The Interaction of Principles and Examples in Instructions

Richard Catrambone and Ronald M. Wachman
Georgia Institute of Technology
School of Psychology
Atlanta, GA 30332-0170
rc7@prism.gatech.edu gt4375a@prism.gatech.edu

Abstract

Learners often have difficulty following instructions written at a general enough level to apply to many different cases. Presence and type of example (example either matched the first task, did not match the first task, or was not present) and presence of a principle (that provided a rationale for part of a procedure) were manipulated in a set of instructions for computer text editing in order to examine whether initial performance and later transfer could be improved. The results suggest that a principle can aid initial learning from general instructions if no example is given or the example does not match the first task. The principle could help users disambiguate the instructions by providing a rationale for potentially misunderstood actions. However, if the example matches the first task, then the presence of a principle seems to slow initial performance, perhaps because the learner tries to compare and integrate the example and the principle. On later training tasks, however, a principle improves performance. These results suggest that the features of instructions that aid initial performance and those that aid later performance are different and careful research on how to integrate these features is important.

Introduction

People frequently have difficulty following instructions (e.g., Reed & Bolstad, 1991; Wright, 1981). One reason for this difficulty is that the procedures described in the instructions are ambiguous or abstract at certain points. These points are often places where options in the procedure exist. If the procedure is described too concretely at these points, that is, a particular choice for that point is described, the learner might not understand that other choices are possible and thus, fail to generalize when confronted with new tasks (Catrambone, 1990). Ideally, the learner needs to understand, or instructions need to convey, the necessary generality. However, if the learner is new to the domain then he or she will have difficulty comprehending the generality and determining how to instantiate the procedure for initial tasks. This is one place where a principle or example could be useful.

A principle provides the learner a way to generate for him- or herself an explanation of the ambiguity (Mitchell, Keller, & Kedar-Cabelli, 1986). This presumably would help the learner apply the instructions to the initial tasks as well as later tasks.

An example can help the learner instantiate the instructions. If the example matches the task the learner needs to perform, it is likely the learner will perform the task successfully. However, if the initial task and the example do not match, the learner typically has difficulty applying the example successfully (Catrambone & Holyoak, 1990; Ross, 1987), perhaps because the learner is unable to distinguish superficial features of the example from ones that are relevant for carrying out the procedure.

The current paper examines the effects of examples and principles that accompany general instructions for the task of deleting text using a word processor. Learners were given instructions that were general enough to cover all deletion situations. With the word processor used in the experiment, deletion is done by placing the cursor at the beginning of the to-be-deleted text, selecting the "delete" option from a menu, highlighting the text, and pressing Enter. To highlight the text the user presses the final character of that text. The instructions say to "Type the character at the end of the text you want to delete, typing it over and over until the text is highlighted." When the user specifies the target, the computer then highlights the text up to that character. The target character can be pressed several times if it occurs more than once in the to-be-deleted text.

The notion of multiple target specification is bewildering to new users who do not understand the idea of target searches (Catrambone, 1990). It is at this point that a principle or example is helpful. An explanation of what the computer is doing when the target character is pressed could help the learner understand why it is sometimes necessary to press the final character more than once (see Table 1). Alternatively, an example showing a to-be-deleted word such as "telephone" that requires its final letter to be typed more than once would help the learner to explain to him- or herself why multiple presses of the target is sometimes necessary.

Another factor to consider is the nature of the initial task the learner attempts. If the first task subjects faced was to delete a word that required only a single keypress (i.e., its final letter did not occur earlier in the word), then the learner could be confused by the instruction that says to type the end character over and over. This in fact was the initial task in this experiment. Two factors were manipulated in order to examine their effects on this potential confusion. The first was whether the instructions were accompanied by a principle that explained why multiple presses of the target letter are sometimes necessary. This is predicted to help the learner determine more quickly why the final letter of the first to-be-deleted word needs to be pressed only once. The other factor was the type of example that accompanied the instructions. If the example is a word whose final letter occurs earlier in the word (such as "telephone"), this could help the learner understand why the final letter sometimes has to be pressed more the once; however, this example does not match the first task and thus, could confuse the learner. Conversely, if the example is a word whose final letter does not occur earlier in the word (such as "airplane"), prior research suggests the example would help the learner with the first task since the example and the task mesh. However, there remains the potential for confusion since the example is in some sense at odds with the instructions. In this situation, the learner would be likely to pay more attention to the example since it meshes with the first task and pay less attention to the instruction (LeFevre & Dixon, 1986). Finally, if no example is given then a principle again becomes important in helping the learner to understand the instructions.

The purpose of this study was to explore the relationship between general instructions, principles, examples, and performance on initial and later tasks.

Prior Work Examining Elaborations and Examples in Learning Procedures

One difficulty that faces new users of a set of instructions is understanding what is really going on when they execute a series of steps. Prior work has suggested that a principle or explanation, at some level, of what the system "really" does, even if that explanation is only an approximation, would help learners understand those steps more rapidly (Kieras & Bovair, 1984) and even apply them to novel situations more effectively (Gentner & Gentner, 1983).

In a similar vein, other studies suggest that background knowledge or elaborations may help initial performance (Barsalou & Hale, 1992). For example, Reder, Charney, and Morgan (1986) found that subjects learning various DOS commands were more successful if the instructions contained elaborations about the commands instead of primarily syntax information. Smith and Goodman (1984) found that subjects who received elaborations of instructions for building circuits that included information about the structure or function of the circuits more accurately built the circuits and showed superior transfer when building new circuits.

Despite the demonstrated value of elaborations and mental models on learning, people prefer to learn from examples (Chi, Bassok, Lewis, Reimann, & Glaser, 1989; LeFevre & Dixon, 1986; Pirolli & Anderson, 1985). One reason examples are often preferred might be that they provide a concrete guide to behavior. The learner typically can visually compare the example to the procedure as well as the current task and decide how to make changes appropriate to the current task. However, one well-established difficulty is that learners often have trouble adapting examples to novel problems (Catrambone & Holyoak, 1990; Reed, Dempster, & Ettinger, 1985).

In the current study it is predicted that learners will do the initial deletion task most successfully if the example matches the task or if the instructions contain a principle. It is unclear, based on prior work, what the nature of the interaction between example type and principle will be.

Experiment

Method

Subjects. Subjects were 61 students at the Georgia Institute of Technology who participated for course credit. Subjects, as indicated on a questionnaire, had computer experience confined to a Macintosh whose interface is considerably different than the interface for the word processor used in this experiment.

Procedure. Subjects performed word processing tasks on an IBM PS/2 Model 80 computer (this will be referred to as the "task" computer). In addition, a second PS/2 80 was used to present instructions to subjects (this will be referred to as the "instruction" computer).

Subjects were first shown several features of the task computer and the word processing program. The task computer screen displayed an "empty" document. Subjects were shown how to move the cursor around the screen with the arrow keys. Subjects were then asked to type a paragraph to allow them to get comfortable with the keyboard.

Next, subjects were shown how to use the instruction computer to read the instructions on how to do various tasks. Instructions consisted of a series of screens of information. The instructions included procedures for retrieving and exiting documents and inserting text into a document. These instructions

were the same for all subjects. In addition, the instructions included the procedure for deleting text. Table 1 contains the part of the instructions for deleting text that varied from group to group.

There were six groups in the experiment defined by the presence or absence of the principle and the type of example (matching first task, not matching, no example). The deletion instructions were identical for all subjects except for Screen 7 (see Table 1). "Principle" subjects received an explanation of the searching the computer does for a target character. "Example" subjects received an example of a word being deleted. The word required either a single keypress (matching first task) or multiple keypresses (not matching first task). If a subject received both a principle and an example, the principle preceded the example. The type of instructions subjects received was confounded with length.

Presentation of Instructions. The instructions could be viewed on the instruction computer one screen at a time. The contents of a screen became visible when the subject held down the space bar. When the space bar was not held down, an outline of the instructions appeared on the display. The outline consisted of rows of dashes where each row corresponded to a screen. Each row that represented the first screen of information for a particular topic (such as retrieving a document) consisted of the title of the topic rather than dashes. This allowed subjects to keep visual track of where they were in the instructions. In addition, one row in the outline was always at a higher intensity than the others. This row corresponded to the screen that would appear if the space bar was pressed. Subjects could go forwards or backwards through the instruction screens by pressing the Next Page key or the Previous Page key. Subjects' movements through the instructions were automatically recorded.

Training and Test Phases. After learning how to read instructions on the instruction computer, subjects were shown the first document on which they were to work. The document was marked-up to show the changes that were to be made. Items to be deleted were underlined in red ink. The name of the document was printed in the upper left-hand corner since the name was needed in order to retrieve the document.

Prior to doing a task (such as retrieving a document) in the training phase for the first time, a subject read the instructions for that task all the way through before attempting to do the task. This was done in order to make sure subjects saw all the steps for the procedure at least once and would be less tempted to guess about how to do a step later. Subjects were told that once they were done reading a section, they could not look back at it while they attempted to do the task.

Once subjects began a task, if they did not know what to do at a particular point or made a mistake from which they could not recover, they had to re-read that section of the instructions and then redo the task. Once subjects successfully completed a task, they did not have to read that section of the instructions again unless they later made a mistake from which they could not recover. The time to do a deletion task was defined as the moment the function key was pressed (that opened the menu containing the delete option) until the Enter key was pressed, causing the appropriate text to disappear from the screen (including time spent redoing the task if the subject made a mistake).

The experiment was broken into a training phase and a test phase. Training tasks included deleting a total of six words, six sentences, and three paragraphs. The test tasks consisted of deleting words, sentences, and paragraphs as well as other entities, such as garbage letters in the middle of a word, that required subjects to apply the procedure to unfamiliar units.

The first three documents (constituting the training phase) each required the following tasks in order: 1) retrieve the document, 2) delete a word, 3) insert a phrase, 4) delete a sentence, 5) insert a phrase, 6) delete a paragraph, 7) insert a phrase, 8) delete a word, 9) insert a phrase, 10) delete a sentence, and 11) exit the document.

The phrase insertions were always seven words long. The word deletions during the training phase never involved a word whose last letter also occurred earlier in the word. Thus, these word deletions required only a single specification of the target letter. Similarly, all sentences ended in a period and no sentence contained any internal periods. The insertion and document retrieval and exiting tasks were included to make the tasks somewhat realistic.

During the test phase subjects performed only deletion tasks. Each of the three test phase documents contained five deletion tasks, two involving words, two involving sentences, and one involving a paragraph. The first deletion task in the test phase was to delete the word "mysterious." The second task was to delete a sentence that had internal periods (and thus a period had to be pressed three times in order to completely highlight the sentence). The third task was to delete a paragraph in which the last character, a period, occurred only once in the paragraph. Other test phase deletion tasks differed from the word, sentence, and paragraph deletion tasks in the training phase in various ways. First, some tasks began in the middle of words, sentences, and paragraphs rather than at the beginning as was the case in the training phase. Second, some tasks did not include the end of some obvious unit (e.g., deleting the first few words of a sentence without deleting the rest of the sentence). Third, some tasks,

other than paragraph deletions, required multiple keypresses.

Results

Given that a prior study (Catrambone, 1990) demonstrated a long start-up time for general instructions, but good transfer to novel tasks, the result of most interest is time to do the first deletion task (deleting a word). The times varied from 31 to approximately 80 seconds (see Table 2). A two-way analysis of variance showed no main effect of either principle ($F(1,55)=.23$, $p=.63$) or example ($F(2,55)=.02$, $p=.98$). However, the interaction was significant, $F(2,55)=3.31$, $p=.04$. The three fastest groups were the groups with the matching example and no principle, the group with the principle and no example, and the group with the mismatching example and the principle.

Table 1: Deletion Instructions

Screen 7:
Type the character at the end of the text you want to delete, typing it over and over until the text is highlighted.

Principle:
Each time you type the character, the computer "searches" in a forward direction, starting from the point at which the cursor is located, until the computer finds the character. When the computer finds the character, it highlights all the text it searched through on the way to finding the character.

Example:
Matched initial task: For example, if the word you wished to delete was airplane then you would type the letter e.

Did not match initial task: For example, if the word you wished to delete was telephone then you would type the letter e three times.

Table 2: Time to Perform Deletion Tasks (seconds)

	Example Matches First Task		Example Does Not Match First Task		No Example	
Deletion Task	Principle (n=10)	No Prin (n=10)	Principle (n=11)	No Prin (n=10)	Principle (n=11)	No Prin (n=9)
1st (Delete Word)	75.9	31.0	42.6	60.6	31.0	79.5
2nd (Delete Sentence)	242.3	112.4	180.4	171.6	103.7	159.6
3rd (Delete Paragraph)	13.3	18.1	13.5	14.4	31.2	26.1
Remainder of Training Phase Tasks	8.9	10.7	9.7	10.1	9.4	11.7
1st Word Requiring Multiple Keypresses	8.7	16.5	9.1	10.2	9.8	13.0
1st Sentence Requiring Multiple Keypresses	10.4	10.9	12.1	12.6	12.2	12.3
1st Paragraph Requiring a Single Keypress	10.2	10.4	9.5	16.0	9.7	10.5
Remainder of Test Phase Tasks	10.0	10.6	11.8	11.2	11.6	11.4

The pattern of results in Table 2 for the first deletion task suggests the following interpretation. If no example is present or the example does not match the current task, then having a principle appears to help the learner apply the procedure. If the example matches the first task and there is no principle, the learner also performs well. However, if the example matches the first task and the principle is present, the learner is slowed, perhaps because the learner spends time trying to reconcile the discrepancy between a principle that explains why multiple presses are needed with an example that only requires a single press. If no principle is given and either no example or a mismatching example is given, performance is also slowed.

The second deletion task, deleting a sentence, caused problems for subjects, primarily because they had difficulty realizing that a period could be used as a target character to specify the range to be highlighted. There was no effect due to the principle, example, or their interaction. This is not entirely surprising given that the major difficulty, realizing that a period is a legitimate target character, does not appear to be benefited in any obvious way by the principle or examples used here.

The third deletion task, deleting a paragraph, showed a trend favoring subjects who received the principle ($F(1,55)=3.60$, $p=.06$). Performance time for all groups dropped considerably from the sentence deletion time (see Table 2). This is reasonable given that subjects had learned from the prior task that a period can be used as a target. The only new feature here is that the target needs to be pressed more than once. The first two deletion tasks, deleting a word and a sentence, only required a single keypress. Perhaps subjects developed an expectation of only having to type the target once. However, principle subjects could have possessed the necessary understanding to realize more quickly why a single keypress was not sufficient to highlight the entire paragraph. There was also a trend towards subjects without an example taking longer, but this was primarily due to two outliers.

Performance on the rest of the training tasks showed a trend favoring subjects who received the principle ($F(1,55)=3.39$, $p=.07$). This suggests some benefit of a principle beyond the performance of the initial tasks. Perhaps the principle provides an additional pathway for helping subjects recall or reconstruct the details of how to specify a target character for both single and multiple specification cases. The example may help only on initial cases that match it.

The test phase tasks involved novel features such as deleting a word using multiple keypresses or deleting only part of a word or sentence. Performance on the first test phase task, deleting a word that required multiple specifications of the target, favored subjects who received the principle ($F(1,55)=8.14$, $p=.006$). It is surprising that subjects who received the word deletion example that involved multiple keypresses did not show superior performance on this task. However, this result is consistent with the training phase result showing no benefit of an example beyond the initial task. Perhaps an example is accessible for initial tasks similar to the example whereas a principle is accessible for, and therefore applied to, many tasks.

Performance on the next task, the first sentence deletion task that involved multiple specifications of the target, did not show performance differences as a function of either manipulation. This makes sense since subjects had just completed a task requiring multiple specifications.

Performance on the next task, the first paragraph deletion task in which the target character had to be specified only once, showed a trend favoring principle subjects ($F(1,56)=3.60$, $p=.06$). This probably occurred because by this time subjects were used to specifying a target multiple times for a paragraph and some subjects pressed the target multiple times before realizing they did not have to do so. Subjects who received the principle were less likely to make this error since they presumably were more aware of what the specification did. Nevertheless, this is a surprising result given that subjects had already done 17 deletions prior to this task.

There were no differences in performance for the remainder of the test phase tasks as a function of the manipulations. Subjects had, by this time, been exposed to all the oddities they would encounter later and presumably were able to handle them (principle: $F(1,55)=.09$; example: $F(2,55)=1.34$, $p=.27$; interaction: $F(2,55)=.48$).

Discussion

The results indicate that a principle is useful in helping learners to follow general instructions initially, particularly if no example or a mismatching example is present. An example is useful on the initial task if it matches that task. Interestingly, if the example matches the initial task, then a principle seems to get in the way of performance of the initial task. These findings suggest that instructions could be written at a general level and still be relatively easy to use initially if certain elaborations or principles are provided. Other research has suggested that instructions can be written in detail for specific tasks that aid initial performance and allow generalization to novel tasks (Catrambone, 1990, Experiment 2).

The decision to write general instructions with principles or to write specific instructions that promote generalization could be a function of other factors. For example, if the user will be performing a limited set of tasks, then specific instructions for each

task is the best approach. However, if it is likely that the user will eventually have to do novel and perhaps unforeseen (by the instruction writer) tasks, then general instructions with principles is the best approach. Clearly, these issues need to be tested in additional experiments.

Experiments that manipulate the ambiguity of general instructions should show differential effects of including principles. It may be the case that well-written general instructions do not benefit from the inclusion of principles and examples. In fact, users might perform best with a well-written minimalist set of instructions (Carroll, Smith-Kerker, Ford & Mazur-Rimetz, 1987-88).

The general instructions used in this experiment were probably not optimal. Screen 7 of the instructions (Table 1) said to type a target character over and over until the text was highlighted. The instructions could have been better worded (e.g., "type the character one or more times...") with little loss of generality. If this improved wording had been used, it is not clear that the inclusion of the principle would have had the same impact as it did in the current study. In any case, the effect of providing a principle needs to be examined for other tasks and with instructions involving varying degrees of generality before strong conclusions can be drawn about the effects of principles on the comprehension and application of instructions.

It would also be useful in future work to build a model to explain how a principle or an example can aid in the comprehension and carrying-out of general instructions. One approach is suggested by Kieras and Bovair (1984) who argue that mental model information is information that maps on to the requirements of a procedure, thus allowing a learner to infer a procedure. Thus, in the current study, if a subject could not remember part of the procedure or had difficulty determining how to apply it, the presence of the principle helped them reconstruct the necessary steps. Another possibility is that the principle helps disambiguate instructions. An explanation of why a certain step is needed could help point the user towards the correct interpretation of the instructions. Thus, a principle should be more useful as the instructions are more general.

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