Research Paper ■

Evaluation of a Command-line Parser-based Order Entry Pathway for the Department of Veterans Affairs Electronic Patient Record

CHRISTIAN LOVIS, MD, MPH, MICHAEL K. CHAPKO, PHD, DIANE P. MARTIN, PHD, THOMAS H. PAYNE, MD, MPH, ROBERT H. BAUD, PHD, PATTY J. HOEY, RPH, STEPHAN D. FIHN, MD, MPH

Abstract **Objective:** To improve and simplify electronic order entry in an existing electronic patient record, the authors developed an alternative system for entering orders, which is based on a command-line interface using robust and simple natural-language techniques.

Design: The authors conducted a randomized evaluation of the new entry pathway, measuring time to complete a standard set of orders, and users' satisfaction measured by questionnaire. A group of 16 physician volunteers from the staff of the Department of Veterans Affairs Puget Sound Health Care System–Seattle Division participated in the evaluation.

Results: Thirteen of the 16 physicians (81%) were able to enter medical orders more quickly using the natural-language–based entry system than the standard graphical user interface that uses menus and dialogs (mean time spared, 16.06 ± 4.52 minutes; $P = 0.029$). Compared with the graphical user interface, the command-line–based pathway was perceived as easier to learn ($P < 0.01$), was considered easier to use and faster ($P < 0.01$), and was rated better overall ($P < 0.05$).

Conclusion: Physicians found the command-line interface easier to learn and faster to use than the usual menu-driven system. The major advantage of the system is that it combines an intuitive graphical user interface with the power and speed of a natural-language analyzer.

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A recent Institute of Medicine[1] report estimated that as many as 95,000 people in the United States die each year because of medical errors in hospitals.[1] That is more than die from motor vehicle accidents, breast cancer, or AIDS. One source of errors and an area suggested for improvement is the entry and tracking of medical orders and automated systems to alert those orders.

Many problems arise with handwritten orders, the first and most obvious being legibility. It has been shown, however, that the handwriting of physicians is no worse than that of other health care providers[2] and that their legibility is not as bad as it is reputed to be.[3] Nonetheless, handwritten orders are a common source of medical errors. Twenty to 70 percent of handwritten medication orders are incomplete.[4,5] More than 10 percent of medication orders and 75 percent of signatures are illegible or legible only with effort.[4,6] Most of these errors could be prevented by electronic order entry systems[7] that have been shown

Affiliations of the authors: Veterans Affairs Puget Sound Health Care System, Seattle, Washington (CL, MKC, THP, PJH, SDF); School of Public Health, University of Washington, Seattle, Washington (DPM); University Hospital of Geneva, Geneva, Switzerland (RHB).

Correspondence and reprints: Christian Lovis, MD, MPH, Integrated Electronic Patient Record Group, Division of Medical Informatics, University Hospital of Geneva, 21, Micheli-du-Crest, CH-1211 Geneva 4, Switzerland; e-mail: <christian.lovis@dim.hcuge.ch>.

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to be cost-effective.[8] Besides mitigating errors due to writing and transcription, electronic order entry can be used as a vehicle to provide comprehensive medical information and decision support.[9–12] Electronic order entry is the fundamental framework for the embedded guidelines designed to support the decision process of health care providers.[13]

One of the major challenges in designing the electronic patient record is to meet the needs of detailed documentation while keeping the burden on direct-care providers within an acceptable range. Tightly controlled and structured data entry can be a major burden for health care providers because of high costs in time.[14–15] There have been many reports on how difficult it is to introduce electronic order entry systems. The well-known story about the OSCAR system at a Calgary hospital,[16] which turned into a battle of physicians against machines, is not unique. Computerized order entry is known to take more time than handwritten order entry, especially for admitting orders.[17]

The evolution of computer interfaces that use a mouse, menus, forms, and dialog boxes has simplified the use of computers, especially for novices. Command-line–oriented systems, while difficult for novices, are very efficient for experienced users. High-speed, robust natural language processing techniques simplify use of command-line systems and permit their use by novices. Such techniques are especially important in academic settings where turnover among residents and other health care providers is high.

In 1998, the Department of Veterans Affairs (VA) Computerized Patient Record System (CPRS) was first released at a national level. The CPRS organizes and presents all relevant patient data to support clinical decision making. It allows clinicians to view and add patients' data, make notes, and enter orders. It supports alerts, notifications, and guidelines. The CPRS became possible because of the extensive set of clinical and administrative applications in the Veterans Health Information Systems and Technology Architecture, VistA. The CPRS can be seen as a line of tightly integrated products that use open and distributed architectures and are able to support evolution and local adaptations.

In a recent review of the implementation of the CPRS system at the VA Puget Sound Health Care System, one of the most common problems described by physicians was the time required to enter orders.[18]

The objective of the present project was to develop a simple and robust natural-language–based order entry pathway for an electronic patient record and determine its effects on order entry time and user satisfaction.

The JIL Project

To improve and simplify the use of the existing electronic order entry in CPRS, we implemented an alternative ordering pathway based on natural language techniques. The new pathway, JIL, uses existing resources for maintaining available orders. It does not disrupt the basic CPRS program and does not introduce security holes. It minimizes modification of the actual code of the CPRS program and is easily maintainable. It is implemented as an additional unit of CPRS and complements CPRS functionality. The source code and the naming convention are similar to those used in CPRS to facilitate integration.

The CPRS can be considered as a semi-thick client at the top of a three-layer architecture. The deepest level consists of the MUMPS databases running on the VistA servers with business rules that govern the interactions with databases at the server level. This level also provides management support for queries. The second level consists of the remote procedure call (RPC) broker that runs on both the server side and the client side and allows communication between servers and clients. The RPC broker plays the key role of bridging servers and clients. It ensures identification of clients and offers standardized interfaces and protocols for communication and for data exchange and functions. It also permits both the client and the server to operate on independent and different hardware platforms. The uppermost and last layer is the CPRS.

Besides offering a common interface for both the client and the server sides, the RPC broker supports a three-part security process. First, it ensures that users have valid access and verify codes to ensure that they are authorized users of an available client/server application. It also guarantees that the remote procedure calls have been registered and are valid for the application being run. Because of these features, it made the most sense to design JIL to be an integral part of the CPRS system rather than an independent order entry system. The JIL system is an alternative to existing systems that use phrase completers, abbreviations, and other command-line methods, and differs mostly by the way dictionary are automatically and dynamically built using the existing menus.

Main Knowledge Base

The quality of the knowledge base used to determine the meaning of users' entries is the most important factor in the success of that analysis.[19] Quality includes not only coverage and precision but also maintainability and availability.[20] In the JIL project, the knowledge base can be compared to a dictionary derived from frequent orders as they appear in the menus and dialogs caption of the GUI. The CPRS GUI allows a complex and deeply structured menu to access specific and common orders. Some sites, such as VA Puget Sound, use deeply nested order menus heavily. These menus display "quick orders." Quick orders comprise a large dataset of frequent orders that are prepared in advance. They cover all specialties and domains, including admission/discharge/transfer, clinical conditions, diagnoses and procedures, drug orders, diet, surveillances, and laboratory orders, among others.

As shown in Figure 1, the dictionaries of JIL are directly extracted from the menu and dialog content of CPRS. Figure 1 shows an open menu example and the result as a structured tree. In CPRS, the menus are built dynamically, during startup, from a central database (Table 1) and are updated as often as needed according to the user's needs, usually daily. These menus provide shortcuts to frequently used orders. Nonetheless, most users find this system difficult because of the vast number of menu items available. While the addition of more quick orders facilitates direct entry, it also increases the difficulty of finding a desired order within a complex menu structure.

This menu structure is used as the main knowledge base for JIL. An important feature of this solution is that it is usable in any menu-driven system. It offers consistency between what is available through standard menus and the alternate command-line pathways. In addition, the CPRS support team needs to update only one source for both menus and natural-language–based entry. Resources needed to maintain this source are already available and familiar to the CPRS support team. Finally, menu-driven entry is the main pathway used in many VA facilities and other electronic patient record systems for entering orders. The VA Puget Sound main menu description files contain more than 6,000 entries that have been refined during the last 2 years in response to the needs of a broad spectrum of clinicians (Table 2).

All orders available in the CPRS GUI menus and dialogs are available in JIL. So the coverage of what can be ordered is the same in both systems and leads to the same result. JIL can be considered an automatic, full-text driven, generalized shortcut system for the existing CPRS GUI. Except for a rule-based engine, the computational heuristic algorithm, and fewer than 50 abbreviations and synonyms, no extra knowledge has been added.

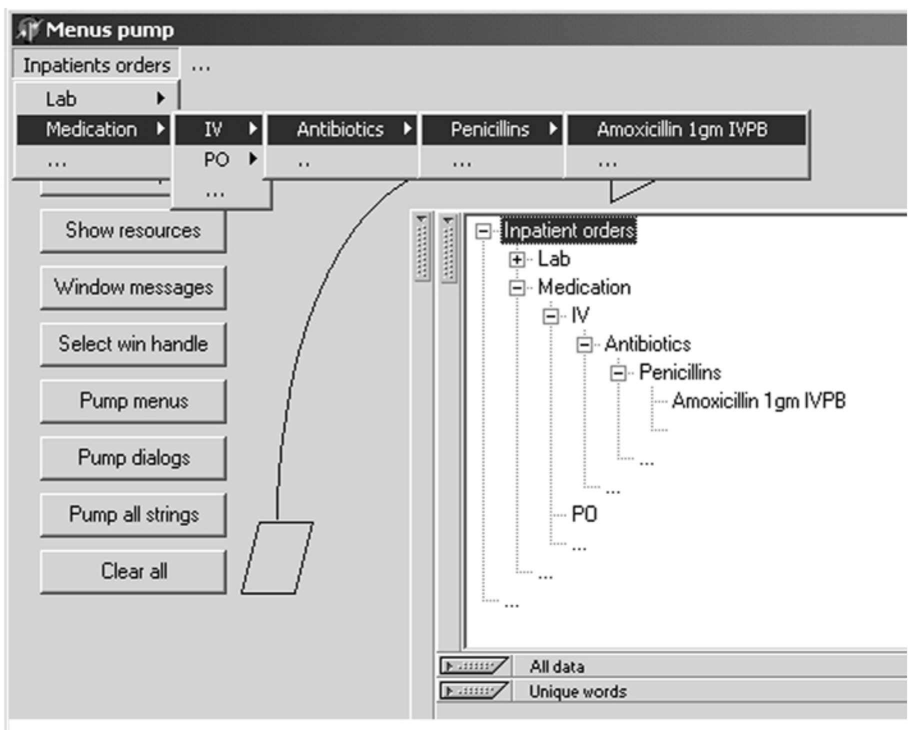

Figure 1 Command-line entry extension in the Veterans Affairs Computerized Patient Record System.

Table 1 ■

Example of Menu Description as Used to Create CPRS Menus and JIL Dictionaries

Menu Caption	System Meta Order	Online Help
ABG	LRT ABG PLUS WC Q4H X24H	ABG, routine, Collect on Ward, Q4H X 24H
ASCORBATE. 1000 QD	PSJQ ASCORBIC ACID 1000MG PO QD	Ascorbic Acid 1000mg, oral, QD
CA QAM X 3	LRT CALCIUM SERUM LC QAM X 3	Calcium, Routine, Collect on Ward

The concept of automatically generating a data source from the dynamic menu of existing software can be used for many other applications and is not restricted to CPRS. One drawback of this approach is the lack of linguistic knowledge in the knowledge base. It contains only basic structure along a mono-axial construction, and very little conceptual knowledge can be inferred from this hierarchy. However, the hierarchic structure of the menu and the accumulated contextual knowledge along the menu axes can be used to increase the power of representation of the menu captions. This can be compared with a mono-axial classification like the International Classification of Disease (ICD), and similar technical approaches can be used to analyze its knowledge.[21]

To improve the quality of the analyzer, extended information is currently added to the existing fields. The available knowledge can be grouped into four categories—the contextual knowledge that is in the hierarchic structure of the menus, the captions of the menus, the metastructure of each menu used to access the RPC broker, and the extra knowledge currently added to refine the results of the JIL analyzer.

Analysis of Text Entered by Users

The analysis is divided into three distinct steps. The first step is a morphologic partial-string pattern matching, which uses the Boyer-Moore-Horspool algorithm because it allows fast processing on streamed texts.[22] The second step is devoted to computing a proximity score index for each entry in the knowledge base. To do this, a pragmatic approach has been taken. The heuristic formula used to compute the proximity score takes into account various factors, like the position of the match, the length of the match, the number of mismatches, the presence and frequency of collocations, and the category of the match. This formula minimizes silence. It has been refined experimentally and iteratively to achieve the best overall results.

This approach has the advantage of being fast and relatively robust even when there are abbreviations and typographic errors. The major drawback is that it generates noise (false-positive matches). Therefore, users can dynamically vary the sensitivity of the formula. The results are presented in a list box and sorted by their proximity scores. One order usually generates between 10 and 20 responses. All processing is done in real time. If an element of the list is selected, the order is sent to CPRS, emulating actions that would have been taken using the usual CPRS ordering pathway. The usual processing of the order is then performed.

Table 2 ■

Number of Orders in Different Categories

Order Configuration Entity	Number
Quick orders	5,981
Ordering menus	703
Order dialogs	667
Order sets	513
Order prompts	206
Order action	8

The recognition of elements is strictly morphologic and is based on an extract-string pattern-matching algorithm. The user's entry is first tokenized into distinct chunks using space as separator. Each chunk is then compared with the knowledge base. The comparison is done to allow a match of the chunk at any position of the knowledge base, therefore permitting abbreviations. The comparison is not case sensitive. Each entry in the knowledge base is divided into two categories, named HLP and TXT, according to their source. The HLP category is used to design the textual information extracted from menu captions, that is, the text in the menus that is shown to users. The TXT category is the combined information that is used internally to describe actions taken by each menu item and the comments added by the informatics team to help maintain the menus.

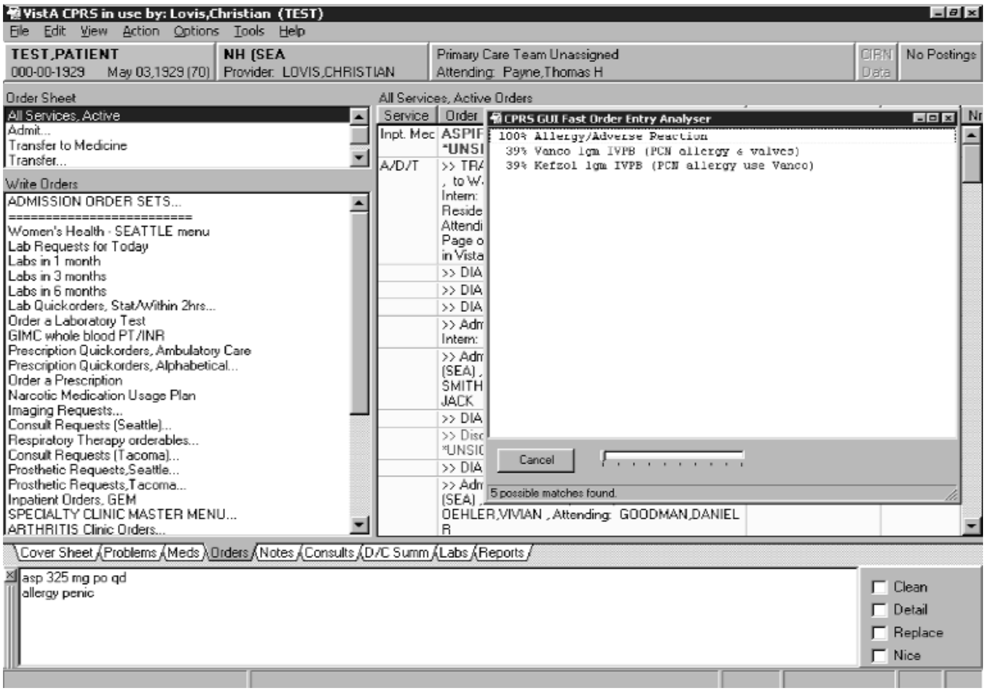

Figure 2 Command-line entry extension in the Computerized Patient Record System.

According to the matches, a proximity score is given to each entry in the knowledge base. The overall best score is kept, representing the maximal score that any entry in the knowledge base might have when compared with the user's entry. The score for every entry in the knowledge base is reported as a fraction of this maximal score. At the end of the processing, every entry in the knowledge base has a score between 0 and 1, the latter being considered a 100 percent match. Thus, an entry that has a score of 1 will be the best match to the user's entry when compared with all other knowledge base entries. The scores are expressed as percentages to be more readable by users.

The score is computed using a heuristic formula that has been refined during preliminary tests. Because no conceptual knowledge is available, a semi-stochastic approach has been taken. The formula takes into account the category in which the match occurs—TXT or HLP. A match in HLP is weighted twice as much as a match in TXT. It takes into account the length of the pattern being matched; that is, the longer the length, the stronger the match.

The formula also takes into account the position of the chunk currently tested in the user entry; the first position receives more weight. Also, it takes into account the position within the knowledge base where the match occurs, the first position receiving more weight. Finally, it gives additional weight if the chunk is the first one and the match occurs at the first position in the knowledge base. All weights are additive. In essence, this formula exploits the fact that the knowledge base is divided into two categories. The TXT category is more specific, and the HLP is more sensitive.

JIL Architecture

JIL was written entirely using an object-oriented approach similar to that used for CPRS. JIL is functionally divided into three parts. The first part is devoted to conditional initialization. The second deals with users' input analysis and conditional launch of commands. The third part manages the dynamic user interface of JIL and user interactions (Figure 2). These three groups of functions are tightly interconnected.

The primary guiding principles for the architectural development of JIL are integration, maintenance, and usability.

Structurally, JIL is completely embedded in an object structure, with two exceptions. First, the initialization function is external to the object structure so that it can be referenced easily by any calling procedure. This also alleviates the burden of JIL object creation, which is done completely within the initialization function. The second exception is the repository for the knowledge base. The data of the knowledge base is kept in a sequentially packed array of structured records external to the JIL object but allocated dynamically. This feature makes the data easily available for other parts of CPRS. In addition, it permits initialization of the data independently of the JIL

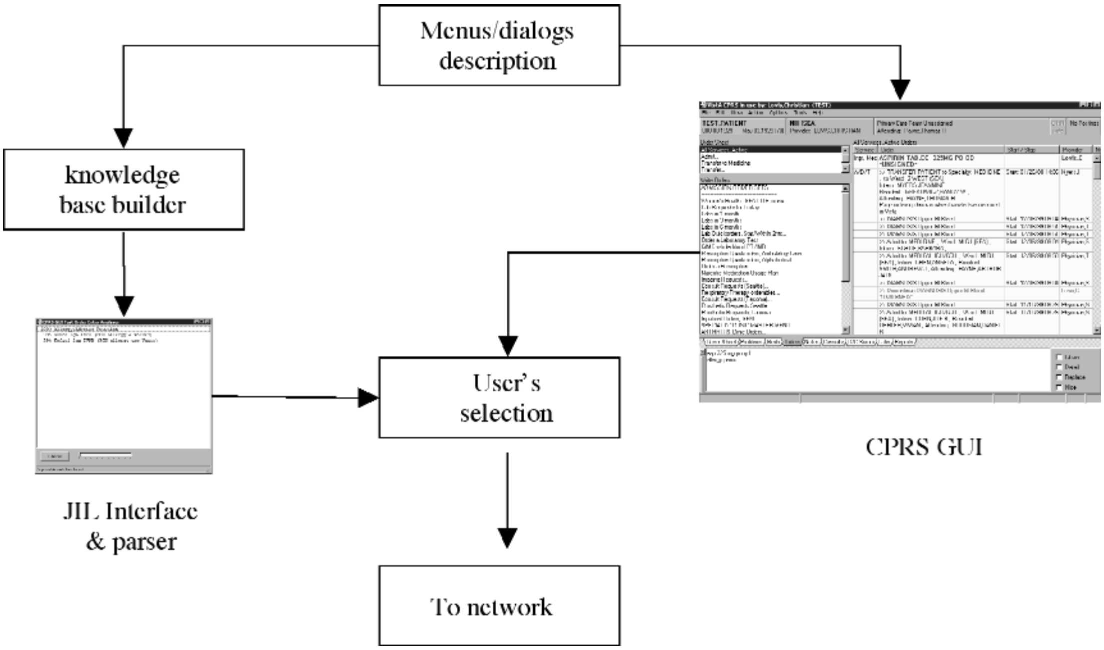

Figure 3 Overall architecture of JIL.

object. Separation of data and source code reduces space complexity.

JIL interacts directly and only with CPRS (Figure 3). The important point about this feature is that privacy, security, and user identification are managed by CPRS. In addition, because JIL interacts with the network only through CPRS, JIL should remain largely compatible with future releases of CPRS. Furthermore, JIL does not require any modification of existing or additional remote procedure calls (RPC) or business rules in the servers. Finally, any modification of access rights for CPRS is automatically valid for JIL.

All the visible elements that are added by JIL to the actual CPRS are built dynamically, which means that only minimal parts of CPRS source code have to be modified to be compliant with JIL.

Users can interact with JIL within CPRS using three distinct elements. The first element is a menu item that is added dynamically and conditionally to the CPRS menu. The second is the main editor that is added to the main window of CPRS. The third element is the dialog box that JIL displays if analysis of the user's command-line entry yields more than one result. This dialog box allows the user to select the most appropriate order from a list that is matched with the command line.

Users can change dynamically the specificity of the analyzer with a slider. All three elements are object-oriented, and their initializations and allocations are done at runtime.

Evaluation Methods

We evaluated JIL vs. CPRS in relation to the time needed to enter a test set of orders and in relation to user satisfaction.

A group of 16 physicians from the staff of VA Puget Sound Health Care System participated in the study on a voluntary basis. No compensation was provided. All physicians were current users of CPRS who received the standard training.

The evaluation was organized into two parts (Figure 4). The first part was devoted to entering a set of orders using the two systems alternately. An independent clinical team unaware of the study provided

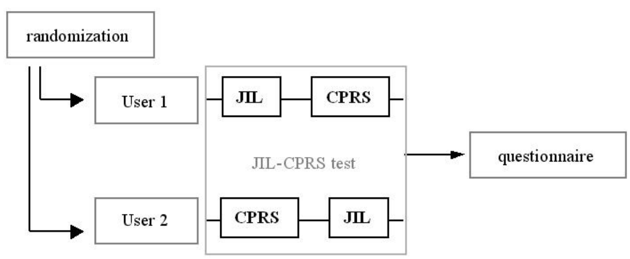

Figure 4 Evaluation study design.

the set of orders used for the evaluation (see Appendixes). The task was a typical set of orders for admitting a patient with severe gastrointestinal bleeding into the medical intensive care unit. It involved several categories of medical orders, including admission, diagnosis, severity assessment, surveillance, catheters, intravenous drug orders, and laboratory tests.

The test set does not differ from other orders that might be analyzed by JIL, and all orders that are handled in CPRS can be handled by JIL. The coverage of knowledge in JIL for the orders in the test set does not differ from the coverage for other orders.

Each participating physician entered the test orders twice, once using the usual CPRS ordering menu structure and once using the JIL natural language support. Before the beginning of the test, each physician was given a 5-minute description of the study and a 5-minute explanation about how to use the JIL system. In addition, the set of orders was reviewed with each physician to ensure clear understanding. To control for any possible learning effect between the two tests, physicians were randomly assigned into groups of two to use either JIL or CPRS first. The time required to enter the orders was recorded electronically by the system.

After completing this order entry exercise, each physician was asked to complete a satisfaction questionnaire that was divided into four sections (see Appendixes). The first section gathered information about the characteristics of the users and their prior experience using CPRS and computers. The second section compared the user's reaction to the GUI components of both CPRS and JIL. The third section focused on differences between CPRS, JIL, and handwritten orders. The last section asked the users to rate their preferences when comparing CPRS, JIL, and handwritten notes. A seven-point Likert scale was used for all items.

All data were recorded anonymously using a CPRS test account and a fictitious test patient. The satisfaction questionnaire was confidential. For these reasons, the University of Washington's Human Subjects Committee exempted the project from formal review.

Statistical Analysis

Based on pilot data, we estimated that a mean of 15.0 min (SD, 2.0 min) would be necessary to enter the set of orders. A sample size of 16 allowed for the detection of a difference of 2 min between the groups, with a power of 0.80 and an alpha of 0.05.

We used a paired *t*-test to compare the time it took to enter the orders with and without JIL. To evaluate the significance of the Likert satisfaction questionnaire, we used a *t*-test to compare duration and a nonparametric Wilcoxon signed-rank evaluation to test the equality of matched pair in the Lickert scales. Linear regression was used to evaluate the learning effect between the two systems as well as the effect of previous skills in computing. All analyses were performed with Intercooled Stata for Windows 6.0. All statistical tests were two-sided.

Results

Twelve physicians were in general internal medicine, three were in surgery, and one was a research fellow (Table 3). Eight physicians cared for inpatients, six cared for outpatients, and two managed both inpatients and outpatients.

Time to Complete Order Entry

The analysis of duration in seconds to enter the order test set showed that entering orders with JIL was about 7 percent faster (16.06 ± 4.52 min) than with CPRS (17.69 ± 6.77 min) for all physicians (Table 4). Among the physicians, three knew of and used a special menu in the CPRS screen on which all orders in the order test set were present. These three physicians were significantly faster than the others in their use of both CPRS and JIL (11.83 ± 1.35 min vs. 13.47 ± 1.82 min).

In a linear regression model adjusting for the ability to use the special screen and for learning effect, JIL

Table 3 ■

Characteristics of the Study Population ($N = 16$)

Male/female ratio	8/8
Position:	
Resident	8 (50%)
Fellow	7 (44%)
Attending	1 (6%)
Specialty:	
Surgery	3 (19%)
Medicine	12 (75%)
Research	1 (6%)
Site of practice:	
Inpatient	8 (50%)
Outpatient	6 (38%)
Both	2 (12%)
Mean length prior use of CPRS (mo.)	7.25 (SD, 8.37)
Mean length prior use of computers (mo.)	60.73 (SD, 36.21)

Table 4 ■

Comparison of Times to Complete Order Entry Using CPRS and JIL

	n	CPRS (min)	JIL (min)	%	Paired *t*-Test
All physicians	16	17.69 ± 6.77	16.06 ± 4.52	−7.33	$P = 0.029$
Physicians able to use the special screen	3	11.83 ± 1.35	13.47 ± 1.82	+12.77	$P = 0.0265$
Physicians not able to use the special screen	13	19.03 ± 6.81	16.66 ± 4.79	−11.97	$P = 0.0039$

NOTE: Responses are mean scores for each item on a seven-point Likert scale, 7 being the best.

Table 5 ■

Comparison of CPRS and JIL Interface Acceptance*

Question	a) CPRS	b) JIL	P value*
How would you rate your learning to use *X* orders entry?	3.56 ± 1.46	5.31 ± 1.14	$P = 0.0005$
How would you rate the *X* order entry menus?	3.69 ± 1.01	4.69 ± 1.14	$P = 0.0131$
How fast is it to find an order in *X* menus?	3.38 ± 1.50	5.31 ± 1.45	$P = 0.0030$
How would you rate medication information provided in *X*?	4.38 ± 1.36	4.44 ± 1.21	$P = 0.8334$

NOTE: Responses are mean scores for each item on a seven-point Likert scale, 7 being the best.
* Wilcoxon test.

Table 6 ■

Comparison of CPRS and JIL Orders with Handwritten Orders and of CPRS Orders with JIL Orders

Question	a) CPRS vs. Handwritten	b) JIL vs. Handwritten	Wilcoxon (a & b)	c) CPRS vs. JIL	Wilcoxon (c)
More difficult	5.50 ± 1.26	4.31 ± 0.79	$P < 0.005$	5.13 ± 1.20	$P = 0.0016$
Slower	2.69 ± 1.66	3.63 ± 1.09	$P < 0.05$	2.94 ± 1.29	$P = 0.0223$
More accurate	4.81 ± 1.72	4.44 ± 1.09	NS	3.94 ± 0.93	$P = 0.4065$

NOTE: Responses are mean scores for each item on a seven-point Likert scale, 7 being the best. NS indicates not significant.

was significantly faster in comparison with the usual CPRS menu entry system ($P < 0.001$). In this model, the order in which the systems were presented to the users was not significant, indicating little or no learning effect during the evaluation ($P = 0.92$).

User Satisfaction

Overall, the CPRS system was well accepted. However, the JIL entry system was considered to be easier to learn and faster than the GUI system. Users rated JIL higher overall than the CPRS system (Table 5).

The perceived quality of medication information provided by the two systems was similar. This was expected, because both systems use the same source of information and display the same text.

In comparison with handwritten orders (Table 6), both CPRS and JIL were rated as being significantly more difficult and slower but were perceived to be more accurate. However, JIL performed significantly better than CPRS with regard to both difficulty and speed.

When CPRS and JIL were compared directly, CPRS was considered significantly more difficult (5.13 ± 1.20 on the Likert scale) and slower (2.94 ± 1.29 on the Likert scale). Perceived accuracy was not significantly different.

Discussion

All but three physicians were faster in their use of the natural-language–based entry system than the usual GUI for computerized medical orders. The mean time spared was 2.38 ± 2.4 min vs. 11.97 ± 7.8 percent for CPRS. The three physicians who were faster (mean time spared, 1.63 ± 0.5 min; 12.76 ± 2.22 percent) with the usual CPRS menu system used a dialog menu, called the diagnosis-specific order screen, that groups most medical orders likely to be considered for a given condition in a unique screen view. This approach is extremely fast as long as the orders proposed in such screens exactly match the patient's condition, including drug orders and dosages. In practice, such screens can be built only by CPRS support staff and cannot be created for every possible clinical condition. Because these diagnosis-specific order screens are so much faster, CPRS support staff have constructed hundreds of them and strongly encourage physicians to use them during training. However, the more such screens are created, the more difficult it is to find the relevant screen for a patient.

A surprising effect was noted: Of the 13 physicians who did not use order sets, 5 choose IV NS 250cc/h instead of 150cc/h as written in the test set, although both orders were found and proposed by JIL. Because of the heuristic used to compute scores, the 250cc/h order was higher in the list proposed by JIL, but both the 250cc/h and 150cc/h orders were visible in the list. We do not explain this, and it should be further studied. Unfortunately, the study design and the data collection do not allow us to further analyze how often JIL missed what the user was looking for, since we did not expect users to choose orders that were not in the test set.

The combination of menus and natural-language processing has already been found to be a fast and efficient way to give novice users access to complex menus structure.[23] In our study, however, the data source was identical for both the menu structure and the natural-language interface. The speed improvement found by using the natural-language interface is easily explained by the complexity of the menu structure. The natural-language interface offers a shortcut to the menu structure, thereby reducing the search burden for users.

Several previously published reports have shown consistently faster access to electronic patient records by use of GUIs instead of text-based interfaces.[24–27] However, to activate orders using text-based order sets, physicians must scroll through various orders before selecting the order of interest. Because they are embedded deep within the menu structure, the correct menus can be difficult to locate, and a user may sometimes have to delve deeply into several roots before finding the correct menu. This search activity is very time consuming and becomes more so as the complexity of the menu structure increases. As a maturing information system that is used daily, VistA has evolved into a highly complex system as a result of efforts to make it comprehensive and responsive to a broad range of users. Thus, it appears that there is point at which graphical interfaces are no longer the most efficient method of data entry.

The perceived acceptance of an information system may also depend on the type of user and on the user's experience. For example, nurses appear to have a more positive perception of electronic order entry systems than do physicians.[28–30] Our results indicate that a GUI alone is not always superior to a command-line interface for speed of order entry, as previously reported,[25] but that performance depends greatly on the type of tasks users have to perform and, consequently, on the complexity of the GUI. It also appears to depend on the experience of the user. Novice users appear to perform better using the natural-language interface.

The system we tested combines a natural language–based interface with a GUI and gives the user the benefits of both approaches. In our study, the use of a natural-language–based alternative pathway to the GUI allowed a statistically significant decrease of slightly more than 10 percent in the time needed to enter the test order set. One can reasonably expect the true performance to be better if users can freely choose the best approach for each task, if they are more familiar with the natural-language interface, and if the knowledge base is improved.

When queried, users appeared to readily accept the natural-language–based interface in terms of ease of learning and use. The quality of information was not found to be different between the two systems, which is not surprising, since both provide the same data and use the same sources.

When the systems were compared with handwritten orders, the menu structure was found to be more difficult and slower whereas the natural language–based interface was not significantly different. When each system is compared with the other, the natural-language interface was found to be significantly easier to use and faster than the menu-driven system.

This study has several limitations. The organization of both CPRS and the JIL natural-language interface could be greatly improved. The design and the structure of menu-driven systems are major elements in how they are perceived by users. The performance of the text parser is very dependent on the quality of the textual information contained in menus and dialog captions as well as in the system description files. The CPRS GUI at the VA Puget Sound has a highly extended and well-maintained menu structure for accessing orders, which could be used by the JIL parser.

The natural-language interface is well accepted by clinicians, who find it more like their usual way of entering orders. It was faster, by both subjective judgment and objective measure, although the improvement in time—about 10 percent—was not great. The use of pre-organized screens containing all orders pertaining to a medical problem also appears to be a way to speed up order entry. Although hundreds of these screens are currently available, an increase in the number of such screens will lead to an increase in menu complexity. The more complex a menu, the longer it takes to find the correct order. In contrast, increasing the knowledge base of a natural-language–based interface does not increase the complexity of the interface (although the complexity of the base increases).

Physicians reported an average of 7 months prior experience with the VA CPRS and an average of 5 years of experience with computers. This level of experience is similar to that reported in the literature.[31]

Conclusions

We have successfully implemented an alternative pathway for order entry in CPRS without introducing major modifications of the CPRS source code, thanks to the three-layered architecture of CPRS and its strong object-oriented implementation. The source knowledge base allowing the analysis is directly and dynamically extracted from the menu structure of CPRS. Despite this apparent simplicity, the system is robust and efficient and allows users to enter most common orders by means of a natural language–based interface. This system is not currently used in CPRS, however, although it is reviewed in a CPRS panel work group and developers are apparently considering making radical changes in CPRS.

To our knowledge, this is the first report on physician satisfaction with and the efficiency of medical order entry in an electronic patient record, which compares a menu-oriented approach with a natural language–based interface. Physicians found the natural-language interface easier to learn and faster to use than the usual menu-driven system. The major advantage of the system is that it combines the advantage of an intuitive GUI with the power and speed of a natural-language analyzer. Such command-line analyzers may be replaced by voice recognition in the near future. Natural-language techniques are necessary steps toward such trends. The shift in the trends from numeric data to textual data is one of the paradigms of modern electronic patient records.[32]

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Appendix A

SURVEY: COMPARISON OF CPRS AND JIL ORDER ENTRY

Physician information

Demographic

Gender:	☐ Female ☐ Male			
Role:	☐ Nurse ☐ Intern	☐ Resident		☐ Fellow ☐ Other: ______
Specialty:	☐ Surgery	☐ Medicine	☐ Research Fellow	☐ Other: ______
Patients:	☐ Inpatients	☐ Outpatients	☐ Both	

Skills / Prior CPRS experience

Are you a regular user of CPRS for orders entry? ☐ No ☐ Yes, if yes, for how many months _____ ?

Are you a regular computer user? ☐ No ☐ Yes, if yes, for how many years _____ ?

Please, rate your typing skills

Poor ①—②—③—④—⑤—⑥—⑦ Excellent

CPRS order entry

How would you rate your learning to use CPRS orders entry?

Difficult ①—②—③—④—⑤—⑥—⑦ Easy

How would you rate the CPRS order entry menus?

Poor ①—②—③—④—⑤—⑥—⑦ Excellent

How fast is it to find an order in CPRS' menus?

Slow ①—②—③—④—⑤—⑥—⑦ Fast

How would you rate medication information (name, dose, route, form) provided in CPRS?

Poor ①—②—③—④—⑤—⑥—⑦ Excellent

JIL order entry

How would you rate your learning to use JIL orders entry?

Difficult ①—②—③—④—⑤—⑥—⑦ Easy

How would you rate the JIL order entry menus?

Poor ①—②—③—④—⑤—⑥—⑦ Excellent

How fast is it to find an order in JIL menus?

Slow ①—②—③—④—⑤—⑥—⑦ Fast

How would you rate medication information (name, dose, route, form) provided in JIL?

Poor ①—②—③—④—⑤—⑥—⑦ Excellent

Electronic order entry versus handwriting

How does the process of entering an order in CPRS compare with handwritten orders?

A CPRS order is

Easier ①—②—③—④—⑤—⑥—⑦ More difficult

Slower ①—②—③—④—⑤—⑥—⑦ Faster

Less accurate ①—②—③—④—⑤—⑥—⑦ More accurate

How does the process of entering an order in JIL compare with handwritten orders?

A JIL order is

Easier ①—②—③—④—⑤—⑥—⑦ More difficult

Slower ①—②—③—④—⑤—⑥—⑦ Faster

Less accurate ①—②—③—④—⑤—⑥—⑦ More accurate

How does the process of entering an order in CPRS compare with entering orders in JIL?

A CPRS order is

Easier ①—②—③—④—⑤—⑥—⑦ More difficult

Slower ①—②—③—④—⑤—⑥—⑦ Faster

Less accurate ①—②—③—④—⑤—⑥—⑦ More accurate

Thank you for your participation.

Appendix B appears on the following page

Appendix B

ORDER TEST SET

Orders for patient Test, John 7654

Date	**Orders**	***Done A***	***Done B***
11/10/99	Admit MICU		
	Team red Attending Goodman R3 Oehler R1		
	Dx GIB		
	Cond critical		
	Vitals per routine, orthostatics on admit		
	All NKDA		
	Activity bed rest		
	Nursing 1 Guaic all stools 2 NG to LIWS 3 Please place Foley catheter		
	Diet NPO		
	IV NS 500cc bolus then 150cc/h		
	Meds 1 Ranitidine 50mg IV Q8 2 Octreotide gtt 50 ug/hr 3 Vit K 10mg iv x1		
	Labs Admit CBC & platelets, M7, PT/PTT, LFTs ward QAM CBC & platelets, M7, PT7PTT		
	Other Call HO T>101.5, 120<p<50, 180SBP<90		
11/10/99	Transfer 2W (medicine)		
	Team RED Attending Morantes, R3 Oelher, R1		
	Dx GIB		
	Cond stable		
	Vitals per routine		
	All NKDA		
	Activity OOB TID with assistance		
	Nursing D/C NG + Foley		
	Diet clear liquids		
	IV D5 1/2 NS at 25cc/hr		
	Meds Ranitidine 150mg po BID		
	Labs QAM CBC + M7		
	Other Call H0 T > 101.5, 120<p<50,180<SBP<100		