facility might have been more suitable than menu-based help for reference. The video study also provided evidence (from sessions V1 and V2) to support the core study finding (from sessions C1 and C3) that subjects used the effects SEO help facility's five coloured hot words boxes as a source of information regarding the colour-effect mappings of partickles.

Mouse menu options were accessed in two sessions and on each occasion this was the first time that the subjects had seen information about the mouse buttons. All the video study subjects already knew how to operate the mouse - though subject R lacked practice. The moves information in the extended SEO help facility and info menu option: getting started contained information about pointers and the functions of the mouse buttons, and both moves and getting started were accessed in all three video study sessions. The video study subjects also advised one another about pointers and mouse buttons. These duplicate sources of information and the checklist exercise involving the mouse menu are probably responsible for the fact that subjects did not need to re-access the moves facility or the mouse menu. The subjects in session V1 may not have had time to investigate the mouse menu during their explore and practise phase, while the subjects in session V3 may have spent more time with this facility than it merited. In session V2 the subjects accessed mouse menu option: which button and quickly identified the single difference in mouse button functionality caused by changing pointers:

subject P: "The only difference is that one <pointing to text>."

subject Q: "Yeh, 'move' and 'explain'."

This shows that the mouse menu successfully provided these subjects with a simple, brief statement (in tabular form) of this simple, but crucial, aspect of Partickles usage.

The video study supported the core study findings that info/help menu options were used to obtain introductory information in preference to other facilities and that info/help menu option: Partickles rules was used more than any other info/help menu option. The effects SEO help facility in the video study version of Partickles had been extended so that subjects would not have to read info and mouse menu options in order to obtain basic introductory information, but the video study subjects accessed menu-based help and obtained introductory information before they discovered the extended SEO help facility. In all the core study sessions menu-based help was used for reference in regard to specific enquiries during game playing, but in two of the video study sessions menu-based help options were not used during the game playing phase. There were two occasions in session V1 and one occasion in session V3 when info menu options were used for reference in the checklist phase, but in all three video sessions the extended SEO help facility was used for reference more often than menu-based help. This differs from the corresponding core study finding and may be linked to the higher number of particle SEO information accesses in the video study. There is also limited evidence to indicate that the effects SEO help facility was used more successfully than menu-based help for reference. The second time that the effects SEO help facility was accessed in both sessions V1 and V2 the subjects found the information they were seeking whereas the two info menu accesses made during the checklist phase of session V1 were unsuccessful. In session V3 the subjects used info menu options for reference successfully twice (once in the checklist phase), and twice unsuccessfully. On one of these unsuccessful

occasions the subjects accessed inappropriate info menu options but later found the information they were seeking in the effects SEO help facility.

Partickles was developed for two reasons: to investigate methods of implementing help facilities based on self-explanatory objects, and to create a research tool for examining the usage of help facilities in a system that has a graphical object-oriented interface. Chapters 6, 7 and 8 have documented the Partickles studies and presented their findings. In Chapter 9 Partickles' help facilities are examined in the context of findings from all three studies to see how this evidence relates to the provision of help in systems that have graphical object-oriented interfaces and to the utility of help facilities based on self-explanatory objects.

Chapter 9

Results of the Studies

9.1 Introduction

The studies were conducted to investigate whether the help facilities in Partickles were used and useful. Usage was indicated by observations of repeated and/or lengthy help facility accesses, by the contexts in which accesses occurred and by subjects' comments. Extensive usage indicated usefulness, because it showed which help facilities subjects considered to be useful. The effectiveness of help facilities could also be determined by the extent to which subjects learned to use the system and play the game. Subjects' progress indicated the effectiveness of the sources of information they had used, and in all the sessions where subjects learned to play competently they also accessed help facilities repeatedly and/or for lengthy periods of time.

The Partickles studies were designed to provide evidence regarding subjects' preferences. The broad choices were:

- usage of a graphical object oriented interface,
- usage of menu-based help,
- usage of object-based help,
- usage of extensions to object-based help.

The Partickles studies concentrated on subjects' preferences because both on-line help facilities and graphical object-oriented interfaces provide information. All the subjects obtained some information from Partickles' interface, but their preferences were indicated when they chose to use help

facilities rather than the interface. The aim of the Partickles studies was to investigate the utility of object-based help, so further choices were added to offer additional and alternative sources of help. This meant that it was also possible to investigate the more general question of the appropriateness of alternative forms of help provision for systems that have graphical object-oriented interfaces.

Three of Partickles' menu-based help options were useful. These were help/info menu options: getting started and Partickles rules and mouse menu option: which button. One form of object-based help, partickle SEO information, was also useful. It was found that these facilities were useful for obtaining introductory overviews and for reference. The other forms of help provision in Partickles were either found not to be useful, or there was a lack of evidence concerning their usage (because the studies had focussed on other facilities).

This chapter examines the usage of all Partickles' help facilities and discusses why these were, or were not, useful. Sections 9.2 to 9.6 consider the individual help facilities in Partickles, and each of these sections ends with a summary of its main findings. The final section summarises the conclusions regarding the usefulness of the help facilities in Partickles and discusses what has been learned in regard to the provision of help in systems that have graphical object-oriented interfaces.

9.2 The mouse menu options

Mouse menu options were accessed 19 times in 8 of the sessions. Subjects mainly accessed all three mouse menu options in the course of obtaining general introductory information or accessed just the which button option for

reference. Mouse menu option: which button was also the only mouse menu option that was accessed twice during a session. Table 9.1 summarises the usage of the mouse menu options and indicates whether the options were accessed during the game playing ("game") or the explore and practise ("e & p") phases:

Session	Option/s	Purpose	Phase
P4	all 3 mouse menu options	general introductory info	e & p
P7	all 3 mouse menu options	general introductory info	game
C2	which button	reference	game
C3	all 3 mouse menu options	general introductory info	e & p
C5	which button (twice)	reference	game
	about mousing, which pointer	general introductory info	game
C6	which button	reference	game
V2	which button	general introductory info	e & p
V3	all 3 mouse menu options	general introductory info	e & p

Table 9.1 The usage of the mouse menu options

Eight out of sixteen subjects (or pairs of subjects) did not access mouse menu options. This suggests that from six to eight subjects (or pairs of subjects) assumed the mouse menu did not contain essential or useful information. Six of the pilot study subjects and one video study subject were inexperienced mouse users but they needed practice rather than the basic information contained in mouse menu option: about mousing. None of the subjects needed the information contained in mouse menu option: which pointer - because they had practised changing pointers with the Intro program. Mouse menu option: which button contained some information which was essential for all subjects to know and some information which was potentially useful to some subjects - though the most significant parts of this information were also available from

several other help facilities. All the subjects began by not knowing the functions of the mouse buttons in Partickles and some subjects seemed unaware that there were three mouse buttons and/or that the mouse buttons had different functions. This was all explained or suggested by the tabular information in which button which matched: pointers, buttons and button functionality. Four subjects (or pairs of subjects) used which button for reference in regard to the functions of the mouse buttons, but the subjects who seemed unaware that there were three mouse buttons (subjects E and M) and/or that the mouse buttons had different functions (possibly subjects C and E) could not recognise that this was the reason for their difficulties and that the mouse menu contained information that might help them.

The about mousing information might have been needed by a user who had never used a mouse and/or was unclear about its function, but the about mousing option was inappropriate in an online facility because it could only be accessed by using the mouse. The which pointer information was contained in other help facilities and was made superfluous in the Partickles studies by the prior use of the Intro program but, like about mousing, it contained potentially essential information for inexperienced beginners. The which button option proved useful, but it could not help users who were unaware that they were using the mouse inappropriately and did not access the option.

The mouse menu options provided information concerning the basic mechanisms and methods involved in the initial usage of a system. The main findings of the studies in regard to this type of information are:

- It may be appropriate to leave explanations of basic computer usage to the documentation and tutorial guides that apply to computer systems rather than to individual application packages.

- Information concerning the initial usage of application-specific mechanisms and methods should be included with other introductory information and be sufficiently prominent to attract early interest.
- Where information that relates to accessing on-line help is not clear or covered in the computer system's documentation or tutorial guides it should be provided as, perhaps, hard copy or on-line demonstrations rather than as on-line help.

9.3 The help/info menu options

The five help/info menu options were described individually in Chapter 4 and their texts are included in Appendix A. The first actions of subjects with previous computer experience showed a preference for introductory information obtained from the help/info menu. Apart from second sessions (in the pilot study), second subjects (in the video study) and the three pilot study sessions where help/info menu options were not used, the first info/help menu option selected during sessions with Partickles was: getting started - eight times, Partickles rules - five times and about the program - once. These preferences reflect the order in which the help/info menu options were presented, and where subjects looked through a number of help/info menu options in sequence they tended to work vertically down through the list of options. Table 9.2 presents an overview of the usage of the five help/info menu options, and their usage and usefulness are discussed individually in the sub-sections that follow:

numbers of accesses/sessions	help/info menu options				
	getting started	Partickles rules	about the program	suggestions	status info
sessions in which accessed	11	14	5	11	6
total number of accesses	20	34	6	12	10
sessions accessed 2 times	2	2	1	1	0
sessions accessed 3 times	2	3	0	0	2
sessions accessed 4 & 4+ times	1	3	0	0	0
sessions scrolled & studied	5	13	3	8	—
sessions glanced at/part-read	4	1	2	3	6
sessions used for introduction	6	11	5	8	6
occasions used for reference	7	22	0	4	2
successful references	2	16	—	0	0

Table 9.2 The usage of the help/info menu options

Help/info menu option: getting started

The **getting started** option was accessed more frequently than any other help/info menu option except **Partickles rules**. The entries in Table 9.2, particularly those that relate to repeated accesses and to accesses in which **getting started** was scrolled and studied, show that **getting started** was useful and that it was more useful as a source of general introductory information than for reference in regard to specific enquiries.

The name "getting started" suggests initial learning and/or setting up a game. Subjects accessed **getting started** immediately prior to game playing in three sessions which shows that they considered it relevant to setting up a game. The information about setting up games was not needed in the studies because the observer was prepared to undertake this task, but there were four documented

instances where subjects set up and started their first games without assistance. On three of these occasions the subjects had already read **getting started** before they started their first games, though subject F discovered how to start a game by systematically exploring the changes and players menu options. The **getting started** option provided 'brief help' information for initial learning but this was preceded by the information about setting up and starting games. After spending three and a half minutes reading **getting started** subject I commented: "It's a bit complicated isn't it". The **getting started** option might have been improved by presenting the information about setting up games separately.

Help/info menu option: Partickles rules

Partickles rules was used in 14 out of the 15 sessions in which help/info menu options were accessed and it was used to obtain introductory information and for reference considerably more often than any other help/info menu option. Subjects found the information they were seeking in seventy-three per cent of the **Partickles rules** accesses that were made for reference - which indicates that the option was an effective source of reference information. The number of sessions in which **Partickles rules** was used to obtain general introductory information and the lengths of time subjects spent with this option indicate that it was also effective in providing general introductory information.

Approximately half of the successful **Partickles rules** references were made by three core study subjects in order to obtain information about the colour-effect mappings of partickles. Most of the other **Partickles rules** references were enquiries concerning effects. The information about colour-effect mappings and effects was inconveniently situated at the end of the **Partickles rules** text and could only be located by scrolling. This suggests that a navigable help facility with information indexed according to probable enquiries might be

more useful, but distributing the 'most used' Partickles rules information could be confusing if users were unable to locate the information or accessed it in an inappropriate order. Some of the reasons why a single, full description of the domain should be provided with systems like Partickles are that it provides:

- a centralised source of descriptive (rather than didactic) information amenable to a variety of approaches and learning styles,
- a facility for resolving detailed, and perhaps obscure, enquiries, and
- a rule 'book' comparable with those of board-games.

Help/info menu option: about the program

The about the program option was accessed fewer times in fewer sessions than any other help/info menu option. All the about the program accesses occurred while subjects were examining several help/info menu options in the course of obtaining general introductory information. This suggests that subjects preferred alternative means for finding out how to operate the system.

Subject H appeared to have recognised the type of information supplied by the about the program option, because when he was discussing his lack of knowledge of the effects SEO help facility he correctly conjectured: "Maybe there's more about that in 'about the program' - should have read that more". None of the subjects used about the program for reference in regard to facilities such as changes menu option: demo-mode, but seven subjects selected demo-mode which suggests that they preferred to find out how to operate the system by experiment and observation. Subjects who had difficulties making moves might also have benefited from studying this option. The name of the about the program option may have discouraged subjects from using it, but the main reason why about the program was little used is probably because Partickles'

graphical object-oriented interface made the functions of its facilities seem obvious and/or discoverable by experiment.

Help/info menu option: suggestions

Most of the **suggestions** accesses occurred while subjects were examining several help/info menu options in the course of obtaining general introductory information. There were four occasions when **suggestions** was used for reference, but these were unsuccessful because the option did not contain information regarding making moves. Although most of the subjects who accessed **suggestions** scrolled and studied its text most of the **suggestions** accesses were fairly brief and only one subject (subject B) appeared to read it thoroughly.

The information in **suggestions** provided a form of help that was not appropriate in the Partickles studies - with the possible exception of the 'Program behaviour' section which was buried at the end of the **suggestions** text and seldom seen. The **suggestions** option was an inappropriate source of information for general introductions and for reference and consequently it can be considered to have been an unhelpful facility for the Partickles studies subjects since its presence obliged subjects in eleven sessions to find this out. The presentation of **suggestions** enabled all but one of the subjects who accessed it to discover its irrelevance to them with one access, but may also have concealed the potentially useful information in the final Program Behaviour section (though this information was available in several other options). The Ideas and Strategies sections were intended to be used by experienced players and might, eventually, have proved useful.

Help/info menu option: status info

The status info option was the only non-scrolling help/info menu option and most of its information (*all* of its information at the start of games) could be absorbed with a brief glance. Most of the status info information duplicated information that was available from Partickles' visual interface, but status info grouped the information and presented it in a clear, tabular format.

The status info option was accessed on seven occasions in explore and practise phases, the accesses were brief and occurred during first examinations of several help/info options. In session V3 both subjects accessed status info during the explore and practise phase and they also accessed the option once, unsuccessfully, during game playing for reference in regard to the colour-effect mappings of partickles. In addition to his first look at status info subject M also accessed it twice during game playing - which suggests that he'd realised that status info was context sensitive and therefore liable to change - and one of these accesses has been counted as an unsuccessful use of the option for reference. There was little potentially useful information in the status info option - but the limited number of times it was accessed and the brief periods of time that the option was viewed suggest that it did not greatly inconvenience subjects. The video pilot session (which was described in Chapter 5) provided the only example of the usefulness of status info. This incident occurred while the subjects in the video pilot session were discussing their imminent defeat in the fourth game. They accessed status info (for the second time in the session) and, because of its alternative representation of partickle positions, they saw a partickle they hadn't previously noticed and commented: "Oh no! We've got one there as well".

The main findings of the studies in regard to menu-based help are:

- Menu-based help can be useful for obtaining introductory information and for reference. Experienced computer users may prefer to tackle an unfamiliar system by obtaining introductory information first, so this should be provided.
- Introductory information should be offered as: a) an overview of the domain and system, and b) a guide to getting started.
- Help information in the form of lengthy texts is not appropriate for reference in regard to specific enquiries.
- Comprehensive information regarding a system's domain can be useful for reference and for extending learning.
- System developers may wish to document all the features of a system, but it may not be necessary to supply this information as on-line help if users prefer to learn about graphical object-oriented interfaces by experiment and observation.

9.4 Object-based help

There are three sorts of object-based help in Partickles: partickle SEO information, control SEO information and area SEO information. These forms of information are produced by clicking with the question pointer and left mouse button on partickles, controls and screen areas in the upper game board window. All the object-based help information appears in the lower window with the exception of parts of the partickle SEO information that appear in bubbles in versions 2 and 3 of Partickles. Partickle SEO information is the most comprehensive form of object-based help in Partickles and is discussed in the next section. This section concentrates upon area and control SEO information and discusses the object-based help facilities in Partickles generally.

There are only two types of area SEO information in all three versions of Partickles. These are simply names: "The Partickles game board" and "The game board frame". There appeared to be little deliberate use of this 'token' facility in the studies, but area SEO information was accessed fairly frequently because subjects often clicked the game board to close windows and menus and to remove bubbles.

In version 1 of Partickles control SEO information was available for five controls, but in versions 2 and 3 three of the controls were replaced by menu options - leaving only the side-to-play boxes. Control SEO information was accessed in six sessions and the only controls for which control SEO information was obtained were the side-to-play boxes. Table 9.3 provides details of all the control SEO information accesses in the studies:

session	accesses	comment
P3	12	The last ten (but possibly all) of the accesses were probably made because the subject thought she was changing the side-to-play after each move - though this was done automatically.
P5	5	The accesses occurred while the subject was only using the left mouse button. He had been clicking on partickles and side-to-play boxes to make moves and continued to click on these for a while after changing to the question pointer.
P7	1	The subject clicked the question pointer on a side-to-play box while attempting to halt a computer versus computer game.
C1	1	This access was the fourth in a block of five contiguous object-based help accesses - the others were all partickle SEO information accesses.
V2	1	The subjects tried to select a side-to-play box to start their first game but obtained control SEO information instead because they used the question pointer and left mouse button.
V3	2	The first access was an attempt to select a side-to-play box to complete a checklist exercise; the second occurred while the subjects were unsure how to complete one of the exercises and made several object-based help accesses including area, control and partickle SEO information accesses.

Table 9.3 Control SEO information accesses in sessions

Subject H, in session C1, appears to have accessed control SEO information deliberately to investigate the potential of object-based help. Almost all the accesses made in the other five sessions appear to have been mistakes. There were no occasions in the studies where subjects appeared to *use* control SEO information - though it may have contributed to the general introductory information that subject H was gathering and possibly showed subject C, in session P3, how to recognise which side was in play. The studies did not show that control SEO information was useful, and it might have been appropriate to make the control SEO information more prominent by placing it in bubbles. For

consistency, and perhaps added accessibility, possibly all forms of object-based help should have been presented (at least in part) in bubbles.

The versions of Partickles used in the studies provide object-based help for all objects in the upper window. An earlier prototype had provided object-based help for almost all onscreen objects but this was changed because object-based help information concerning the names and general functionality of the objects in the lower window did not seem potentially useful. One of the outcomes of focussing investigations upon partickle SEO information has been the identification of the usefulness of 'would do' help. It is now clear that the menu options in the lower window *would* provide access to a variety of types of information, that the hot word boxes in the effects SEO help facility *would* provide information and further hot words boxes, and that the lower window *would* scroll. Observations of the subjects in the Partickles suggest that they might have benefited from summaries of the contents of menu options, from a guide to the navigation of the effects SEO help facility, and from a reminder that the lower window can be scrolled. If, as this suggests, appropriate object-based help can be provided for a variety of display objects, it might be desirable to supply object-based help for all onscreen objects - possibly with an option to reduce this to only the most significant objects after an initial examination of the interface.

The remainder of this section consists of a discussion of the presentation of object-based help. This discussion relates to object-based help generally but mainly refers to partickle SEO information - since most of the development of object-based help and investigations of its usage concentrated on partickle SEO information. The next section discusses partickle SEO information in more detail.

Partickles version 1, which was used in most of the pilot study sessions, presented all the partickle SEO information in the lower window as a single block of text, on a grey background, away from the focus of interest and always in the same position. In versions 2 and 3 of Partickles bubbles were used to present part of the partickle SEO information on a white background next to the partickle that had been clicked while the rest of the partickle SEO information remained in the lower window. There is evidence to show that the partickle SEO information in bubbles was used in both the core and video studies. There was no clear evidence from the core study that the partickle SEO information in the lower window was read, though some actions by subjects suggested they were using it. Subject P in session V2 showed that she was aware of the partickle SEO information in the lower window by reading some of it out.

Bubble help may have been effective because it was brief and situated close to the item of interest. There is probably a maximum amount of text that can be presented in a bubble before it ceases to be brief and causes users to forget the details of the interaction that preceded the help access. Larger amounts of object-based help information could be divided and presented partly in a bubble and partly in an overflow area such as Partickle's lower window. Alternatively users could be provided with facilities for changing the information in bubbles. This could be achieved globally with a facility for customising bubbles, or locally with a single options button.

The subjects in the Partickles studies did not find area and control SEO information useful. This contrasts with the findings regarding partickle SEO information and highlights two issues: the significance of the information presented by object-based help (which is discussed in the next section) and the

presentation of object-based help. The main findings of the studies in regard to the presentation of object-based help are:

- Bubbles are an effective means of presenting object-based help information. This may be because they can be scanned quickly, because they are situated close to items of interest and/or because their positions vary. A less prominent and less intrusive form of presentation may be appropriate once users are aware of the facility and what it can offer.
- The information presented in bubbles might be varied locally with a "More" button, or globally with a "customise bubbles" facility.
- It may be appropriate to provide object-based help for all display objects initially. This would allow object-based help to be accessed in groups to obtain general introductory overviews. An option could be provided to limit object-based help to only the most significant display objects later.

9.5 Partickle SEO information

Partickle SEO information was the most comprehensive form of object-based help in Partickles. Table 9.4 shows the sessions in which partickle SEO information was accessed and the number of times that subjects accessed partickle SEO information in these sessions:

session	P1b	P2b	P3	P4	P5	P6	P7	C1	C2	C3	C4	C6	V1	V2	V3
no. accesses	16	5	12	5	7	8	6	31	46	18	72	13	114	113	205

Table 9.4 The number of partickle SEO information accesses in sessions

With each subsequent study there was a noticeable increase in the number of accesses - which can be attributed to the length of sessions, the choice of subjects, the use of bubbles, the information in the bubbles and the default

pointer. The entries in Table 9.4 show that an object-based help facility that presents information drawn from self-explanatory objects was used. Table 9.5 presents an overview of the usage of partickle SEO information in the sessions in which it was accessed:

session	whether prompted	phase/s accessed	general info or reference	grouping of accesses	'would do' evidence
P1b	yes	game	general info	1 group	yes
P2b	yes	game	reference	1 group	yes
P3	no	ep	general info	4 groups	no
P4	no	ep & game	both	1 group 1 single	yes
P5	no	ep	both	2 groups 2 single	no
P6	slightly	ep	general info	1 group 2 single	no
P7	yes	game	both	6 single	no
C1	no	ep & game	both	some grouping	yes
C2	no	game	reference	some grouping	no
C3	no	game	reference	no grouping	no
C4	yes	game	reference	no grouping	yes
C6	yes	game	reference	1 group 2 single	yes
V1	no	game	reference	some grouping	yes
V2	no	game	reference	some grouping	yes
V3	no	game	reference	some grouping	yes

Table 9.5 The usage of partickle SEO information in sessions

The next five paragraphs discuss the entries in Table 9.5.

The **whether prompted** entries in Table 9.5 indicate whether the observer had demonstrated or suggested using the question pointer or help facilities prior to the subjects' use of partickle SEO information. Observer briefings, in which object-based help was mentioned/demonstrated if subjects had not already used it, have not been included in Table 9.5. There were observer briefings between the explore and practise and game playing phases of all the sessions of

the pilot and core studies, but in the video study the observer briefings were replaced by the checklist phase. The **phase/s accessed** category shows whether partickle SEO information was accessed in the explore and practise phase ("ep"), the game playing phase ("game") or both. The next paragraph considers the extent to which the usage of partickle SEO information may have been influenced by the observer.

There were seven sessions in which subjects began to use partickle SEO information without prompting and a further two sessions in which subjects began to use partickle SEO information after it had been mentioned/demonstrated in the observer briefing. There were five sessions in which subjects used partickle SEO information after the observer had suggested using this or using help facilities generally, but in session C5, even though the observer reminded the subject about the question pointer, the subject chose not to use it. The aim of the video study's checklist phase was to acquaint subjects with all Partickles' help facilities so that the observer briefing and observer interventions would not be needed. There was one observer intervention during the game playing phase of one video session, but this occurred after the subjects had already accessed partickle SEO information. In the pilot and core studies the numbers of partickle SEO information accesses in sessions where the observer prompted subjects to use help facilities are approximately equivalent to those where there were no observer interventions. In the video study, where there were no observer interventions prior to subjects' use of partickle SEO information, there were high numbers of partickle SEO information accesses. These results indicate that although the observer may have helped some pilot and core study subjects to discover partickle SEO information, the influence of the interventions upon subjects' subsequent use of partickle SEO information was negligible.

In documenting the Partickles studies it has been useful to distinguish between the usage of help facilities to gain general information (usually of an introductory nature) and their usage for reference in regard to specific enquiries. The **general info or reference** entries in Table 9.5 are assessments of whether subjects used partickle SEO information to gain general information or for reference. The evidence that partickle SEO information was accessed to gain general information has been inferred from accesses made early in sessions while subjects were gaining introductions, and from accesses made in sufficiently large groups to indicate that subjects were aggregating information. The evidence that partickle SEO information was accessed for reference has been inferred from accesses made while subjects were planning moves, and from single, or small groups, of accesses.

The **grouping of accesses** category in Table 9.5 indicates whether subjects grouped some partickle SEO information accesses. In the pilot and core studies subjects made most of their moves using the arrow pointer. In these studies groups consisted of groups of at least three (but usually more) partickle SEO information accesses which were not separated by changes of pointer or by the use of attention-diverting facilities such as menu-based help options. The subjects in the video study sessions also grouped some partickle SEO information accesses, but groups could not be identified by changes of pointer in the video study because there were very few occasions where the pointer was changed. As the entries in Table 9.5 indicate, there were four sessions in which subjects obtained partickle SEO information in groups to aggregate general information. On these occasions subjects used object-based help to browse the interface. Subjects also obtained partickle SEO information in groups for

reference in regard to specific enquiries such as finding a partickle that would perform a specific effect, or comparing alternative moves.

The entries in the **'would do' evidence** category of Table 9.5 indicate whether the trace records show that subjects rotated partickles and/or switched effect on/off before, or between, partickle SEO information accesses. This constitutes evidence of the usage of 'would do' partickle SEO information because the 'would do' information is the only part of partickle SEO information that changes when partickles are rotated and when effect is switched on and off. It is difficult to separate the usage of descriptive partickle SEO information and 'would do' partickle SEO information because both types of information are available simultaneously. The use of bubbles in the core and video studies made each of these types of information more prominent and two of the core study sessions provided evidence that descriptive partickle SEO information was used. In the video study the dialogues between subjects provided firm evidence that 'would do' partickle SEO information was used.

The usefulness of partickle SEO information

The numbers of partickle SEO information accesses made in the studies indicate that this facility was useful. The average rate of partickle SEO information accesses for all the sessions where it was accessed was 1 access every 1.3 minutes. More partickle SEO information accesses were made in session V3 than in any other session, but the average rate of partickle SEO information accesses for all the sessions where it was accessed excluding session V3 was 1 access every 1.7 minutes.

Success in games provides a crude indicator of the effectiveness of the information that subjects obtained. Partickle SEO information was accessed in

all the sessions in which subjects won games. In the six sessions in which subjects won games partickle SEO information was accessed 376 times. In the twelve sessions in which subjects did not win games partickle SEO information was accessed 295 times (but only 90 times if the number of accesses in session V3 is discounted).

Chapters 6 to 8 and Appendices D to F contain further evidence of the usefulness of partickle SEO information by citing individual accesses, periods of accesses and games, and by quoting subjects' comments. Four examples of this evidence follow:

- In session C2 the subject accessed partickle SEO information three times consecutively, then said, "What's this thing?" and accessed partickle SEO information again. The question indicated that he was seeking descriptive information.
- In session C6 the subject accessed partickle SEO information eleven times in a period of one and three-quarter minutes using the rotate and effect mouse buttons to investigate what partickles 'would do'. This group of accesses provided an overview of the moves that partickles could make.
- In session C4 the subject made little progress until he began to use partickle SEO information in the tenth game. This contributed to his eventual victory in the twelfth game.
- Subject J, in the informal debriefing at the end of his session, stated that he found partickle SEO information (which was the only facility that he accessed with the question pointer more than once) useful:

Obsv: "Which of the help systems did you find most useful?"

Subj: "I found *that* useful <pointing to the question mark pointer>"

Obsv: "With the question mark pointer?"

Subj: "Yes."

Another way in which the usefulness of partickle SEO information could be assessed was by observing changes of pointer and the use of the make move facility. In the pilot and core studies the subjects made almost all their moves using the arrow pointer. This meant that the subjects in the pilot and core studies considered partickle SEO information sufficiently useful to be worth the effort of changing to the question pointer. In the video study the subjects used the question pointer and make move to make almost all their moves (apart from the last two games of session V2). The video study indicated that the partickle SEO information was useful because the subjects were reluctant to change to the arrow pointer. When the session V2 subjects were asked not to use the question pointer during their third game one replied: "O.K. That's not too bad 'cos we know what we're doing with it now". There were occasions in each of the three video studies where subjects' comments indicated a preference for the question pointer:

- In session V1 subject O changed to the arrow pointer and his partner, subject N, responded by saying: "I think we need the question mark not the arrow."
- In session V2 subject P asked: "It moved - why did it do that?" and subject Q replied: "Go get your question mark."
- In session V3 when subject R changed to the arrow pointer subject S replied: "No, you don't have to change that."

Two core study sessions provided evidence that the frequency with which partickle SEO information was accessed decreased as subjects gained knowledge and experience. The video study subjects in session V2 chose not to use the question pointer during their fourth game. The transition of these subjects from early usage of, and preference for, object-based help to competent play

with the arrow pointer also suggests that partickle SEO information was most useful while subjects were learning how to play.

The content of partickle SEO information

An example of partickle SEO information is shown below in each of the forms in which it appeared in the three versions of Partickles:

Version 1 - presented in the lower window:

A blue partickle with 3 parts - it can unpack, push and resist.
Its move would be an effect move. It would move 3 places and unpack 2 partickles.

Version 2 - presented in a bubble and in the lower window:

A blue partickle
with three parts.
It can unpack, push
and resist.

The partickle's move would be an effect move.
It would move 3 places and unpack 2 partickles.

Version 3 - presented in a bubble and in the lower window:

Effect move. It would
move 3 places and
unpack 2 partickles.

A blue partickle with three parts.
It can unpack, push and resist. Effect is on.

Table 9.6 categorises the partickle SEO information in the above message in terms of four types of information. These are the partickle's name, its state and attributes, its general functionality and its current functionality:

Message	Information type
A blue partickle	<i>name</i> (class and sub-class - not individual)
with three parts	<i>state</i> (or perhaps <i>attributes</i>)
It can unpack, push and resist	<i>general functionality</i> (a selection - the move and combine functions are not mentioned)
Effect is on / Effect move	<i>state</i> (effect on/off = effect/non-effect move)
It would move 3 places and unpack 2 partickles	<i>current functionality</i> ('would do' help)

Table 9.6 The information in partickle SEO information

Table 9.6 shows that partickle SEO information contained four types of information. The remainder of this subsection considers the usefulness of each of these types of information:

- names

....The information concerning the names of partickles identified them as partickles belonging to the red or blue side. The name "partickle" labelled the playing pieces, but the colours of partickles were clearly indicated by their graphical representations. The names in object-based help messages acted as titles for the messages, and as indicators of their referents.

- states and attributes

....The information concerning the states and attributes of partickles described the number of parts they contained, whether effect was on

or off, and, in the video study, the number of steps remaining in a step effect move. The graphical representations of partickles showed the number of parts they contained, but the term "part/s" labelled the coloured triangles in partickles. The information that stated whether a partickle would make an effect or non-effect move may have been useful for explaining these terms and confirming that effect was on or off, while the information concerning the number of steps remaining in a step effect move relieved players of the need to count and remember steps.

- general functionality

.....The information concerning the general functionality of partickles described the effects that they could perform - which were the aspects of their general functionality that were not common to all partickles. Several subjects were observed using this information to map the colours of the parts in partickles to the names of effects, and though most subjects preferred to memorise the colour-effect mappings subject I preferred to use partickle SEO information to obtain this information than to remember it.

- current functionality ('would do' help)

.....The information concerning the current functionality of partickles described specific moves that partickles would make. This provided a wide variety of context sensitive information. Information concerning the current functionality of partickles included information concerning their general functionality. For example, the 'would do' information, "It would move 3 places and unpack 2 partickles", indicates that: "It can unpack". Also, the descriptions of what partickles *would* do related directly to what subjects *could* do.

The four types of object-based help information that have been identified in this subsection may be appropriate for display objects other than partickles. Some suggestions why it may be useful to supply these types of information as object-based help messages for a variety of display objects follow:

- names to label display objects and help messages,
- states and attributes to explain aspects of display objects that change,
- general functionality to make the possibilities for action clear,
- current functionality to make the current options for action clear.

The usage of 'would do' partickle SEO information

'Would do' partickle SEO information describes the moves that partickles would make, but this information can be used in a variety of ways. The following four forms of usage have been identified:

- investigating moves,
- comparing moves,
- confirming a move, and
- specifying a move for purposes of collaboration.

Subjects' comments provided evidence of the ways in which they were using 'would do' partickle SEO information. The remainder of this subsection presents examples of this evidence.

Subject S in session V3 made the following comments while she was using 'would do' partickle SEO information to investigate a move:

Subject S: "Hang on <thoughtful pause>. Would it just push those two or would it have to do the full move? Don't know. Find out. Turn it round. See what it'll do. No it didn't. So, <pointing> move him <a different partickle> out of the way."

The video tape recording of session V3 shows that while subject S was making these comments subject R rotated a partickle ("Turn it round") and then obtained partickle SEO information ("See what it'll do"). The 'would do' partickle SEO information disconfirmed subject S's theory ("No it didn't") so she recommended an alternative move ("So, move him out of the way").

The following example from session V2 shows that the subjects used 'would do' partickle SEO information to compare moves:

Subject P: <reading from bubble> "It would move one place."

Subject Q: "No, you want an effect move, so click on this one <points to the mouse button that switches effect on>. Right. Now see what it would do."

In the debriefing at the end of session C4 subject K indicated that 'would do' partickle SEO information was useful for confirming moves:

Observer: "Did you find it useful being able to change pointers?"

Subject K: "Yeh, it does, it confirms, if you know what you're doing it confirms your move doesn't it."

In the video study the 'would do' information in bubbles proved useful for collaborative work by *separating the specification of an action from its enactment*. It was easier for the paired subjects in the video study to discuss moves that the 'would do' information had specified for them. For example, in one instance subject Q read the bubble of 'would do' partickle SEO information and, having assumed her partner, subject P, had done the same, asked: "Do you want to do that?"

The main findings of the studies in regard to the content and usage of object-based help are:

- Object-based help is useful for obtaining general overviews with sequences of accesses, and for obtaining specific reference information with individual and/or sequences of accesses.
- Object-based help is of most use to inexperienced users.
- The brevity of object-based help messages may relate to their effectiveness.
- Useful object-based help messages can include the following four types of information: the names, state and attributes, general functionality and current functionality of display objects.
- Object-based help information concerning the current functionality of display objects ('would do' help) indicates some of the general functionality of display objects and describes what users can do.
- 'Would do' help can be useful for: investigating, comparing, confirming and specifying (when collaborating) the current functionality of display objects.

9.6 Other SEO facilities

This section discusses the usage of the following facilities: make move, move value, the effects SEO help facility, the extended SEO help facility, SEO error messages and the trace facility. Most of these facilities were used too little for their effectiveness to be assessed, but make move and the effects SEO help facility were found to be unhelpful.

Make move

The make move facility was introduced to demonstrate that an object-based help facility can provide users with access to the functionality of objects. Table 9.7 provides an overview of the usage of the make move facility. Each access represents an instance where make move was clicked - which usually resulted in a move.

session	no. of accesses	comment
P7	2	once as part of a general investigation of SEO facilities and once while playing the game
C2	1	once after observer mentioned the facility
C3	2	once while attempting to start a game and once following an observer demonstration
C4	44	about half of the total moves made in the last three games - but usage diminished: 25, 16 then 3 accesses
V1	93	used to make all moves
V2	68	used to make almost all moves in the first two games
V3	90	used to make all moves

Table 9.7 Usage of the make move hot words box

The arrow pointer was the default pointer in the pilot and core studies and the subjects in these studies became accustomed to using the arrow pointer to make moves before they discovered make move. In the video study the question pointer was the default and the video study subjects in sessions V1 and V3 used make move to make all their moves. In session V2 the subjects switched to the arrow pointer during the checklist phase and learned how to use it to make moves. The observer intervened to remind them about make move and they used the question pointer with make move to make all the moves in their first two games apart from four occasions when they temporarily changed to the arrow pointer to speed up the process of making

multiple step effect moves. These occasions indicate that **make move** was inconvenient to use because it involved clicking on two objects, whereas making moves using the arrow pointer involved clicking on only one object. This inconvenience may explain why the session V2 subjects chose to use only the arrow pointer for their fourth game. Similarly, in the last three games of session C4, subject K used the question pointer with **make move** but gradually reverted to using the arrow pointer and only used **make move** three times while winning the last game.

Move value

Move value demonstrated that a SEO help facility can provide users with the option to access information from a system object that does not have a corresponding display object. The system object was the 'computer player' (the `dir_val` object described in Chapter 4), and the **move value** hot words box was a display object provided to represent that system object after **partickle SEO** information accesses had established the context and focus of help enquiries. **Move value** provided two values: a value for a **partickle's** current move and a value for the best effect (or non-effect) move that it could make. The **move value** facility was accessed in five sessions as Table 9.8 shows:

session	no. of accesses	comment
P6	2	both times while exploring in the explore & practise phase - once after using the effects SEO help facility
P7	3	twice in 7th game (probable absence of make move), once in 8th prior to using the effects SEO help facility
C1	1	during general exploration in the explore & practise phase and after accessing the effects SEO help facility
V1	5	4 times in the checklist phase, once during a game - all probably because make move wasn't available
V3	2	in the game playing phase while uncertain about the function of the effects SEO help facility

Table 9.8 Usage of the move value hot words box

All the move value accesses seemed to occur for two reasons:

- while subjects were investigating move value's function - which may explain why many of these accesses were preceded by, or followed, exploration of the effects SEO help facility,
- when the make move hot words box was absent - which occurred when the selected partickle could not make a move and subjects selected move value because it had become the rightmost hot words box instead of make move.

Move value was also accessed once during the video pilot session and this was the only time it was accessed in order to *use* the facility - though the subjects decided not to use its advice. Subject I selected move value in the third game after subject H had suggested using it, but subject I then said: "You don't go by the computer's strategy man - it's as dim as crap. We beat it every time". The computer player's game was only strong enough to beat beginners and the quality of its moves varied - making it an unreliable source of advice. Nevertheless, the computer player did win the fourth game in the video pilot

session and after one of the computer player's earlier moves subject I had commented: "That's a good tactic. We should try it".

Move value was meant to enhance long-term usage in which users would have the chance to formulate general queries regarding the game and the system. The subjects in the Partickles studies did not have enough time to investigate move value, but the facility would probably need to provide better advice and a value for a partickle's best move overall to be useful.

The effects SEO help facility

The effects SEO help facility demonstrated that a centralised information-providing facility could be attached to, and made available by, an object-based help facility. The effects SEO help facility was used in ten out of eighteen sessions, but seven of the sessions in which it was not used were in the pilot study where there were fewer observer interventions, sessions were shorter and the colours hot words box was a grey box against a grey background. Table 9.9 provides details of the usage of the effects SEO help facility:

session	accesses	comment
P6	1	navigated while investigating facilities during the explore and practise phase
P7	2	navigated twice - in the 6th game to investigate the facility, and in the 8th game it was used for reference successfully
C1	5	not navigated - once in the explore and practise phase to investigate the facility, four times during the game to obtain colour-effect mappings from the 5 coloured hot words boxes
C2	2	navigated twice (after an observer demonstration) for reference during the game playing phase
C3	1	not navigated - the 5 coloured hot words boxes were used in the game playing phase to obtain colour-effect mappings
C4	1	the observer talked the subject through the process of finding the answer to a question the subject asked
C6	2	navigated to investigate the facility in the first game and later accessed for reference but not navigated because the subject could not match its options with his enquiry
V1	4	navigated twice in the checklist phase for reference - once successfully. The 5 hot words boxes were used twice in the game playing phase to obtain colour-effect mappings
V2	2	navigated twice in the game playing phase: first the five hot words boxes were used to obtain colour-effect mappings and the facility was navigated due to the effect mode error, the second navigation was for reference but was unsuccessful
V3	22	the large number of accesses indicates that the subjects were confused by the facility and includes both appropriate and inappropriate (q.v. 'effect mode error' - Appendix F) usage

Table 9.9 Usage of the effects SEO help facility

The usage of the effects SEO help facility can be divided into the following categories:

- initial investigations of the facility (4 accesses),
- using the colours and labels of the facility's five coloured hot words boxes to obtain colour-effect mapping information (8 accesses),

- using the facility for reference (7 accesses), and
- using the facility inappropriately (1 access in session V2 and at least 8 in session V3).

Subject K's access in session C4 has not been included with the accesses mentioned in the above categories, and neither have most of the session V3 accesses since the subjects' confusion in this session made it difficult to identify their reasons for accessing the effects SEO help facility. The most useful feature of the effects SEO help facility was its top level index of five coloured hot words boxes which were labelled with the names of effects. The effects SEO help facility provided appropriate information on four occasions when it was accessed for reference, but three attempts to use the facility for reference were unsuccessful. The 'effect mode error' appeared once in session V2 and at least 8 times in session V3. This involved subjects navigating the effects SEO help facility because they thought that selecting hot words boxes labelled with the names of effects would cause partickles to perform those effects.

The effects SEO help facility was not used to obtain general introductory information about the domain during early usage of the system (with the possible exception of subject F's single access in session P6). The effects SEO help facility was intended to be used for reference regarding effects, but was not used more than twice in any one session for this purpose. Apart from the usage of the five coloured hot words boxes there were too few successful examples of the usage of the effects SEO help facility to indicate that it was useful, and the 'effect mode error' in session V3 suggests that the facility was actually unhelpful. Some possible reasons why the effects SEO help facility was not a success are presented below:

- The facility was only available after object-based help had been obtained.

- The form and function of the facility was not explained by any other help facility, or made clear by the label ("colours" or "effects") on the hot words box used to access it.
- It was potentially confusing that the hot words boxes fulfilled different roles - make move provided functionality, move value supplied dynamic information and the effects/extended SEO help facility provided hot words boxes and canned text in a hypertext format.
- The control panel arrangement of the effects SEO help facility's hot words boxes, and the "effects" label used in Partickles version 3, may have suggested access to functionality rather than information.
- After obtaining SEO information subjects had to make up to three hot words box selections (four in version 3) to obtain some items of information. Only the first three lines of each text were visible initially - and scrolling the lower window involved additional mouse-work.
- By the time that subjects discovered the effects SEO help facility they had already learned, or discovered other sources of, the information it contained.

The extended SEO help facility

The effects SEO help facility was extended in version 3 of Partickles so that it would offer an alternative to menu-based help as a source of general introductory information. The moves option was accessed once in each of the video study sessions. It was read in two of the sessions, but only part-read in session V1. The ? pointer option was only accessed once, in session V3, and was not read completely then. All of these accesses occurred after the explore and practise phases and only one, the moves access in session V1, occurred during a checklist phase. The video study subjects used menu-based help options to obtain general introductory information, probably because the extended SEO

help facility was not available until after object-based help accesses. This indicates that general introductory information should be made available (to beginners) at the start of sessions.

SEO error messages

SEO error messages were supplied because some object-based help information remained onscreen during actions, such as rotating partickles and changing the side to play, which could make the object-based help information inapplicable. SEO error messages only appeared in two sessions - once in session V2 and twice in session V3 - and on all three occasions enabled subjects to correct the errors. This limited evidence demonstrates that it can be preferable to present error messages instead of merely ignoring inappropriate inputs.

The trace facility

The trace facility proved that it is possible to provide dynamic information concerning system objects. The trace facility was switched on in four sessions as follows:

- Subject D switched trace on, then off again after only 24 seconds.
- Subject F switched trace on shortly before starting her first game. The observer interrupted the game for the observer briefing and switched trace off at the end of the briefing. The observer briefing occupied approximately half of the eleven minutes that trace was on.
- Subject H switched trace on immediately after starting a computer versus computer demonstration game. It remained on for three and a half minutes during which the subject watched the computer versus computer game. The observer switched demo-mode and trace off at the start of the observer briefing.

- Subject L switched trace on then immediately started a computer versus computer demonstration game. He watched the game for two and a quarter minutes then stopped it with the observer's help, read a help menu option then set up and started his first game. The trace remained on for thirty-one and a half minutes until the end of the session.

All four subjects switched trace on during explore and practise phases while investigating several menu options: subject D also switched the sound option off and subjects F, H and L switched demo-mode on. A demonstration game did not start in subject F's session because a game was already in progress, but subjects H and L were able to read the trace during the computer versus computer games.

The most useful function of the trace facility could be that of translating from a dynamic, graphical, interactive environment to text - which might make some of the other text in the system (which uses the same terminology) more comprehensible, but all four subjects who switched trace on in the studies had already read some of the help information in other facilities. The Particles studies did not demonstrate the utility of the trace facility - though only one subject turned it off. At the end of session C5 subject L indicated that he had not found trace useful:

Obsv: "What do you think of the trace? Is that giving you any useful..."

Subj: "Not really. I put it on so I could see what happens <meaning: what trace *does* not what it *shows*>, but I didn't ... a great deal."

The main findings of the studies in regard to the SEO facilities described in this section are:

- Object-based help can be extended with facilities that provide access to the functionality of system objects, information from system objects, additional information and dynamic information concerning system objects.
- Inexperienced users may demonstrate a preference for the pointer with which they are initially presented.
- Beginners should be able to access general introductory information at the start of interactions.
- The current functionality described by 'would do' help involves those parts of a display object's general functionality that are possible given the display object's and the system's states. It is also possible to indicate what a display object would do if the states were changed. Information regarding these changes can be supplied retrospectively using error messages.

9.7 Discussion

The main findings listed at the end of sections 9.2 to 9.6 of this chapter comprise specific points and issues regarding the provision of help in systems that have graphical object-oriented interfaces. There is considerable diversity in these findings, but those which relate directly to the solution proposed by this thesis concern: the content and brevity of object-based help messages, object-based help accesses made discretely and in groups, the use of help to obtain overviews and for reference, and the usefulness of both menu-based and object-based help facilities. These points, and their implications for the provision of help in systems that have graphical object-oriented interfaces, are discussed later in this section. The next two paragraphs summarise the findings concerning the usefulness of Partickles' help facilities.

The following menu-based help options were found to be useful: mouse menu option: which button and help/info menu options: getting started and (particularly) Partickles rules. The following menu-based help options were not tested in the studies and remain potentially useful: mouse menu option: which pointer and help/info menu option: suggestions. It may be more appropriate to supply the following menu-based help options as hard copy, rather than on-line, documentation: mouse menu option: about mousing and help/info menu option: about the program. Help/info menu option: status info was not found to be useful. A general reorganisation of the menu-based help facilities was indicated which would involve dividing the information into general introductory information for beginners and a large number of comprehensively indexed topics for specific reference.

Partickle SEO information was the most useful SEO facility, and speech bubbles were a powerful means of presentation and worked well with object-based help. The SEO error messages were useful when they appeared and this form of feedback seems preferable to ignoring inappropriate inputs. The move value and trace facilities required improvements and further testing. Make move was inconvenient to use, but it showed that object-based help was sufficiently useful in the early stages of learning to compensate for this inconvenience. The information in the effects SEO help facility was also provided by help/info menu options: getting started and Partickles rules, whereas the extended SEO help facility supplied additional information for beginners. Although the information in the effects SEO help facility was useful, and the additional information in the extended SEO help facility was potentially useful, the effects/extended SEO help facility was an inappropriate way of presenting this information.

The next two paragraphs indicate the utility of an object-based help facility that draws information from self-explanatory objects, and discusses the four types of object-based help information that were found to be useful.

The Partickles studies demonstrated the utility of an object-based help facility that draws information from self-explanatory objects. The video study results showed that the observer had not unduly influenced subjects in favour of using object-based help in previous studies, and the core study results showed that the video study version of Partickles had not unduly influenced subjects in favour of using object-based help. The core study provided evidence that descriptive object-based help was useful and the video study provided evidence that 'would do' object-based help was useful.

One of the main findings that have been presented in this chapter listed four types of object-based help information that were found useful in the studies. These are: the names, states and attributes, general functionality and current functionality of display objects. Information concerning the names and general functionality of display objects allows users to *find out what a display object is and what it can do*. Information concerning the states and attributes of display objects adds context sensitive information to this description. Information concerning the current functionality of display objects allows users to *find out what a display object would do*. This form of information is also context sensitive, it relates directly to users' actions and is especially useful in situations where inexperienced users are unable to predict the outcomes of their actions. Even context-sensitive information can become redundant as users gain experience, but until that stage is reached 'would do' information can fulfil a function that

is sufficiently useful to recommend the provision of object-based help in systems that have graphical object-oriented interfaces.

The next two paragraphs discuss the main conclusions that have been reached regarding the provision of suitable help facilities and appropriate help information for systems that have graphical object-oriented interfaces.

The Partickles studies showed that subjects used both menu-based and object-based help facilities. This indicates that it can be appropriate to provide users of systems that have graphical object-oriented interfaces with more than one type of help provision. Overviews can compensate for the distributed nature of the information available from graphical object-oriented interfaces, and one way of obtaining overviews is by grouping object-based help accesses. Subjects found overviews useful for obtaining general introductory information, and the menu-based help options that provided useful overviews in the Partickles studies supplied information regarding initial usage and the domain. Subjects also used both menu-based and object-based help facilities for reference in regard to specific enquiries.

Object-based help can augment the information available from graphical object-oriented interfaces by supplying additional information and/or offering explanations as alternatives to experimentation. Subjects accessed some object-based help in groups to obtain overviews and for reference, and this indicates that users should be able to access object-based help repeatedly and quickly so that accesses can be made in groups. One subject used object-based help frequently instead of memorising some of its information, and the video study subjects combined obtaining object-based help with game playing. This indicates that the usage of object-based help can be integrated with the usage of

a main interface if it is quick and easy to access, use and exit. Also, as Chapter 4 has described, the coding of object-based help can be integrated with that of main interfaces by adding self-explanatory capabilities to the functionality of the system objects that generate and maintain display objects.

This chapter has summarised and discussed the results of the Partickles studies. The next, and final, chapter draws together all the work that has been described in the thesis and presents conclusions, suggestions and recommendations regarding the provision of help in systems that have graphical object-oriented interfaces.

Chapter 10

Conclusions

10.1 Introduction

The first two sections of this chapter summarise the thesis and consider the contributions it has made. These are followed by sections that examine its limitations and make suggestions for further work. The thesis ends with a brief summary and three recommendations concerning the provision of help in systems that have graphical object-oriented interfaces.

10.2 Summary of work

This section outlines the work that has been described in this thesis:

- Reviews of the literature concerning graphical object-oriented interfaces, help facilities and object-oriented programming were carried out.
- A survey of seven systems containing nine object-based help facilities was conducted.
- A noughts and crosses program was implemented. This was a relatively simple first investigation of object-oriented programming styles, self-explanatory objects and object-based help. The noughts and crosses program was implemented in BASIC, its self-explanatory objects were based on BASIC's procedures and they contained methods that supplied help information.
- The Partickles program was implemented to continue the investigation of object-oriented programming styles, self-explanatory objects and object-

based help facilities. Partickles also contained menu-based help facilities and extensions to its object-based help facilities. Partickles was implemented in the C language and its self-explanatory objects were based upon data structures which could be accessed by the object-based help facility. Partickles provided the central activity in three studies which investigated the usage and usefulness of its help facilities.

- The pilot study was conducted. This consisted of nine sessions with seven subjects studied individually. The pilot study provided some examples of the usage of Partickles' help facilities, but was mainly used to fine-tune the materials, to practice the procedure and to focus observations for the next Partickles study.
- The core study was conducted. This consisted of six sessions with six subjects studied individually. The core study provided a 'core' of examples of the usage of Partickles' help facilities and it raised a number of questions related to its findings and format.
- The video study was conducted. This consisted of three sessions with six subjects studied in pairs. The audio tape recorder used in previous studies was replaced by a video recorder in this study. The video study was used to obtain further examples of the usage of Partickles' help facilities and to address the questions raised by the core study.
- The format of the studies was adapted and Partickles was reversioned during the studies to focus observations and conduct experiments. Data was collected in the form of machine-readable trace records, notes made by the observer and audio/video recordings.

The next section reviews the contributions made by this work.

10.3 Contributions

The work described in this thesis relates to the appropriateness of help provision in systems that have graphical object-oriented interfaces. As this question concerns the usage of computer systems the work as a whole represents a contribution in the field of human-computer interaction (HCI). The practical implications of the work relate to programming, interface design and the provision of help, while details of the formats of the studies and their results may be useful to other researchers. The main contributions of the work are summarised below and explained in more detail in the subsections that follow:

- The thesis has extended previous work concerning help facilities by investigating object-based help.
- A set of general guidelines for the provision of help in systems that have graphical object-oriented interfaces are presented in this chapter.
- Specific issues and points regarding the provision of help in systems that have graphical object-oriented interfaces were presented in Chapter 9.
- Four types of object-based help information are recommended as a template for object-based help messages.
- A framework for the provision of object-based help has been provided in which: a) system objects in systems programmed in object-oriented styles are used as a source of object-based help information, and b) display objects in graphical object-oriented interfaces are used to access object-based help.
- The term: 'self-explanatory object' has been coined to indicate a system object which has been written to be used as a source of help information.
- The format of the Partickles studies can be used for similar investigations of usage and the preferences of subjects.

- The results of the Partickles studies can be used to inform the design of new systems and further studies.
- The term: 'object-based help (OBH)' was introduced in this thesis.

Help facilities and graphical object-oriented interfaces

The work described in this thesis has extended previous work concerning help facilities. Trenner [1989] examines the help systems of sixteen information retrieval systems which were mainly available on mainframe computers, and Kearsley [1988] describes nine, varied examples of commercially available help facilities. Neither of these surveys refers to forms of object-based help, though they are concerned with issues relating to help modes. Both Trenner and Kearsley point to the advantages of presenting help in windows and they refer to accessing help facilities by typed commands, help keys or menus. Kearsley describes these methods as the: "three principal ways for users to activate helps". Kearsley mentions hypertextual help systems that can provide help: "when a user selects a marked object (i.e., a word, box, graphic)", but this relates to display objects within a help system rather than display objects that are part of a main system's interface. Object-based help constitutes a fourth "principal way" that users can activate help.

The contribution that this thesis makes to work concerning systems that have graphical object-oriented interfaces relates to the provision of help. Graphical object-oriented interfaces and help facilities were discussed in Chapter 2 and the Partickles studies showed that help facilities were used and useful in a system with a graphical object-oriented interface. A set of general guidelines for the provision of help in systems that have graphical object-oriented interfaces has been drawn from the conclusions discussed in the last section of Chapter 9.

The conclusions indicated that it is appropriate to provide help for systems that have graphical object-oriented interfaces that includes:

- More than one type of help provision.
- Overviews that provide an introduction to the system and explain the domain.
- Overviews which compensate for the distributed nature of the information available from graphical object-oriented interfaces.
- Information for reference in regard to specific enquiries. This includes object-based help and navigable help facilities with information indexed according to probable enquiries.
- Object-based help that augments the information available from graphical object-oriented interfaces - particularly in regard to what the user can see and what the user can do.
- Object-based help that can be obtained repeatedly and quickly (in groups) so that users can compare and/or aggregate information.
- Object-based help which is sufficiently quick and easy to access, use and exit to allow its usage to be included in - rather than to interrupt - the usage of a main interface.
- Object-based help which might be considered as part of the functionality of a display object - such as an icon that can move, *explain itself*, open its window and so on.

Chapter 9 presented the main findings of the studies in regard to the provision of help in systems that have graphical object-oriented interfaces. These findings relate to specific points and issues including: menu-based help, help in bubbles, the functions of object-based help information, extensions to object-based help, the length of help messages/texts, help usage by beginners and more experienced users, initial and later usage of help, pointers and error messages.

One of the main findings of the studies concerns four types of information that can be used as a basis for object-based help messages. These are the names, states and/or attributes, general functionality and current functionality of display objects. These four types of information provide a principled basis for the design of object-based help messages, and help systems designers may find the following template for object-based help messages useful:

name
state and/or attributes
general functionality
current functionality

Figure 10.1 A template for object-based help messages

This template has been derived from investigations and examinations (described in Chapter 9) of the content of particle SEO information. The four types of object-based help information shown in the template were found to be useful when presented as particle SEO information. Of these four types of information the one which the Partickles studies showed to be most useful, and hence which is most strongly recommended, concerns the current functionality of display objects - or 'would do' help. The template is only intended provide a *basis* for object-based help messages; it can assist help system designers to achieve consistency in their object-based help messages and to avoid omissions or too much detail.

Self-explanatory objects and object-oriented programming styles

Self-explanatory objects are system objects which have been written to be used as a source of help information. When a system has a graphical object-oriented

interface and has been programmed in an object-oriented programming style help information can be drawn from self-explanatory objects and presented by an object-based help facility. The implementations described in Chapter 4, and the results of the studies described in Chapter 9 have shown that this form of help provision is both practical and useful. The combination of self-explanatory objects and object-based help uses the correspondences between display objects and the system objects that create and maintain them to provide and present help. This suggests the following framework for the application of object-orientation to the provision of help in systems that have graphical object-oriented interfaces (GOOIs) and which have been written in object-oriented programming styles (OOPS):

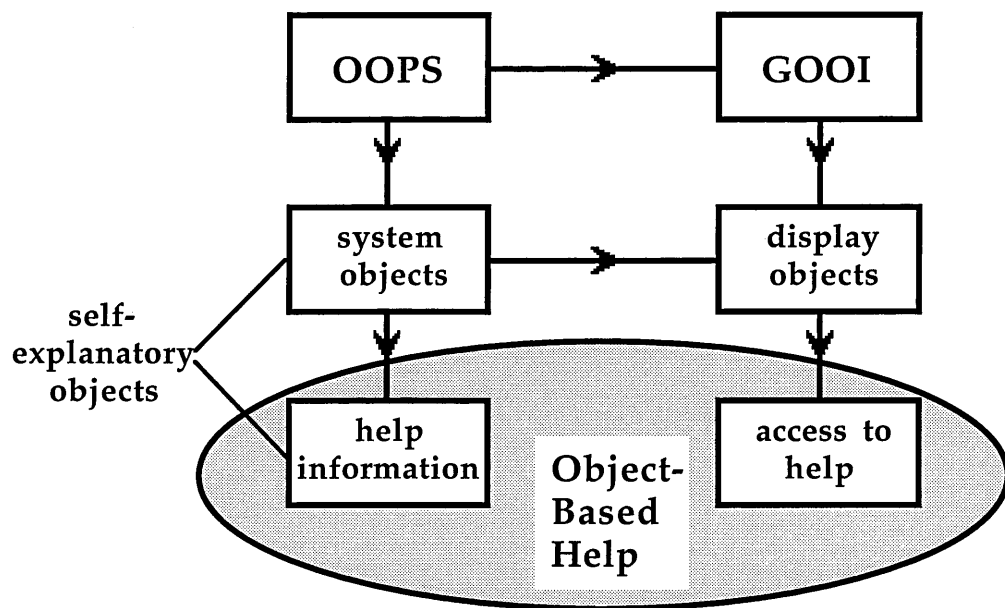


Figure 10.2 A framework for the provision of object-based help

The innovative aspect of the work described in this thesis concerns the left-hand side of Figure 10.2. Object-oriented programming styles were investigated using the BASIC and C languages. The solution that was achieved using C (described in Chapter 4) corresponds with some of the suggestions made by

Duff & Howard [1990]. Self-explanatory objects were used to overcome some of the problems of obtaining help information from program code - such as those noted by Rich [1982] which were discussed in Chapter 3.

The format and results of the studies

The format of the Partickles studies can be used for similar investigations of usage and the preferences of subjects. Chapter 5 describes the format, Chapters 5 to 8 describe the modifications that were made to the format, and the final section of Chapter 8 draws conclusions regarding the effectiveness of the modifications. Although the format is recommended for further studies, the points raised in the next two paragraphs may assist other researchers.

The influence of an observer is difficult to discount. The use of checklists in the video study reduced the observer's input and indicated that the observer had not significantly influenced results in the studies, but the checklists could not be completed without the observer's supervision. This made it necessary to document (in Appendix F) all the observer interventions that occurred during checklist phases to show that the observer had not influenced subjects. Reports of further studies would be simpler if the studies provided checklists that could be completed without supervision, or if they provided other means of making subjects aware of alternatives that did not involve an observer.

The Partickles studies were conducted to investigate help provision in a system with a graphical object-oriented interface. This differs from studies conducted to provide evidence of the usage and usefulness of help provision. Although the evidence did become apparent after three studies, in further studies it may be appropriate to distinguish between the aims of investigation and of obtaining evidence.

Terminology

The term 'object-based help' has been used in this thesis to refer to a help facility that supplies information about a display object when the display object is specified and to help information which is indexed by and accessed by display objects. Object-orientation has been applied to analysis (OOA), design (OOD), programming (OOP), behaviour analysis (OBA), databases (OODBs) and so on. One of the contributions that this thesis makes is the addition of object-based help (OBH) to this list. Object-based help has been implemented in a number of commercially available systems - some of which are described in Chapter 3 - and the authors of MacroMind Director used the term: 'Object Sensitive Help' to refer to their version of object-based help, but the term has been copyrighted and is not available for general use. Lee [1987] and Draper [1986] referred to the use of object-based help and Gould & Finzer [1984] implemented a form of object-based help in the Rehearsal World (described in Chapter 3), but though the principle is known it has not been the subject of research and it has lacked a name. This thesis, and earlier accounts of the work it describes (for example Clark [1990] and Clark [1992]), have provided both the initial research and a name.

The next section considers some of the limitations of this research and is followed by a section which discusses some of the directions that further work could take.

10.4 Limitations

This section considers some limitations of this research. These relate to the extent of the work and to aspects of the problem that have yet to be addressed.

The examples of self-explanatory objects presented in this thesis are limited in number and in the number and types of programming languages used. Further examples of self-explanatory objects may clarify issues relating to their features and usage and might also assist program developers to overcome potential problems such as: objects that are created while the programs are running and/or whose coded form is changed by compilation, and objects whose methods and data are distributed throughout a hierarchy of classes.

The main recommendations of this thesis are based on observations of the usage of a single system. Partickles did not include some features (such as undo facilities) which might reduce help requirements, its domain was a game and the studies of object-based help concentrated on only one type of display object - the partickles playing pieces.

The Partickles studies did not show that facilities that extend object-based help (such as the effects/extended SEO help facility and the move value and make move facilities in Partickles) were useful, though they did show that subjects were prepared to use these facilities. The studies also showed that help information was required for overviews and for reference in regard to specific enquiries, but did not investigate the most appropriate ways of meeting these requirements.

The Partickles studies were initially quite broad in scope (the number of types of observations made), though they became more focussed later - particularly in regard to the usage of partickle SEO information. The scope of the studies helped to identify issues concerning help provision in systems that have graphical object-oriented interfaces, but further focussing in some areas - such

as controlled experiments regarding the usefulness of information concerning the names and states of display objects - might increase the strength of the recommendations of this thesis.

The next section contains suggestions for further work based on the work described in this thesis.

10.5 Further work

This section presents ideas for further work relating to the following:

- the implementation and testing of object-based help facilities that draw help information from self-explanatory objects,
- the content of object-based help messages, and
- the usability of object-based help.

Further examples of self-explanatory objects

It might be useful to system developers to be able to refer to self-explanatory objects implemented in a variety of programming languages and by a variety of techniques. The data structures that were used as objects in Particles may provide a model for self-explanatory objects implemented in C++, while the inclusion of methods that supply help information in the code of objects in the noughts and crosses program may provide a model for self-explanatory objects implemented in Smalltalk. The next paragraph considers some of the possibilities.

The implementation of a help facility based on self-explanatory objects involves choosing and coding system objects so that they can be used as a source of help information, and providing facilities for accessing, preparing

and presenting the help information. These facilities could be distributed amongst self-explanatory objects (for example: they might each have an 'explain' method and/or contain strings of help information), or be more centralised (like a code compiler or interpreter) or combine distributed and centralised forms of management. Prototyping environments could be constructed which would, initially, provide listings of self-explanatory objects when their corresponding display objects were indicated and which allowed the listings to be converted to object-based help messages, edited and linked conditionally with the self-explanatory objects' attributes and states and the states of other parts of systems.

Other types of graphical object-oriented interfaces

Chapter 3 described nine object-based help facilities, but though these show some of the diversity of systems for which object-based help is available it would be interesting to compare the results obtained in the Partickles studies with the results of experiments conducted using other systems. For example, the usefulness of 'would do' help could be examined where graphical object-oriented interfaces have been provided for: operating systems (such as the Macintosh's desktop), programming languages (such as National Instrument's LabVIEW) and applications (such as Color MacCheese). The next paragraph consists of two examples of 'would do' help provision that could be applied in these domains.

'Would do' help can be used to describe what a menu option would do if selected. This could be useful if a user thought that a command (such as the 'Copy' option in the Macintosh desktop's Edit menu) was having no apparent effect. There may be difficulties associated with the provision of 'would do' help for some display objects that can be operated by direct manipulation - for

example, a document icon that can be moved onto a variety of other icons. In this case one solution could be a continuously displayed window (or several bubbles) of help information that indicated what would occur if the document was dropped onto any of these icons.

Testing the template for object-based help messages

A template for object-based help messages was described in section 10.3. The partickle SEO information in Partickles included the four types of information in the template and Chapter 1 showed how an object-based help message which included the four types of information could be provided for a zoom box display object. Researchers may wish to investigate the use of the template for other display objects - such as icons, menu options, composite display objects (such as windows and scroll bars) and editing tools. The remainder of this subsection considers how the template might be used in these investigations.

Table 10.1 shows how the template for object-based help messages might have been applied to object-based help for Partickles' side-to-play boxes:

name.....	Blue side-to-play box.
state/attributes	It is <not> blue's turn to play <or> A side to play has not been selected.
general functionality.	This control selects blue as the side to play.
current functionality.	It would select blue as the side to play <or> It would have no effect because the blue side is already in play.

Table 10.1 The OBH message template applied to side-to-play boxes

If the blue side-to-play box had already been selected, then an object-based help message created using the template for object-based help messages and the information in Table 10.1 would look like this:

Blue side-to-play box. It is blue's turn to play.

This control selects blue as the side to play.

It would have no effect because the blue side is already in play.

The template for object-based help messages is intended to assist help system designers to select object-based help information. For example, it may be unhelpful to explain that a frog object 'moves' by positioning and removing a series of images along the path of a sine wave, and it may be easier to select help information by concentrating on *what users can see and do*. An object-based help message concerning the frog object might be based on the following: "Frog. It is leaping. It can start or stop leaping. It would stop leaping". This message includes all four types of information that are in the template.

Other types of object-based help information

There are alternatives to the four types of object-based help information recommended in this thesis. Several other types of information that may be appropriate for object-based help messages were considered and four of these are presented below as ideas that other researchers might use for investigating alternative templates for object-based help messages:

- 'how to' information

....this information could be presented as 'would do ... if you ...' help. The word "Click" in some of Partickles' control SEO information constituted limited 'how to' information.

- 'could do ... if' information

....this information would explain the difference between the general and current functionality of display objects and perhaps indicate how to get the display object into a state where it 'would do' part or all of what it 'can do'.

- information about tasks and topics
...these types of information consist of ordered groups of actions and concepts - and may be too long for object-based help messages.
- comments
...this information occupies a miscellaneous, 'catch-all' category for information specific to individual display objects that cannot be identified as a more general type of information.

It may not be appropriate to use the types of information listed above as a *basis* for object-based help messages, but it may be appropriate to include some of them as optional extensions to object-based help messages.

Investigating the way object-based help is used

Further research regarding object-based help might concentrate on its usability rather than its implementation or content. This research could investigate issues such as the placement/persistence of help windows/bubbles, help modes and pointers and the presentation of object-based help information. It may be possible to conduct some experiments using prototyping tools, partially simulated systems and some currently available systems. One question which has not yet been addressed concerns the amount of information and further options that it may be appropriate to provide as object-based help, and this is discussed in the next subsection.

Distinguishing between two types of object-based help

All object-based help facilities initially provide information relating to the indicated display object, but this can be limited to a one-shot access or extended with further options. Table 10.2 describes some of the characteristics of these two approaches:

characteristic	one-shot object-based help	extended object-based help
activity:	using display object	using help facility
duration:	brief	longer
information:	limited in number of types /amount of information, potentially a dependable source of some types of information e.g. names.	specific enquiries, browsing and reference.
examples:	partickle SEO information, Color MacCheese, Acorn !Help, Macintosh system 7's Balloon and Get Info help, LabVIEW's Info boxes and The Rehearsal World.	extensions to object-based help facilities in Partickles, LabVIEW's help facility and its Related Topics section and Microsoft Word 4's help facility.
comparison:	pelmanism/pairs (memory game with playing cards)	using a book

Table 10.2 Characteristics of one-shot and extended object-based help

The object-based help facilities in Color MacCheese, Acorn !Help and Macintosh System 7 offer brief information and no additional options, but they allow repeated object-based help accesses. LabVIEW and Microsoft Word 4 take the alternative approach which is to use object-based help as a means of entering a help facility - at which point the object-based help mode is cancelled. MacroMind Director's object-based help offers a compromise by providing relatively brief information, allowing further one-shot object-based help accesses *and* providing options for navigating its help facility. The two extremes follow different conceptual models: the first extends the information available from an interface and minimises interruptions to normal usage while the second involves a change of activity. The advantage of the first approach may be that its help is brief and quick enough to allow users retain the immediacy and details of the interaction that preceded the help access - thus minimising

breakdowns in interactions and becoming part of the normal usage of an interface. Further research may be able to establish a maximum amount of help information and options that one-shot object-based help can offer without interrupting an interaction and requiring the user to recall the details of a previous action.

10.6 Summary

This thesis has examined the problem of providing help in systems that have graphical object-oriented interfaces. The potential value of this work is indicated by the growing numbers of commercially available systems that have graphical object-oriented interfaces and help facilities, and the limited amount of previous research that has been directed toward this problem.

The investigation described in this thesis has been broad enough to produce general guidelines and specific in regard to an object-oriented approach to the problem. This approach involves using object-oriented programming styles to create graphical object-oriented interfaces and self-explanatory objects, and using self-explanatory objects as a source of information for object-based help facilities. Two systems were implemented to investigate, and demonstrate the viability of, this approach. One of these systems, called Partickles, provided the central activity in a series of three studies that consisted of eighteen sessions with nineteen subjects. The studies investigated the usage of a variety of forms of help provision in a system that has a graphical object-oriented interface. Evidence from the studies has suggested general guidelines for the provision of help, showed the usefulness of some of the overviews and some of the object-based help in Partickles and indicated four types of information that can be used as a basis for object-based help messages.

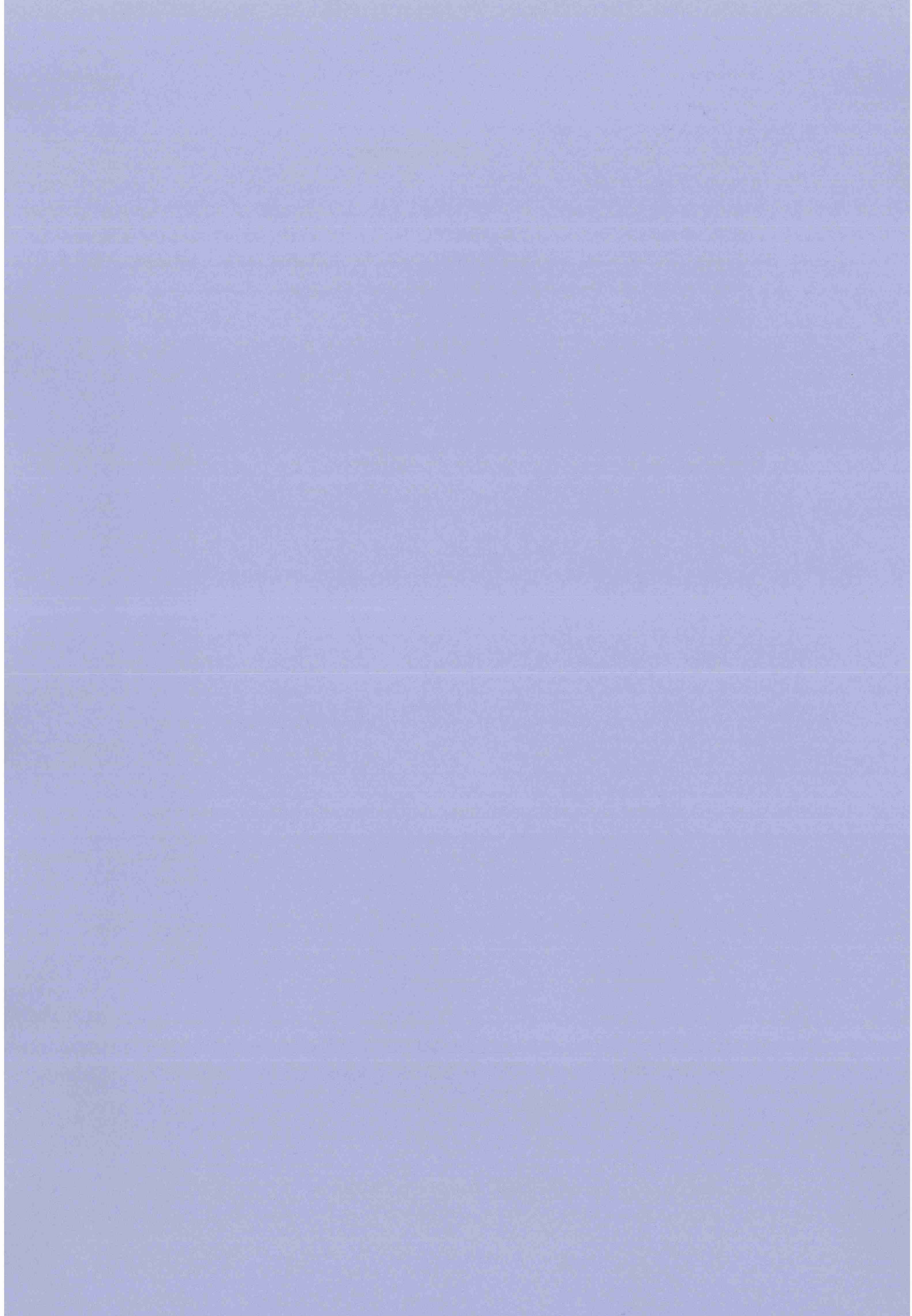
The main practical implications of this thesis in regard to the provision of help facilities that users of systems that have graphical object-oriented interfaces will find useful are as follows:

- Providing users of systems that have graphical object-oriented interfaces with help in the forms of: overviews, reference facilities and object-based help.
- Programming systems that have graphical object-oriented interfaces in an appropriately object-oriented style so that object-based help information can be drawn from self-explanatory objects.
- Basing object-based help messages on information concerning the names, states and/or attributes, general functionality and current functionality of display objects.

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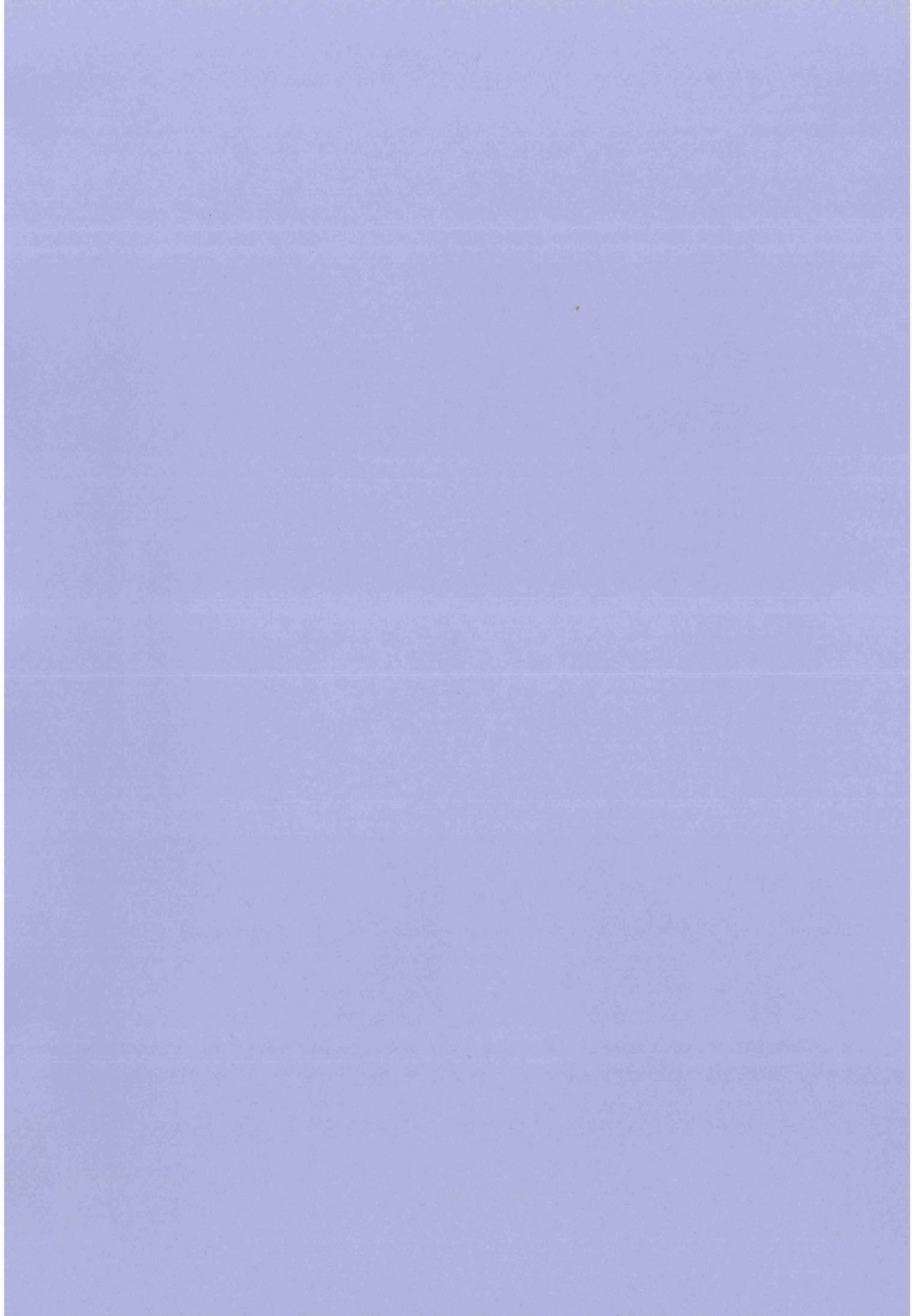
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The first part of the document discusses the importance of maintaining accurate records of all transactions. It emphasizes that every entry should be supported by a valid receipt or invoice. This not only helps in tracking expenses but also ensures compliance with tax regulations. The second part of the document provides a detailed breakdown of the company's financial performance over the last quarter. It includes a comparison of actual results against the budget and identifies areas where costs were higher than expected. The third part of the document outlines the company's strategy for the upcoming year, focusing on reducing operational costs and increasing revenue through new market expansion. It also mentions the need for regular communication and reporting to the board of directors to ensure transparency and accountability.

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The first part of the document discusses the importance of maintaining accurate records of all transactions. This includes not only sales and purchases but also any other financial activities that may occur during the course of the business. It is essential to ensure that all records are kept up-to-date and are easily accessible for review.

The second part of the document outlines the various methods used to collect and analyze data. This includes the use of surveys, interviews, and focus groups to gather information from customers and other stakeholders. The data is then analyzed to identify trends and patterns that can be used to inform business decisions.

The third part of the document describes the various tools and techniques used to manage and analyze data. This includes the use of spreadsheets, databases, and data visualization software to present information in a clear and concise manner. It also discusses the importance of data security and the need to protect sensitive information from unauthorized access.

The fourth part of the document discusses the various ways in which data can be used to improve business performance. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to make informed decisions about marketing, sales, and other business activities.

The fifth part of the document discusses the various challenges associated with data management and analysis. This includes the need to ensure data accuracy and consistency, the need to protect data from security threats, and the need to ensure that data is used in a responsible and ethical manner.

The sixth part of the document discusses the various ways in which data can be used to improve customer service. This includes the use of data to identify customer needs and preferences and to develop strategies to address these needs. It also discusses the importance of using data to monitor customer satisfaction and to identify areas for improvement.

The seventh part of the document discusses the various ways in which data can be used to improve operational efficiency. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor operational performance and to identify areas for improvement.

The eighth part of the document discusses the various ways in which data can be used to improve financial performance. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor financial performance and to identify areas for improvement.

The ninth part of the document discusses the various ways in which data can be used to improve overall business performance. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall business performance and to identify areas for improvement.

The tenth part of the document discusses the various ways in which data can be used to improve the overall quality of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall quality and to identify areas for improvement.

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The twelfth part of the document discusses the various ways in which data can be used to improve the overall success of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall success and to identify areas for improvement.

The thirteenth part of the document discusses the various ways in which data can be used to improve the overall sustainability of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall sustainability and to identify areas for improvement.

The fourteenth part of the document discusses the various ways in which data can be used to improve the overall innovation of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall innovation and to identify areas for improvement.

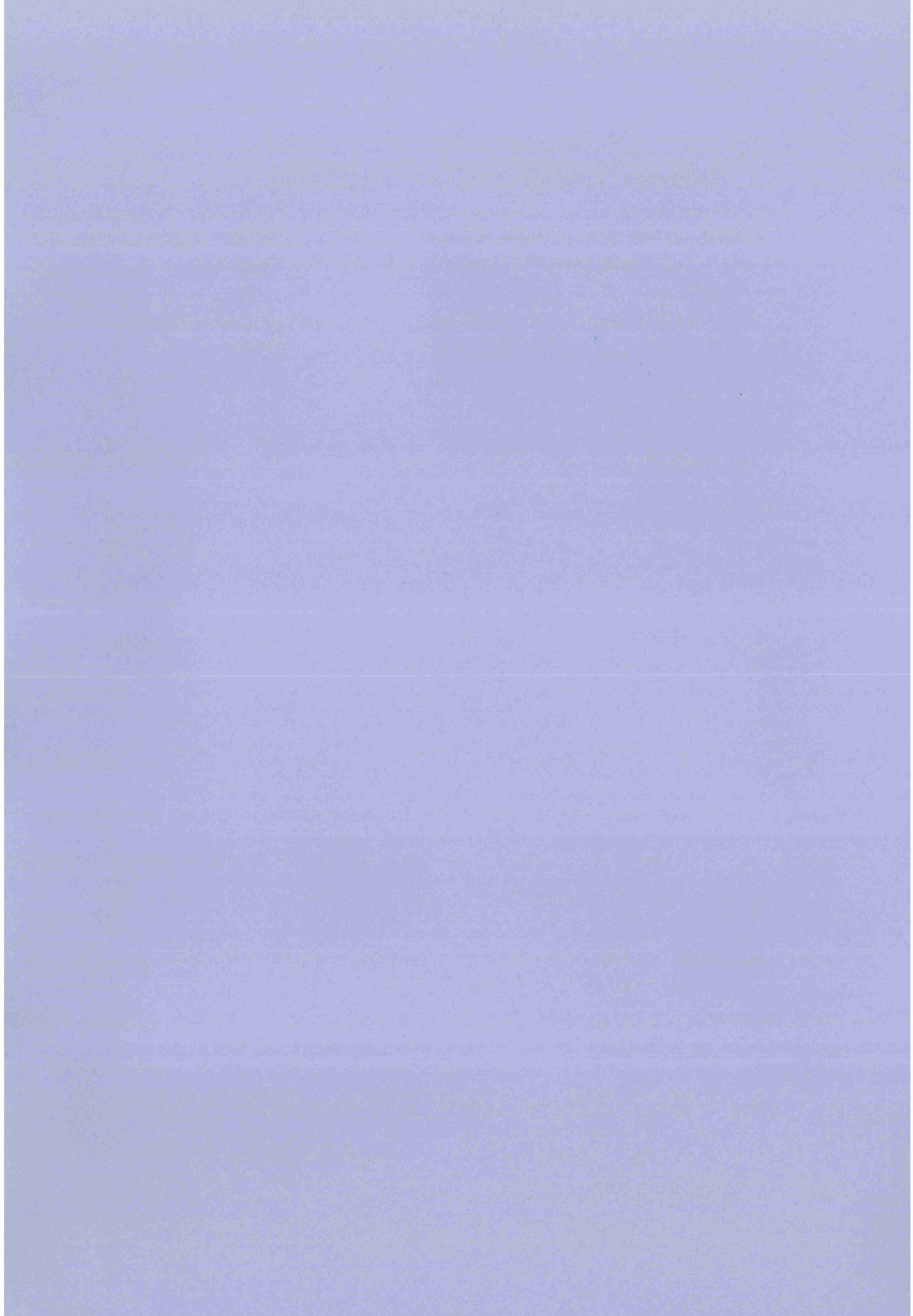
The fifteenth part of the document discusses the various ways in which data can be used to improve the overall resilience of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall resilience and to identify areas for improvement.

The sixteenth part of the document discusses the various ways in which data can be used to improve the overall flexibility of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall flexibility and to identify areas for improvement.

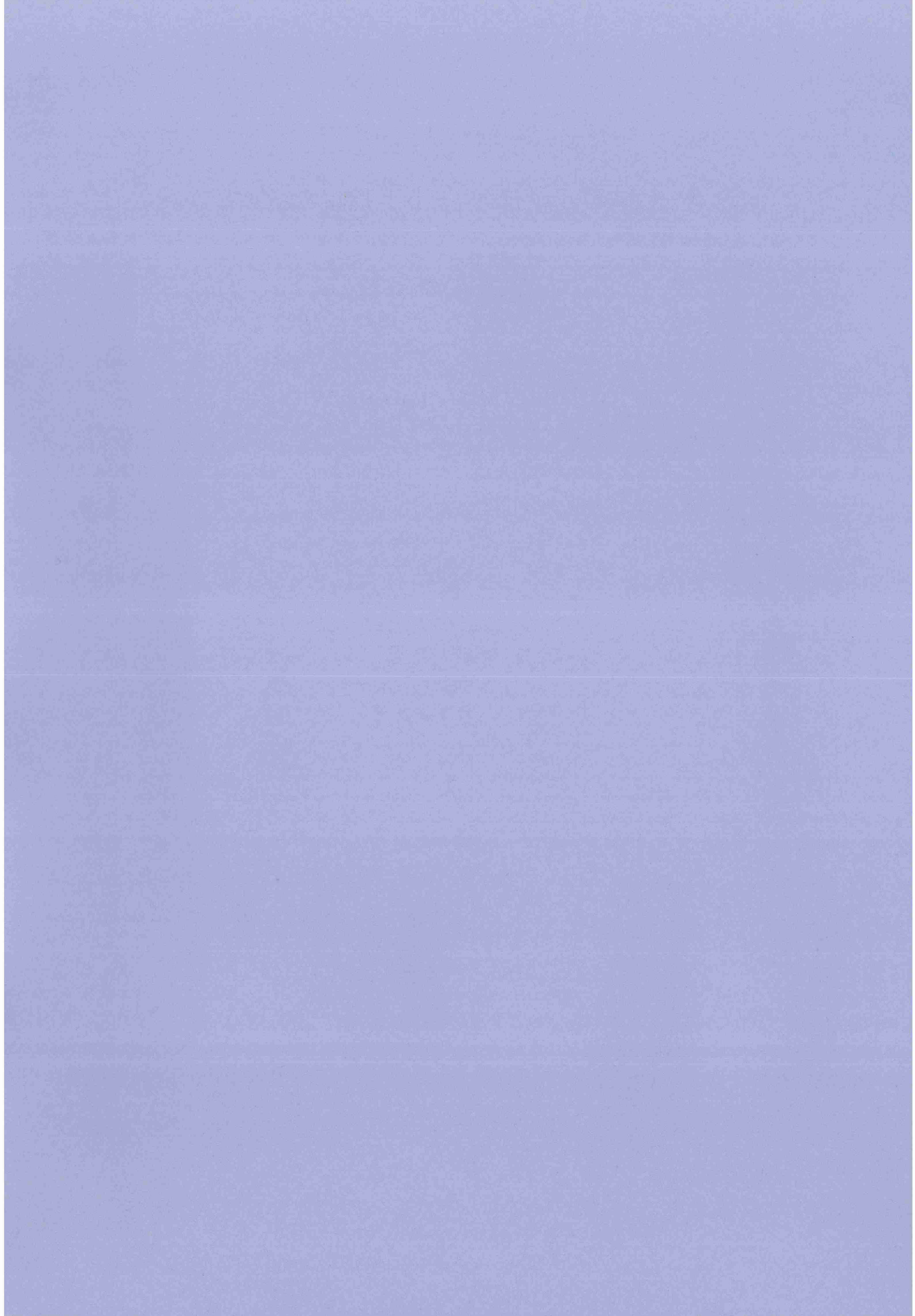
The seventeenth part of the document discusses the various ways in which data can be used to improve the overall adaptability of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall adaptability and to identify areas for improvement.

The eighteenth part of the document discusses the various ways in which data can be used to improve the overall agility of the business. This includes the use of data to identify areas of inefficiency and to develop strategies to address these issues. It also discusses the importance of using data to monitor overall agility and to identify areas for improvement.

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Partickles Help Texts (from version 3)

mouse menu option: about mousing

This computer uses a three-button mouse attached by a cable to the computer keyboard. The mouse should be placed on a flat surface such as a table top (use a book or mouse-mat on a slippery table top). When the mouse is pushed along this surface a pointer on the screen will also move.


The computer screen is a picture made up of, or containing, smaller pictures. These smaller pictures are screen-objects such as: windows, icons, Partickles pieces and controls.


Sometimes an object will react when a pointer is placed over it (e.g. the info menu control).

Mostly an object will only react if a pointer is placed over it and a mouse button is pressed.

mouse menu option: which button

The Left, Middle and Right mouse buttons function as follows when these pointers are on a partickle:

 : Left=move Middle=rotate Right=effect

 : Left=explain Middle=rotate Right=effect

When the question pointer is the current pointer the left mouse button gives explanations.


Controls can usually be operated by any mouse button (except left button with question pointer).

Scroll bars on help windows are operated by the left button or, for reverse, the right button.

mouse menu option: which pointer

There are two Partickles pointers:

 the arrow pointer

 the question pointer

One pointer is always available and moves when the mouse is moved. The other pointer is located in the centre of the lower edge of the Partickles game-board. To change pointers place the current pointer on top of the other and press a mouse button. The question pointer is only active in the top window - and gives information when the left mouse button is clicked.

help/info menu option: getting started

The aim of the game is to get eleven partickles on the other side of the centre column of hexagons.

At the start of a game:

Decide on the red and blue players and who will start.

Select players:

- choose one of the top four options from the players menu.

Select automatic alternate turns:

- make sure "auto turns" (changes menu) is ticked.

Select a side-to-play (box gets white border):

- click red or blue side-to-play box,
- or choose "random first turn" from the players menu,
- or, if a person will start, simply make the first move.

Note:

When the computer becomes the current side-to-play it starts choosing a move immediately. Controls and menus respond faster with person as the current side-to-play.

Making a move:

Place pointer on a partickle of the current side-to-move and press mouse buttons as follows:

Left = Move Middle = Rotate Right = Effect

1stchoose a particklemove mouse.

2ndrotatemiddle button (optional).

3rdselect effect moveright button (optional).

lastmake the moveleft button.

If the question pointer is the current pointer the left button gives information and, if a move could be made, a [make move] box. Clicking [make move] attempts the move.

If nothing happens when the left button is pressed the move cannot be made - select alternative partickle and/or move. Check partickle belongs to current side-to-move.

If a partickle is highlighted (right button: effect on) only that partickle can be rotated (middle button), moved (left button) or unhighlighted (right button: effect off).

If a partickle remains highlighted after a move... the move is a multiple step move. The partickle can be rotated (middle button), unhighlighted (right button) which ends the turn, or the move can be continued (left button).

Combining partickles / Effect moves:

Partickles of the same side can be combined by moving one on top of the other in a non-effect move. Combined partickles can move further than one-part partickles.

Effects: Jump - orange Resist - purple Step - yellow
 Push - green Unpack - white

Jump and step effect moves can only be made by combined partickles, and only combined partickles can be unpacked. Partickles containing resist parts cannot be pushed.

Combined partickles need to be unpacked when they reach }¹
 the far side of the board. Unpacking occurs when a }
 combined partickle with an unpack part makes an effect }
 move across an empty place. An unpack part is swapped }
 into another partickle if the unpack partickle makes an }
 effect move to the other partickle's position. }

help/info menu option: Partickles rules

Terms:

hexagon....a six sided figure.

board.....a grid of hexagons.

place.....one of the hexagons on the board.

part.....coloured triangle in a partickle indicating an effect.

partickle ...hexagonal red or blue playing piece containing from 1 to 5 parts and an arrow direction indicator.

¹ This paragraph also appeared as the 'unpack' information in the effects SEO help facility.

The aim of the game:

The game ends when one player gets eleven partickles in the other player's half of the board. This means:

- (a) moving all the pieces of one side past the column of hexagons that runs vertically down the centre of the board, then
- (b) unpacking all combined pieces.

Making moves:

A partickle may move in any direction except when stopped by the edge of the board or when the move is blocked by another partickle. There are two types of move:

- (a) a non-effect move to a neighbouring place. Partickles only combine in non-effect moves.
- (b) an effect move. Each part of a partickle may perform its effect i.e. unpack, step, jump and/or push (the resist effect is only performed in response to a push). The number of places moved will be less than or equal to the number of parts in a partickle. A move of more than one place is made in a straight line and once begun must continue until as many places have been moved as there are parts in the partickle unless the partickle reaches the edge of the board or is blocked by another partickle. An effect move is not blocked by any partickle that would be pushed or jumped during that move. A swap move (see unpack effect) is the only move that does not involve a whole partickle moving to another place.

Turns:

Partickles is a game for two players. Each player plays with either the red side or the blue side for the duration of a game. Players may choose sides and choose the first side-to-play. Players take turns to play. A turn consists of one partickle making one move or one multiple move

(see step effect). A move must be either a non-effect move or an effect move. If a side-to-play cannot make a move the other side may claim victory.

Combining partickles:

A partickle combines with another partickle by making a non-effect move onto the place occupied by the other partickle.

A partickle only combines with a partickle of its own side, i.e. both red or both blue. A partickle only combines with another partickle if the sum of the parts of both partickles is less than or equal to five.

Combined partickles:

The maximum number of places that a partickle can move in one turn is the same as the number of parts it contains.

There is no significance in the relative positions of parts within a partickle. A partickle may contain two or three parts of the same effect type (e.g. a partickle containing two push parts) - but such duplications (or triplications) do not add to, or alter, a partickle's effects.

Resist (purple):

A resist partickle is unaffected by attempts to push it. }²

Resist parts are the first choice parts to be unpacked or swapped. }

² This paragraph also appeared as the 'resist' information in the effects SEO help facility.

Push (green):

A push effect will push any non-resist partickle back until }³
 it reaches another partickle or the edge of the board. Push }
 operates in the direction indicated by the push partickle's }
 arrow (i.e. the direction that the push partickle will }
 move). The push effect occurs before any other effect and }
 before the push partickle changes its location. Push parts }
 are the second choice parts to be unpacked or swapped. }

Jump (orange):

The jump effect may only apply when a partickle contains a }⁴
 jump part and at least one other part - because the minimum }
 jump (over a single partickle to an empty place) is the }
 equivalent of moving two places. A jump partickle can jump }
 several partickles (grouped or divided) in one move - }
 providing that the jump partickle can move/jump far enough }
 to reach an empty place. Partickles with unpack and jump }
 parts may not unpack while jumping because the places }
 jumped are already occupied. Jump parts are the third }
 choice parts to be unpacked or swapped. }

Step (yellow):

The step effect may only apply when a partickle contains a }⁵
 step part and at least one other part - i.e. when the }
 partickle can make a multiple move. A multiple move is a }
 move that can be divided into two or more individual moves }
 or "steps". The step effect allows a partickle to change }
 direction or to end the turn after each step. }

³ This paragraph also appeared as the 'push' information in the effects SEO help facility.

⁴ This paragraph also appeared as the 'jump' information in the effects SEO help facility.

⁵ This paragraph also appeared as the 'step' information in the effects SEO help facility.

A step is a move of one place, or one jump move (of two or more places) or a swap move. A step may be a jump of several places, a push and move, a move and unpack, a swap etc. A partickle with push and step parts may only attempt a push at the start of the first step of a multiple move. A partickle with unpack and step parts may not unpack during the first step of a multiple move. Step parts are the fourth choice parts to be unpacked or swapped.

Unpack (white):

The unpack effect operates in two ways:

Unpack - when a partickle containing an unpack part and at least one other part moves from a place one of its parts will be unpacked and left in that place. The unpacked part will become a new partickle with one part. A part will not be unpacked at the start of a turn i.e. when the partickle first moves away from the place it occupied at the start of the turn. Resist parts are unpacked first, then push parts, then jump parts, then step parts.

Swap - when an unpack partickle attempts to make an effect move to a place occupied by another partickle of the same side the unpack part will swap with a part from the other partickle - i.e. the part moves instead of the partickle. The unpack part will swap with a resist part if there is one, otherwise with a push part if there is one, otherwise with a jump part if there is one, otherwise with a step part.

⁶ This paragraph also appeared as the '...step' information in the effects SEO help facility.

⁷ This paragraph also appeared as the '...unpack' information in the effects SEO help facility.

⁸ This paragraph also appeared as the '...swap' information in the effects SEO help facility.

help/info menu option: about the program

Making a move:

Partickles is played using the mouse and pointer. The pointer is placed on a partickle belonging to the current side-to-play. The MIDDLE mouse button is used to rotate the partickle until its arrow points in the desired direction. The RIGHT mouse button is used to switch the effect mode on or off (the colour of the partickle changes/highlights when effect is on). In effect mode only the partickle selected to make an effect move can be rotated or moved. The LEFT button is used to start the move, or - with the question pointer - to provide information and a [make move] option. In SEO mode, moves are made by clicking the [make move] box. If the move cannot be made nothing will happen and an alternative move can be chosen. If the partickle makes an effect move and it contains a step part (yellow) and at least one other part it may pause after each step of the move - allowing its direction to be changed with the middle button, the turn to be continued with the left button, or the turn to be ended with the right button.

Self-Explanatory Objects (SEO):

SEO help information is obtained using the question pointer. Game controls, partickles and screen areas in the upper window produce explanations when the left mouse button is clicked. The middle and right buttons have their usual function so, when the question pointer is current, partickles can be rotated, effect mode can be switched on and off, and controls and menus can be operated.

Moves can be made in SEO mode by clicking the [make move] hot word box. When the left button + question pointer is clicked on a partickle, [make move] appears to the right of the menus if the partickle's direction and the state of effect allows a move. Clicking [make move] makes the move described or warns if the game controls are not set up to allow the move, or if the partickle's direction or the

effect state has been changed. The other hot words boxes provide a variety of information about partickles. With the question pointer, the three mouse buttons can be used to make any partickle explain any of the moves it can make and to obtain the computer player's assessment of each move. The question pointer only affects the function of the left mouse button.

Controls - top window:

red side-to-play indicator (bottom left):

makes red the next side-to-play. White outline shows red is the next side-to-play.

pointer exchange (bottom middle):

swaps the arrow and question pointers.

blue side-to-play indicator (bottom right):

makes blue the next side-to-play. White outline shows blue is the next side-to-play.

Controls - lower window:

scroll bar (right side):

scrolls lower window up and down. Menus and hot words scroll with the window and may become temporarily out of view and hence unselectable.

hot words (if present: top line to right of menus):

when help information is shown in the lower window hot words boxes may be available. These display alternative, related information when clicked.

menus (top line towards left):

these invert their colour when the pointer is over them and present menus when clicked. Menu options that are followed by three dots (e.g. "which button...") produce windows of help information when clicked. Clicking on or outside a menu or help information window closes it.

help windows:

there are three mouse windows and five help windows.

Clicking on or outside these windows closes them.

Four of the help windows have a scroll bar on the right side of the window for moving through a longer text.

"players" menu:

```

      _____
      | person  | v | person  |
red  ___| person  | v | computer |___ blue
player | computer | v | person   | player
      | computer_| v | computer_|

```

random first turn - chooses a side-to-play. It is only available at the start of a game.

"changes" menu:

demo-mode - when demo-mode is on (ticked) then every time a game has been won there will be a short pause, the board will be reset and a computer versus computer game will begin. Switching demo-mode on or off does not affect the current game in progress, but if demo-mode is switched on before a game has started (i.e. a side-to-play has not been chosen) a computer versus computer game will begin.

auto turns - when on (ticked) the side-to-play will change automatically when a turn ends. This is the recommended state for normal play. When auto turns is off the side-to-play can be changed by clicking a side-to-play box. It may be easier to rearrange partickle positions when auto turns is off.

- | | |
|----------|--|
| trace | - when on (ticked) this option provides information about the program's activities in the lower window. The current or most recent activity is shown on the top line below the menu buttons. Previous activities are progressively moved onto lower lines. |
| sound | - Partickles has sound effects for signalling a win and indicating a change of pointer. If sound is switched off (not ticked) these sounds will not be heard. |
| reset | - cancels the current game (without warning!) and resets the board. |
| icon bar | - closes all Partickles windows but does not interrupt or reset the program (a left click on the Partickles icon on the icon bar will reopen the windows). |

Program behaviour:

The computer player takes time to choose a move. Controls may be slow to react while the computer player is active.

During a computer versus person game controls and menus should be operated at the start of the person's turn.

During a computer versus computer game controls & menus may need to be clicked more than once.

help/info menu option: suggestions

Ideas...

Using the question pointer + left button:

Find out what a partickle can do, would do and, perhaps, should do - and find out which parts of the upper window provide information when clicked.

With auto turns off and players set to person v person:

Make a series of moves (altering the side-to-play as necessary) to set up "interesting" effect moves and arrangements of partickles.

Arrange partickles so that the computer player cannot make a move.

Find situations in which computer player doesn't make the best move.

Compare the help information with your experiences of, and ideas about, Partickles.

What happens if demo-mode is switched on after the board has been reset?

Check the "status info..." help window during a game. What is the "State of play" when both sides have won?

As (and when) you read each one of the suggestions in the "Strategy..." section below, ask yourself why their author thinks it is good advice.

Don't read the "Strategy..." section if you are still developing your own strategies - scroll down to the "Program behaviour..." section instead.

Strategy...

The unpack partickle is the most important partickle. Move it across the centre column early in the game.

Avoid combining unpack partickles with resist partickles.

Try to combine the unpack partickle with a step partickle.

Avoid combining partickles of the same type.

Avoid one-part partickle moves except when combining.

Make sure the last partickle left on its own side of the board has been combined.

Don't leave partickles where they can be pushed back or boxed in.

Use resist partickles to secure advances and build barriers.

Leave push partickles on their own side of the board for as long as possible.

Use jump partickles to jump barriers and "rescue" boxed in partickles.

Use step partickles to move around barriers and, sometimes, to make partial moves.

Use push to get the unpack partickle to the far side of the board instead of making the partickle containing unpack perform an effect move on its own side of the board.

It is sometimes useful to use swap to move an unpack part instead of moving the unpack partickle.

Use swap to move an unpack part into a partickle containing five parts.

Play against your opponent. Use push, build barriers and try to work out (and then thwart!) your opponent's plans.

Program behaviour...

Altering controls and selecting from menus during a game:

This is best done when the current side-to-play player is a person - NOT when a computer player is choosing a move.

Using controls and menus during computer v computer game:

Move the pointer to the "players" menu button, and click when the button inverts its colour. When the menu appears select person v person. This will (eventually) halt the game. The computer v computer game can be restarted by selecting computer v computer again.

Demo-mode (setting up a computer v computer game):

If demo-mode (changes menu) is on (ticked) then after a game has been won a new computer v computer game will be set up and started. If demo-mode is switched on when there is no current side-to-play (neither side-to-play box is outlined in white) a computer v computer game will be set up and started. There will be no current side-to-play when the program is first loaded, when a side has won, and after a reset (changes menu).

Clicking on or outside a help window closes it - but take care not to accidentally click above a control or partickle!

SEO 'effects' information (versions 1, 2 and 3)

The coloured wedges in a partickle represent effects.

An effect move can be started (by pressing the left button) after the partickle has been highlighted (by the right button).

SEO 'help' information (version 3 only)

The aim of the game:

The game ends when one player gets eleven partickles in the other player's half of the board. This means:

- (a) moving all the pieces of one side past the column of hexagons that runs vertically down the centre of the board, then
- (b) unpacking all combined pieces.

SEO 'moves' information (version 3 only)

Buttons: LEFT=explain/move, MIDDLE=rotate, RIGHT=effect

With the question pointer the left button gives information and, if a move can be made, a [make move] box. With the arrow pointer the left button makes the move immediately.

The right mouse button switches effect on or off. If the partickle contains a step part (yellow) and at least one other part it may pause after each step of an effect move.

Between steps the left and middle buttons can be used, but the right button will end the turn. When effect is on only the effect partickle can be rotated or moved.

SEO '? pointer' information (version 3 only)

With the question pointer:

The left mouse button gives information. This appears in the lower window which scrolls when the arrows on its right are clicked. Some partickle information appears in bubbles. The middle and/or right buttons can rotate partickles, switch effect on and off and change the side-to-play boxes - so the three mouse buttons can be used to make any partickle explain any of the moves it can make. Boxes appear to the right of the menus when the left button is clicked. Clicking the [make move] box attempts to make the move described.

Materials from the Partickles Studies

Contents:

- Subjects' Guidelines used in the Pilot and Core Studies
- Subjects' Guidelines used in the Video Study
- Observer's Guidelines used in the Pilot and Core Studies
- Observer's Guidelines used in the Video Study
- Partickles Study Record Sheet used in the Core Study
- Partickles Study Record Sheet used in the Video Study
- Checklist A used in the Video Study
- Checklist B used in the Video Study

Box borders have been used to indicate the original pagination of the Partickles Studies materials. The font sizes of documents have been reduced to fit the boxes and, as far as possible, the original formatting has been preserved. Each box represents an A4 sheet, and the dotted parts of some box borders indicate where the original documents contained more blank lines than are shown. The Partickles Study materials and their functions are described in Chapter 5.

Subjects' Guidelines used in the Pilot and Core Studies

Partickles Study

- first - brief exercise on the computer,
- then - explore and practise using the Partickles program,
- then - play the Partickles game,
- finally - a short chat.

The observer won't be able to answer questions while you are using the Partickles program. But he/she may make some comments and perhaps ask the occasional question.

Do comment on the program and on your progress whenever you like. Apart from making comments you should limit yourself to working with the mouse. There is no need to use the keyboard and you are requested not to make notes, not to take breaks and to ignore any distractions that may occur.

When you have spent some time exploring and practising using Partickles you will be told when a computer versus person game should begin, and how it should proceed. The observer will set up the computer versus person game for you.

Subjects' Guidelines used in the Video Study

Partickles Study

- first - brief exercise on the computer / these notes
- then - explore and practise using the Partickles program
- followed by checklists & exercises
- then - play the Partickles game
- with, possibly, variations of play mode
- finally - a few short questions

The observer won't be able to answer questions while you are using the Partickles program. But he/she may make some comments and perhaps ask the occasional question.

Do talk about the program and about your progress and plans whenever you like. There is no need to use the computer keyboard and you are requested not to make notes, not to take breaks and to ignore any distractions that may occur.

This study will consist of a number of activities. The observer will indicate which activity he/she would like you to do. The observer will also load the Partickles program and set up some Partickles games for you.

Observer's Guidelines used in the Pilot and Core Studies

Observer's Guidelines

<Check system. Set the time of its clock>

Beginning: subject's first name, your name, place of work and aim of this study: to see how people use programs - in this case a game of strategy (a bit like draughts or chess) called Partickles.

"The aim of the session is to get records of your use of the program: what you do and say and any notes I make - so that I can write about what happens. Your name will be kept separate from the records. I am interested in what you do and how well the program does - not how well you do and what the program does."

<Load Intro, start tape recorder - state Partickles Study, time and date>

"I'd like you to do a brief exercise. When an instruction or question appears on the screen please carry out the instruction or answer the question. You will use the mouse for all your actions and answers, and also for the Partickles program. Let me know if you have any problems or comments to make."

<Open Intro. Note time. Indicate first instruction if necessary>

"Please start."

During this phase:
Fill in record sheet.

After this phase:
Repeat Intro if necessary
Complete record sheet.
Record subject's name (get spelling right), form, date and time separately.

Observer's Guidelines, page 2

<Load Partickles>

"Please read through these notes"

Give subject's guidelines sheet to be read. (If it gets scant attention offer to read it to them. If this offer is rejected summarise its points).

"This is the exploring and practise phase. You will need to find out about the game of Partickles and to find out how to operate the program. There are a number of facilities in the program that will help you. You will need to find out what these are. All you have to remember* is how to find things out, so that you will be able to find the information you need when you are playing the game. Don't spend too long with any one facility - you can do that later if you wish."

<Open Partickles. Note time.>

"Please start."

During this phase:

Fill in record sheet - noting attainment targets and: activities, strategies and comments of particular interest (i.e. time & subject flags for tape & trace).

Ending this phase:

If the subject or the clock decides this phase has ended but the subject has not thoroughly explored/practised (and seems unlikely to do so) assist them.

If the subject ends this phase by beginning to play and they have thoroughly explored (or are obviously going to) point out that the second phase has now begun and ask if they want to restart the game from the beginning.

If the subject ends this phase by beginning to play and they have not thoroughly explored (and seem unlikely to do so) regard their activities as practice. Ask them to stop, then assist them to find out as above. If they are able to preserve the state of their game during this further exploration offer them the option of continuing the game or restarting from the beginning. Their game was practice and they were warned that they would be interrupted at the start of the game playing phase.

* the observer almost invariably added the words "at this stage" here.

Observer's Guidelines, page 3

<Reset Partickles and set up computer vs. person game as necessary>

"You will be able to play for as long a time as is left - this may involve one long game or several short games. You will be told when it is time to finish. After which there should be enough time for a brief chat.

The computer takes time to decide on a move. It is best to wait until it is your turn to play before pressing a mouse button.

You can use any of the facilities to find any information you may need.

You can decide to abandon a game and start a new one. If this is what you are doing or wish to do please say so.

You will be able to find a way around any difficulty by using the program.

Do not ask for help, but do comment on any difficulties you have, discoveries you make and if anything that interests you happens."

<Note time>

"Please start."

During this phase:

Note progress & interesting activities [see record sheet] and comments

Intervene to assist only if the subject's strategies completely break down and they are about to give up. Assist (as in exploration phase): firstly pointing the problem out (e.g. it is not that side's turn to move), secondly (if necessary) describing the context of the error (e.g. side-to-play control is wrongly set), finally (if necessary) describing what to do (if you click the side-to-play selector the side that you want to play will be able to play).

Intervene with a question if immediate goal is not clear and activity is significant and interruption would be minimal.

Ending this phase:

Give reason for ending (i.e. time) and begin discussion (see transition management).

<Quit and SAVE TRACE, noting name of Trace file>

Short chat as necessary. Ask about goals (if not asked previously).

"Would you be prepared to come back for another session with Partickles?"

Note reply.

Observer's Guidelines, page 4

Procedure for Intervention (Intro & exploration phases):

Deficiencies in the awareness targets should be regarded as implementation failures and the subject should be coached in the use of each facility by:

- firstly pointing it out,
- secondly (if necessary) suggesting trying it,
- finally (if necessary) describing what it does.

In the case of a lack of information:

- firstly the lack should be pointed out,
- secondly (if necessary) the source of information should be mentioned,
- thirdly (if necessary) suggesting that they look for it,
- finally (if necessary) the information should be summarised and told.

Note: only the function and operation/effect of a facility, not its significance, should be mentioned.

Managing transitions:

The observer must not use the mouse (except for loading, opening, setting up a session, coaching in the use of the mouse, and in emergencies) or treat the system/screen proprietarily.

At the end of the exploration phase do not immediately take the mouse away from the subject. Instead try:

- Telling them you will set up the board for them (pregnant pause).
- Go through the checklist of their activities with them (asking for confirmation - noting comments)
- Fiddle purposefully with notes.
- Etc. - until they relinquish possession of the initiative in the session. (If they give it away it can be given back)

At the end of the game playing phase discuss the state of play, most recent game etc. to effect the transition of attention from program use/play mode to conversation. It may be beneficial to switch off the computer/screen.

Observer's Guidelines used in the Video Study

Observer's Guidelines

<Check system. Set the time of its clock>

"The aim of the session is to get records of your use of the program: what you do and say and any notes I make - so that I can write about what happens. Your name will be kept separate from the records. I am interested in what you do and how well the program does - not how well you do and what the program does."

<Load Intro, start camera - state Partickles Study, time and date>

"I'd like you each to do a brief exercise and to read through these notes."

"When an instruction or question appears on the screen please carry out the instruction or answer the question. You will use the mouse for all your actions and answers, and also for the Partickles program. Let me know if you have any problems or comments to make."

<Open Intro. Note time. >

"Please start."

<Fill in record sheet.>

After both have used INTRO complete names & details on record sheets.

<Load Partickles>

"This is the exploring and practise phase. You will need to find out about the game of Partickles and find out how to operate the program. There are lots of facilities in the program that may help you. All you have to remember at this stage is how to find things out, so that you will be able to find the information you need when you are playing the game. Try to discover as much as possible... and tell the other person what you think ."

<Open Partickles. Note time.>

"Please start."

<5 minutes or so each>

Observer's Guidelines, page 2

"Now there are two checklists for you to run through and fill in. One person reads through the checklist while the other uses the mouse. Please demonstrate each item on the computer and tick it on the checklist. When the first checklist is complete swap the checklist reader / mouse user jobs and work through the second checklist."

<Reset Partickles and set up computer vs. person game as necessary>

"You can now play together against the computer player - this may involve one long game or several short games. You will be told when it is time to finish. The computer takes time to decide on a move. It is best to wait until it is your turn to play before pressing a mouse button. You can use any of the facilities to find any information you may need. You can decide to abandon a game and start a new one. If this is what you are doing or wish to do please say so. Do not ask the observer for help, but please mention any difficulties you have, discoveries you make and if anything that interests you happens - and, of course, you will need to discuss what you are doing with your partner."

<Note time>

"Please start."

"I would now like you to try a variation of the play mode. There are two alternatives:
- using the ? pointer with make move + hot words (help, effects, move value etc.),
- using the arrow pointer + info menu (getting started, Partickles rules, etc). I'd like *subject* to try *mode* first."

<Note time>

"Please start."

<record progress - events/comments etc>

If there's time allow play according to preference: play mode and possibly playing one another.

<Quit and SAVE TRACE, noting name of Trace file>

<Ask the questions>

Partickles Study Record Sheet used in the Core Study*

<u>Partickles Study</u>		
_____	filename of trace	
_____	date	_____
_____	age	__M/___F
_____	__ L/___R handed (mouse user)	
__Y/___N Will they come back for another session with Partickles?		
<u>First phase - Intro:</u>		
___ Move the arrow pointer to the blue rectangle and click a mouse button.		
___ Move the arrow pointer to the yellow rectangle and click a mouse button.		
___ Move the arrow pointer to the white rectangle and click a mouse button.		
___ Move the arrow pointer to the purple rectangle and click a mouse button.		
___ Move the arrow pointer to the orange rectangle and click a mouse button.		
___ Move the arrow pointer to the green rectangle and click a mouse button.		
___ Move the arrow pointer to the red rectangle and click a mouse button.		
__Y/___N Have you ever played Chess, Draughts, Go or a similar game?		
__Y/___N Have you ever used a computer system with a mouse?		
__Y/___N Have you ever used this sort of computer before?		
__Y/___N Have you ever played Partickles?		
___ Move the arrow pointer onto the blue question mark and click a button to change pointers.		
___ Move the question pointer around the screen clicking (with the left mouse button) on objects.		

* This record sheet is similar to the one used in the pilot study. The core study version contained spaces for observer's notes between sections, but in the pilot study the observer's notes were written on a blank page appended to the record sheet.

Core Study Record Sheet continued:

Partickles Study, page 2

Second phase - exploring and practising:

_____ time exploration phase began

___ has tried the mouse menu (or has no difficulty with the mouse and pointers)

___ has tried at least two of the help menu options

___ has operated and/or knows about side-to-play boxes *

___ has practised making moves with partickles

___ has changed pointers and obtained help about a partickle

___ has, at least, noticed the hot words boxes

___ knows what the scroll bar is for and how to use it

___ knows the aim of the game

* The pilot study record sheet referred to "all six of the controls" whereas the core study record sheet (used with version 2 of Partickles) just mentioned the "side-to-play boxes".

Partickles Study Record Sheet used in the Video Study

<u>Partickles Study</u>	
_____ filename of trace	
_____ date	_____ time
<u>Intro</u> *	
_____ name	_____ age
___M/___F	___ L/___R handed (mouse user)
___ Move the arrow pointer to the blue rectangle and click a mouse button.	
___ Move the arrow pointer to the yellow rectangle and click a mouse button.	
___ Move the arrow pointer to the white rectangle and click a mouse button.	
___ Move the arrow pointer to the purple rectangle and click a mouse button.	
___ Move the arrow pointer to the orange rectangle and click a mouse button.	
___ Move the arrow pointer to the green rectangle and click a mouse button.	
___ Move the arrow pointer to the red rectangle and click a mouse button.	
___Y/___N Have you ever played Chess, Draughts, Go or a similar game?	
___Y/___N Have you ever used a computer system with a mouse?	
___Y/___N Have you ever used this sort of computer before?	
___Y/___N Have you ever played Partickles?	
___ Move the arrow pointer onto the blue question mark and click a button to change pointers.	
___ Move the question pointer around the screen clicking (with the left mouse button) on objects.	

* Page 2 (not shown) of the video study record sheet contained another Intro section for use with the second subject of each pair.

Video Study Record Sheet page 3:

_____ time explore and practise phase began

_____ time checklist phase began

_____ time game playing phase began

_____ time alternate play mode phase began

_____ time preferences play began

_____ time Trace saved

Questions:

"If it is necessary, and you have time, would you be prepared to come back for another session with Partickles?"

Video Study Record Sheet page 4:

"What do you think of the game?"

"What do you think about all the information provided in the program?"

"Which of the two modes of play/types of help do you prefer? Why?"

"Any suggestions for improving the program?"

Checklist A used in the Video Study

<u>Explore and Practise Checklist A</u>	
Names:	_____

Date:	_____
_____	has selected an option from the mouse menu
_____	knows the functions of all three mouse buttons
_____	has selected at least two of the info menu options
_____	knows where the info and lower window scroll bar are, and how to use their arrows
_____	knows how to click and drag the scroll bar "block"
_____	can use the side-to-play boxes to see which side is in play
_____	has practised rotating a partickle
_____	has practised making a non-effect move with a partickle

Checklist B used in the Video Study

<u>Explore and Practise Checklist B</u>	
Names:	_____

Date:	_____
_____	has practised combining partickles
_____	has practised making effect moves with partickles
_____	has changed pointers
_____	has used the question pointer to get information about partickles
_____	has demonstrated changes in bubble information when partickles are rotated and when effect is off and on
_____	has selected at least three of the boxes (e.g. help) that appear when the question pointer is used
_____	knows the aim of the game

Extracts from Trace Records

Introduction

Chapter 5 presents details of the subjects of the Partickles studies and Appendices E and F describe the core and video study sessions individually.

This Appendix contains extracts from the trace records of three sessions:

- Core study session C2 with subject I
..... extracts from the whole session.
- Core study session C4 with subject K
..... the whole of the tenth game.
- Video study session V2 with subjects P and Q
..... the explore and practise phase and most of the second game.

There were three versions of the trace program used to decode trace records: View_Trace for version 1 of Partickles, Show_Trace for version 2 and List_Trace for version 3. Show_Trace was also used to decode traces from the modified versions of Partickles used in the last three pilot study sessions. Once a trace record file had been 'unpacked' by the trace program its output was loaded into a word processing program for examination and annotation. Full trace records were too long to include with the thesis. For example, the full trace record of session C2, which was one of the shortest sessions, occupied 32 pages. In these shortened extracts lines of "/" characters show where sections of the trace records have been removed and some of the blank lines produced by the trace decoder programs have also been removed. The session C2 extracts, which include the first and last parts of the output from the trace decoder

program, show how the full trace records were presented, and the session C4 extract shows an entire game. The output from the decoder programs is shown in a non-serif font, and where comments have been added they appear to the right of the trace record entries in a serif font.

The extracts from all three sessions show a considerable amount of particle SEO information usage. Most of subject I's particle SEO information accesses were made to obtain descriptive particle SEO information, but, in the extracts from the other two sessions, some particle SEO information accesses have been labelled as evidence of the "use of 'would do' particle SEO information". In these instances particles were manipulated (by rotating them and switching effect on or off) between particle SEO information accesses and before a move was made. 'Would do' particle SEO information was used if subject/s adjusted the particle's direction and/or effect state because the first 'would do' information had revealed that the particle would not do what was desired. The video and audio records provided evidence of subjects reading out, and reacting to, particle SEO information, but the trace records do not show whether the descriptive and/or 'would do' particle SEO information was read. Every particle SEO information access (represented as "- particle info" in the trace records) was generated by a subject clicking on a particle using the question pointer and left mouse button.

Pointer changes can be seen in the extracts from all three sessions, but subject I made all but one of his moves using the arrow pointer and changed to the question pointer to obtain object-based help (opting in) whereas the other subjects generally retained the question pointer in the periods covered by these

extracts (not opting out) and made most of their moves by clicking the make move hot words box (represented as "- [make move]" in the trace records). All hot words box accesses in the trace records are shown within square brackets - including the hot words boxes provided by the effects SEO help facility. Usage of the effects SEO help facility appears in the extracts of all three sessions. Subject I accessed menu-based help during game playing and the use of all four menus: mouse, help/info, players and changes, can be seen in the explore and practise phases of sessions C2 and V2. The extracts also show a computer versus computer game begun with changes menu option: demo-mode in subject I's session and an SEO error message in subjects P and Q's session.

Extracts from the Trace Record of Session C2

These extracts span the whole session. The entries that have been removed contained details of moves and partickle SEO information accesses. The running total of partickle SEO information accesses in the right hand column shows how many of these were removed. Only one game was played in this session. The extracts include parts of the observer briefing (12:27:56), an observer intervention (12:42:47) and the informal debriefing at the end of the session (12:57:06). An episode which begins at 12:36:22 shows the subject using help menu option: Partickles rules and mouse menu option: which button to successfully research push effect moves, and another episode starting at 12:49:39 shows that the effects SEO help facility was successfully used to research unpack effect moves. The subject's use of the effects SEO help facility was prompted by an observer intervention at 12:42:47, but when the subject used the facility again at 12:54:00 this indicated that he had found it useful.

|	turn done.....	12:26:52	}	are done automatically
|	side-to-play.....	12:26:52	}	at the end of each turn
|	players menu.....	12:26:52		end of explore and practise phase
|	computer turn.....	12:26:52		
-	effect on.....	12:26:59		
-	rotate	12:26:59		
-	move	12:27:00		
-	jump.....	12:27:00		
-	person v person	12:27:00		end of demonstration game
|	effect off.....	12:27:00		
|	control.....	12:27:46		
-	side-to-play.....	12:27:46		
|	control.....	12:27:56		observer talks subject through SEO
-	exchange pointer.....	12:27:56		demonstration
-	pointer sound	12:27:56		
/	/	/	/	/
/	/	/	/	/
|	mouse menu.....	12:29:21		subject checks buttons after observer's comment
-	which button	12:29:25		
|	rotate	12:29:42		
-	move	12:29:48		
/	/	/	/	/
/	/	/	/	/
|	changes menu.....	12:30:06		
-	reset.....	12:30:07		end of observer briefing
-	reset board.....	12:30:07		
|	players menu.....	12:30:13		
-	computer v person.....	12:30:18		
|	players menu.....	12:30:23		
-	grey random first turn.....	12:30:26		(must have mis-clicked a menu option)
|	players menu.....	12:30:27		
-	random first turn	12:30:28		
|	side-to-play.....	12:30:28		start of game playing phase
|	computer turn.....	12:30:28		
-	rotate	12:30:31		
-	move	12:30:32		
-	combine.....	12:30:32		
|	turn done.....	12:30:32		
|	side-to-play.....	12:30:32		
|	help menu	12:30:42		looks at help menu but doesn't select an option
|	mouse menu.....	12:30:45		looks at mouse menu but doesn't select an option

| control.....	12:30:50	
- exchange pointer.....	12:30:50	chooses partickle SEO information instead
- pointer sound.....	12:30:51	
| SEO help.....	12:30:52	
- partickle info.....	12:30:52	one - first partickle SEO information access
| SEO help.....	12:30:57	
- partickle info.....	12:30:57	two
| SEO help.....	12:31:05	
| SEO help.....	12:31:05	
- partickle info.....	12:31:05	three
| SEO help.....	12:31:08	
| SEO help.....	12:31:08	
- partickle info.....	12:31:08	four
| SEO help.....	12:31:09	
- partickle info.....	12:31:09	five
| SEO help.....	12:31:09	
- partickle info.....	12:31:09	six
| SEO help.....	12:31:12	
| SEO help.....	12:31:13	
- partickle info.....	12:31:13	seven
| SEO help.....	12:31:16	
| SEO help.....	12:31:16	
- partickle info.....	12:31:16	eight
| SEO help.....	12:31:18	
| control.....	12:31:24	
- exchange pointer.....	12:31:24	
- pointer sound.....	12:31:24	changing pointers before making a move
| rotate.....	12:31:35	
- move.....	12:31:36	
| turn done.....	12:31:36	
/ / / / / / / /		(entries removed)
| SEO help.....	12:36:18	
- partickle info.....	12:36:18	seventeen
| SEO help.....	12:36:22	
- partickle info.....	12:36:22	eighteen - checking a pushed partickle thinking it had caused the push effect
| help menu.....	12:36:31	

- Partickles rules.....	12:36:33	reading about effect moves re above
| mouse menu.....	12:37:19	
- which button.....	12:37:20	checking role of effect mouse button
| control.....	12:37:26	
- exchange pointer.....	12:37:26	
- pointer sound.....	12:37:26	
| effect on.....	12:37:30	subject's first use of effect mouse button
- push.....	12:37:31	- successfully makes a push effect move
- move.....	12:37:31	
- effect off.....	12:37:31	
| turn done.....	12:37:32	
/ / / / / / / /		(entries removed)
| SEO help.....	12:40:37	
- partickle info.....	12:40:37	twenty-seven Subject: "What's this thing?" (enjoying clicking with question pointer on partickles, but wishes to know more about effects)
| control.....	12:40:44	
- exchange pointer.....	12:40:44	
- pointer sound.....	12:40:44	
| help menu.....	12:40:51	
- Partickles rules.....	12:40:53	not counted (only 3 secs), next Partickles rules can
| players menu.....	12:40:56	
| players menu.....	12:40:58	
| help menu.....	12:40:59	
- Partickles rules.....	12:41:02	reading about effects
/ / / / / / / /		(entries removed)
| control.....	12:42:47	observer demonstration of effects SEO help facility and move value facility (also describes make move facility)
- exchange pointer.....	12:42:47	
- pointer sound.....	12:42:47	
| SEO help.....	12:42:48	
- partickle info.....	12:42:48	
- [colours].....	12:42:50	
- [jump].....	12:42:55	
| window scroll.....	12:43:06	
| SEO help.....	12:43:12	
- partickle info.....	12:43:12	
- [move value].....	12:43:14	
| control.....	12:43:20	
- exchange pointer.....	12:43:20	
- pointer sound.....	12:43:20	end of observer demonstration
| control.....	12:43:20	

- exchange pointer.....	12:43:20	
- pointer sound	12:43:20	
I SEO help.....	12:43:21	
- partickle info.....	12:43:21	twenty-nine
- [make move].....	12:43:23	subject tries make move facility but doesn't use it again
I move	12:43:23	
- combine.....	12:43:23	
I turn done.....	12:43:23	
/ / / / / / / /		(entries removed)
I control.....	12:49:36	
- exchange pointer.....	12:49:36	
- pointer sound	12:49:36	
I SEO help.....	12:49:37	
- partickle info.....	12:49:37	forty-three
- [colours].....	12:49:39	- navigating the effects SEO help facility
- [unpack].....	12:49:40	- checks before unpacking a 5x combination
I window scroll.....	12:49:51	- reading the unpack information
I control.....	12:50:07	
- exchange pointer.....	12:50:07	
- pointer sound	12:50:08	
I effect on.....	12:50:14	
- push	12:50:14	
- move	12:50:14	
- move	12:50:25	
- unpack.....	12:50:25	subject successfully unpacks
- rotate	12:50:27	
- move	12:50:28	
- unpack.....	12:50:28	
- move	12:50:29	
- unpack.....	12:50:29	
- move	12:50:30	
- unpack.....	12:50:30	
- effect off.....	12:50:30	
I turn done.....	12:50:30	
/ / / / / / / /		(entries removed)
I SEO help.....	12:53:59	
- partickle info.....	12:53:59	forty-six
- [colours].....	12:54:00	navigates effects SEO help facility for the second time
- [step].....	12:54:01	
I control.....	12:54:10	
- exchange pointer.....	12:54:10	
- pointer sound	12:54:10	
I move	12:54:26	

I	turn done.....	12:54:26	
	/ / / / / / /		(entries removed)
I	side-to-play.....	12:55:34	
I	effect on.....	12:55:37	
-	move	12:55:38	
-	move	12:55:38	
-	unpack.....	12:55:38	
-	move	12:55:38	
-	unpack.....	12:55:38	
I	side has won.....	12:55:38	subject wins
-	congratulate.....	12:55:38	
-	victory sound.....	12:55:38	end of game playing phase
I	control.....	12:57:06	
-	exchange pointer.....	12:57:06	
-	pointer sound	12:57:06	
I	SEO help.....	12:57:09	Observer demonstrates move value in debriefing.
-	partickle info.....	12:57:09	Subject: "Yeh, I did have a look at that but I
-	[move value].....	12:57:20	couldn't be bothered."
-	partickle info.....	12:57:24	
I	control.....	12:57:36	
-	side-to-play.....	12:57:36	
I	SEO help.....	12:57:38	
-	partickle info.....	12:57:38	
-	[make move].....	12:57:44	make move facility demonstrated/discussed
	/ / / / / / /		(entries removed)
I	changes menu.....	13:00:59	
-	icon bar	13:01:01	
I	iconbar menu	13:01:04	
-	end of session	13:01:04	

End of trace. Press Escape key.

Extract from the Trace Record of Session C4

This extract consists of the entire 10th game from subject K's session. Subject K was the only core study subject who retained the question pointer and made frequent use of the make move facility rather than changing to the arrow pointer to make moves. Further details of this game and its context are

provided in the session C4 description in Appendix E. The trace record extract shows that the subject obtained partickle SEO information forty times and used make move twenty-five times. Partickle SEO information accesses which were not followed by the use of make move suggest that information, rather than access to the make move facility, was being sought. Sequences where partickles were manipulated between partickle SEO information accesses and before the use of make move suggest the use of 'would do' partickle SEO information. An episode which begins at 12:34:09 shows the successful use of the effects SEO help facility to find information about unpacking partickles. Subject K changed to the arrow pointer twice: the first time (12:30:11) he changed back to the question pointer immediately but the second time (12:36:33) he used the arrow pointer on five of his turns then changed back to the question pointer in the middle of a multiple step effect move - presumably to start obtaining partickle SEO information again.

/	/	/	/	/	/	/	/	(entries removed)
I	changes menu	.....	12:29:34					
-	reset	.....	12:29:36					
-	reset board	.....	12:29:36					
I	players menu	.....	12:29:39					
-	person v computer	.....	12:29:40					
I	control	.....	12:29:41					
-	side-to-play	.....	12:29:41					start of 10th game
I	control	.....	12:29:45					
-	exchange pointer	.....	12:29:45					switches to question pointer
-	pointer sound	.....	12:29:45					
I	SEO help	.....	12:29:47					
-	partickle info	.....	12:29:47					one - first partickle SEO information access
-	[make move]	.....	12:29:58					1st use of make move
I	move	.....	12:29:58					
-	combine	.....	12:29:58					
I	turn done	.....	12:29:58					
I	side-to-play	.....	12:29:58					

| computer turn.....	12:29:58	
- rotate	12:30:01	
- move	12:30:02	
- combine.....	12:30:02	
| turn done.....	12:30:02	
| side-to-play.....	12:30:02	
| effect on.....	12:30:05	
- rotate	12:30:05	
| control.....	12:30:11	
- exchange pointer.....	12:30:11	switches to arrow pointer
- pointer sound	12:30:11	
| control.....	12:30:13	
- exchange pointer.....	12:30:13	switches to question pointer
- pointer sound	12:30:13	
| SEO help.....	12:30:15	
- partickle info.....	12:30:15	two ('would do' partickle SEO information shows effect is on)
| effect off.....	12:30:33	
| SEO help.....	12:30:36	
- partickle info.....	12:30:36	three
- [make move].....	12:30:40	2nd use of make move
| move	12:30:40	
- combine.....	12:30:40	
| turn done.....	12:30:40	
| side-to-play.....	12:30:40	
| computer turn.....	12:30:41	
- rotate	12:30:43	
- move	12:30:44	
- combine.....	12:30:44	
| turn done.....	12:30:44	
| side-to-play.....	12:30:44	
| SEO help.....	12:30:47	
- partickle info.....	12:30:47	four
- [make move].....	12:30:52	3rd use of make move
| move	12:30:52	
- combine.....	12:30:52	
| turn done.....	12:30:52	
| side-to-play.....	12:30:52	
| computer turn.....	12:30:52	
- effect on.....	12:30:55	
- rotate	12:30:55	
- move	12:30:55	
- computer turn.....	12:30:56	

-	move	12:30:57	
-	unpack.....	12:30:57	
-	computer turn.....	12:30:57	
-	rotate	12:30:58	
-	move	12:31:01	
-	unpack.....	12:31:01	
-	effect off.....	12:31:01	
|	turn done.....	12:31:01	
|	side-to-play.....	12:31:01	
|	rotate	12:31:02	
|	SEO help.....	12:31:04	
-	partickle info.....	12:31:04	five
-	[make move].....	12:31:07	4th use of make move
|	move	12:31:07	
|	turn done.....	12:31:08	
|	side-to-play.....	12:31:08	
|	computer turn.....	12:31:08	
-	effect on.....	12:31:13	
-	rotate	12:31:13	
-	push	12:31:13	
-	move	12:31:13	
-	effect off.....	12:31:13	
|	turn done.....	12:31:13	
|	side-to-play.....	12:31:13	
|	rotate	12:31:13	
-	effect on.....	12:31:16	
|	SEO help.....	12:31:17	
-	partickle info.....	12:31:17	six
|	SEO help.....	12:31:23	obtains area SEO information to remove bubble
|	rotate	12:31:24	evidence of 'would do' partickle SEO information
|	SEO help.....	12:31:26	
-	partickle info.....	12:31:26	seven - more 'would do' partickle SEO information (decided not to make this move)
|	SEO help.....	12:31:32	
|	rotate	12:31:33	
-	effect off.....	12:31:35	
|	SEO help.....	12:31:36	
-	partickle info.....	12:31:36	eight
-	[make move].....	12:31:39	5th use of make move
|	move	12:31:39	
-	combine.....	12:31:39	

|	turn done.....	12:31:39	
|	side-to-play.....	12:31:39	
|	computer turn.....	12:31:40	
-	move	12:31:44	
-	combine.....	12:31:44	
|	turn done.....	12:31:44	
|	side-to-play.....	12:31:44	
|	rotate	12:31:46	
|	SEO help.....	12:31:52	
-	partickle info.....	12:31:52	nine
-	[make move].....	12:31:57	6th use of make move
|	move	12:31:57	
|	turn done.....	12:31:57	
|	side-to-play.....	12:31:57	
|	computer turn.....	12:31:57	
-	effect on.....	12:32:01	
-	rotate	12:32:02	
-	push	12:32:02	
-	move	12:32:02	
-	effect off.....	12:32:02	
|	turn done.....	12:32:02	
|	side-to-play.....	12:32:02	
|	rotate	12:32:02	
-	effect on.....	12:32:03	
-	rotate	12:32:04	
|	SEO help.....	12:32:05	
-	partickle info.....	12:32:05	ten
|	SEO help.....	12:32:11	
|	rotate	12:32:17	use of 'would do' partickle SEO information
|	SEO help.....	12:32:18	
-	partickle info.....	12:32:18	eleven
-	[make move].....	12:32:27	7th use of make move
|	move	12:32:27	
-	effect off.....	12:32:27	
|	turn done.....	12:32:27	
|	side-to-play.....	12:32:27	
|	computer turn.....	12:32:27	
-	rotate	12:32:31	
-	move	12:32:32	
-	combine.....	12:32:32	
|	turn done.....	12:32:32	

|	side-to-play.....	12:32:32	
|	rotate	12:32:33	
|	SEO help.....	12:32:35	
-	partickle info.....	12:32:35	twelve
-	[make move].....	12:32:38	8th use of make move
|	move	12:32:38	
-	combine.....	12:32:38	
|	turn done.....	12:32:38	
|	side-to-play.....	12:32:38	
|	computer turn.....	12:32:38	
-	rotate	12:32:43	
-	move	12:32:44	
-	combine.....	12:32:44	
|	turn done.....	12:32:44	
|	side-to-play.....	12:32:44	
|	rotate	12:32:44	
|	SEO help.....	12:32:49	
-	partickle info.....	12:32:49	thirteen
|	SEO help.....	12:32:52	
-	partickle info.....	12:32:52	fourteen
-	[make move].....	12:32:54	9th use of make move
|	move	12:32:54	
-	combine.....	12:32:54	
|	turn done.....	12:32:54	
|	side-to-play.....	12:32:54	
|	computer turn.....	12:32:54	
-	move	12:32:59	
-	combine.....	12:32:59	
|	turn done.....	12:32:59	
|	side-to-play.....	12:33:00	
|	rotate	12:33:00	
-	effect on.....	12:33:04	
-	effect off.....	12:33:04	
-	rotate	12:33:05	
|	SEO help.....	12:33:06	
-	partickle info.....	12:33:07	fifteen
-	[make move].....	12:33:09	10th use of make move
|	move	12:33:09	
-	combine.....	12:33:09	
|	turn done.....	12:33:09	
|	side-to-play.....	12:33:09	

| computer turn.....	12:33:09	
- move	12:33:15	
- combine.....	12:33:15	
| turn done.....	12:33:15	
| side-to-play.....	12:33:15	
| effect on.....	12:33:16	Subject makes a multiple, 3 step, effect move with jump below:
- rotate	12:33:16	
| SEO help.....	12:33:18	
- partickle info.....	12:33:18	sixteen
- [make move].....	12:33:25	11th use of make move
| move	12:33:25	
- jump.....	12:33:25	
| SEO help.....	12:33:30	
- partickle info.....	12:33:30	seventeen
- [make move].....	12:33:33	12th use of make move
| move	12:33:33	
| SEO help.....	12:33:36	
- partickle info.....	12:33:36	eighteen
- [make move].....	12:33:37	13th use of make move
| move	12:33:37	
- effect off.....	12:33:37	
| turn done.....	12:33:37	
| side-to-play.....	12:33:37	
| computer turn.....	12:33:37	
- effect on.....	12:33:43	
- rotate	12:33:43	
- move	12:33:44	
- computer turn.....	12:33:45	
- move	12:33:46	
- computer turn.....	12:33:47	
- rotate	12:33:48	
- move	12:33:51	
- computer turn.....	12:33:51	
- move	12:33:52	
- computer turn.....	12:33:53	
- move	12:33:53	
- effect off.....	12:33:53	
| turn done.....	12:33:53	
| side-to-play.....	12:33:53	
| rotate	12:33:54	
- effect on.....	12:33:56	
| SEO help.....	12:33:57	
- partickle info.....	12:33:57	nineteen

- [make move].....	12:34:07	14th use of make move
| move	12:34:07	
| SEO help.....	12:34:09	
- partickle info.....	12:34:09	twenty
- [colours].....	12:34:28	selects effects SEO help facility
- [unpack].....	12:34:31	navigates as far as unpack
| window scroll.....	12:34:37	reads text
- [...unpack].....	12:34:42	navigates as far as ...unpack
| window scroll.....	12:34:45	reads text
| SEO help.....	12:35:02	
| SEO help.....	12:35:06	
- partickle info.....	12:35:06	twenty-one
- [make move].....	12:35:14	15th use of make move
| move	12:35:14	
- unpack.....	12:35:14	subject successfully unpacks
- effect off.....	12:35:18	
| turn done.....	12:35:18	
| side-to-play.....	12:35:18	
| computer turn.....	12:35:18	
- rotate	12:35:22	
- move	12:35:23	
| turn done.....	12:35:23	
| side-to-play.....	12:35:23	
| SEO help.....	12:35:23	
- partickle info.....	12:35:23	twenty-two
| SEO help.....	12:35:26	
| rotate	12:35:27	use of 'would do' partickle SEO information
| SEO help.....	12:35:29	
- partickle info.....	12:35:29	twenty-three
- [make move].....	12:35:31	16th use of make move
| move	12:35:32	
| turn done.....	12:35:32	
| side-to-play.....	12:35:32	
| computer turn.....	12:35:32	
- move	12:35:36	
- combine.....	12:35:36	
| turn done.....	12:35:37	
| side-to-play.....	12:35:37	

| rotate	12:35:37	
- effect on.....	12:35:39	
| SEO help.....	12:35:40	
- partickle info.....	12:35:40	twenty-four
| rotate	12:35:47	use of 'would do' partickle SEO information
| SEO help.....	12:35:48	
- partickle info.....	12:35:48	twenty-five
- [make move].....	12:35:50	17th use of make move
| move	12:35:50	
- effect off.....	12:35:50	
| turn done.....	12:35:50	
| side-to-play.....	12:35:50	
| computer turn.....	12:35:50	
- effect on.....	12:35:54	
- rotate	12:35:54	
- move	12:35:55	
- computer turn.....	12:35:55	
- rotate	12:35:55	
- move	12:35:58	
- computer turn.....	12:35:59	
- effect off.....	12:35:59	
| turn done.....	12:35:59	
| side-to-play.....	12:35:59	
| rotate	12:36:00	
| SEO help.....	12:36:01	
- partickle info.....	12:36:01	twenty-six
- [make move].....	12:36:03	18th use of make move
| move	12:36:03	
| turn done.....	12:36:03	
| side-to-play.....	12:36:03	
| computer turn.....	12:36:03	
- move	12:36:07	
| turn done.....	12:36:07	
| side-to-play.....	12:36:07	
| rotate	12:36:07	
| SEO help.....	12:36:08	
- partickle info.....	12:36:08	twenty-seven
- [make move].....	12:36:10	19th use of make move
| move	12:36:10	
- combine.....	12:36:10	

|	turn done.....	12:36:10	
|	side-to-play.....	12:36:10	
|	computer turn.....	12:36:10	
-	effect on.....	12:36:14	
-	rotate	12:36:14	
-	push	12:36:15	
-	move	12:36:15	
-	move	12:36:15	
-	effect off.....	12:36:15	
|	turn done.....	12:36:15	
|	side-to-play.....	12:36:15	
|	rotate	12:36:15	
-	effect on.....	12:36:17	
|	SEO help.....	12:36:18	
-	partickle info.....	12:36:18	twenty-eight
|	SEO help.....	12:36:25	
-	partickle info.....	12:36:25	twenty-nine (same partickle as twenty-eight?)
-	[make move].....	12:36:30	20th use of make move
|	move	12:36:30	
|	control.....	12:36:33	
-	exchange pointer.....	12:36:33	subject switches to arrow pointer
-	pointer sound	12:36:33	
|	move	12:36:34	first use of arrow pointer to make a move
-	rotate	12:36:35	(step effect move)
-	move	12:36:36	
-	move	12:36:37	
-	move	12:36:43	
-	effect off.....	12:36:43	
|	turn done.....	12:36:43	
|	side-to-play.....	12:36:43	
|	computer turn.....	12:36:43	
-	effect on.....	12:36:44	
-	rotate	12:36:44	
-	move	12:36:47	
-	move	12:36:47	
-	effect off.....	12:36:47	
|	turn done.....	12:36:47	
|	side-to-play.....	12:36:47	
|	rotate	12:36:49	
-	move	12:36:49	second use of arrow pointer to make a move
|	turn done.....	12:36:49	
|	side-to-play.....	12:36:49	
|	computer turn.....	12:36:50	
-	effect on.....	12:36:50	

- rotate	12:36:50	
- move	12:36:50	
- computer turn.....	12:36:50	
- rotate	12:36:51	
- move	12:36:52	
- unpack.....	12:36:52	
- effect off.....	12:36:52	
I turn done.....	12:36:52	
I side-to-play.....	12:36:52	
I move	12:36:54	third use of arrow pointer to make a move
I turn done.....	12:36:54	
I side-to-play.....	12:36:54	
I computer turn.....	12:36:54	
- effect on.....	12:36:54	
- push	12:36:54	
- move	12:36:54	
- move	12:36:54	
- effect off.....	12:36:54	
I turn done.....	12:36:54	
I side-to-play.....	12:36:54	
I rotate	12:36:56	
- move	12:36:57	fourth use of arrow pointer to make a move
I turn done.....	12:36:57	
I side-to-play.....	12:36:57	
I computer turn.....	12:36:57	
- rotate	12:36:57	
- move	12:36:59	
- combine.....	12:36:59	
I turn done.....	12:37:00	
I side-to-play.....	12:37:00	
I rotate	12:37:00	fifth use of arrow pointer to make a move
- move	12:37:02	
- rotate	12:37:03	(step effect move)
- move	12:37:05	
I control.....	12:37:06	
- exchange pointer.....	12:37:06	switches to question pointer
- pointer sound	12:37:06	
I SEO help.....	12:37:07	
- partickle info.....	12:37:08	thirty
I SEO help.....	12:37:12	
I rotate	12:37:13	use of 'would do' partickle SEO information
I SEO help.....	12:37:13	

- partickle info.....	12:37:13	thirty-one
- [make move].....	12:37:15	21st use of make move
I move	12:37:15	
I turn done.....	12:37:15	
I side-to-play.....	12:37:15	
I computer turn.....	12:37:15	
- effect on.....	12:37:15	
- rotate	12:37:15	
- move	12:37:16	
- jump.....	12:37:16	
- computer turn.....	12:37:16	
- effect off.....	12:37:16	
I turn done.....	12:37:16	
I side-to-play.....	12:37:16	
I SEO help.....	12:37:18	
- partickle info.....	12:37:18	thirty-two
I SEO help.....	12:37:21	
I rotate	12:37:22	use of 'would do' partickle SEO information
I SEO help.....	12:37:24	
- partickle info.....	12:37:24	thirty-three
I SEO help.....	12:37:25	
I effect on.....	12:37:26	use of 'would do' partickle SEO information
I SEO help.....	12:37:26	
- partickle info.....	12:37:27	thirty-four
- [make move].....	12:37:32	22nd use of make move
I push	12:37:32	
- move	12:37:32	
- effect off.....	12:37:32	
I turn done.....	12:37:33	
I side-to-play.....	12:37:33	
I computer turn.....	12:37:33	
- effect on.....	12:37:33	
- move	12:37:33	
- move	12:37:33	
- unpack.....	12:37:33	
- move	12:37:33	
- unpack.....	12:37:33	
- effect off.....	12:37:33	
I turn done.....	12:37:33	
I side-to-play.....	12:37:33	
I SEO help.....	12:37:41	

- partickle info.....	12:37:41	thirty-five
| rotate	12:37:42	use of 'would do' partickle SEO information
| SEO help.....	12:37:45	
- partickle info.....	12:37:45	thirty-six
- [make move].....	12:37:46	23rd use of make move
| move	12:37:46	
| turn done.....	12:37:46	
| side-to-play.....	12:37:46	
| computer turn.....	12:37:47	
- effect on.....	12:37:47	
- rotate	12:37:47	
- move	12:37:49	
- jump.....	12:37:49	
- computer turn.....	12:37:50	
- rotate	12:37:50	
- move	12:37:51	
- jump.....	12:37:51	
- computer turn.....	12:37:51	
- effect off.....	12:37:51	
| turn done.....	12:37:51	
| side-to-play.....	12:37:51	
| rotate	12:37:53	
| SEO help.....	12:37:54	
- partickle info.....	12:37:54	thirty-seven
- [make move].....	12:37:57	24th use of make move
| move	12:37:57	
- combine.....	12:37:57	
| turn done.....	12:37:58	
| side-to-play.....	12:37:58	
| computer turn.....	12:37:58	
- effect on.....	12:37:58	
- rotate	12:37:58	
- move	12:37:59	
- swap.....	12:37:59	
- effect off.....	12:37:59	
| turn done.....	12:37:59	
| side-to-play.....	12:37:59	
| rotate	12:37:59	
| SEO help.....	12:38:03	
- partickle info.....	12:38:03	thirty-eight
| effect on.....	12:38:07	use of 'would do' partickle SEO information

|	SEO help.....	12:38:08						
-	partickle info.....	12:38:08	thirty-nine					
|	SEO help.....	12:38:11						
-	partickle info.....	12:38:11	forty					
-	[make move].....	12:38:13	25th use of make move					
|	move	12:38:13						
-	move	12:38:13						
-	effect off.....	12:38:13						
|	turn done.....	12:38:13						
|	side-to-play.....	12:38:13						
|	computer turn.....	12:38:13						
-	effect on.....	12:38:13						
-	rotate	12:38:13						
-	move	12:38:14						
-	computer turn.....	12:38:14						
-	rotate	12:38:14						
-	move	12:38:15						
-	unpack.....	12:38:15						
-	computer turn.....	12:38:15						
-	rotate	12:38:15						
-	move	12:38:16						
-	unpack.....	12:38:16						
-	computer turn.....	12:38:16						
-	rotate	12:38:16						
-	move	12:38:19						
-	unpack.....	12:38:19						
-	computer turn.....	12:38:19						
-	move	12:38:19						
-	unpack.....	12:38:19						
|	side has won.....	12:38:19	computer wins					
-	congratulate.....	12:38:19						
-	victory sound.....	12:38:19						
/	/	/	/	/	/	/	/	(entries removed)

Extracts from the Trace Record of Session V2

The extracts from session V2 comprise the explore and practise phase and all of the second game (apart from an uneventful two minute section). The session is described in detail in Appendix F. Only menu options were looked at during the explore and practise phase but info menu option: Partickles rules was read particularly thoroughly. The question pointer was the main pointer and the make move hot words box was used to make almost all moves in the first two

games. The subjects changed to the arrow pointer twice in the second game at 12:18:51 and 12:26:49. The first change was in place of make move for a single move which was part of a multiple step effect move, while the second was for a single turn consisting of a multiple step effect move. The subjects accessed and navigated the effects SEO help facility once in the second game at 12:22:17 and did not use menu-based help during the game playing phase. They won the second game and during their 25 turns they used the make move facility 36 times and obtained partickle SEO information 61 times. There are 17 examples in the trace record of the potential use of 'would do' partickle SEO information and the helpful appearance of an SEO error message occurs at 12:23:08. An interesting episode begins at 12:22:56 in which the subjects identify the problem of unpacking a partickle that is full of parts but doesn't contain an unpack part. After contemplating defeat, the subjects experiment and discover by reading 'would do' partickle SEO information that the unpack part can be *swapped* into a full partickle.

|	Partickles opened.....	11:27:31	
|	info menu.....	11:27:37	subject P's explore and practise phase
-	Partickles rules.....	11:27:43	(reads all, checks subject Q has finished before)
			(scrolling. Subjects swap mouse-use themselves)
|	players menu.....	11:33:53	subject Q's explore and practise phase
|	changes menu.....	11:34:05	
|	mouse menu.....	11:34:08	
-	which button.....	11:34:13	
|	info menu.....	11:34:55	
-	suggestions.....	11:35:02	skimmed through (avoiding Strategies section)
|	info menu.....	11:36:18	
-	getting started.....	11:36:26	start to read thoroughly but stopped by observer
			end of explore and practise phases
	/ / / / / / / /		(entries removed)
|	side-to-play.....	12:15:45	start of 2nd game

| rotate	12:15:45
| SEO help.....	12:15:46
- partickle info.....	12:15:46
- [make move].....	12:15:50
| move	12:15:50
- combine.....	12:15:50
| turn done.....	12:15:50
| side-to-play.....	12:15:50
| computer turn.....	12:15:50
- rotate	12:15:53
- move	12:15:54
- combine.....	12:15:54
| turn done.....	12:15:54
| side-to-play.....	12:15:54
| SEO help.....	12:15:56
- partickle info.....	12:15:56
| rotate	12:15:59
| SEO help.....	12:16:00
- partickle info.....	12:16:00
- [make move].....	12:16:03
| move	12:16:03
- combine.....	12:16:04
| turn done.....	12:16:04
| side-to-play.....	12:16:04
| computer turn.....	12:16:04
- rotate	12:16:06
- move	12:16:07
- combine.....	12:16:07
| turn done.....	12:16:07
| side-to-play.....	12:16:07
| rotate	12:16:09
| SEO help.....	12:16:13
- partickle info.....	12:16:13
- [make move].....	12:16:15
| move	12:16:15
- combine.....	12:16:15
| turn done.....	12:16:15
| side-to-play.....	12:16:15
| computer turn.....	12:16:15
- effect on.....	12:16:18
- rotate	12:16:18

use of 'would do' partickle SEO information

-	move	12:16:19
-	computer turn.....	12:16:19
-	move	12:16:20
-	unpack.....	12:16:20
-	computer turn.....	12:16:20
-	move	12:16:21
-	unpack.....	12:16:21
-	effect off.....	12:16:21
|	turn done.....	12:16:21
|	side-to-play.....	12:16:21
|	SEO help.....	12:16:31
-	partickle info.....	12:16:31
-	[make move].....	12:16:33
|	move	12:16:33
-	combine.....	12:16:33
|	turn done.....	12:16:33
|	side-to-play.....	12:16:33
/	/	/
/	/	/
/	/	/
/	/	/
|	turn done.....	12:18:24
|	side-to-play.....	12:18:24
|	rotate	12:18:31
|	SEO help.....	12:18:33
-	partickle info.....	12:18:33
|	effect on.....	12:18:37
|	SEO help.....	12:18:37
-	partickle info.....	12:18:37
|	rotate	12:18:39
|	SEO help.....	12:18:47
-	partickle info.....	12:18:47
|	control.....	12:18:51
-	exchange pointer.....	12:18:51
-	pointer sound	12:18:51
|	move	12:18:54
-	jump.....	12:18:54
-	rotate	12:18:56
|	control.....	12:18:59
-	exchange pointer.....	12:18:59
-	pointer sound	12:18:59
|	SEO help.....	12:19:01

(two minute section removed which mainly consisted of single moves, most of which involved building combined partickles. All the subject's moves were made using the question pointer and make move facility.)

use of 'would do' partickle SEO information

use of 'would do' partickle SEO information

switches to arrow pointer

part of move made using arrow pointer (a 4 step multiple effect move. 1st step made with arrow pointer, remaining 3 made with question pointer + make move facility)

switches to question pointer - in mid-move

- partickle info.....	12:19:01	
I rotate	12:19:03	use of 'would do' partickle SEO information
I SEO help.....	12:19:04	
- partickle info.....	12:19:04	
I rotate	12:19:05	use of 'would do' partickle SEO information
I SEO help.....	12:19:08	
- partickle info.....	12:19:08	
- [make move].....	12:19:22	
I move	12:19:22	
I SEO help.....	12:19:24	
- partickle info.....	12:19:24	
- [make move].....	12:19:26	
I move	12:19:26	
I SEO help.....	12:19:28	
- partickle info.....	12:19:28	
- [make move].....	12:19:29	
I move	12:19:29	
- effect off.....	12:19:29	
I turn done.....	12:19:29	
I side-to-play.....	12:19:29	
I computer turn.....	12:19:29	
- rotate	12:19:33	
- move	12:19:34	
I turn done.....	12:19:34	
I side-to-play.....	12:19:34	
I SEO help.....	12:19:43	
- partickle info.....	12:19:43	
I effect on.....	12:19:45	use of 'would do' partickle SEO information
I SEO help.....	12:19:46	
- partickle info.....	12:19:46	
I rotate	12:19:49	use of 'would do' partickle SEO information
I SEO help.....	12:19:51	
- partickle info.....	12:19:51	
I rotate	12:19:57	use of 'would do' partickle SEO information
I SEO help.....	12:19:58	
- partickle info.....	12:19:58	
I rotate	12:19:59	use of 'would do' partickle SEO information

|	SEO help.....	12:20:02	
-	partickle info.....	12:20:02	
-	[make move].....	12:20:04	
|	push	12:20:04	first move of a 4 step multiple effect move
-	move	12:20:04	
|	SEO help.....	12:20:11	
-	partickle info.....	12:20:11	
|	SEO help.....	12:20:28	
-	partickle info.....	12:20:28	
-	[make move].....	12:20:31	
|	move	12:20:31	
-	unpack.....	12:20:31	
|	SEO help.....	12:20:33	
-	partickle info.....	12:20:33	
|	rotate	12:20:45	
|	SEO help.....	12:20:47	
-	partickle info.....	12:20:47	
-	[make move].....	12:20:49	
|	move	12:20:49	
-	unpack.....	12:20:50	
-	rotate	12:20:51	
|	SEO help.....	12:20:54	
-	partickle info.....	12:20:54	
-	[make move].....	12:20:57	
|	move	12:20:57	
-	unpack.....	12:20:57	
-	effect off.....	12:20:57	
|	turn done.....	12:20:57	
|	side-to-play.....	12:20:57	
|	computer turn.....	12:20:57	
-	effect on.....	12:21:01	
-	rotate	12:21:01	
-	move	12:21:02	
-	computer turn.....	12:21:02	
-	rotate	12:21:04	
-	move	12:21:07	
-	computer turn.....	12:21:07	
-	move	12:21:08	
-	computer turn.....	12:21:08	
-	rotate	12:21:09	
-	move	12:21:09	
-	effect off.....	12:21:09	
|	turn done.....	12:21:09	
|	side-to-play.....	12:21:09	

| SEO help.....	12:21:13	
- partickle info.....	12:21:13	
| effect on.....	12:21:18	use of 'would do' partickle SEO information
| SEO help.....	12:21:19	
- partickle info.....	12:21:19	
- [make move].....	12:21:24	
| push	12:21:24	
- move	12:21:24	
- effect off.....	12:21:24	
| turn done.....	12:21:24	
| side-to-play.....	12:21:24	
| computer turn.....	12:21:24	
- effect on.....	12:21:27	
- move	12:21:28	
- computer turn.....	12:21:28	
- rotate	12:21:28	
- move	12:21:28	
- computer turn.....	12:21:29	
- move	12:21:29	
- computer turn.....	12:21:29	
- rotate	12:21:29	
- move	12:21:32	
- effect off.....	12:21:32	
| turn done.....	12:21:32	
| side-to-play.....	12:21:32	
| rotate	12:21:35	
- effect on.....	12:21:36	
| SEO help.....	12:21:36	
- partickle info.....	12:21:36	
| effect off.....	12:21:48	use of 'would do' partickle SEO information
| SEO help.....	12:21:49	
- partickle info.....	12:21:49	
- [make move].....	12:21:52	
| move	12:21:52	
- combine.....	12:21:52	
| turn done.....	12:21:53	
| side-to-play.....	12:21:53	
| computer turn.....	12:21:53	
- rotate	12:21:55	
- move	12:21:56	
- combine.....	12:21:56	
| turn done.....	12:21:56	
| side-to-play.....	12:21:56	

I effect on.....12:21:59	checks several partickles reading 'would do' partickle SEO information below
I SEO help.....12:21:59	
- partickle info.....12:21:59	
I effect off.....12:22:01	
I SEO help.....12:22:03	
- partickle info.....12:22:03	
I effect on.....12:22:04	
I SEO help.....12:22:05	
- partickle info.....12:22:05	
I effect off.....12:22:06	
I SEO help.....12:22:07	
- partickle info.....12:22:07	
- [help].....12:22:13	
- [effects].....12:22:17	effects SEO help facility
- [push].....12:22:36	navigated as far as push and read re. enquiry about pushing more than one partickle at a time
I SEO help.....12:22:43	
I effect on.....12:22:48	
I SEO help.....12:22:49	
- partickle info.....12:22:49	use of partickle SEO information to check several partickles here and below:
I SEO help.....12:22:53	
- partickle info.....12:22:53	
I SEO help.....12:22:56	
- partickle info.....12:22:56	subjects begin to discuss problem of unpacking a 5x combination that doesn't contain an unpack part
I SEO help.....12:23:04	
- partickle info.....12:23:04	
- [make move].....12:23:08	SEO error message appears: "Cannot make the described move because another partickle has been highlighted". Subjects unhighlight it by switching effect off.
I effect off.....12:23:16	
I SEO help.....12:23:18	
- partickle info.....12:23:18	
- [make move].....12:23:21	
I move.....12:23:22	
- combine.....12:23:22	
I turn done.....12:23:22	
I side-to-play.....12:23:22	
I computer turn.....12:23:22	
- effect on.....12:23:24	
- rotate.....12:23:24	
- push.....12:23:27	
- move.....12:23:27	

-	move	12:23:27
-	effect off.....	12:23:27
|	turn done.....	12:23:27
|	side-to-play.....	12:23:27
|	rotate	12:23:30
-	effect on.....	12:23:48
|	SEO help.....	12:23:49
-	partickle info.....	12:23:49
-	[make move].....	12:23:59
|	move	12:23:59
|	SEO help.....	12:24:01
-	partickle info.....	12:24:01
-	[make move].....	12:24:03
|	move	12:24:03
-	unpack.....	12:24:04
|	SEO help.....	12:24:05
-	partickle info.....	12:24:05
-	[make move].....	12:24:07
|	move	12:24:07
-	unpack.....	12:24:07
-	effect off.....	12:24:07
|	turn done.....	12:24:07
|	side-to-play.....	12:24:07
|	computer turn.....	12:24:07
-	effect on.....	12:24:08
-	rotate	12:24:08
-	move	12:24:09
-	move	12:24:09
-	effect off.....	12:24:09
|	turn done.....	12:24:09
|	side-to-play.....	12:24:09
|	rotate	12:24:09
|	SEO help.....	12:24:13
-	partickle info.....	12:24:13
-	[make move].....	12:24:17
|	move	12:24:17
|	turn done.....	12:24:17
|	side-to-play.....	12:24:17
|	computer turn.....	12:24:17
-	effect on.....	12:24:18
-	rotate	12:24:18
-	move	12:24:18

first move in a 3 step multiple effect move to get the unpack part to the 5x combination

moves unpack partickle up to the 5x combination (subjects discuss possible defeat if the 5x) (combination can't be unpacked)

- computer turn.....12:24:18
 - move12:24:18
 - computer turn.....12:24:19
 - effect off.....12:24:19

I turn done.....12:24:19
 I side-to-play.....12:24:19

I SEO help.....12:24:45
 - partickle info.....12:24:45

I effect on.....12:24:47

I SEO help.....12:24:48
 - partickle info.....12:24:48
 - [make move].....12:24:52

I move12:24:52
 - swap.....12:24:53
 - effect off.....12:24:53

I turn done.....12:24:53
 I side-to-play.....12:24:53

I computer turn.....12:24:53
 - rotate12:24:53
 - move12:24:53
 - combine.....12:24:54

I turn done.....12:24:54
 I side-to-play.....12:24:54

I effect on.....12:24:59

I SEO help.....12:24:59
 - partickle info.....12:25:00
 - [make move].....12:25:03

I move12:25:03

I SEO help.....12:25:05
 - partickle info.....12:25:05
 - [make move].....12:25:07

I move12:25:07
 - unpack.....12:25:07

I SEO help.....12:25:08
 - partickle info.....12:25:09
 - [make move].....12:25:10

I move12:25:10
 - unpack.....12:25:10

I SEO help.....12:25:11
 - partickle info.....12:25:11
 - [make move].....12:25:13

Subjects attempt to combine the unpack partickle with the full 5x combined partickle - but the 'would do' partickle SEO information says: "The partickle cannot make a non-effect move". The subjects switch effect on and obtain more partickle SEO information. The 'would do' partickle SEO information says: "The partickle would swap." Subjects exclaim: "Swap!" and do it.

successful swap of unpack part into 5x combination

first move of 5 step multiple effect move to unpack the 5x combined partickle

|	move	12:25:13
-	unpack.....	12:25:13
-	rotate	12:25:16
|	SEO help.....	12:25:17
-	partickle info.....	12:25:17
-	[make move].....	12:25:19
|	move	12:25:19
-	unpack.....	12:25:19
-	effect off.....	12:25:19
|	turn done.....	12:25:19
|	side-to-play.....	12:25:19
|	computer turn.....	12:25:19
-	effect on.....	12:25:19
-	rotate	12:25:19
-	push	12:25:20
-	move	12:25:20
-	computer turn.....	12:25:21
-	rotate	12:25:21
-	move	12:25:22
-	unpack.....	12:25:22
-	computer turn.....	12:25:22
-	rotate	12:25:22
-	move	12:25:25
-	unpack.....	12:25:25
-	computer turn.....	12:25:25
-	rotate	12:25:26
-	move	12:25:27
-	unpack.....	12:25:27
-	effect off.....	12:25:27
|	turn done.....	12:25:27
|	side-to-play.....	12:25:27
|	effect on.....	12:25:34
|	SEO help.....	12:25:35
-	partickle info.....	12:25:35
-	[make move].....	12:25:37
|	push	12:25:37
-	move	12:25:37
-	effect off.....	12:25:37
|	turn done.....	12:25:37
|	side-to-play.....	12:25:37
|	computer turn.....	12:25:37
-	rotate	12:25:38
-	move	12:25:39
|	turn done.....	12:25:39
|	side-to-play.....	12:25:39

| SEO help.....12:25:42
 - partickle info.....12:25:42
 - [make move].....12:25:44

 | move12:25:44

 | turn done.....12:25:44
 | side-to-play.....12:25:44

 | computer turn.....12:25:44
 - rotate12:25:45
 - move12:25:45

 | turn done.....12:25:45
 | side-to-play.....12:25:45

 | rotate12:25:55

 | SEO help.....12:25:57
 - partickle info.....12:25:57
 - [make move].....12:26:00

 | move12:26:01
 - combine.....12:26:01

 | turn done.....12:26:01
 | side-to-play.....12:26:01

 | computer turn.....12:26:01
 - move12:26:01

 | turn done.....12:26:01
 | side-to-play.....12:26:01

 | SEO help.....12:26:03
 - partickle info.....12:26:04

 | effect on.....12:26:05

 | SEO help.....12:26:07
 - partickle info.....12:26:07
 - [make move].....12:26:09

 | move12:26:09
 - move12:26:09
 - unpack.....12:26:10
 - effect off.....12:26:10

 | turn done.....12:26:10
 | side-to-play.....12:26:10

 | computer turn.....12:26:10
 - rotate12:26:10
 - move12:26:11

 | turn done.....12:26:11
 | side-to-play.....12:26:11

use of 'would do' partickle SEO information

|	SEO help.....	12:26:15	
-	partickle info.....	12:26:15	
-	[make move].....	12:26:17	
|	move	12:26:18	
-	combine.....	12:26:18	
|	turn done.....	12:26:18	
|	side-to-play.....	12:26:18	
|	computer turn.....	12:26:18	
-	rotate	12:26:18	
-	move	12:26:18	
-	combine.....	12:26:19	
|	turn done.....	12:26:19	
|	side-to-play.....	12:26:19	
|	rotate	12:26:22	
|	SEO help.....	12:26:39	
-	partickle info.....	12:26:40	
|	effect on.....	12:26:41	
|	SEO help.....	12:26:42	
-	partickle info.....	12:26:42	
|	control.....	12:26:49	
-	exchange pointer.....	12:26:49	switches to arrow pointer (for multiple move)
-	pointer sound	12:26:49	
|	push	12:26:53	
-	move	12:26:53	
-	move	12:26:54	
-	unpack.....	12:26:54	
-	move	12:26:54	
-	unpack.....	12:26:54	
|	side has won.....	12:26:54	subjects win 2nd game
-	congratulate.....	12:26:54	
-	victory sound.....	12:26:54	

Details of the Pilot Study Sessions

Introduction

Each session description contains details of: the number of games played, impressions of subjects' progress, details from the explore and practise phase, the usage of object-based help and of pointers, the usage of the effects SEO help facility and the usage of menu-based help. The descriptions attempt to capture the 'stories' of subjects' encounters with Partickles, but they have been kept brief because the pilot study produced fewer significant findings than the core or video studies. The timings given at the beginning of session descriptions indicate the time spent during and between the two Partickles phases.

There were nine pilot study sessions. Two of the pilot study subjects returned for second sessions with Partickles, but all of the pilot study subjects were still learning the game at the end of the sessions and consequently none of the subjects won a game against the computer player.

Session P1a - subject A - 40 minutes

Subject A played two games against the computer in her first session. The subject initially just made 'safe', single, non-effect moves and only combined partickles once during the twelve and a half minutes of the explore and practise phase. The observer's notes state that in the game playing phase her observations of the computer player "started expansion" of her repertoire of moves.

At the start of the explore and practise phase the subject rotated a partickle and switched effect on - but got stuck because this is modal (allowing no other

partickle to be moved or rotated). After 2 minutes and 40 seconds of futile partickle-clicking she selected help menu option: getting started. She read this for 47 seconds then looked at help menu option: suggestions for 32 seconds. After this she was able to switch effect on and off without difficulty - possibly because help menu option: getting started had broadened her conception of what making moves involved. No other help facilities were accessed during the explore and practise phase.

The observer demonstrated SEO and other help facilities at the end of the explore and practise phase but the subject did not access any form of help during the game playing phase.

Session P1b - subject A - 56 minutes

Subject A played four games against the computer in her second session. She came fairly close to winning the 2nd game but couldn't win because she didn't know how to unpack combined partickles. In the 3rd game, rather than trying to win, the subject tried experimenting with moves. She could have won the 4th game but still didn't know how to unpack.

The subject spent the 6 minutes and 12 seconds of the explore and practise phase just making moves. She did not use any menu-based help options during this session. After the 3rd game the observer asked, "Had you thought about changing pointers in the game?" Six moves into the 4th game the subject changed pointers and obtained partickle SEO information 16 times and in between these accesses rotated partickles and switched effect on and off which suggests use of 'would do' information. All the partickle SEO information was obtained contiguously in one period.

Session P2a - subject B - 45 minutes

Subject B played two games against the computer. He spent the first fifteen minutes of the explore and practise phase just making partickle moves without using any form of help or knowing the aim of the game. However, he did learn about making moves and about all three mouse buttons. Consequently the observer briefing at the end of the explore and practise phase was quite thorough and included all the Partickles help facilities.

The subject didn't use SEO help facilities at all during this session. He accessed help menu option: Partickles rules seven and a half minutes into the first game (he wanted and found further information about making moves) and again, briefly, about seven and a half minutes into the second game.

Session P2b - subject B - 31 minutes

The subject played three games against the computer in this session, and gradually improved his knowledge of the game. The subject just made moves for the three and a half minutes of the explore and practise phase, after which a short observer briefing described all 4 menus, but not the SEO help facilities.

Seven and a half minutes after the start of the first game the subject accessed help menu option: Partickles rules in order to find out how to unpack partickles (the observer asked about this afterwards), and shook his head <observer's notes> when confronted by what may have seemed a large amount of text. Seven minutes later the observer suggested further exploration and the subject chose help menu option: suggestions. During the third game the subject agreed with the observer's comment that, "You still haven't found it yet", and the observer suggested changing pointers. The subject did, obtained partickle SEO information and as he read it turned to the observer and grinned. The observer's

notes state, "He had found what he was looking for!" The trace record indicates that the subject only unpacked one partickle during the short time that remained and at the end of the session when he was asked, "Do you know how to unpack now?", the subject said, "I think so, yeh". The subject had obtained partickle SEO information five times contiguously while manipulating partickles (suggesting the use of 'would do' information), and he also described obtaining 'would do' partickle SEO information at the end of the session.

Session P3 - subject C - 42 minutes

Subject C played four short games. The subject learned slowly but steadily and enjoyed doing so - the observer's notes state that she was "v. keen to try a fourth <game>". Subject C's first action was to click a side-to-play box before making a move, then she obtained control SEO information about a side-to-play box. These actions were repeated after which the subject obtained partickle SEO information 12 times and control SEO information 10 times interspersed with making moves. The explore and practise phase lasted 17 minutes and after the initial period in which object-based help was obtained the subject just made partickle moves - playing for both sides and discovering the functions of the mouse buttons.

The subject accessed object-based help in four 'groups' during the first 8 minutes of the explore and practise phase, but at no other time, and there is no evidence that she was using 'would do' partickle SEO information. She did not use object-based help again after this.

Subject C did not use the effects SEO help facility or menu-based help during the session. The observer briefing and object-based help may have provided sufficient background knowledge to assist comprehension of basic rules

regarding moves and effects, but the subject did not progress further than this and did not encounter any problems which might have necessitated reference.

Session P4 - subject D - 51 minutes

Subject D played four games against the computer but did not learn all the basic game rules. He began by spending 65 seconds with help menu option: Partickles rules, then 41 seconds with mouse menu option: which button, after which he made moves and switched the side-to-play boxes for four and a half minutes. Then he began a second burst of information gathering which included: turning trace on then off, turning the sound off, looking at two mouse menu options (which may have reminded him about the facility for changing pointers), changing pointers and obtaining partickle SEO information 4 times while manipulating partickles (suggesting use of 'would do' information). The observer's notes state that the subject changed the pointer back to the arrow after he found that he couldn't move partickles with the question pointer. During the game playing phase the subject accessed help menu option: suggestions (which he hadn't looked at before) and obtained partickle SEO information once.

Session P5 - subject E - 43 minutes

Subject E played two games against the computer. His early progress was slowed by difficulties with the mouse which the observer briefing helped him solve and during the game playing phase he became fluent in making moves and began to experiment with playing strategies.

The explore and practise phase lasted 22 minutes. The subject spent the first 15 minutes clicking partickles and side-to-play boxes using just the left mouse button. After 9 minutes, when all the partickles of both sides had moved as far

as they could without being rotated (which would have required the middle mouse button), the subject asked the observer, "Do I have to get rid of them all?" Six minutes later the subject obtained partickle SEO information twice and control SEO information once then looked at help menu option: Partickles rules and checked the players and changes menus. Shortly afterwards (having tried futilely to make moves again) the subject obtained partickle SEO information 5 more times and control SEO information 4 more times.

The observer briefing at the end of the explore and practise phase included an explanation of the functions of the mouse buttons and demonstrations of mouse menu option: which button and help menu option: about the program. The subject did not access any form of help during the game playing phase.

Session P6 - subject F - 47 minutes

Subject F played two games against the computer and made slow progress throughout the session. For the first 13 minutes of the explore and practise phase the subject moved and manipulated partickles - gradually learning about combining, rotating and switching effect on and off. The observer then suggested that she try looking at some of the other parts of the program and she changed pointers and obtained partickle SEO information 6 times, then asked if she could press a hot words box. She chose colours and navigated as far as colours: step, then tried move value. She switched demo-mode on, but a game was already in progress (hence no result). She switched trace on (it remained on for 11 minutes until the observer switched this, and demo-mode, off) obtained partickle SEO information once more, reset the board then obtained partickle SEO information and clicked the move value hot words box.

The subject began the first game during the explore and practise phase by selecting person v computer from the players menu. Two minutes and forty seconds later the observer interrupted the game (because the subject said she wanted to continue it) for the observer briefing after which the subject did not access any form of help. Menu-based help options were demonstrated to the subject in the observer briefing but the subject did not use these at all during the session.

Session P7 - subject G - 1 hour and 20 minutes

In this long session subject G played eleven games against the computer and may have experienced difficulty in changing pointers and in reading. As a client of the school's special needs department the subject was superficially familiar with computers and highly competent at learning to perform, and performing, tasks such as setting up games. By the end of the session the subject knew about moving and combining partickles and making effect moves - but not about complex effect moves such as multiple step moves and it was only during the last few games that the subject competently made unpack effect moves - which are essential for winning. The subject made progress, but he did not locate a source of help information that he was able to use easily, though there is slight evidence that the SEO help facilities were useful.

At the start of the explore and practise phase the subject changed pointers and changed back again (without using the question pointer), selected the players menu option: random first turn, clicked side-to-play box(es) twice and looked at the changes, help and mouse menus. Then the subject looked at help menu option: getting started for two minutes, and this was followed by clicking a side-to-play box and making a move with a partickle. After trying out two changes menu options (sound and icon bar) the subject experimented with making

moves and then selected players menu option: computer versus computer. This started a computer versus computer game which the subject tried to stop rather than watch. He began to select other options six seconds after the game began and two minutes later he successfully stopped the game. He then set up and started a person versus computer game.

The observer intervention which prompted the subject to begin using SEO facilities occurred after the 6th game. The observer asked, "Do you know how to find out information about particular partickles?" and the subject responded by immediately changing pointers. He then obtained partickle SEO information, used make move and explored the effects SEO help facility as far as colours: unpack: ...unpack. Two and a half minutes later, during the 7th game, the subject obtained partickle SEO information and used make move successfully once, then obtained partickle SEO information again. This time he chose move value, but this was probably a mistake arising from having selected a partickle that couldn't make a move and then selecting move value in place of the absent make move box. During the 8th game the subject changed pointers (with some difficulty) and obtained partickle SEO information during a computer turn after which he obtained partickle SEO information, clicked move value and then navigated the effects SEO help facility as far as colours: unpack: ...unpack. He went from ...unpack to unpack and then back again which suggests that this information was of interest to him and his comments to the observer around this time indicate that he particularly wanted to find out about unpacking. The subject might have made greater use of the SEO facilities if he hadn't had difficulty changing pointers due to a tendency to double-click mouse buttons. This tendency could have resulted from the observer advising subject G to "hammer away at the mouse buttons" during the computer versus computer

game - which was appropriate advice in that context. There are several examples of double-clicking in the trace record.

The observer briefing (at the end of the explore and practise phase) had occurred during the middle of the 1st game and included all three mouse menu options. At the end of the 7th game the subject looked at mouse menu options: which pointer and about mousing again. These two options and help menu option: getting started (in the explore and practise phase) were the only menu help options that the subject was not (probably) influenced to choose, but at the end of the 4th game the observer prompted, "Don't forget that there are all sorts of ways of finding things out" and the subject then looked at help menu option: Partickles rules and mouse menu option: which button.

Details of the Core Study Sessions

Introduction

Each session description contains details of: subjects' progress in learning and game playing; the usage of object-based help, the effects SEO help facility, menu-based help and pointers; observer interventions; changes and variance of help facility usage within sessions and accounts of illustrative, exemplary and/or unusual incidents. The results relate to the twelve features of sessions listed in the method section of Chapter 7 and the descriptions attempt to capture the 'stories' of subjects' encounters with Partickles. The timings given at the beginning of session descriptions indicate the time spent during and between the two Partickles phases.

Session C1 - subject H - 45 minutes

Subject H played one game against the computer and lost, but ended the session with sufficient knowledge and experience to be able to beat the computer player. This was indicated by the quality of his play in the later stages of the game and demonstrated by several victories against the computer player (achieved jointly with subject I) in the video pilot session which is described at the end of Chapter 5.

Subject H began the explore and practise phase by reading help menu options: getting started (for two minutes and forty-two seconds), Partickles rules (for four minutes and four seconds) then suggestions (for twenty-five seconds). After this he obtained object-based help five times contiguously as follows: three partickle SEO information accesses, one control SEO information access for a side-to-play box then a further partickle SEO information access. After glancing

at the changes menu options he selected the colours hot words box but did not navigate the effects SEO help facility any further. He selected the move value hot words box then briefly looked at help menu options: status info (for twenty-nine seconds) and about the program (for one minute and eight seconds). He selected changes menu options: demo-mode and trace and he spent the last three and a half minutes of the explore and practise phase watching a computer versus computer demonstration game and, perhaps, reading the output from the trace facility. This had been a fairly thorough examination of the Partickles help facilities, but the subject had not selected a mouse menu option or practised making moves with partickles during the explore and practise phase.

Subject H obtained partickle SEO information a further twenty-seven times during the game playing phase. Evidence that he progressed from using descriptive partickle SEO information to 'would do' partickle SEO information. was provided, in the later stages of the game, by the subject adjusting the state of partickles with the rotate and effect buttons before obtaining partickle SEO information about them. There are seven examples of this in the trace record. However, after using the question pointer to obtain partickle SEO information the subject always changed back to the arrow pointer in order to make a move.

Subject H didn't navigate the effects SEO help facility. When it was demonstrated to him at the end of the session he expressed the opinion that the effects SEO help facility would have been more "convenient" <his word> than the method he had used which was to access the information in help menu option: Partickles rules. However, the subject did access the effects SEO help facility five times - once to investigate the facility in the explore and practise phase and four times during the game to obtain information from the five hot words boxes that appear when the colours hot words box is clicked. The

subject was able to derive information from this source because the colours and labels (indicating effects) of the five hot words boxes match partickle colours to partickle effects and because the five hot words boxes group this information and present it in a sequence that relates to the priorities of effects. The five hot words boxes had not been intended to be used in this way since most of this information would have been presented by the effects SEO help facility if its five hot words boxes had been clicked. Nevertheless, as he accessed the effects SEO help facility for the final time the subject correctly conjectured that the arrangement of the five hot words boxes reflected the order in which partickle parts are unpacked and swapped.

The subject accessed help menu option: Partickles rules 7 times during the game playing phase, but twice the accesses immediately followed a previous access. He also accessed help menu option: getting started, but closed its window after only 5 seconds. The subject *used* help menu option: Partickles rules on five occasions during the game playing phase in order to find out about partickle effects and to research specific problems. After the game playing phase, when the subject had been shown the effects SEO help facility, the observer asked:

Obsv: "How useful did you find the help information?"

Subj: "Well, I was relying on that totally, especially about that <in help menu option: Partickles rules> that I could have got using that other method <the effects SEO help facility>. Maybe there's more about that in 'about the program' <a help menu option> - should have read that more."

Subject H was correct in assuming that there was information regarding the effects SEO help facility in help menu option: about the program, but the information was very limited and it is possible that the SEO facilities were under-documented in the help menu options. It is worth noting the phrase

"relying on that totally" in relation to the subject's strategy for learning about the domain and the system - which was to use help to check everything new or indeterminate while constraining himself to win the first game (which he did not achieve though he made a very creditable attempt). This self-constraint reduced the option of discovery by trial and error - since he was unwilling to make errors. He was prepared to learn by observation, however, and during the explore and practise phase he sat back in his chair very deliberately to observe a computer versus computer game for three and a half minutes.

Session C2 - subject I - 39 minutes

Subject I played one game against the computer and won. The computer player did not play a strong game, but even so the subject's victory in his first game indicates some effective playing strategies, a good grasp of the rules and competence with the system.

The subject began the explore and practise phase by reading help menu option: getting started for three and a half minutes, after which he commented "It's a bit complicated isn't it". This was a reasonable criticism of the amount of detail in this help option - but the complexity might have been reduced had the subject explored and practised some of the features it described and hence distributed the memory load between reading and observation/experience. The subject looked at all the menus during the explore and practise phase, read help menu option: Partickles rules for three and a half minutes and help menu option: suggestions for one and a half minutes. He also selected a players menu option and then changes menu option: demo-mode which began a computer versus computer game that lasted for one and a half minutes.

During the Partickles phases the subject accessed partickle SEO information 46 times in order to obtain descriptive partickle SEO information. The trace record shows that the subject did not manipulate partickles before obtaining partickle SEO information and this suggests that 'would do' partickle SEO information was not used. Two of the subject's comments showed that he was using the descriptive partickle SEO information:

- He explained why he was obtaining partickle SEO information by saying, "I've forgotten what step is, now". On this occasion he was using partickle SEO information to find a partickle with the description: "The partickle can ... step" in its speech bubble.
- After obtaining partickle SEO information three times consecutively the subject said, "What's this thing?" and then clicked on another partickle. The question indicates that he was seeking descriptive information.

The subject began the game playing phase by opening the help and mouse menus, but did not select a menu option. He then obtained descriptive partickle SEO information 8 times contiguously before making his first move. Six minutes after the start of the game - by which time the subject had obtained partickle SEO information 18 times - the subject investigated effect moves by accessing help menu option: Partickles rules for 1 minute and 16 seconds to find out how to make a push effect move, then mouse menu option: which button to briefly check which mouse button selected effect move mode. The subject then made his first effect move successfully. Later the subject accessed help menu option: Partickles rules twice briefly to match effects to colours and the observer then demonstrated the effects SEO help facility (because subject H, in the previous session, had claimed he was not aware of this facility). The subject did not access any more menu-based help options, but he did use (and navigate) the effects SEO help facility twice - 7 minutes and 11 minutes after the

demonstration. In both cases help was required in regard to specific problems. The subject might have made more use of the effects SEO help facility had he been aware of it earlier, but by the time it was demonstrated to him he was already past the initial learning stage. While demonstrating the effects SEO help facility the observer also mentioned the make move facility and the subject tried this once immediately but did not use it again. Apart from this occurrence the subject made all his moves using the arrow pointer.

Session C3 - subject J - 1 hour and 13 minutes

Subject J played five games against the computer - losing the first three but winning the fourth and only narrowly losing the fifth. This record suggests that in addition to his use of Partickles' help facilities the subject had been prepared to learn by trial and error, and that by the fourth game he had become a fairly competent player.

In the explore and practise phase the subject methodically examined all the menu-based help options: scanning, reading and scrolling through large sections of information in help menu options: getting started, Partickles rules, about the program and suggestions, then selecting and quickly glancing at the three mouse menu options and help menu option: status info. After examining all the menu-based help options the subject selected players menu option: person v computer and began making partickle moves (at which point the observer ended the phase). The subject had not used SEO help facilities during the explore and practise phase, but these were demonstrated to him during the observer briefing.

The subject obtained partickle SEO information 18 times during the first three games, but apparently only to obtain descriptive partickle SEO information. The

observer's notes state that three minutes after the first game began the subject was "using SEO extensively to check partickle types". The observer's notes also mention that after the third game the subject was "not using 3 button SEO" which indicates that he wasn't rotating partickles or switching effect on or off in order to obtain 'would do' partickle SEO information.

Subject J did not navigate the effects SEO help facility. The observer briefing at the end of the explore and practise phase had included a demonstration of the SEO help facilities and the observer demonstrated these again at the end of the first game with the emphasis on the make move facility and 'would do' partickle SEO information using the rotate and effect buttons. The subject tried the make move facility four minutes later, but did not use it again.

Apart from his initial examination of the menu-based help the subject only accessed help menu options: getting started and Partickles rules once each in order to find out how to reset the board for the second game (the observer provided this information), and he later accessed Partickles rules once to determine the function of resist parts. This was at the end of the third game. The subject wished to know about the resist effect and the observer suggested finding this out. The subject immediately changed to the question pointer (a potentially significant response to the recognition of a need for help), accessed the effects SEO help facility and looked at the information represented by the five hot words boxes, but did not navigate further (i.e. he did not click any of the five hot words boxes). He then selected help menu option: Partickles rules and found the information he was seeking there. After this the observer talked the subject through obtaining the same information with the effects SEO help facility. However, the subject had already learned most of the information in the effects SEO help facility by then. The only form of help used in the

remainder of the 3rd game were two partickle SEO information accesses, and the subject did not use any help facility during the 4th and 5th games.

Session C4 - subject K - 1 hour and 38 minutes

Subject K played twelve games against the computer and won the fifth and twelfth games. The subject won the fifth game by the fortuitous use of simple strategies, but he seemed unable to repeat this victory. The following comments reflect the subject's developing realisation that a change of learning strategy was needed.

After winning the 5th game:

Subj: "<pleased> And I let him start as well didn't I?"

After losing the 7th game:

Subj: "Good game... addictive."

After losing the 9th game:

Subj: "Seems to be getting harder."

These comments might suggest: optimism, determination and eventual frustration. In saying that the game was "getting harder" the subject was admitting that something was wrong. The disparity between the computer's level of play and that of the subject had remained more or less constant, because neither player was improving. However, the subject had expected to improve and as a consequence he attributed the computer player with a similar, if not greater, improvement.

After the ninth game the observer demonstrated the SEO facilities for the third time. The subject started to use SEO help facilities frequently in the tenth game and continued to use them, with diminishing frequency but greater precision,

until the end of the session. The subject achieved closer results in the 10th and 11th games and won the 12th game. This indicates that the 'would do' partickle SEO information he was using had enabled him to move from a state in which he was making little or no progress to one in which he was learning effectively.

The subject did not use any SEO facilities in the explore and practise phase. He began the phase by glancing at all four menus then read help menu option: getting started for 41 seconds, help menu option: Partickles rules for 2 minutes and 37 seconds and the first part of help menu option: suggestions for 50 seconds. He then explored three changes menu options and watched a computer versus computer game for about one and a half minutes. When he was ready to continue exploring the observer helped him interrupt the computer versus computer game and the subject reset the game board, looked at help menu option: getting started for a further 20 seconds, then set up and started a game against the computer.

The subject used help menu options: getting started and Partickles rules during the first game, but was unable to find the information he was looking for. He also accessed Partickles rules three times during the second game to match partickle colours to effects:

Subj: "<rhetorical> It jumped over me - which one does that then - orange isn't it?"

This prompted the observer to demonstrate SEO help facilities for a second time (the first had been during the observer briefing at the end of the explore and practise phase). The demonstration was achieved by talking the subject through the process of finding the information in the effects SEO help facility:

Obsv: "Can I show you an alternative way of finding that information - Can you change pointers - Now click on a partickle - If you choose

colours - And then push - You've got exactly that same text that you got that other way."

Subj: "Yeh, I think that's a bit quicker."

The subject did not access any help facility during the 3rd, 4th, 5th, 6th, 7th, 8th and 9th games. After the 9th game the observer demonstrated the use of the SEO help facilities for the third time - this time emphasising the possibilities of the make move facility. This was almost three quarters of an hour since the previous demonstration. There was time for three more games which are described in some detail below. The subject used object-based help 72 times in the last three games but had only used it twice (following the observer's demonstrations) before that.

In the 10th game the subject obtained partickle SEO information 15 times and additionally obtained partickle SEO information and used the make move facility 25 times. He made moves using the arrow pointer on only 5 of his turns - these were consecutive turns and in the middle of the fifth he changed back to the question pointer and completed the turn using the make move facility. This demonstrates that the subject was prepared to use, and might even have reasons for preferring, the question pointer mode. Four and a half minutes after the start of the 10th game the subject asked if SEO help facilities would give information regarding which partickle would be unpacked:

Subj: "Can I <indicating a combined partickle and meaning the SEO help facilities> find out what partickle it would unpack?"

Obsv: "You can but not by directly enquiring, you'd have to go into colours <the effects SEO help facility> and find out which is the partickle that is unpacked first."

He navigated the effects SEO help facility as far as colours: unpack: ...unpack, but in scrolling and scanning he missed the answer and the observer (who had stated that the information was there) was obliged to point this out to him.

In the 11th game the subject obtained partickle SEO information 8 times and additionally obtained partickle SEO information and used the make move facility 16 times. He made moves using the arrow pointer on 18 of his turns, though some of these moves were preceded by, or included, partickle SEO information and/or the make move facility. The subject lost the 11th game, though he could have won - he seemed to get over-excited at the end and did not use the question pointer. However, the question pointer had been the main pointer during this game.

In the 12th game the subject obtained partickle SEO information 6 times and additionally obtained partickle SEO information and used the make move facility 3 times. The arrow pointer was the main pointer during this game, but the subject had included 'would do' partickle SEO information in his repertoire of activities and, significantly, obtained 'would do' partickle SEO information at moments of uncertainty or to double-check before important moves. The subject won the 12th game and used the make move facility to make the winning move.

Session C5 - subject L - 41 minutes

Subject L played and lost three games against the computer player, but the third game was closest. After the third game the observer and the subject discussed this result :

Obsv: "Well, it <the computer player> got there, but you've got two partickles on the centre line, one ... partickle on its own side, all the

others are on the other side and you've only got one left to unpack. And you've found out how to unpack. So, you're making good progress."

Subj: "Um <affirmative>. I tried to block him in there - I had two there <points to screen>, one there. To see if I could block him in, but he jumped over me so that didn't work."

Obsv: "Do you know which is the one that jumps... which is the jump part?"

Subj: "Orange one is it?"

Obsv: "Yup."

Subj: "The one that jumps."

The subject learned by observation and trial and error plus two periods of reference to menu-based help options, but by the end of the session he was still unsure about some of the more complex partickle moves. The subject constrained himself not to use help facilities during games.

At the beginning of the explore and practise phase the subject worked his way vertically down the list of help menu options. He read or scanned through most of them, but merely glanced at **getting started** - apparently saving this for when he was ready to start. When he had looked at all the help menu options he selected the **changes** menu, switched **trace** on and then selected **demo-mode** which started a computer versus computer demonstration game. He watched this for two and a quarter minutes before ending the demonstration (with the observer's assistance). At that point he seemed to consider that the explore and practise phase was over (or, at least, the explore phase), he consulted help menu option: **getting started** for 1 minute and 16 seconds then set up and started a person versus computer game.

Although he seemed to read the 'Self-Explanatory Objects' section in help menu option: about the program and the SEO help facilities were demonstrated to him at the end of the explore and practise phase in the observer briefing, the subject made no use of the SEO help facilities during the session. The subject was aware of the SEO facilities, but hadn't used them. The observer obtained confirmation that, before the third game, the subject had been looking for information about unpacking partickles in the help menu options and added:

Obsv: "There is another way to find out more directly about partickles..."

Subj: "Using the... <points to the question pointer>."

Since the first game had started during the explore and practise phase the observer briefing took place between the first and second games. At the beginning of the second game the subject consulted mouse menu option: which button - which had been mentioned in the observer briefing. During the second game the subject accessed help menu options: Partickles rules and getting started in order to find out how to unpack partickles and he also checked mouse menu option: which button again. After losing the first two games and before starting the third the subject looked at help menu options: about the program, getting started and Partickles rules (in which he found out how to unpack) then mouse menu options: about mousing and which pointer, but he did not obtain any help during the third game.

Session C6 - subject M - 1 hour and 45 minutes

Session C6 was a long session in which the subject played twelve games against the computer and won five of them. The subject made slow but effective progress, winning the 4th, 8th, 10th, 11th and 12th games. At the start of the explore and practise phase the subject scrolled through, and seemed to read,

help menu options: Partickles rules and getting started and he also looked at help menu options: about the program and status info. The observer intervened during the explore and practise phase to ask if the subject had meant to begin a game against the computer. The subject agreed that he had, but he briefly looked at all four menus again, opened and immediately closed help menu option: status info, switched changes menu option: demo-mode on (which didn't begin a demonstration game because a game was already in progress) and then continued the game. The subject had begun the explore and practise phase by reading solidly for 4 minutes and then proceeded with game playing - during which his learning seemed to be mainly through trial and error, experiment, observation, reflection and so on. He seemed to draw most of his information from his experiences of playing, but he did use help facilities occasionally.

The observer briefing at the end of the explore and practise phase included a demonstration of the SEO help facilities, and after the computer had won the fifth game the observer demonstrated the SEO help facilities for a second time with emphasis on 'would do' partickle SEO information. The subject then spent one and three-quarter minutes obtaining 'would do' partickle SEO information 11 times using the effect and rotate buttons to investigate partickle moves. The subject tried to absorb all the information contiguously and only obtained partickle SEO information twice in subsequent games. The observer also demonstrated 'would do' partickle SEO information after the tenth game, but the subject did not use it again.

The subject used SEO help facilities twice on his own initiative in response to encountering specific problems as follows:

- The first occurrence was about a minute after the observer had demonstrated and talked the subject through the use of SEO facilities at

the end of the explore and practise phase (which coincided with the end of the first game). On this occasion the subject clicked on a partickle that contained unpack, resist and step parts then navigated the effects SEO help facility as far as colours: unpack: ...unpack.

- The second occurrence was during the seventh game when the subject encountered a problem involving a type of effect move, the swap effect, of which he was unaware. The subject said, "Stuck" and immediately changed to the question pointer and clicked on the problem partickle. Then, instead of navigating the effects SEO help facility until he had found colours: unpack: ...swap he opened help menu option: suggestions which he hadn't previously looked at. After looking through suggestions for one minute he selected the effects SEO help facility, but didn't navigate. Instead he changed back to the arrow pointer and made an experimental move with the problem partickle, but this did not solve the problem. The observer's notes state that the subject's lack of knowledge of the swap effect resulted in him losing the seventh game. He had mixed his usage of the help facilities, he had made an inappropriate choice of help menu option and he had failed to persevere with the effects SEO help facility.

After the seventh game the observer suggested exploration to find out how to unpack a full partickle (i.e. how to find out about the swap effect) and the subject briefly glanced at all four menus then had a quick look at help menu option: status info just as he had when the observer intervened during the explore and practise phase. This was a response, but it seemed aimless and it was certainly ineffectual. However, in the eighth game the subject swapped on six occasions which indicates that he was practising this effect. Questioning confirmed that the subject had learned about swap, but it is not clear how he

had found out - possibly as a result of exploration followed by confirmation by experiment.

During the game playing phase the subject accessed help menu option: suggestions twice when he encountered specific problems - though in both cases the information he sought was in help menu option: Partickles rules rather than suggestions. The subject had not accessed help menu option: suggestions during the explore and practise phase and may have formed the impression that this was a promising, unexplored source of information. It also suggests that he had not identified more appropriate sources for reference.

The subject did not use the right mouse button (effect on/off) at all during the first game - but when questioned about this it turned out that the subject was accustomed to using a two-button mouse. It wasn't until the fourth game that the subject became proficient in making effect moves. The mouse menu option: which button contained essential initial information for this subject - who tended to overlook (and hence not experiment with) the third button. The observer briefing at the end of the explore and practise phase had included a demonstration of mouse menu option: which button and the subject accessed it 10 minutes later during the third game while he was still clarifying procedures for making effect moves.

Details of the Video Study Sessions

Introduction

Since the format of the video study was more complex than that of the pilot and core studies the session descriptions have been divided into the explore and practise phase, the checklist phase and the game playing phase. Each session description presents examples of the use of Partickles' help facilities within the context of the interaction as a whole. The times given at the beginning of the descriptions of each session indicate the amount of time spent on all three phases and include observer interventions and introductions to the phases. The explore and practise phases were all approximately 10 minutes long, but the time spent in completing the checklists and in game playing are presented at the beginning of these sections.

Session V1 - subjects N and O - 1 hour and 20 minutes

Explore and Practise phase (session V1)

Subject N selected info menu option: Partickles rules and spent his five minute explore and practise period scrolling through and reading the Partickles rules information. Subject O's first action was to select the players menu and this action closed the Partickles rules window. Subject O explored some of the players menu options then clicked on the game board using the question pointer and left mouse button. This produced area SEO information regarding the game board plus the help hot words box. The subject clicked the help box but didn't go on to select one of the extended SEO help facility options. Instead the subject opened the players menu and clicked person v person again then hovered the question pointer near to some partickles. Subject N said, "Try changes". Subject O opened the changes menu and selected demo-mode and the

subjects spent the last two minutes of the explore and practise phase watching a computer versus computer demonstration game.

Checklist phase (session V1) - 25 minutes

The observer interventions during this phase were:

- to indicate that subject N's selection of a players menu option rather than a mouse menu option was not correct
- to indicate that knowing that Select, Menu and Adjust were the standard Acorn mouse button functions did not fulfil the second checklist exercise
- to indicate that a non-effect move hadn't been made
- to suggest that subject O could help solve the problem of making a non-effect move
- to indicate that a non-effect move had been made
- to indicate that an effect move hadn't been made
- to indicate that object-based help was not being used when the subject opened info menu option: Partickles rules to get information about partickles (which he probably heard as "Partickles")
- after subject N had assisted subject O to obtain object-based help, the observer confirmed that the exercise had been successfully completed
- to indicate that changing "bubble information" referred to the bubbles and required more than one bubble for comparisons
- to prompt the subjects socratically in regard to rotating partickles and switching effect move on and off
- to indicate that bubble information had been changed by rotating partickles and switching effect move on and off
- to indicate that sufficient hot words boxes had been selected
- to add details regarding unpacking combined partickles to subject O's accurate description of the aim of the game

The subjects spent approximately three and a half minutes trying to make a non-effect move. The problem here was that they were using the question pointer but hadn't used the make move hot words box. While searching for the solution to this problem the subjects navigated the effects SEO help facility as far as effects: jump. The observer intervened to suggest that subject O (who had seemed more inclined to experiment and to use the SEO facilities than subject N) could help and subject O recommended causing hot words boxes to appear. However, subject N opened Particles rules and they scrolled through this discussing the sections they wanted to look at. Then subject O repeated his advice and as a result subject N clicked on a partickle and used make move successfully.

The subjects spent eight minutes attempting to make an effect move. Subject O spent three and three-quarter minutes making non-effect moves, then when subject N ticked this on the checklist the observer indicated that an effect move had not been made. They then looked through info menu option: getting started for about a minute, but scrolled too quickly past the sections that might have helped them. Subject O continued making non-effect moves for fifty seconds then subject N said, "Instead of making moves why not get some help?" Subject O described the theory he was testing - that a non-effect move would be an effect move if performed by a partickle containing the right combination of parts. However, the theory failed, the make move hot words box didn't appear and subject O clicked move value instead. He then looked at the help: moves information, but didn't scroll the lower window. The top line of the moves information might have reminded them about the right mouse button (effect on/off) if they'd read it, but subject O clicked the effects hot word box and they found the information to solve their problem in the effects SEO help facility.

Subject O selected the move value hot words box 3 times while trying to complete the exercise that involved changing bubble information. It is probable that in each case the subject selected move value in place of the absent make move hot words box because the move value box becomes the rightmost hot words box instead of the make move box when the partickle referred to by the partickle SEO information cannot make a move.

Game Playing phase (session V1) - 40 minutes

The subjects played two games against the computer player. They lost the first game but won the second and in each game the question pointer was the only pointer used. No menu-based help options were accessed during the game playing phase. The move value hot words box was accessed once - but not, apparently, usefully, and the effects SEO help facility was accessed twice but not navigated - though the second access implied that the five coloured hot words boxes matching colours to effects supplied useful information. Subject N tended to dominate the session and his misconceptions contributed to the subjects' defeat in the first game. However, Subject N's playing strategy of 'blocking' ensured their victory in the second game. By the end of the session the subjects seemed to have overcome 'their' misconceptions and they were sufficiently familiar with the game to be able to implement winning strategies. The observer's notes state that, halfway through the second game, the subjects had "forgotten resist can't be pushed" which indicates that the subjects were playing effectively (indicated by their win) while unsure of some fairly basic information regarding moves. This could be because 'would do' partickle SEO information was allowing them to concentrate on developing playing strategies instead of, or in addition to, learning move making.

In the first game partickle SEO information was obtained 62 times and the make move hot words box was used to make every move, but as only 47 moves were made there was little investigation of alternative moves using 'would do' help. In the second game 46 moves were made, all using the make move hot words box, and partickle SEO information was obtained 52 times. The subjects discussed their moves before clicking on partickles and seldom changed their minds even when the 'would do' information differed from the move they had discussed. The question pointer was used throughout the first game. When subject O took over the mouse for the second game he changed pointers almost immediately but changed back again quickly after subject N said, "I think we need the question mark not the arrow". The observer only intervened once during each game, the first time asking the subjects to speak up and the second time to suggest that subject N point with his hand at the screen rather than engage in tortuous verbal disambiguation.

The effects SEO help facility was accessed twice but not navigated on either occasion. Both accesses related to the same move but were preceded by partickle SEO information accesses concerning different partickles. The first access occurred when a one-part jump partickle wouldn't jump, but although subject N said, "Oh yes, jump" he did not press the jump hot words box. It appeared that he was unaware that this would produce information, but as he had already selected jump during the checklist phase it could be that the information offered by the five coloured effects hot words boxes may have satisfied or distracted him. The second access seemed to be in order to *use* the information to match colours to effects. This was only three and a half minutes into the first game, and a requirement for this information was demonstrated one and a half minutes later when subject N wrongly matched a colour to an effect.

There were many instances in which 'would do' help appeared to be read. For example, subject N, reading that a partickle would unpack, said, "Don't want to unload". Later, subject N obtained partickle SEO information and, reading from the bubble that the partickle "would move 1 place", he said, "No, it would only move one place. Can't push it 'cos there's three in a row" and then switched his attention to another partickle. In the second game subject N asked subject O to obtain 'would do' partickle SEO information: "See if you can jump over the piece. <reads bubble> Yeh, it can jump". There were also several instances in which the mouse user obtained partickle SEO information and asked "Yeh?" or made some other request for confirmation before making the move. However, there is no evidence that the partickle SEO information in the lower window was read, and some early confusion regarding step effect moves suggests that the subjects were not reading it.

Two major misconceptions became manifest in the first game:

- The first was introduced by the more dominant subject, subject N, who, at the end of the game when a computer win had revealed his error, said, "I thought we had to get them all into the places that we had before, on the other side". This misconception was responsible for some rather strange play in the first game, for example: the subjects' attempts to block partickles that had no need to move. Subject O had explained the aim of the game during the checklist phase - but subject N did not seem to have taken this in, and subject O had acceded to subject N's suggestions regarding strategy. Consequently, before the second game the observer reiterated the aim of the game using (and scrolling) the information obtained by clicking the help hot words box.

- The second misconception appeared eight and three quarter minutes into the first game, and again seemed to be introduced by subject N. This misconception involved using the unpack partickle as a shuttle to ferry partickles across to the far side of the board. This meant moving the unpack partickle backwards and forwards which the subjects were partly able to achieve by using push partickles in what subject N described as a "sort of pulley system". This imaginative misconception appears inexplicable, but it did appear that the subjects were so involved in their own play that they took little notice of the computer player's strategies and progress and its victory in the first game took them by surprise. The 'shuttle' theory was also very much in evidence at the start of the second game, but was gradually abandoned when it was realised that resist partickles, even when combined with the unpack partickle, could not be pushed across to the far side of the board and that it would be quicker to allow some partickles to move across without the unpack partickle. In spite of being slowed down by their initial 'shuttling' the subjects won the second game, largely because they were more aware of the possibilities than the computer player, but also by blocking one of their opponent's pieces on its own side of the board.

In the questions phase Subject N said that he thought the game was, "Confusing at first but once you know what you're doing it's easy". When asked if they thought the game was enjoyable both subjects said "Yes" and subject N added, "It's good fun". Subject O suggested an information sheet containing "just the important bits" and subject N agreed. Subject O also suggested replacing the colour representations of partickle parts, possibly by numbers. This would probably not be an improvement since the problem of mapping between representation and effect would still exist, but it does show

that subject O had recognised the limitations of the representations of partickles and that the compensatory information in the lower window had not been sufficiently prominent.

Session V2 - subjects P and Q - 1 hour and 28 minutes

Explore and Practise phase (session V2)

Subject P selected info menu option: Partickles rules and both subjects read through the entire option - which took six minutes rather than five. Subject Q began by opening the players menu followed by the changes and mouse menus. The first menu option she accessed was mouse menu option: which button, which the subjects read, then they accessed and skimmed info menu option: suggestions. The subjects followed the advice in the 'Ideas' section of the suggestions option and deliberately avoided the 'Strategies' section - "Because," subject P explained, "it would be more fun". They began to read info menu option: getting started, but were interrupted by the observer ending the phase.

Checklist phase (session V2) - 10 minutes

The subjects discovered the features of Partickles in a different order from that which the checklists were intended to contrive. Also, the subjects used the arrow pointer for most of the checklist phase - which meant they were operating without SEO information to identify aspects of the domain (such as effect or non-effect moves) and to translate between system functionality and checklist terminology. Nevertheless, the subjects coped very well. They still seemed unsure about the effect move mode by the end of the checklist phase, but seemed to have worked it out early in the game playing phase - probably because the computer player provided an example.

There were eight observer interventions during this phase:

- to answer subject P's question: "Do you mean the mouse buttons in the game or just as normal?" by indicating that knowing the standard Acorn mouse button functions did not fulfil the second checklist exercise
- to indicate that sufficient mouse button functionality had been demonstrated
- to prevent the subjects beginning a game
- to ask them to swap the mouse user
- to point out that: "That wasn't actually an effect move"
- to indicate that the right mouse button switched effect on
- to let them know that they had made an effect move
- to show them how to find out about the aim of the game (using the help hot words box)

The observer's interventions, though mainly intended to compensate for the fact that the checklists were not suitable for use in arrow pointer mode, resulted in removing the subjects' need to use any of the help facilities for reference during this phase. The observer allowed the subjects to hurry through the checklist phase, even though two of the exercises were not completed satisfactorily. The subjects revealed misconceptions concerning making effect moves, the significance of the unpack partickle and the aim of the game, but none of these misconceptions was transferred to the game playing phase, and minimising the time spent on this phase increased the time available for game playing.

When subject Q took the mouse and changed pointers subject P commented that, "It makes a lovely <sort of> sound". The first time that bubble information appeared subject P said, "Aaaah, that's interesting" and later,

when she had read some bubble information, subject P commented that, "It says it all down here as well <indicating the lower window>". She had, therefore, noticed the descriptive partickle SEO information as well as the 'would do' partickle SEO information.

When they were considering starting a game subject P briefly accessed info menu option: getting started to check the procedure but subject Q immediately persuaded her that this was not needed. Apart from this incident the subjects did not use menu-based help as a source of help during the checklist phase.

Game Playing phase (session V2) - 1 hour and 5 minutes

The subjects played four games. The first two games were played against the computer, the subjects used the question pointer as their main pointer and they won both games. For the third game the observer restricted them to the use of the arrow pointer - they played against the computer player and won. In the fourth game they played against one another and again used the arrow pointer though they they had not been explicitly constrained to do so. The subjects collaborated throughout the fourth game and the result was effectively a draw - because the player who started first won by one turn. These were the only subjects to achieve a perfect record of wins against the computer player.

The subjects changed to the arrow pointer three times in the first game. They made the very first move using the arrow pointer - but its selection in this case was comparable to clicking the make move hot words box - since they had already obtained partickle SEO information before using the arrow pointer and they changed back to the question pointer immediately afterwards. The observer intervened at this point to remind them of the existence of the make move hot words box. They used make move for their next turn and retained the

question pointer for the next eight minutes. After this they changed to the arrow in order to reduce the number of selections needed during a multiple step effect move. They kept and used the arrow pointer during their next turn, then changed back to the question pointer. This time the question pointer was used for eleven and a half minutes before it was again exchanged for the arrow pointer in order to make a multiple step effect move. The arrow pointer was kept and used for the next two 'and a bit' turns. The 'bit' was the first part of a multiple step effect move in which a partickle moved (correctly) rather than moving *and* unpacking. The subjects exchanged the following remarks:

subject P: "It moved - why did it do that?"

subject Q: "Go get your question mark."

The subjects changed to the arrow pointer twice in the second game. The first change was in place of make move for a single move which was part of a multiple step effect move, while the second was for a single turn consisting of a multiple step effect move. On four out of the five occasions that the arrow pointer was used in the first two games the arrow pointer was used selectively and for brief periods in order to reduce the number of actions required to make multiple step effect moves. The maximum number of consecutive turns in which the subjects used the arrow pointer in the first two games without changing pointers was two and two-fifths turns which indicates that the question pointer was the main pointer used during these games.

The help hot words box was selected twice during the first game and once in the second game. After the first help selection the subjects clicked on effects and then discussed the information provided by the five coloured hot words boxes. Subject P clicked on the push hot words box with the, apparent, aim of causing a push move but subject Q told her that this wouldn't be the case.

Shortly afterwards the subjects selected help: moves while they were investigating effects. They scrolled and read (partially out loud) the moves information which was, in part, appropriate for them at that time. In the second game they navigated the effects SEO help facility. This was at subject P's instigation: "Press help and see if it will tell you why it can't make an effect move. No, it only says the aim of the game. No point. Effects <pointing> try effects". The subjects wished to know whether the number of parts in a push partickle could be equated with the number of partickles it could push at once. They selected effects and then push but even though the subjects had found an explanation of the push effect this did not refer to their theory, and hence neither disproved or supported it.

After winning the first game the subjects had the following discussion:

subject P: "Considering the instructions it's not that difficult."

subject Q: "No, the instructions are more confusing than the game is, that's for sure. I think if we'd done the instructions in a different order it might have made more sense, mind you, but there we go."

subject P: "These bits down here are the most helpful." <points to lower window where most of the SEO information is>

subject Q: "Yes."

On several occasions subject P read aloud parts of the partickle SEO information in the lower window, noticing not only the descriptive information, "It can jump and resist", but also the context sensitive information based on a partickle's state, "It can step four places". The following exchange indicates that the subjects were also reading the bubble information and manipulating partickles to use 'would do' partickle SEO information:

subject P: <reading from bubble> "It would move one place."

subject Q: "No, you want an effect move, so click on this one <indicates right mouse button>. Right. Now see what it would do."

At one point during the second game the subjects obtained partickle SEO information four times contiguously while investigating alternative moves. They had switched on the effect move mode of the first partickle they interrogated, but they eventually decided to move a different partickle. When they clicked make move the following SEO error message appeared: "Cannot make the described move because another partickle has been highlighted." The subjects read the message, unhighlighted the partickle by switching its effect move mode off and then made the move successfully.

The question pointer was not used during the third and fourth games. The observer asked the subjects not to use the question pointer during the third game and subject Q's response was, "O.K. That's not too bad 'cos we know what we're doing with it now". At the beginning of the fourth game the observer offered, "the arrow pointer or a choice of pointers..?" and the subjects responded:

subject P: "It's actually easier..."

subject Q: "with the arrow."

subject P: "Yeh."

Twelve minutes later subject P reiterated, "Its actually easier without the question mark, once you've got used to it". The phrase "getting used to it" seems to refer to learning the game, and this suggests that object-based help had been useful while the subjects were learning the game.

No menu options were accessed in the game playing phase and there was no use of any form of help in the last two games - though there were occasions when help might have resolved difficulties. For example, in the third game subject P asked, "What does this yellow one do?" and neither subject was sure. Also, in the fourth game when a partickle did not do what she wanted it to do, subject Q said, "I can't figure out why. I think it's to do with the colours".

During the fourth game, amidst a lot of laughter from both subjects (they were pushing one another's pieces with push partickles) subject P said, "Oh this is good fun, good fun".

Session V3 - subjects R and S - 1 hour and 22 minutes

Explore and Practise phase (session V3)

Subject R selected and looked briefly at all five info menu options then opened the players and changes menus but did not select an option. None of the info windows were fully scrolled and the mouse menu was not looked at. The subject clicked the mouse menu button once - but this closed the changes menu rather than opening the mouse menu. After this the subject asked her partner, "What do I do next?" Quickly and firmly subject S replied, "Rules" and subject R accessed info menu option: Partickles rules. Subject S began her part of the explore and practise phase almost immediately after this and continued scrolling through all of the Partickles rules information, apparently reading some of it and scanning the rest. Then she looked briefly at info menu option: status info and followed this by opening the players and changes menus (without selecting options). Finally the subject opened the mouse menu and accessed, and appeared to read, each of the three mouse menu options in turn.

In the explore and practise phase subject R showed evidence of unskillful mousing: accidentally closing windows and missing or clicking on the wrong buttons/options. She tended to click while moving the mouse and hence sometimes missed the target icons. All exploration, by both subjects, was confined to menus. No players or changes options were tried. None of the info menu options seemed to be read thoroughly, though Partickles rules received most attention. The subjects did not spend much time with any option that indicated how to operate the program and this corresponds with some of the difficulties they experienced later.

Checklist phase (session V3) - 15 minutes

There were relatively few observer interventions during this phase. These were:

- to indicate that a non-effect move had to be *made* - because 'would do' information alone did not satisfy the checklist requirement
- to confirm that a non-effect move had been made
- to indicate that a non-effect, rather than an effect, move had been made
- to confirm that an effect move had been made
- to clarify the aim of the game

Subject R seemed hesitant and experienced a number of difficulties (such as not knowing which side was in play or which mouse button to press). One of the checklist exercises required her to rotate a partickle and she clicked on partickles ten times with the left mouse button rather than the middle mouse button which would have rotated the partickles. Subject S suggested using the middle mouse button, but the partickle that subject R clicked didn't rotate. Subject S then told her to make a move and indicated the make move hot words box. Subject R clicked make move which resulted in the following SEO

error message: "Can't make the described move because the red side is no longer in play." Subject S said, "It's not in play" and both subjects laughed. Shortly afterwards a mistake by subject R produced a similar error message relating to the blue side. This was only the second occasion on which SEO error messages appeared in the Partickles studies (the first was in session V2), and in both sessions the messages proved helpful and the subjects were able to rectify the errors immediately.

Subject S frequently told subject R what to do - such as when she told subject R to, "Change that back to that" <which, with gestures, meant: change the arrow pointer to the question pointer>. This was the second time subject S had dictated a return to the question pointer and she may have done this because she felt on more familiar ground with the (default) question pointer. Her use of the word "back" seems particularly significant in this respect.

When it was subject S's turn to use the mouse she was unsure how to combine partickles. Subject R theorised that combining partickles involved making their direction indicator arrows touch and subject S suggested that it had something to do with the colours of partickles. This exchange seemed to convince subject S of the need for help and she then accessed info menu option: **getting started** and commented, "Should have read this properly". However, it was subject R who identified and tentatively directed subject S to the appropriate information. This episode also provided examples of the non-use and the use of 'would do' partickle SEO information. The 'would do' information was not used when the subjects first tackled the combining exercise - because they did not seem to notice a bubble which indicated a partickle that "would move 1 place and combine". However, once they had found information about combining partickles in info menu option: **getting**

started and had begun clicking partickles purposefully a bubble of identical 'would do' partickle SEO information told them that they were correct - subject S read the bubble and said, "Yeh, that's it" before they made the move and combined partickles.

Although subject S had already pointed out the make move hot words box and subject R had already used it, subject S had to rediscover it for herself when she had the mouse. After clicking with the left mouse button and question pointer on a partickle she must have read the 'would do' information that appeared next to it in a bubble because she said, "Do it then". She then revealed probable previous experience with mouse-operated systems by clicking on the place that she wished the partickle to move to. When this failed she paused briefly, saw the make move hot words box and when clicking that had achieved the desired result both subjects made affirm/confirm noises.

Game Playing phase (session V3) - 57 minutes

Only one game was played which the subjects lost - though they did achieve a position from which they could have won. They generated a number of inappropriate theories about the game and its operation that hampered their learning, and although they made progress they did not master the game. This could be because they spent little time with help facilities that described *how* to make moves. The subjects' difficulties had become apparent during the checklist phase - particularly in relation to making effect moves.

The subjects used object-based help extensively: they only changed pointers once (briefly) during the game, they retained the question pointer for the last forty-nine minutes of the game and all moves were made using the make move hot words box. During the game the subjects used make move to make all 90 of

their moves, but they obtained partickle SEO information 205 times which indicates considerable use of 'would do' help since the trace record shows that partickles were often manipulated and interrogated before moves were chosen and made. The frequent use of 'would do' partickle SEO information is also clearly shown in the video tape of the session. The 'would do' information was seldom read aloud but was regularly referred to. One exchange between the subjects which referred to the 'would do' information took the compact form:

subject R: "Yeh?"

subject S: "Yeh."

Other examples of the use of 'would do' partickle SEO information include subject S saying, "Do it then" during the checklist phase in response to the appearance of a bubble of 'would do' information. She also predicted that a partickle would push some neighbouring partickles, but when she read the 'would do' information regarding the move she changed this to, "It's going to jump them". Later, subject S tried an experiment using 'would do' partickle SEO information:

subject S: "Hang on <thoughtful pause>. Would it just push those two or would it have to do the full move? Don't know. Find out. Turn it round. See what it'll do. No it didn't. So, <pointing> move him <a different partickle> out of the way."

Three misconceptions, which had been encountered (and resolved) by subjects in previous sessions, seriously impeded the subjects in session V3. These misconceptions involved the aim of the game, the push effect and effect mode:

- The subjects seemed to consider that the aim of the game involved moving partickles as far across the board as possible rather than just across the centre line. The observer's notes state that on two occasions the subjects seem to have "forgotten" and "lost track of" the aim of the

game, and the game went on for so long and the subjects became so deeply mired in other problems that it is, perhaps, not surprising that they forgot this detail of the ultimate goal. Also, because only one game was played, they were not able to rely upon observations of the computer player to see what constituted a win.

- The second misconception involved attributing the push functionality to a pushed partickle instead of to the partickle that pushed it, though this misconception was partially cleared by observations of the computer player. This problem took twenty minutes to resolve (a large portion of the total game playing time) - largely because the pair had difficulty making effect moves due to a more serious misconception...
- Perhaps the most serious difficulty that troubled these subjects was a misconception referred to in the observer's notes as the 'effect mode error'. The first occurrence of this was during the checklist phase and occurred because the subjects linked making effect moves with the effects SEO help facility. The effect mode error initially did not involve the use of the right mouse button (effect on/off), but, when the subjects realised that the right mouse button was necessary, making an effect move with the effect mode error usually consisted of:
 1. choosing/matching a partickle and an effect
 2. rotating the partickle if necessary (using the middle mouse button)
 3. switching the partickle's effect on (using the right mouse button)
 4. obtaining partickle SEO information about the partickle (using the left mouse button)
 5. clicking the help hot words box
 6. clicking the effects hot words box
 7. navigating the effects SEO help facility then clicking the hot words box representing the effect chosen in 1.

8. clicking the -go back- hot words box 3 or 4 times
9. clicking the make move hot words box

Steps 5 to 8 above are not needed and the make move hot words box should have been clicked to perform the effect move after step 4. The effect mode error was not consistently applied and tended to appear only in moments of uncertainty. There are eight occurrences of the effect mode error recorded in the observer's notes.

During the game the subjects accessed the extended SEO help facility 20 times, looked at the moves information once (and scrolled the lower window) and the ? pointer information once (but didn't scroll the lower window). They also accessed the effects SEO help facility 22 times. However, many of these accesses were related to the effect mode error though the subjects did read some of the effects SEO help facility's information. The move value hot words box was also accessed twice during the game, but both times were during examples of the effect mode error when, after clicking the hot words box relating to the effect they wanted to occur (rather than to find out about), the subjects explored a number of possibilities in their attempts to make the theory work.

Subject S had looked at info menu option: getting started during the checklist phase and successfully located information regarding combining partickles. Ten minutes after the start of the first game the subjects accessed info menu options: getting started and Partickles rules in order to find out about the push effect, but they misinterpreted some of the information that they found - largely by reading it out of context. Seven minutes after that they accessed info menu option: about the program (briefly, by mistake) then info menu option: status info to find out about effects. This was a general enquiry regarding matching colours to effects - but this information was not available in the

status info option. They found it immediately afterwards in the effects SEO help facility. Thirteen minutes later they looked at info menu option: Partickles rules in order to find out how to unpack a partickle containing five parts but no unpack part (one of the 'classic' Partickles' problems). Partickles rules was accessed five times in one contiguous period because subject R tended to click fractionally off the scroll bar instead of on it - hence accidentally closing the window. However, on the fifth attempt they located the appropriate information and realised that swap effects could be performed. They did not take in the precise meaning of what they read, but they did learn that swaps are possible and that these involve two adjacent partickles - which gave them a sub-goal and an area on which to focus, and shortly afterwards, in spite of the effect mode error, they achieved a swap by experimentation.