Heuristic comparison of prescribing module/functions of GPASS and VISION General Practice Clinical Systems

Dr Ian M Thompson MBBS/PhD MRCGP DFSRH

Locum GP, Scotland

Correspondence to: ian.thompson@nhs.net

1 Abstract

This paper provides a comparative discussion of the prescribing interfaces of GPASS and InPractice VISION General Practice Clinical systems, using the "Discount Usability Engineering Approach". Prescribing scenarios are investigated using a heuristic approach to cover typical tasks in every day use of the systems. A comparative table is produced looking at the features of each system and identifying those which are significant usability issues. GPASS is found to have a greater number of severe usability issues than VISION. Recommendations that software developers use operating system conventions suggestions are also made about potential improvements to the drug search strategy used by both systems. Brief discussion is made of possible extensions and improvements to the comparison presented.

Keywords: comparison, prescribing, GPASS, VISION

2 Background

2.1 eHealth Context

This paper provides a comparative discussion of the prescribing interfaces of GPASS[1]

and InPractice VISION[2] General Practice Clinical systems. There are five GP Clinical IT Systems, in use in NHS Scotland; GPASS, InPS VISION, Ascribe's Exeter – GP System, iSoft (formerly Torex) Synergy. At the time this comparison was undertaken GPASS had approximately an 80% to 85% market share for GP Clinical IT Systems in Scotland[3,4] this compares with England where 90% of the market is between 3 suppliers (EMIS, VISION and iSoft/Torex) with EMIS having over 50% of the English market[4]. Changes produced from Connecting for Health (CfH) and the National Programme for Information Technology (NPfIT) will have had some affect on these figures in England, but the overall picture remains similar with EMIS in the predominate market position. As the 'in-house' system for NHS Scotland, GPASS has previously been subject to review and independent assessment in the Ritchie[5] and Pringle[6] reports, and is generally regarded as requiring improvements. Indeed the British Computer Society Primary Health Care Specialist Group commented in a report to the National Audit Office on the (English) NPfIT "While GPASS was arguably the best available system at the time [1980s'], the result of the removal of effective competition and the bureaucratic restrictions inevitable faced by a single 'National' system has led to a position where GPASS is now acknowledged as being by far the weakest of any widely implemented GP system, a situation with which Scottish GPs are stridently unhappy." The Ritchie and Pringle reports identified significant problems with the Consulting Room (F8) interface which made up the main part of a clinician's interaction with the systems during a consultation with a patient. Since then, the GPASS Clinical (F3) interface has been created to try and address some of the shortfalls identified in these assessments.

Given these various problems identified with a system which has the predominate market share in Scotland it seems suitable to consider a comparison between GPASS and one of the other systems. The choice of the two systems for this paper was guided by ongoing eHealth developments in some Scottish NHS Health Board regions, where at the time this study was undertaken a change of GP clinical system was under consideration; both of the systems under study are in day-to-day use in a number of GP practices in the region.

This paper will compare the prescribing functions of the GPASS F3 interface as currently installed in Version 5.7 with VISION Version 3. It should be noted however that the majority of GPs using GPASS still use the "F8" Consulting Room interface in day-to-day practice.

2.2 User Interface Design

User interfaces in healthcare computing are crucial to ensuring patient safety, inappropriately designed healthcare system interfaces can result in users making decisions that adversely affect patient's health. User interface design forms part of the process of human-computer interaction in healthcare systems and requires an understanding of both the human and technological aspects; these encompass psychological and cognitive aspects from the human side, and aspects of computing devices both from the presentation of information and input of user response from the technological side.

Well designed interfaces should support usability by complying with the following principles as defined by Shneiderman[7,8] in that they should;

1. Strive for consistency
2. Enable frequent users to use shortcuts
3. Offer informative feedback
4. Design dialogs to yield closure
5. Offer error prevention and simple error handling
6. Permit easy reversal of actions
7. Support internal locus of control
8. Reduce short-term memory load

Similarly Nielsen[9] considers ten usability principles for interface design which are discussed in the next section and used as the basis of the analysis in this paper.

2.3 Usability Heuristics

Nielsen[9] describes ten general principles for interface design, which he describes as heuristics or "rules of thumb":

1. Visibility of system status
2. Match between system and the real world
3. User control and freedom
4. Consistency and standards
5. Error prevention
6. Recognition rather than recall
7. Flexibility and efficiency of use
8. Aesthetic and minimalist design
9. Help users recognize, diagnose, and recover from errors
10. Help and documentation

These have been widely cited and used in clinical settings by a number of researchers[10], problems in these domains can be categorised on a severity scale[9];

0. Not a usability problem.
1. Cosmetic problem only: need not be fixed unless extra time is available on project.
2. Minor usability problem: fixing this should be given low priority.
3. Major usability problem: fixing this should be given high priority.
4. Usability catastrophe: imperative to fix this before product can be released.

This scale will be used to rate problems identified by the investigator during the analysis.

2.4 Interface usability assessment

There are a number of techniques for assessing computer interface usability in use in modern day software engineering these include; Direct Observation; Questionnaires, interviews and surveys; Usability inspection or Cognitive walkthrough; and Usability testing via video analysis. The table below summarises the various advantages and disadvantages of various approaches:

Usability assessment method	Advantages	Disadvantages
Direct Observation (ethnography)	•Rich qualitative data •Provides valuable initial information	•Cannot apply experimental rigour •Analysis of data difficult
Questionnaires; interviews; survey	•Easy to administer •Can be used for large numbers of users	•Questionnaires cannot always tell what users are actually doing •Possible bias in interviews
Usability inspection; cognitive walkthrough	•Few resources needed •High potential return •Can complement usability testing	•Broad assumptions of users' cognitive operations •Does not examine actual user behaviour •Needs a skilled inspector
Usability testing; video analysis	•Can identify severe problems •Reveals users' cognitive processing •Scientific rigour and control •Reliability and validity	•Higher resource demands •Cannot always generalise

Table 1: Advantages and Disadvantages of Usability Assessment Methodologies taken from the University of Bath Healthcare Informatics Masters Degree Programme course notes by Maged N Kamel Boulos (now at University of Plymouth, UK) based on a paper by Kushniruka and Patel[11]

As can be seen from Table 1 each technique has costs and benefits, with some such as video analysis traditionally requiring complex and expensive equipment setups to record user reaction, user screen interaction to a video which must be then be intensively analysed. Due to resource constraints of having a single freelance GP as the principal investigator the analysis this paper will take is that of Usability Inspection, in the expectation that whilst limited, this will provide some useful data. The approach adopted is based on *modifying* the "Discount Usability Engineering Approach" described by Nielsen[12], in that a set of tasks are identified (the Scenario), these are then evaluated by the investigator using a Heuristic approach. This will be presented as a comparative task analysis of the two systems, commenting on the relevant heuristics that apply at each stage.

3 Methodology

The comparison was of each interface was by a locum GP (the author) with limited prior experience of the systems under test, as a result of previous experience and use of another different clinical system (EMIS[13]), and no formal training beyond what is given by local practice staff/GPs to an incoming locum GP. Assistance was gained from practice administrative staff when the investigator was unsure of how to complete the required task, in the same way that would occur for a locum GP who was naïve of the clinical system in use. Only a single investigator undertook the comparison and the comparison was restricted to the aspects of the interface involved with prescribing in an average consultation.

3.1 Prescribing Tasks

In order to compare the two systems consideration was given to the workflow within a typical surgery involving consultations, and a number of prescribing tasks were identified, by the investigator, as potential scenarios to reflect the typical day to day prescribing activities of a GP. The list of tasks identified is as follows,

- List current (active) medication
- Add and issue (print) an acute prescription
- Add and issue a repeat prescription
- Add a new acute prescription for a medicine previously issued
- Change a previously given acute prescription to a repeat prescription
- Reprint a prescription after printer failure/paper jam
- Delete a prescription entered in error

In addition to considering the workflow, consideration was given to useful safety functionality, based on the investigators previous experience with another clinical system and previous reports which had suggested desirable features for a GP clinical system[4,5,14], the following were chosen as important safety functionality that was desirable in a real world usable prescribing interface:

- Report relevant drug-drug interactions during the process of adding a prescription (e.g. prescribing an NSAID to a patient on warfarin)
- Report relevant drug-disease interactions (e.g. prescribing beta-blockers to an asthmatic)

Each prescribing task is analysed in turn with consideration of the Nielson's heuristics

identified above with the severity of poor design features indicated using the scale discussed in section 2.3. Good usability features are highlighted in italics next to the relevant heuristic.

4 Comparative Task Analysis

The prescribing tasks outlined above are completed in sequence, with stepwise descriptions using a dummy patient. Thereafter the usability issues of interface design are highlighted in a comparative table.

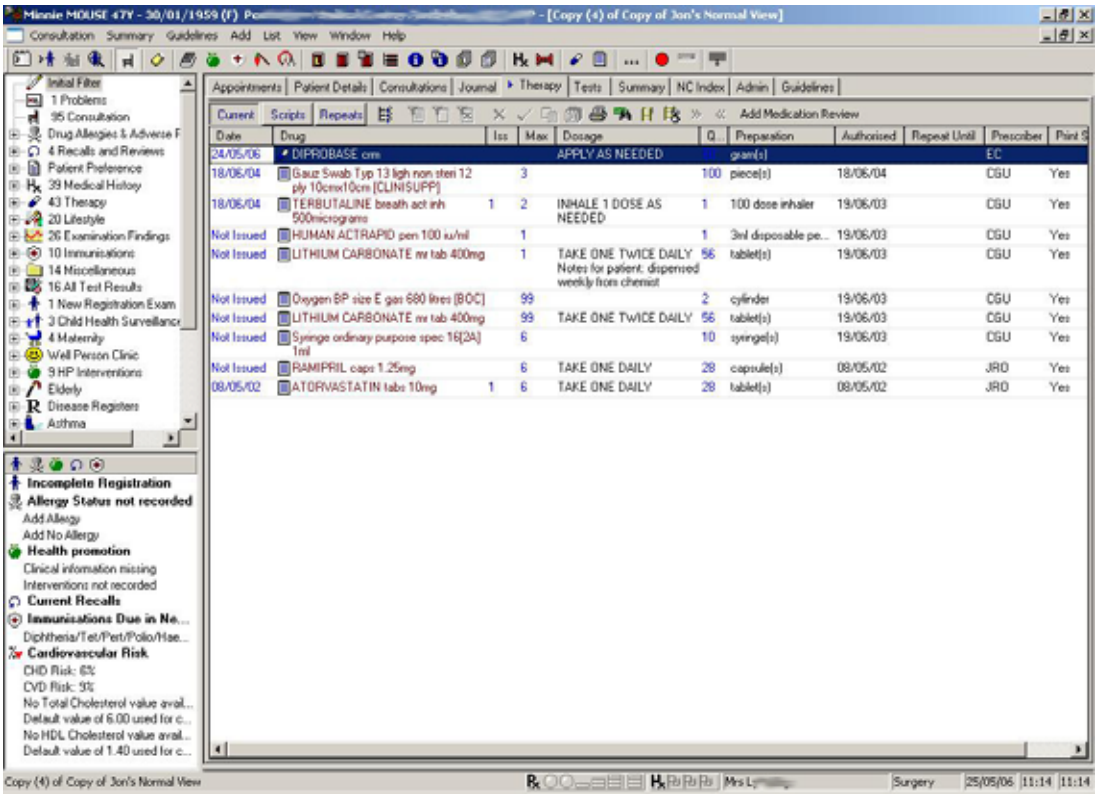

Figure 1: VISION Current Medication

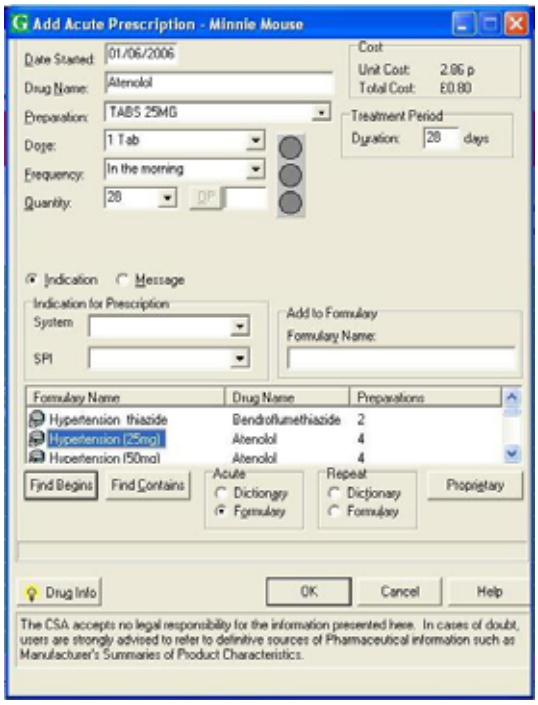

Figure 3: GPASS Clinical Add Prescription Dialogue

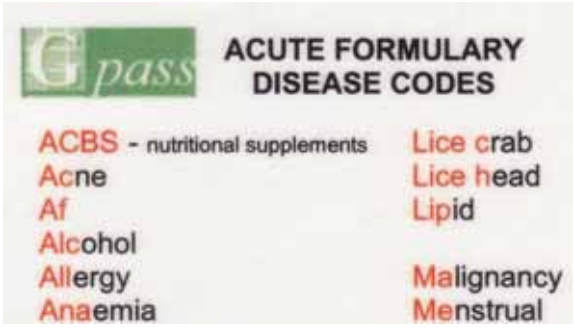

Figure 2: GPASS Formulary Quick Reference card

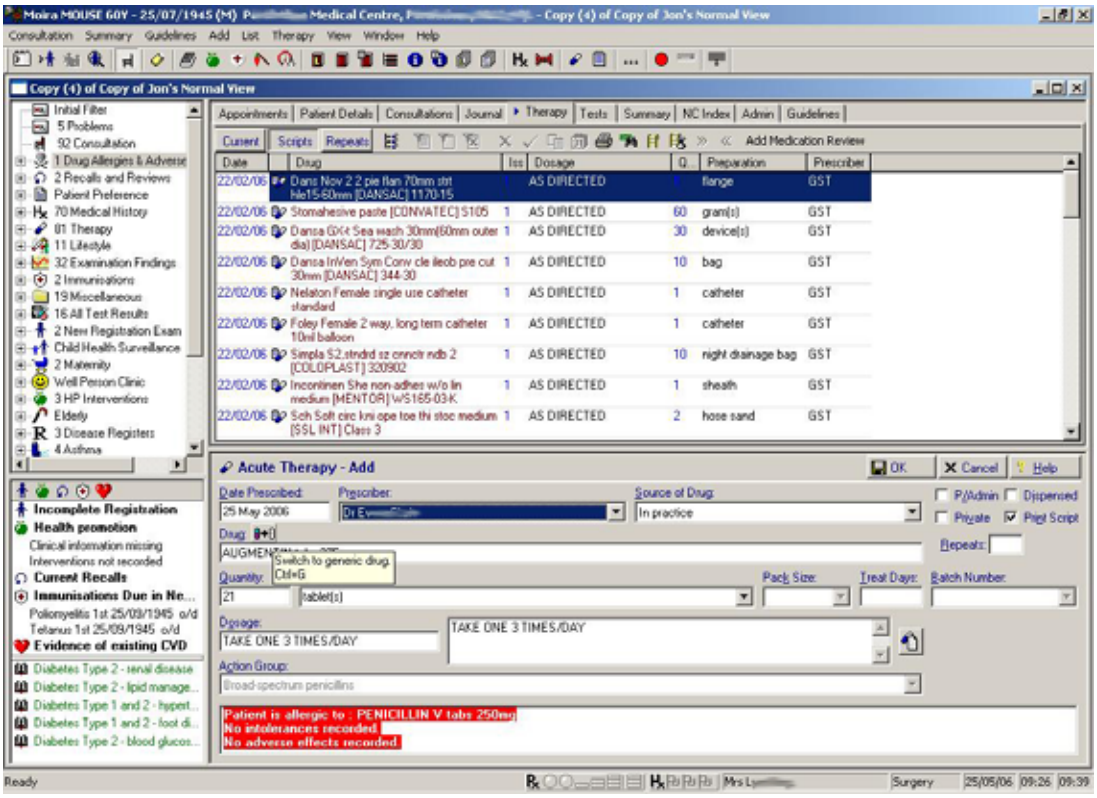

Figure 4: Adding a prescription in VISION

4.1 List current (active) medication

The default view opened by GPASS Clinical (F3) is the prescribing list, possibly reflecting the historical fact that GPASS was initially an administration system and not an electronic patient record (EPR), thus this could be regarded by developers as the most logical view if clinical notes were on paper. Vision opens a view of the EPR showing a clinical summary, the medication list must be selected separately by choosing therapy. Both systems display medication in reverse chronological order with most recently dispensed medicines at the top; this is a good interface feature.

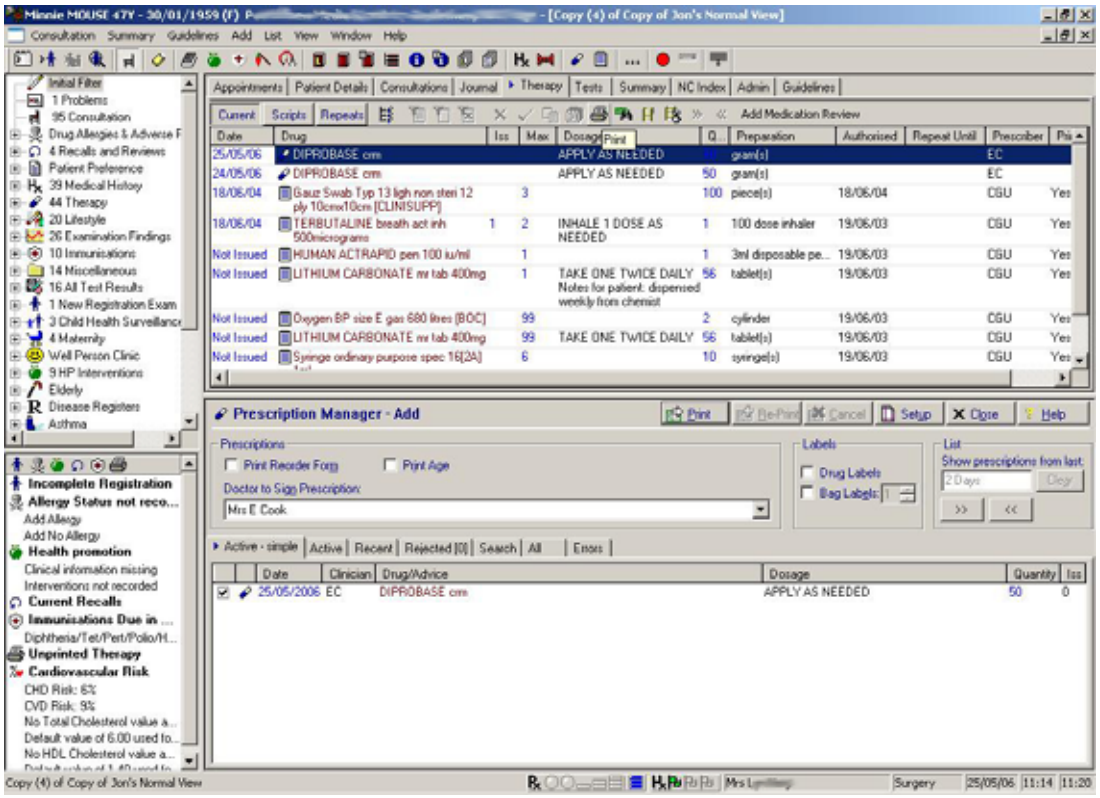

Figure 5: printing a prescription in VISION

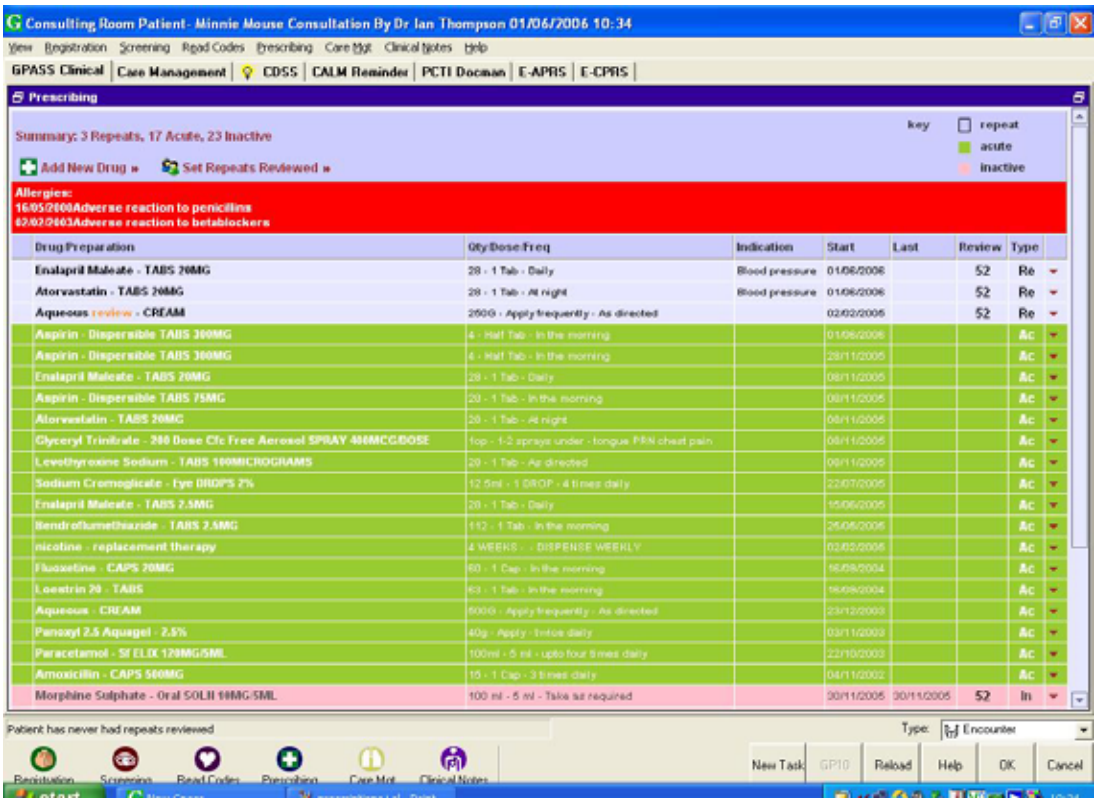

Figure 6: GPASS Current Medication List

Heuristic	GPASS	VISION
Consistency		*Icons used to indicate type of medication match those on menu bar for adding acute or repeat prescribing.*
Flexibility/Efficiency	Whilst current medication is the first thing to display and thus appears efficient it takes longer to then view the EPR. Problem severity: 1	*Vision can be customised to show current therapy as the initial screen on opening the record, this is one of many configuration options.*
Design	The prescribing list shows both repeat and acute medication in colour coded blocks. The contrast between foreground and background is poor and the choice of colours does not consider the possibility of red-green colour blindness. Problem severity: 2	

4.2 Add and issue (print) an acute prescription

In both systems this is a multi-step process as described below. In GPASS Clinical:

1. To add a new therapy the user clicks “Add New Drug” (Figure 8) which produces the dialogue similar to that shown in Figure 4.
2. The user then enters the minimum initial letters of the appropriate formulary name into the Drug Name field and clicks “Find Begins”. The formulary, shown in Figure 5, provides a list of drugs categorised by disease rather than drug name.
3. A number of possible drug options for that disease condition are presented based on the local formulary. Selecting one of these automatically populates the preparation, dose, frequency and quantity fields, as shown in Figure 4.

4. Alternatively to search by drug name directly, the user selects the “Dictionary” radio button and chooses “Find Begins” or “Find Contains” as appropriate.
5. A list of matching drugs is then presented and the user selects the desired one. They must then complete the preparation, dose, frequency and quantity fields from the pull down list controls.
6. Proprietary-Generic Switching (and vice versa) is achieved by pressing the “Proprietary” button, on the right side of the dialogue.
7. The user can then choose both a system and then a “SPI” (Specific Prescribing Indication) to record the indication for the drug.
8. The user can enter a free-text message to print on the right side of the script for the patient by choosing the message radio button and typing in the resultant text field that appears.
9. Allergies are listed, in red, at the top of the screen in Figure 8.
10. The “traffic light” system (greyed out in Figure 4) is intended to indicate and drug-drug or drug-disease interactions by showing red or yellow as appropriate, to access the reasoning behind the traffic light the user must press the “Drug Info” button in the left lower corner of the dialogue.
11. Once the drug has been added to the patients record it appears at the end below old acute and old repeat drugs on the current medication screen (Figure 8), a prescription can be printed by clicking the “GP10” button (see bottom of screen in Figure 8).

In VISION:

1. The user access the “Acute Therapy -Add” dialogue (Figure 6), via one of the following;
    - choosing “Therapy Acute” on the “Add” menu
    - by clicking the medication icon in the tool bar
    - by pressing the relevant keyboard shortcut (F4)
    - if viewing medication at the time then ESC or “+” or by starting to type the drug name will also initiate the add therapy dialogue.
2. The user then types the drug name into the drug field and presses return/enter, the system then finds the first match to that name.
3. Where this is correct the user can review the defaults provided for quantity, formulation and dosing and adjust them as appropriate. The system has a set of usual defaults for dosing, and pack size.
4. Desired drug formulation is not initially presented, e.g. Injectable augmentin appears before tablet form, the user must press F3 (find) to access a dialogue box to choose the desired form of the drug.
    4.1. It is possible to specify the formulation (tablets/injection) and strength by typing this with the drug name in the box separated by space e.g. “augmentin tabs 375”.
5. As seen in Figure 6 there is a small button above the Drug field in the dialogue which will perform a proprietary-generic switch, this can also be accessed by the control-g key combination.

6. The user can add a free-text message to the patient by clicking the button 
7. Allergies are clearly shown at the bottom of the dialogue; if an attempt is made to prescribe a drug that a patient is allergic to a new dialogue appears to confirm this action with the user. At the bottom of the screen the "Rx" and "Hx" sections in the information bar provide some indication of the presence drug and disease interactions; these are also listed in an optional pop up dialogue that appears after the allergy dialogue giving a specific list of drug and disease interactions and a colour coded indication (red/yellow) of their severity. The user can then still continue to prescribe the drug.
8. To print the script the user clicks the print icon in the therapy tool bar (Figure 6) or presses F9 and is then presented with the print dialogue where they can review the items to print (Figure 7) and print them by pressing return of F9 again or clicking the button labelled print in the lower half of the screen.

Heuristic	*GPASS*	*VISION*
Visibility of System Status	Error messages, such as "drug not found" or incomplete fields appear in the line above the "OK", "Cancel" and "Help" buttons and are not prominent for users thus may be missed by the user. Problem Severity: 2	*Error messages such as drug not found produce a new dialogue that the user must respond to, clearly indicating the error that occurred. If required fields (dosage, quantity etc.) are missing when the OK button is pressed they are highlighted in red to draw the users attention to them (Figure 9)*
Real World Match	Default use of formulary is not a good real world match as users have to remember the formulary name rather than just type the drug name	

Heuristic	GPASS	VISION
	they already know[15] perceived both by the investigator and others as complicating the process of selecting the drug. Problem Severity: 2	
Consistency and Standards	Not all fields in the prescribing dialogue have keyboard shortcuts (underlined letters) Problem Severity: 1	*All fields in the prescribing dialogue have kepboard shortcuts.*
	"OK" and "Cancel" buttons do not have keyboard equivalents. Problem Severity: 2	"OK" and "Cancel" buttons do not have keyboard equivalents. Problem Severity: 2
	There appear to be two default buttons (with darker surrounds) "Find Begins" and "OK", but the one activated by hitting return is "OK" Problem Severity: 1	*Return (and tab) provide sequential progression through the fields in the dialogue in a logical fashion taking focus to the "OK" button after hitting return (this behaviour can be customised).*
	Focus after an error message remains with the last clicked button and the user must then select the "Drug Name" field again before typing in a new search term. Problem Severity: 2	
Error prevention	A confirmatory "lose all changes?" dialogue appears after selecting cancel in the add prescription dialogue.	

Heuristic	*GPASS*	*VISION*
Error prevention	There are no checks in place to prevent prescription of a drug to which the patient has a recorded allergy. In some cases whilst the presence of allergy is noted the specific drug is not displayed. Problem severity: 4	*A specific dialogue appears in relation to confirming prescription where an allergy is listed.*
	Drug interaction alerts frequently produce "red" traffic lights for nonexistent (due to time separation) or inappropriate (topical vs systemic) interaction, this leads to user fatigue and a tendency to ignore warnings. Alerts should be appropriate and relevant. Problem severity: 3	*Drug checks can be customised on a per user/per session basis adjusting both duration of drug history considered and what general types of clinical conditions are considered.*
Flexibility and Efficiency	There is only one means of accessing the add prescription dialogue, and no keyboard shortcut for expert users. Problem severity: 3	*Many ways of accessing prescribing dialogue supporting both novice and expert users.*
	User must select between either formulary or drug dictionary and between find begins or find contains to search for medication. Problem Severity: 2	
	System does not know drug formulations (e.g. user must know that drug is capsule of tablet) or always present correct pack sizes. Problem severity: 3	*System has appropriate defaults for drug formulations, quantities and understands pack sizes.*
	User is restricted to predetermined usage	*User can add own abbreviations for dosage*

Heuristic	GPASS	VISION
	directions from the pull down menu; there is no option to use common abbreviations that are then translated to patient understandable language. Problem Severity: 3	*instructions which are expanded to patient understandable directions e.g. QDS becomes one four times a day.*
Design	Newly added and modified items appear at the bottom of the drug list which may be off screen and may require scrolling to view. Problem severity: 2	*Newly added items appear at the top of the drug list and are easily visible.*

4.3 Add and issue a repeat prescription

The approach is very similar to that for adding an acute prescription; in GPASS the process is virtually identical to that for an acute prescription, but the user must click either repeat formulary or dictionary radio buttons (see Figure 4) **after** having selected the desired drug.

In VISION the user can either enter details in the repeats field on the right side for the

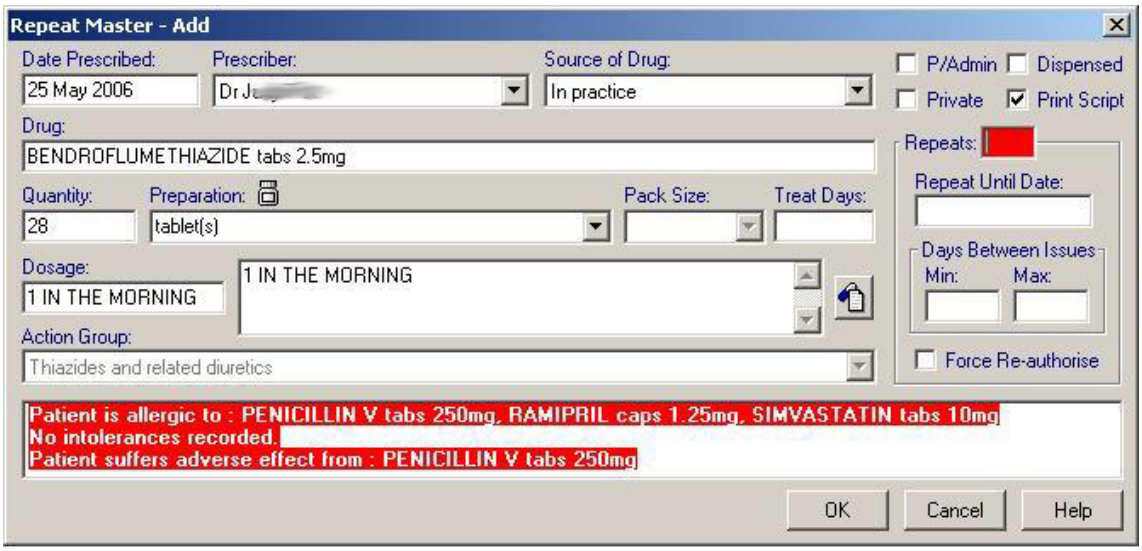

Figure 7: VISION add repeat prescription.

page and the dialogue becomes a repeat prescribing one, or they can choose menu option add repeat or the keyboard shortcut (F5), or if in the repeats list of drugs press ESC or "+" or start typing the name.

In both systems the duration of repeat and interval must be specified, otherwise the process is the same as adding an acute prescription.

Heuristic	*GPASS*	*VISION*
User Control and Freedom	*User can change a prescription to repeat by clicking on repeat dictionary radio buttons at any point in the drug selection process.*	*User can change prescription to repeat by completing repeats box in acute therapy add dialogue.*
Consistency and Standards	Selecting "Repeat Formulary" radio button and then attempting to search with a valid formulary name produces no results. User must search acute formulary and then choose one of repeat options. Problems Severity: 4	

Figure 9: GPASS right click menu

Figure 10: GPASS right click menu hidden by window frame.

Figure 8: VISION Floating Drag Menu

4.4 Add a new acute prescription for a medicine previously issued

This is achieved in GPASS by right clicking on the item to restart and choosing “copy as acute” from the menu that appears (Figure 10). The user is then presented with a dialogue to confirm the dose, frequency and quantity which is similar to Figure 4, but the drug name field is greyed out indicating it can't be modified. The user then proceeds as described above with adding an acute medication.

VISION has several methods, including; right click and choose copy or click and hold causing Floating Drag Menu (Figure 11) to appear and then drag to the appropriate target (top right icon  for “another”). This brings up the “Acute Therapy - Add” dialogue seen in the lower half of Figure 6 pre-populated with drug and dosage information.

Heuristic	GPASS	VISION
Design	When right clicking on a drug at the bottom of the screen the menu appears "behind" grey frame, as in Figure 12, preventing selection of hidden options. Problem Severity: 3	

4.5 Change a previously given acute prescription to a repeat prescription

As with issuing another acute prescription in GPASS this is achieved by using the right click menu, choosing "copy as repeat" and then proceeding as for prescribing a repeat prescription as above. In VISION again there are many routes to the same goal, the Floating Drag Menu (Figure 11) can be used this time dragging to the icon  in the lower middle section of the menu.

Heuristic	GPASS	VISION
Flexibility and efficiency		*The multiple ways of adding a previous acute therapy to the repeats list allows expert users to use short cuts.*

4.6 Reprint a prescription after printer failure/paper jam

GPASS asks after printing every script if it has printed OK. Vision has a reprint button, which allows reprinting, whilst producing a dialogue to provide a reason for reprinting as part of an audit trail.

Heuristic	GPASS	VISION
User control and freedom	Users must wait for each script to print before proceeding to the next task.	

Heuristic	GPASS	VISION
	Problem Severity: 2	
Error prevention	No audit trail recording re-prints exists. Problem Severity: 4	*User must record a reason for requesting a reprint.*

4.7 Delete a prescription entered in error

This is achieved in GPASS via the right click menu (Figure 10) a reason is recorded in a pop up dialogue which defaults to “wrong patient”. VISION allows deletion by choosing delete from the right click menu, if it has already been been printed a dialogue requesting confirmation of the deletion appears with the default option being “No”, then a further dialogue appears to record a reason for deletion in the Event log.

In either system Repeat Drugs which have been issued cannot be deleted and must be made “inactive”.

Heuristic	GPASS	VISION
Error Prevention	*In both systems the user is given option to cancel deletion.*	
	In both systems there is an audit trail recording reason for deletion	

5 Summary

There results of this comparison are summarised below, in considering these it should be remembered that this is a restricted study, which has various limitations which will be outlined later.

Heuristic Problem Severity	Frequency of item with severity level	
	GPASS	VISION
Problem Severity 4	3	0
Problem Severity 3	6	0
Problem Severity 2	7	1
Problem Severity 1	1	0

Table 2 Summary of Heuristic Problem Severity frequency for GPASS and Vision

Both systems were identified by the investigator to have good interface features and bad ones, as can be seen from the above summary table. Clearly the assessment of severity is significantly limited in being from only one instigator; having additional investigators perform a similar analysis may result in disagreement as to the importance and impact of certain problems.

On the whole Vision has fewer usability issues than GPASS. It may be considered that the historical roots of GPASS as an administration system rather than an EPR have a part to play in the larger number of interface problems discovered. However, it is worrying that despite the problems previously highlighted by the independent reports into GPASS[5 6] the current GPASS Clinical (F3) interface still fails in various major (show stopper) areas, e.g. drug allergy warnings. These failings should not be present in a production version of the software.

5.1 Recommendations for Developers

In general, usability is greatly improved by following expected interface conventions for the operating system (OS) in question; specifically in terms of appropriate colour use, presence of keyboard shortcuts, default buttons and behaviour of dialogue boxes. Both systems have failings by not following these; GPASS significantly more so than VISION. Priority should be given to developing an interface that utilises expected OS conventions and features.

Searching to select the desired therapy is a key part of the prescribing interface and could be improved in both systems. In the "drug search" fields of the prescribing dialogues, presenting possible matches by frequency of use would be likely to improve the users experience and speed of using the interface. Both systems could also utilise a "google-like" spell check function[16] providing a nearest match ("did you mean: X?") as a feature for their drug searches. GPASS would benefit from a drug dictionary with usual dose, frequency and quantity such as the "normalex" drug dictionary used in VISON.

The tables in the comparative task analysis section above list specific areas that need further development or improvement to enhance the usability of each of the systems studied; especially those with high level of severity.

6 Discussion

The decision to use the heuristics approach was taken due to the lower resource implications involved compared with alternative more formal usability testing observational methods of evaluation, which would have required greater personnel, time

and equipment than were available. Although this could be considered to limit the strength of the analysis as Nielsen points out from a usability standpoint "even tests that are not statistically significant are well worth doing since they will improve the quality of [design] decisions substantially"[9].

7 Further Evaluation and Comparison

This comparison is significantly limited by the fact that **only one** investigator undertook the usability inspection, within a limited time-scale. The latter resulting in little consideration of the help and documentation provided in each system. The comparison is further limited by considering only 2 of the possible systems available in the GP clinical system market place, as highlighted in the methods this was due to resource restrictions; with the choice of which two being guided by changes in local ehealth policy.

The heuristic comparison could be improved by having other investigators attempt the same tasks whilst considering the same heuristic guidelines. Nielsen[17] advocates that these should be independent, Sawyer *etal*[18] suggest that pairs of people inspecting the interface may be a better approach, and achieve more rewards in identifying problems. It may also be appropriate to consider usability in the situation where the users have attended a formal training course.

Alternatively to provide greater power, by triangulating the findings, more formal usability techniques could be employed; such as the think-aloud methodology[19] using a wider sample of typical GP users or, considering that both systems are in use in various practices throughout the local Health Board region, usability questionnaires could be

employed with existing users of each system.

Clearly this paper considers only one aspect of the clinical system interface (prescribing) so an extended study looking at the overall consulting room interface would provide a more complete comparison than was possible here. Equally to provide a fair comparison of systems consideration should be given to including systems from other major GP system providers such as EMIS or System One.

References

1 GPASS: *General Practice Administration System for Scotland* URL: http://www.show.scot.nhs.uk/gpass/ [accessed 10 June 2006]

2 VISION *In Practice Systems: Vision 3* http://www.inps3.co.uk/anm/anmviewer.asp?a=99&z=63 [accessed 10 June 2006]

3 Personal Communication, Stuart Scott, Clinical Director e-Health, NHS Grampian

4 Royal College of General Practitioners (2005) *RCGP Information Sheet No. 7: Information Management and Technology in General Practice* URL: http://www.rcgp.org.uk/pdf/ISS_INFO_07_Feb05.pdf [accessed 03 August 2008]

5 GPASS Review Group [Ritchie *etal*] *Primary Care IM&T in Scotland: Promoting Progress, Securing Success*, ISD Scotland, June 2002, URL: http://www.show.scot.nhs.uk/gpassslg/GPASSReviewReport.pdf [accessed 10 June 2006]

6 Pringle *etal* (2002) *Independent External Assessment of GPASS: Looking to the Future of Health Informatics in Scotland* URL: http://www.show.scot.nhs.uk/gpassslg/GPASSPringleReview.pdf [accessed 10 June 2006]

7 Dix A, Finlay J, *etal*. (2003), *Human-Computer Interaction* - companion Web site URL:http://www.hcibook.com/e3/ [accessed 14 August 2008]

8 Shneiderman, B. (1998) *Designing the User Interface*, in Tenenberg, J (2004) *Course notes for TCSS 360: Software Development and Quality Assurance Techniques*, Institute of Technology at the University of Washington, Tacoma URL: http://faculty.washington.edu/jtenenbg/courses/360/f04/sessions/schneidermanGoldenRules.html [accessed 14 August 2008]

9 Nielsen, J. *Heuristic evaluation*. In Nielsen, J., and Mack, R.L. (Eds.), *Usability Inspection Methods*, John Wiley & Sons, New York, NY, 1994 URL: http://www.useit.com/papers/heuristic/heuristic_list.html [accessed 18 June 2006] Book URL: http://www.useit.com/jakob/inspectbook.html [accessed 18 June 2006]

10 Zhang, J. *etal., Using usability heuristics to evaluate patient safety of medical devices.* Journal of Biomedical Informatics. 2003, Vol. 36 Issue 1-2 pp 23-30

11 Kushniruk, A. W. and Patel, V. L. (2004) *Cognitive and usability engineering methods for the evaluation of clinical information systems*, Journal of Biomedical Informatics Vol. 37, Issue 1, pp 56-76. URL: http://www.sciencedirect.com/science/article/B6WHD-4BS0DH2-2/2/9a7f2fe61ec37860b2a1fa3b3f53f300 [accessed 03 August 2008]

12 Nielsen, J *Guerrilla HCI: Using Discount Usability Engineering to Penetrate the Intimidation Barrier,* 1994 URL: http://www.useit.com/papers/guerrilla_hci.html [accessed 2 July 2006]

13 Egton Medical Information Systems *EMIS LV 5.2*, 2006 http://www.emis-online.com/lv.asp [accessed 12 July 2006]

14 Scottish Executive Health Department (1999) *Requirements for accreditation for general practice computer systems in Scotland* URL: http://www.show.scot.nhs.uk/publications/me/gpcomputerrecords/rfav1.pdf [accessed 03 August 2008]

15 Pringle *etal., Functionality of GPASS within Consultation Screen Medication,*2002, pp29 *in* Pringle *etal., Independent External Assessment of GPASS: Looking to the Future of Health Informatics in Scotland 2002* URL: http://www.show.scot.nhs.uk/gpassslg/GPASSPringleReview.pdf [accessed 10 June 2006]

16 Google, *Google Help: Spelling Checker,* 2006 http://www.google.com/help/features.html#spell [accessed 12 July 2006]

17 Nielsen, J and Mack, R. L. *Usability Inspection Methods*, John Wiley & Sons, New York, NY, 1994. ISBN 0-471-01877-5 (hardcover). URL: http://www.useit.com/papers/heuristic/heuristic_evaluation.html [accessed 14 June 2006]

18 Sawyer, P. *etal., Making A Difference - The Impact of Inspections* Proceedings of the Association for

Computing Machinery Special Interest Group in Computer-Human Interaction Conference 1996 URL: http://www.acm.org/sigchi/chi96/proceedings/papers/Sawyer/ps_txt.htm [accessed 14 June 2006]

19 Jaspersa, M.W.M. *etal., The think aloud method: a guide to user interface design* International Journal of Medical Informatics, 2004, Vol. 73, Issues 11-12 , pp 781-795 doi:10.1016/j.ijmedinf.2004.08.003 [accessed 12 July 2006]