Using Instructions in Procedural Tasks

Elsa Eiríksdóttir (gtg702v@mail.gatech.edu)
School of Psychology, Georgia Institute of Technology, 654 Cherry Street
Atlanta, GA 30332-0170 USA

Richard Catrambone (rc7@prism.gatech.edu)
School of Psychology, Georgia Institute of Technology, 654 Cherry Street
Atlanta, GA 30332-0170 USA

Abstract

The study examined whether an instruction-based strategy (studying the instructions before attempting the task) or task-based strategy (attempting the task and referencing instructions) is more effective for procedural performance and learning. Four groups of participants performed two macramé tasks, and received detailed instructions at different times in the process of attempting the tasks. Performance was measured with task completion time. The results indicated that the instruction-based strategy helped procedural performance as compared to the task-based strategy. Participants not made to use a specific strategy showed the best performance and participants not having access to detailed instructions did the worst. When repeating the tasks a week later without instructions there was no performance difference among the groups.

Keywords: Procedural tasks; Instructions; Learning.

Introduction

People engage in procedural tasks many times a day, and some of these tasks are well learned and performed effortlessly, such as tying shoelaces or driving. Others are unfamiliar or seldom encountered, like assembling furniture or setting up a stereo system, in which case instructions of some kind are needed to help perform the task. The most common kind of instructions for procedural tasks consists of pictures and text explaining each step of the procedure in a linear fashion. Given that instructions are needed and available, how do people make use of them? It is often assumed that instructions should be read before performing a task, but more often than not people do not look at the instructions until they do not know (or cannot guess) what to do next (Ganier, 2004).

A procedural task can be thought of as a series of steps, where each step consists of actions applied if certain conditions are met, according to some production rules (Anderson, 1993; Newell & Simon, 1972). A distinction can be made between two different goals of performing a procedural task. In some cases the goal is simply to perform the task only once, without any intention to learn the procedure. An example of this kind of *one-time procedural performance* is when new furniture is assembled. In other cases the goal is to learn to perform the procedure from memory, and be able to apply it across situations. An example of this kind of *procedural learning* is when children learn to tie their shoelaces.

The nature of the procedural task is important in terms of how easy or difficult it is to learn and perform. The complexity of a procedural task is contingent upon various factors, for instance the materials needed (e.g., tools and parts), the physical manipulations required for the task, the affordances, or the acts permitted by the materials used in the task, and prior experience with similar tasks (Norman, 1988). Most consumers base their decision to read the instructions on whether they think the product needs instructions (Schriver, 1997). This indicates that the complexity of a task will influence whether people use instructions or not; instructions become presumably more important if a task is unfamiliar and involves complicated manipulations.

Traditionally, procedural instruction documents have been designed to be read before the learner attempts the task and it is assumed that the knowledge is first learned from the instructions and then applied to the task (Carroll, Mack, Lewis, Grischkowsky, & Robertson, 1985; Ganier, 2004; Schriver, 1997). This is a linear process because the learner reads through the instructions step by step before applying the information to the task. This linear or *instruction-based* strategy is commonly used by novices or cautious users. Another strategy often seen, but not commonly supported by instructional materials, is more interactive. The learner attempts the task and uses the instructions for referencing. This *task-based* strategy is preferred by experienced users and a subset of novices (Ganier, 2004; Schriver, 1997). In order to use instructions as references the learner must have some idea about what he or she has to do. The task cannot be too complex or unfamiliar. Given that learners employ different strategies for using instructions when approaching procedural tasks, which strategy, the task-based or the instruction-based, is more helpful? More specifically, how does the strategy affect one-time procedural performance on one hand and procedural learning on the other?

It seems that learners could clearly benefit from using an instruction-based strategy because it provides them with clear delineation of what to do and how to go about doing it. This might be more beneficial to one-time procedural performance, but it might actually be detrimental to procedural learning because the learner does not necessarily actively engage in what he or she is doing. Research on procedural tasks indicates that the key to effective procedural learning is to get the learner actively engaged with the task. For instance, Vakil, Hoffman, and Myzliek (1998) showed that active training (learners actively explored the materials) resulted in better performance on a procedural task compared to passive training (following auditory step-by-step instructions). Similarly, work comparing learning for groups that were either presented with goal-free training problems or solved problems with explicitly stated goals, has shown that the goal-free method is more effective for subsequent transfer (Sweller, van Merrienboer, & Paas, 1998). The goal-free method emphasizes learning by encouraging the learners to explore the problem space instead of focusing on step-wise problem solving of a particular problem. In addition, guided exploration where instructional materials are designed to specifically encourage active learning has been found to be more effective for learning to use word processing software than a conventional step-wise study manual (Carroll et al., 1985).

It intuitively seems straightforward that reading the instructions beforehand would be the most logical course of action. However, research has indicated that explicit what-to-do information can lead learners to rely on a simple rote rehearsal procedure and to not generate as rich a task representation as they might form in a situation in which they need to work out what to do (Duff & Barnard, 1990; Green, 2002). In another line of argument, Alterman, Zito-Wolf, & Carpenter (1991) suggested that instructions are difficult to understand when encountered outside the context of action as they tend to be abbreviated and assume the learner has an understanding of the situation. Without context it is unlikely that the learner can comprehend more than just a general sense of what the instructions mean and the operations involved. Also, instructions tend to be phrased in terms of concrete actions and advice, and as such refer to actions that the learner is supposed to be doing.

In sum there is evidence to suggest that a task-based strategy could be more effective than an instruction-based strategy because it encourages engagement with the task and information is accessed in the context of action. This is important because step by step instructions do not require the learner to engage in active or elaborate processing, but might instead encourage passive imitation and promote the illusion of comprehension (Renkl, 1997).

In the current study (which is a part of a ongoing research investigating strategies of instructions usage), we manipulated whether participants engaged in a task-based or an instruction-based strategy by introducing detailed instructions at different times in the process of completing two macramé knots (see Figure 1). One group of participants studied the instructions before attempting the task (instruction-based strategy; *Before* group), the second group had to attempt the task for a few minutes before receiving the instructions (task-based strategy; *Later* group), the third received instructions and attempted the task at the same time (*Simultaneous* group), and the fourth did not receive detailed instructions (*No-Instructions* group). The two groups that initially attempted the tasks without detailed instructions (the Later and No-Instructions groups) were given pictures of the finished tasks for guidance and to ensure they understood what the task entailed. The tasks were chosen because most people are somewhat familiar with tying knots, and they should know what the tasks entail even if the macramé knots themselves are presumably unfamiliar.

One-time procedural *performance* was measured by the time it took the participants to complete the tasks correctly. We expected that the Before group would have better one-time procedural performance than the Later group. Working out the procedure without detailed instructions is presumably more time consuming and error prone than following the stepwise instructions. We expected the Simultaneous group to show the best performance of all the groups because the participants could use whichever strategy they were accustomed to. Finally, we expected the No-Instructions group to have the poorest performance because they did not have access to detailed instructions to resolve ambiguities.

Procedural *learning* was assessed by having the participants complete the tasks again a week later without detailed instructions. After reviewing the literature we were uncertain which group would show the best performance in the second session. On the one hand an instruction-based strategy (Before group) might allow the learner to perform the task correctly more easily and establish appropriate representations of the task from the beginning. On the other hand, a task-based strategy (Later group) might encourage the participants to become more actively engaged in the task and lead to better learning through more elaborative processing (e.g. Sweller et al., 1998; Vakil et al., 1998).

Method

Participants

Participants (N = 80) were recruited from undergraduate psychology courses at the Georgia Institute of Technology, and were compensated for their participation with extra course credit. Age range was 18 to 23 years (M = 19.1), and 48 were male (60%). All participants were randomly assigned to one of the four conditions, 20 participants in each.

Design

A four group between-subjects experimental design was used. The Before group studied the instructions before receiving the materials for the task. The Later group attempted the task for a few minutes before receiving the instructions. The Simultaneous group received the instructions and the task materials at the same time. The No-Instructions group received only the task materials and pictures of the finished task.

Participants completed two sessions; in the first session participants completed the tasks using instructions as determined by the condition. In the second session they completed the tasks again without detailed instructions (only using pictures of the finished tasks for guidance). Time on task was measured in both sessions.

Materials

Participants were taught to tie two different macramé knots, one at a time; a square knot and a pretzel knot (Meilach, 1971). To tie the knots participants used a wooden board with a horizontal bar onto which three cords were fastened, each three feet long. The square knot task consisted of tying a square knot five times, and the pretzel knot task consisted of tying a series of three knots in a row (see Figure 1).

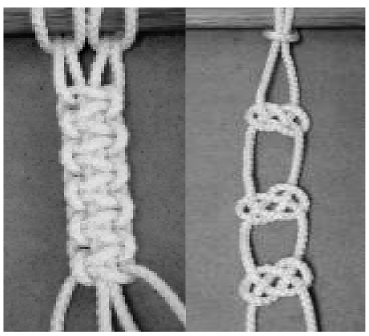

Figure 1: Pictures of finished tasks, square knot on the left and the pretzel knot on the right.

The instructions were based on published instructional materials for doing macramé knots (Lunger, 1998; Meilach, 1971). They represent the type of instructions that are traditionally used for teaching procedural tasks, consisting of pictures showing each step in the procedure accompanied by supporting text explaining the step in more detail (see Figure 2). The pictures of the finished tasks showed the overall completed task and one knot partially unraveled. This was found necessary because pilot testing indicated it was impossible to infer the makings of the knots when shown tightly knotted. Computers were used to administer the experiment. For all the groups only the pictures of the finished task were shown by default. To view the instructions the participant had to hold down the left mouse button (see Figure 2). We did this in order to measure the time spent viewing instructions separately from the time spent on doing the task.

Procedure

Participants were presented with the task materials and/or instructions depending on the condition we assigned them to. There was no time limit; participants (with several exceptions noted below) performed the tasks until they successfully completed them.

Participants in the Before condition were presented with the detailed instructions and asked to study them for 3.5 minutes before attempting the task. After the designated time had elapsed (indicated by an alert window) the participants were given the task materials. Participants in the Later condition started attempting the task using only pictures of the finished task and the partially unraveled knot. After 3.5 minutes elapsed they had access to the instructions. The time limit was determined by pilot testing; an average of 3.5 minutes was needed for participants to attempt each knot. Participants in the Simultaneous condition were presented with the task materials and the instructions at the same time. Participants in the No-Instructions condition were presented with pictures of the completed tasks and asked to perform each task using only the pictures of the finished task for guidance.

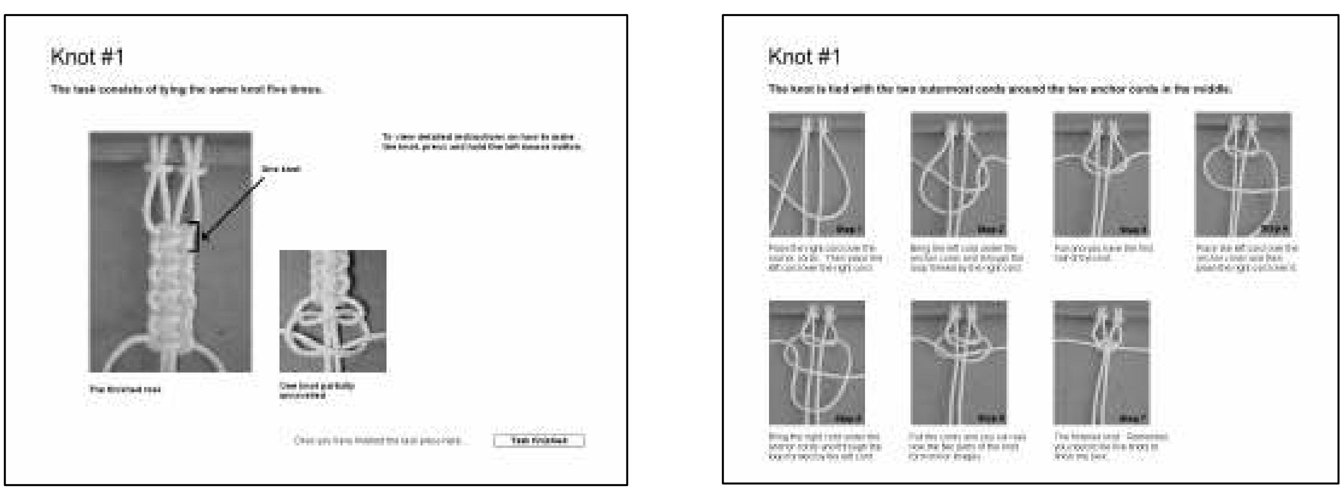

Figure 2: Instructions for the square knot. On the left side are the pictures of the finished task (visible by default). On the right side are the detailed instructions showing each step of the procedure (only visible if left mouse button was held down).

The second session took place a week after the first (six to eight days) and was identical for all four conditions. All participants completed the knots again, but without detailed instructions, receiving only pictures of the finished tasks for guidance

Results

The majority of participants completed both tasks correctly in the first session (93.8% and 94.9% for square knot and pretzel knot, respectively), and only data for the correctly completed tasks were used in the analysis. This criteria excluded five participants in the square knot analysis and four participants in the pretzel analysis.

Time on task was calculated for each task in both sessions. Time on task was defined for the first session as the overall duration of task minus the time spent viewing the instructions. Outliers (3 *SD*'s from the *M*) were removed from the task duration variables for both sessions.

By excluding outliers and including only cases where the task was correctly completed, there were a total of 74 cases for the square knot and 72 cases for the pretzel knot, out of 80 in the first session.

Of the original 80 participants 73 returned a week later for the second session, leaving 17 participants in the Before and No-Instructions groups, 20 in the Later group and 19 in the Simultaneous group. In the second session the majority of all participants finished the tasks correctly (88.9% and 94.4% for square knot and pretzel knot respectively), and only those cases were included in the analysis of time on task. Using this criteria and by removing outliers, there were a total of 63 cases for the square knot and 66 cases for the pretzel knot.

Performance

In the first session, participants generally needed more time for the square knot than the pretzel knot, but the pattern of results is similar across both tasks; the Later and the No-Instructions groups had a longer time on task than the Before and Simultaneous groups (see Figure 3).

For both knots planned linear comparisons between the Before and Later groups revealed a significant difference in time on task; square $t(70) = -2.60$, $p < .05$ (two-tailed), and pretzel $t(68) = -2.28$, $p < .05$ (two-tailed).

One-way ANOVAs revealed a significant difference among the conditions for both knots; Square: $F(3,70) = 6.25$, $MSE = 29469.1$, $p < .01$, and pretzel: $F(3,68) = 4.58$, $MSE = 17077.6$, $p < .01$. Post-hoc analysis (*HSD*) for the square knot revealed that the Simultaneous group was significantly faster than the Later ($p < .05$) and No-Instructions groups ($p < .01$) and that the Before group was significantly faster than the No-Instructions group ($p < .05$).

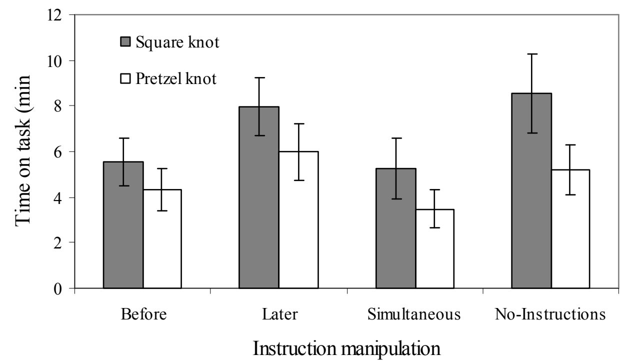

Figure 3: Time on task in minutes for both tasks and all four conditions in the first session.

A post-hoc analysis (*HSD*) for the pretzel knot showed that the Simultaneous group was significantly faster than the Later group ($p < .01$). Unlike performance on the square knot, there was no difference between the No-Instructions groups and the Before and Simultaneous groups, respectively.

Eta squared (η^2) represents effect size or the proportion of variance in the dependent variable accounted for by the manipulation. For the square knot task η^2 was .21, indicating that 21% of the variance of the time on task for the square knot can be attributed to the instruction manipulation. For the pretzel knot task η^2 was .17, and therefore 17% of the pretzel knot time on task variance can be attributed to the instruction manipulation.

Learning

In the second session the time on task was longer for the square knot than the pretzel knot (see Figure 4). A one-way ANOVA revealed no difference among the groups on either task; square: $F < 1$, and pretzel: $F < 1$. The performance in the second session was therefore very similar for all four groups in terms of time on task.

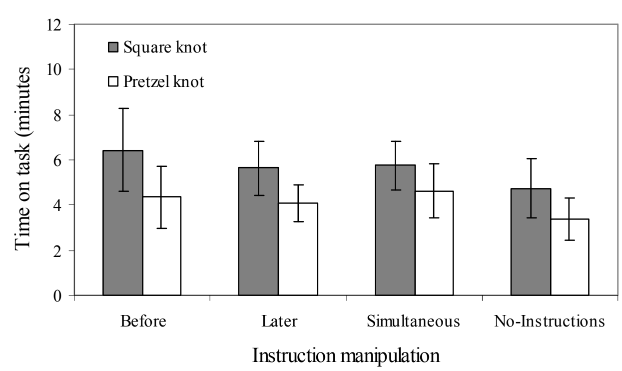

Figure 4: Time on task in minutes for both tasks and all four conditions in the second session.

The time needed to complete each knot was compared for each group across the sessions to investigate learning effects. A paired sample t-test showed a significant shorter time on task for the Later and No-Instructions groups ($t(14) = 2.56$, $p < .05$ (two-tailed), and $t(14) = 3.97$, $p < .01$ (two-tailed) respectively), but not for the Before and Simultaneous groups. The same results were found for the pretzel knot: Participants in the Later and No-Instructions groups completed the tasks in a significantly shorter time in the second session than the first ($t(14) = 4.24$, $p < .01$ (two-tailed), and $t(12) = 5.02$, $p < .001$ (two-tailed) respectively), but there was no difference in time on task found for the Before and Simultaneous groups.

Discussion

We expected that the Before group would show better performance in the first session than the Later group. On both knots there was a significant difference between the two groups, giving support to the hypothesis. This indicates that studying the instructions beforehand is beneficial for one-time procedural performance as compared to using the instructions as a reference later. The learner is able to translate the instructions directly into actions which is less time consuming and error prone than having to work out for herself/himself what needs to be done.

We also expected that the Simultaneous group would have the best performance in the first session and that the No-Instructions group would have the worst. The results partially support this prediction. On one hand the Simultaneous group had significantly shorter time on task than both the Later and No-Instructions groups, but not the Before group. On the other hand, the No-Instruction group had significantly longer time on task than the Simultaneous and Before groups (only on the square knot in the latter case), but not the Later group. This indicates an ordering of the groups, from fastest to slowest: Simultaneous, Before, Later, and No-Instructions. There was little difference between the Before group and Simultaneous groups, suggesting that it is as beneficial to study the instructions beforehand as using whichever the strategy is convenient under the circumstances.

In the second session there did not appear to be any difference in performance among the groups. This indicates that once the procedure has been successfully carried out once (in the first session), some baseline learning has taken place and how it came about does not have an effect on retention.

When analyzing the difference between sessions we found significant decrease in time on task only for the Later and No-Instructions groups. This supports the idea that even if doing the tasks the first time was harder for participants in these two groups their learning was as effective as for the participants in the Before and Simultaneous groups.

One concern, that would need to be addressed in further studies, is that the tasks were not complicated enough. That the majority of participants correctly completed the tasks on the second session could be taken to indicate a ceiling effect. More complex tasks, even when successfully completed under different training situations (Before, Later, etc.) might produce different performance and transfer due to different memory representations being formed as a function of training condition. Thus, the question remains unanswered as to whether the different instructional strategies would have a differential effect on how well procedural knowledge transfers to new tasks within the domain or how well it is retained over a longer period.

It would also be interesting to explore in detail the strategy used by the participants in the Simultaneous group by analyzing when they use the instructions. This would describe the default strategy people use when faced with an unfamiliar procedural task.

Studying the effect of using instructions to perform and learn procedural tasks can have implications for instructional design and procedural training. By identifying conditions for which a particular strategy is beneficial, there is the possibility of structuring instructions or task context to encourage the learner to adopt the more beneficial instructional strategy.

Acknowledgments

Elsa Eiríksdóttir was supported by Fulbright graduate award, as well as by the Thor Thors Memorial Fund Fellowship of the American-Scandinavian Foundation.

References

Alterman, R., Zito-Wolf, R., & Carpenter, T. (1991). Interaction, comprehension, and instruction usage. *The Journal of the Learning Sciences, 1*(3&4), 361 – 398.

Anderson, J. R. (1993). Problem solving and learning. *American Psychologist, 48*(1), 35 – 44.

Carroll, J. M., Mack, R. L., Lewis, C. H., Grischkowsky, N. L., & Robertson, S. R. (1985). Exploring exploring a word processor. *Human-Computer Interaction, 1*, 283 – 307.

Duff, S. C., & Barnard, P. J. (1990). Influencing behavior via device representation: Decreasing performance by increasing instruction. *Human-Computer Interaction – INTERACT '90,* 61- 66.

Ganier (2004). Factors affecting the processing of procedural instructions: Implications for document design. *IEEE Transactions on Professional Communications, 47*(1), 15-26.

Green, A. J. K. (2002). Learning procedures and goal specificity in learning and problem-solving tasks. *European Journal of Cognitive Psychology, 14*(1), 105 – 126.

Hart, S. G. & Staveland, L. E. (1988). Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. In P.A. Hancock & N. Meshkati (Eds.), Human mental workload, (pp. 139 – 183). Amsterdam, Netherlands: North-Holland.

Lunger, M. (1998). *Hemp masters: Ancient hippie secrets for knotting hip hemp jewelry*. Liberty, UT: Eagle's View Publishing.

Meilach, D. Z. (1971). *Macramé: Creative Design in Knotting*. New York: Crown Publishers.

Newell, A. & Simon, H. A. (1972). *Human problem solving*. Englewood Cliffs, NJ: Prentice-Hall.

Norman, D. A. (1988). *The design of everyday things*. New York: Basic Books.

Renkl, A. (1997). Learning from worked-out examples: A study on individual differences. *Cognitive Science, 21*(1), 1 – 29.

Schriver, K. A. (1997). *Dynamics in document design*. Canada: John Wiley & Sons, Inc.

Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychology Review, 10*(3), 251 – 296.

Vakil, E., Hoffman, Y., & Myzliek, D. (1998). Active versus passive procedural learning in older and younger adults. *Neuropsychological Rehabilitation, 8*(1), 31 – 41.