The Effect of Contextual Relevance on Motor Skill Transfer

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Key Words: environment • learning • psychomotor performance

Objective. The purpose of this study was to investigate whether practicing a complex self-care occupation in a contextually relevant environment would enhance the learning and transfer of skill.

Method. The design consisted of an acquisition phase, a rest period, and a transfer phase. Fifty-six women were recruited for this study and randomly assigned to one of three groups: (a) a contextually relevant (CR) group that practiced tying a necktie knot onto a mannequin, (b) a non-contextually relevant (NCR) group that practiced tying the same type of knot with a rope onto a wooden pole, and (c) a control group that did not practice at all during the acquisition phase. Participants in all three groups tied a necktie onto themselves during the transfer phase. Dependent variables were movement time, movement units, and the quality of the necktie knot.

Results. No difference in the rate of performance change was found during the acquisition phase between the CR and NCR groups. The difference among the CR, NCR, and control groups' initial transfer phase performance was near significance for movement time and movement units. A significant difference in the rate of performance change was found among the three groups in movement time and movement units during the transfer phase but not in the quality of necktie knot measures.

Conclusion. The degree of similarity during the acquisition of a dressing skill may influence the rate of performance improvement in a similar dressing skill during a transfer phase. Until further research has been established, generalization of these results to special populations should be done conservatively.


Occupational therapy focuses on increasing the occupational performance of persons with injuries and disabilities through the therapeutic use of occupation. To accomplish this goal, clients practice skills in the clinic that they will perform once discharged to home. The therapist assumes that the client will successfully transfer these skills to the tasks he or she will perform at home. Although knowledge is growing about the immediate effects of occupationally embedded tasks, little research documents the effectiveness of skill transfer with occupationally based tasks. The purpose of this study was to examine the effectiveness of skill transfer by varying the context of an occupationally based task.

Research evidence strongly suggests that occupational performance is enhanced when clients perceive the occupational forms as having meaning and purpose (Bloch, Smith, & Nelson, 1989; Ferguson & Trombly, 1997;...
The purpose of the present study was to examine the effects of contextual relevancy during skill acquisition on the transfer of skill.

One such study, however, examined the effects of context on skill acquisition and transfer (Ma, Trombly, & Robinson-Podolski, 1999). During the acquisition phase, participants learned to use a pair of metal chopsticks to pick up and eat chunks of cheese (natural context) or to pick up chunks of erasers (simulated context). In the transfer phase, participants picked up and ate cooked shell-shaped pasta with wooden chopsticks. Results showed that the natural context elicited a significantly larger improvement of success rate (e.g., the success of picking up items with the chopsticks) in the acquisition and transfer phases than did the simulated context. No differences were found in the kinematic variables of movement time, total displacement, and amplitude of peak velocity between the two contexts.

An important theoretical factor in learning any task is the principle of transfer of learning. Schmidt and Lee (1999) defined transfer as the gain (or loss) in the capability for performing differently in one task as a result of practice or experience on some other task. A common goal of therapy is to have the occupations practiced in therapy transfer positively to occupations the client will engage in at home or work.

Several factors can influence the transfer of skill. One of the most important in increasing the success of transfer of learning is the degree of similarity between the learning task and the task to which transfer is to occur (Schmidt & Lee, 1999). The concept of similarity has been studied for nearly a century. Thorndike (1903) articulated the theory of identical elements, which stated that the greater the number of common elements between two tasks, the more likely transfer of learning would occur.

The perception of similarity between tasks can be divided into two concepts: surface similarities and structural similarities (Gick & Holyoak, 1987). Surface similarities are the macro characteristics of two tasks that on the surface appear to be similar. Structural similarities are the micro characteristics of each task. Surface similarities have been shown to influence whether transfer will occur, whereas structural similarities have been shown to influence whether the transfer will be negative or positive (Gick & Holyoak, 1987). Positive transfer occurs when the response during the transfer phase is in the same direction as the learned response in the acquisition phase. Negative transfer occurs when performance on a transfer task is poor due to previously learned skills. For the purposes of this study, the term transfer of skill assumes a positive transfer.

The purpose of the present study was to examine whether an enhanced level of contextual relevancy would improve transfer of learning in a complex task. Environments with enhanced contextual relevancy include a number of occupational forms that are consistent with the goals of a particular occupation. In contrast, an environ-
ment with a low level of contextual relevancy may include several occupational forms, but none of them would be consistent (or normally associated) with the occupation or its goals. The occupation used in this study was tying a necktie, a relatively complex self-care occupation that could be incorporated into an occupational self-care training regime. The necktie is recognized by society as being a common article of clothing, yet tying a necktie may be a relatively novel task to a particular subgroup.

The method for tying a necktie depends on the material from which it is made, the collar of the shirt, and the preference of the wearer. The four most popular knots are the Four-in-Hand, the Full Windsor, the Half Windsor, and the Shelby knot (Adam, 1996). This study used the New Classic style of knot because it is not commonly used. The important characteristics of a well-tied necktie are the length of the tails, the shape of the knot, the symmetry of the knot, and the distinct dimple at the top just under the knot (Thourlby, 1990).

This study’s first hypothesis was that the rate of performance change during the acquisition phase would be significantly different between the contextually relevant (CR) group and the noncontextually relevant (NCR) group in terms of movement time and movement units. The rate of performance change was defined as the variation of performance across the trials. The second hypothesis was that a significant difference would exist among the CR, NCR, and control groups during the initial transfer trial in terms of movement time, movement units, and quality of necktie knot. The third hypothesis was that the rate of performance change during the transfer phase would be significantly different among the CR, NCR, and control groups in terms of movement time, movement units, and quality of necktie knot.

**Method**

**Design**

The design of this study is similar to that of Ma et al. (1999) and is one that has been commonly used in motor learning studies to examine the effects of knowledge of results on task performance (McCullagh & Little, 1990; Wulf & Schmidt, 1989; Wulf, Shea, & Rice, 1996). The design consisted of three phases: a skill acquisition phase, a rest phase, and a transfer phase. During the skill acquisition phase, participants in the CR group learned to tie a necktie knot onto a mannequin, and the participants in the NCR group learned to tie a similar knot with a rope onto a wooden pole. During the transfer phase, the participants in the CR, NCR, and control groups learned to tie a necktie onto themselves. Because the control group did not participate in the acquisition phase, it served to determine whether the performance of the CR and NCR groups during the transfer phase was due to the experience gained from the acquisition phase. Participants were randomly assigned to one of the three groups.

Knot tying, be it with a necktie or rope, is a common occupation within society. Necktie tying is an acceptable practice, and neckties themselves are an important component of many types of dress. Likewise, rope is common within society, and its use often requires the tying of a knot. It was assumed that neckties and rope are perceived as meaningful and that society perceives the concept of knot tying as a “normal” occupation.

**Participants**

The convenience sample was made up of 56 college-aged women. The participants’ mean age was 25.10 years (SD = 6.75); 52 were right-handed. Participants self-reported to be unskilled in tying neckties and were recruited as volunteers via flyer announcements posted at several Midwestern universities and colleges. The participants self-reported no neuromuscular or cognitive impairments that would have adversely affected their performance in this study.

**Apparatus**

A Motion Analysis Corporation High-Resolution 3-Dimensional System$^1$ with EVa HiRES software version 4.0$^2$ was used to measure the participants’ movement during each test phase. The system was calibrated before each new data collection session. Four strobe-equipped Cohu 4915$^3$ cameras recorded the movements at a sampling rate of 60 frames per sec. One reflective marker, 2 cm in diameter, was attached to the dorsal surface of the right hand just proximal to the third metacarpophalangeal (MCP) joint. A digital camera$^4$ was used to take pictures of the knots in the transfer phase.

**Materials**

A black 150-cm–long necktie and mannequin were used with the CR group. The circumference of the mannequin’s neck was 38.5 cm. The mannequin wore a buttoned white dress shirt. An adjustable-height table was used to control for variance in participant height. For the CR group, the table height was adjusted so that the jugular notch in both the mannequin and the participant were at the same level. The apparatus used in the NCR group also had a 38.5 cm circumference. The table height for the NCR group was adjusted so that the cross bar on the apparatus was at the same height as the participant’s jugular notch (see Figure 1).

As part of the transfer phase, several typical white-collared button dress shirts of various sizes and a navy blue
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textually relevant group (b).

relevant group (a), and the apparatus used with the noncontextually relevant group (b).

Figure 1. Apparatus used during the acquisition phase, including the mannequin and tie used with the contextually relevant group (a), and the apparatus used with the noncontextually relevant group (b).

150-cm–long necktie were used. A mirror was also provided in this phase for the participants to use as needed.

Procedure

Twenty-one participants were assigned to the CR group, 18 to the NCR group, and 17 to the control group. The sample size variance between the groups was due to the random assignment algorithm (pulling a number out of a hat, then returning it to the hat so all participants have the same group assignment probability regardless of when their assignment occurred). After obtaining informed consent, participants in all three groups received a brief orientation to the study. The CR group participants tied a necktie onto the mannequin using the New Classic knot. The NCR group participants tied a piece of rope onto a pole with the New Classic knot and were not aware that they were tying a necktie knot. All participants from the CR, NCR, and control groups performed in the transfer phase, which involved tying a dark blue necktie on themselves using the New Classic knot.

All of the testing sessions in the CR and NCR groups were conducted in the following manner. The participants watched a brief videotape that instructed and demonstrated the task that they would be performing. The participants were then given written and illustrated instructions of the task; the instructions were also available during all trials. A reflective marker was placed just proximal to their right third MCP joint. This position was chosen because of its distal position; displacement of the third MCP joint reflects all of the biomechanical degrees of freedom proximal to that joint and, therefore, is representative of the movement solution compiled by the participant. Before starting the task, participants were asked to stand in an 18-in. square “box” marked on the floor with tape and to place their right hands on a starting spot on the adjustable-height table. A trial consisted of tying the knot one time regardless of its quality. Participants were asked to complete 20 trials. Breaks were provided as needed. After completing the 20 trials, participants were reminded that they needed to return in 24 hr for the remaining testing session. They were also instructed not to physically or mentally practice the task within the “rest” period.

The transfer phase required the participants to tie a necktie onto themselves. During this final phase, each participant (CR, NCR, control) performed the task for 10 trials. Written and illustrated instructions were available during each trial. All participants received the same verbal instructions regardless of their group assignment.

Data Reduction

A movement unit is a measure of the “smoothness” of a movement (Kluzik, Fettet, & Coryell, 1990). A continuous movement is one in which the position of the limb being moved changes smoothly from the beginning to the end of the movement (Brooks, Cooke, & Thomas, 1973). For this type of movement, the acceleration curve crosses the zero point and back again only one time. During a discontinuous moment, the acceleration curve crosses the zero line at several points. These movements do not appear to be smooth and “fluid” compared with continuous movements. Using Kluzik et al.’s (1990) definition, a movement unit was one acceleration and one deceleration on the acceleration profile with one crossing of the zero line from negative to positive and back again with a magnitude of + 5 mm/sec² or greater. Movements with fewer movement units are more efficient than movements with a greater number of movement units.

Movement time was measured from when the participant moved her hand from the starting spot until she placed her hand back onto the starting spot after completing the required task. The rate of performance improvements with movement time generally follows the Law of Practice, which predicts greater improvement in the early stages of learning with subsequent smaller increments of improvement over time (Schmidt & Lee, 1999).

The quality of the knots were determined by calculating two separate measures, both of which were developed for this study. The first involved the ratio of the length of the top edge to the length of the bottom edge of the knot. The greater the ratio, the better the knot. For instance, a knot with a proportional ratio of 2, where the top edge is twice as long as the bottom, indicated a well-tied knot. The second involved the difference in the slopes of the top edge and the bottom edge of the knot. Small slope differences (<.10) indicated that the knots had relatively parallel top and bottom edges and were considered to be of high quality. A digital camera was used to take a picture of the completed knot. The x and y pixels of each corner of the knot were identified and used to derive the proportional ratio and slope.

Data Analysis

For the first hypothesis, data were recorded on trials 1, 5, 10, 15, and 20 from the acquisition phase. Separate 2 x 5 (group x trial) repeated-measures analyses of variance (ANOVA) were performed on movement time and move-
ment units. The group-by-trial interaction statistically analyzed the "rate" of change in performance for each dependent variable across time between the two groups. For the second hypothesis, separate one-way ANOVAs were performed on the first trial of the transfer phase, using movement time, movement units, proportional ratio, and slope difference. For this hypothesis, effect sizes ($f$) were also calculated for each dependent variable (Cohen, 1988). For the third hypothesis, data were collected on trials 1, 5, and 10. Separate 3 x 3 (group x trial) repeated-measures ANOVAs were performed on movement time, movement units, and quality of the completed knot. Again, the group-by-trial interaction statistically analyzed the rate of change in performance for each dependent variable across time between the two groups.

Results

Although 56 participants were recruited for this study, kinesiological data from 9 were discarded because of missing data segments. During the course of tying the rope or tie, if the marker was obscured and caused a "gap" considered too large for computer interpolation, then the data were discarded. Data with gaps > .1% of the individual trial data were discarded.

The first hypothesis was not supported in that during the acquisition phase, no significant difference was found between the CR and NCR group rates of performance change (see Table 1). However, a significant difference for the main effect of group was found for both movement time and movement units. The CR group demonstrated a greater amount of movement time and movement units than the NCR group throughout the acquisition phase. Significance was also found on the repeated factor of trial for movement time and movement units. Both groups demonstrated a learning curve that followed the prediction of the Law of Practice (Schmidt & Lee, 1999). Figure 2 illustrates these learning curves as well as the relatively parallel relationship of the lines for the CR and NCR groups with respect to movement time and number of movement units. The parallel lines illustrate the lack of statistical interaction between the two groups across the acquisition phase.

The second hypothesis was not supported in that for the initial trial of the transfer phase, no significant difference was found among the groups with regard to movement time, $F(2, 45) = 2.93, p = .06$; number of movement units, $F(2, 45) = 2.85, p = .07$; proportional ratio, $F(2, 54) = 1.75, p = .18$; or slope difference $F(2, 54) = 1.65, p = .20$. The means and standard deviations are shown in Table 2. Because two of the four dependent variables had relatively small $p$ values ($p = .06$ for movement time, $p = .07$ for movement units), effect sizes were calculated for all the dependent variables for the second hypothesis. The effect size ($f$) gives information about the magnitude of the effect without regard to the statistical degrees of freedom. For

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Note. Alpha was set at .05.
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movement time, $f = .54$; for movement units, $f = .55$; for the proportional ratio, $f = .51$; and for the slope difference, $f = .19$. All effect sizes were large except that for the slope difference, which was small (Cohen, 1988).

The third hypothesis was supported in that no significant difference was found in the rate of performance change during the transfer phase in terms of movement time and movement units (see Table 1). The CR group initially demonstrated better performance than the NCR and control groups. As the transfer phase progressed, the NCR and control groups decreased their movement time and number of movement units at a greater rate than the CR group. That is, the CR group reached its learning plateau before the NCR and control groups. Hence, the change in the rate of performance was greater in the NCR and control groups. By the end of the transfer phase, all three of the groups were relatively similar with regard to movement time and number of movement units, indicating that the transfer of learning from the acquisition phase was successful for both the CR and the NCR groups. However, success occurred initially with the CR group and subsequently with the NCR group. The NCR group’s performance difference between the 5th and 10th trials was relatively small compared with that of the control group. This finding suggests that the NCR performance benefited from earlier practice over the control group across the transfer phase.

No significant interaction (group x trial) was found with slope difference, $F(4, 106) = 1.16, p = .33$, and proportional ratio, $F(4, 106) = .84, p = .51$. Although not significant, during the transfer phase, all groups increased their proportional ratio and decreased their slope difference. The means and standard deviations of each dependent variable are shown in Table 2.

**Discussion**

The results of this study did not support the first hypothesis. The CR group did not improve its performance at a different rate than the NCR group during the acquisition phase of the study. Both groups learned at almost the same rate during this phase, hence, there was no significant interaction. However, the NCR group performed the task relatively faster and more smoothly throughout the phase. Additionally, larger variances were found in movement time and number of movement units for the CR group than for the NCR group. These differences in magnitude and variability may be attributed to the large difference in the level of difficulty of the two tasks. Tying a knot with a rope compared with tying the same knot with a necktie requires less attention to the orientation of the rope and shape of the knot. Regardless of which side of the rope knot faced out, its color and design were the same. Conversely, if the seam on the necktie was observable, the wrong side of the necktie was showing. With the rope being round, and the necktie being flat, additional adjustments may have been required to achieve the desired shape.

![Figure 2](http://ajot.aota.org/attachment/ajot_563-563.png)

*Figure 2. The acquisition phase means and standard deviations for each trial for movement time (a) and movement units (b). Note. CR = contextually relevant group, NCR = noncontextually relevant group. The main effect for group was significant for both movement time and movement units.*
been needed to make sure the knot was shaped correctly and the front side was facing out.

The second hypothesis was not supported in that no significant difference was found among the groups for the initial trial of the transfer phase. Although a significant difference was not found, the group effect size was large (Cohen, 1988). During the first trial of the transfer phase, the NCR and control groups performed almost equally with regard to movement time and number of movement units, whereas the CR group performed with a smaller movement time and fewer movement units. The large effect size for movement time and movement units during the initial trial of the transfer phase indicated a relative difference among the groups. No trend could be detected during the initial transfer phase with regard to the quality of the knot because of the large proportional ratio effect size and the small slope difference effect size.

The third hypothesis was supported in that the rate of performance change during the transfer phase was significantly different across the groups in terms of movement time and movement units. The rate of performance change for the CR group was smaller than that of the NCR and control groups. When comparing the CR and NCR acquisition contexts to the transfer phase context, it appears that the CR group had a greater degree of surface similarity. Both tasks (CR group task, transfer phase task) involved a necktie, a white shirt, and a specific type of necktie knot. The only similarity between the NCR and transfer phase contexts was the style of knot. This similarity could be considered structural in that it is on a more micro level than the more easily observable surface similarities between the CR and the transfer phase contexts. Because transfer of learning occurred in both the CR and the NCR groups, this finding suggests that the structural similarities between the acquisition and transfer phase tasks were strong enough to facilitate the transfer of learning. In addition to the structural similarity (style of knot), the additional surface similarities (white shirt, tie) may have enhanced the transfer of learning in the CR group.

Although the rate of performance change during the transfer phase was significant for movement time and movement units, no such performance change was found with the quality measures of proportional ratio and slope difference. Perhaps the occupation of necktie tying involves several levels of complexity. First, at a more fundamental level, the participant must learn the mechanics involved with tying this specific style of knot. The direction and rate of the performance change during both the acquisition and the transfer phases provided evidence that learning at this rudimentary level occurred. It can be argued that a second, more sophisticated level of skill is needed to actually end up with a “nice-looking” knot for reasons stated previously. Whereas movement time and movement units are a measure of the first level, the proportional ratio and slope difference were more sensitive to the second level. Perhaps if more trials were provided, performance improvements may have been exhibited (although our experience is that despite more than 5 decades of combined experience, our ties still come out looking disheveled).

The rate of improved performance during the acquisition phase with regard to movement time is similar to the findings of Ma et al. (1999) in which no significant difference was found in movement time performance between the natural and simulated contexts. However, the movement time performance in the transfer phase differed from the Ma et al. findings in that our study demonstrated a significant difference among the groups (CR, NCR, control) across time. A comparison between these two studies needs to be approached cautiously because of data reduction differences. For example, our study measured the performance on specific trials at specific intervals, whereas the Ma et al. study averaged trials within blocks of trials. Another important aspect to consider in comparing these two studies is that our study involved a relatively complex task compared with the discrete reaching task in the Ma et al. study. Perhaps the complexity of movements in a continuous task lends itself to exhibit kinesiological changes, where such changes may not be exhibited during more simple movements in discrete tasks.

This study raises an important issue that occupational therapy grapples with every day—task equivalency. Thorndike’s (1903) theory of identical elements stated that the more similar the task in the acquisition phase to the task in the transfer phase, the more successful the transfer of learning. Often in occupational therapy situations, setting up an environment identical to the one to which the client will be discharged is impractical or impossible. This study has demonstrated, in a controlled manner, that the more similar the acquisition phase context is to the transfer phase context, the greater the transfer of learning. Transfer also occurred with the NCR group but without the initial advantage that the CR group experienced. The results from this study suggest that the therapeutic environment should be as similar as possible to the discharge environment, but if resources and time do not allow for such a context, then a more contrived environment can still be effective as long as the structural components of the therapeutic environment have some similarity with the task(s) to be performed after discharge.

The relatively small homogeneous sample population limits the results of the study from being generalized to other populations. A second limitation was the method used to judge the quality of the necktie knot. A high-quality knot has many characteristics of which are subjective and difficult to quantify. In this study, the proportional ratio and slope difference of the top and bottom edges of the knot determined the knot’s quality. It is possible that these measurements were not sensitive enough or descriptive enough to show changes in the quality of a necktie knot. For example, the process of taking a two-dimension-
al picture of a three-dimensional knot for later measurement may not have resulted in a true measurement of the knot’s size. In addition, there was no way of ensuring that the participants in the CR and NCR groups refrained from knot-tying practice during the rest period.

Conclusion
The results of this study demonstrated that practicing an occupation within a contextually relevant environment resulted in significantly different rates of performance change in movement time and movement units in a transfer phase with healthy right-hand-dominant women. Specifically, the transfer phase movement time and movement units suggest that practice in a contextually relevant environment may afford better transfer of learning. This study supports the importance of ensuring that the tasks learned in the clinic are as similar as possible with regard to surface and structural similarity to the tasks the client will be performing once discharged. However, transfer of learning can still occur with contexts that have only structural similarities. This line of research needs to be extended to include varying the levels of task complexity and the similarity of the task between the skill acquisition and transfer phases. Most importantly, this line of research should include special populations commonly seen by occupational therapists. Once these variables have been examined, occupational therapists can be more confident that contextually relevant training and practice will result in better carryover and, hence, improved occupational performance when clients return home. ▲

References