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The Influence of Naturalistic Materials on Motor Learning for

Assistive Device Use in Adults with Arthritis

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Abstract

Motor learning is an important aspect of occupational therapy, especially as it relates to learning the fine motor skills necessary to use a novel tool or assistive device in order to maximize independence. The present study aimed to assess the influence of occupational embeddedness on motor learning of a fine motor task involving a novel tool. The influence of the human mirror-neuron system on rate of motor learning, specifically action-observation (AO) and verbal instruction (V), was also analyzed and results are described in a separate study. It was hypothesized that rate of motor learning would be significantly greater in the occupationally embedded (OE) condition than in the non-occupationally embedded, or rote (R), condition.

Twenty-six male and female adults with arthritis were recruited for this study and were randomly assigned to the OE and R conditions. The task involved using ergonomically modified pliers to pick up small objects and sort them into a divided container using either naturalistic or simulated materials. Kinematic data was analyzed for the dependent variables of movement time, average velocity, movement displacement, and movement units. Statistical significance was found for the repeated factor of trial, but not between the OE and R conditions except for the variable of displacement. A significant interaction was also found between the four groups in favor of AO/OE and V/R conditions. Our results suggest that occupational embeddedness alone does not significantly increase the rate of fine motor learning. Based on our results, pairing OE with AO or R with V can result in significantly improved rates of fine motor learning pertaining to the use of a tool or assistive device. This translates to the fundamental necessity of effectively manipulating occupational forms to elicit the best motor performance and subsequent therapeutic benefits.
Introduction

At the core of occupational therapy is the use of objects and tasks meaningful to the client to encourage increased occupational performance. It is the role of the occupational therapist to create environments that elicit meaning and subsequent purpose for an individual which also challenge one’s functional competencies with an appropriate level of difficulty in order for progress to be made. Meaning can be defined as “the person’s entire interpretive process when encountering an occupational form, including perceptual, symbolic, and affective experience” (Nelson, 1996, p. 776). The functional abilities and characteristics of the client in combination with the environment surrounding the occupation at hand may facilitate the perception of meaning which is unique to that individual. To enhance one’s occupational performance, it is not enough for the occupational therapist to create only meaning for the client, as purpose must then be brought forth. Purpose is one’s motivation to do something, or as Nelson (1996, p. 777) describes, “...the experience of wanting an outcome from an anticipated occupational performance.” Meaning must be first established before purpose can be formed. It is also important to note that even if something is perceived as meaningful for a certain person, he or she may or may not generate purpose, or in other words, be motivated to elicit a particular outcome. It is important for the occupational therapist to construct environments that will both facilitate the perception of meaning for an individual and subsequently generate a sense of purpose towards the situation.

The literature supports the use of purposeful occupations over those which are non-purposeful. Hsieh, Nelson, Smith, and Peterson (1996) studied whether adding purpose in a dynamic standing balance exercise would lead to more repetitions than rote exercise alone in clients with hemiplegia. Three conditions were established, materials-based, imagery-based, and
rote exercise. In the materials-based condition, subjects bent down, picked up a small ball from
the ground with their unimpaired hand, stood back up, and threw the ball at a target. The
imagery-based condition required performing this same movement pattern while imaging picking
up and throwing the ball, while the rote condition involved only performing the movement
pattern. The results of this study show a significant increase in the number of repetitions
completed in the materials- and imagery-based conditions compared with rote exercise. The
authors thus concluded that adding purpose to therapeutic occupations can lead to enhanced
performance.

Bakshi, Bhambhani, and Madill (1991) conducted a study in which healthy females
participated in a most-preferred and least preferred task, each under a purposeful and non-
purposeful condition. For example, one of the tasks that could be chosen was painting. This
modality was considered purposeful if the subject had actual paint, brushes, and a canvas with
which to create a finished product; this was considered to be less meaningful if there were no
materials or end product and the client repetitively moved the arm similar to as if he or she was
actually painting. Subjects chose two tasks to engage in from a list of eight options, one being
their most preferred and the other their least preferred. They engaged in each task under
purposeful and non-purposeful conditions. Heart rate, blood pressure, repetitions, and rating of
perceived exertion were measured under each of the four conditions. The number of repetitions
was found to be lower during the purposeful condition for both the least preferred and most
preferred tasks, but the difference was not significant. However, increase in heart rate and ratings
of perceived exertion were significantly higher for the non-purposeful activity. Based on these
results, the authors concluded that physiological and perceived stress is higher while
participating in non-purposeful activity, thus suggesting using purposeful tasks in therapy to decrease this stress.

Keh-chung, Lin et al. (1997) conducted a meta-analysis of over fifty articles and abstracts which studied a relationship proposed by Nelson (1988) in which participation in purposeful activity produced better quality of movement compared to focusing on movement itself. Three typologies of environmental conditions were incorporated into studies included in this analysis. These were materials-based occupation, imagery-based occupation, and rote exercise. Conventional and process-oriented measures were conducted. Conventional outcome measures included range and duration of movements and the number of repetitions. Process-oriented measures included smoothness of movement, reaction and movement times, velocity, and displacement. Results of the analysis showed a relationship between occupational form and performance, thereby supporting the hypothesis that occupationally embedded tasks lead to enhanced motor performance in comparison with rote exercise. This effect was true for both materials-based and imagery-based occupational forms. Larger effects were found for the process-oriented measures, suggesting that the type of occupational form had a greater impact on the quality of one’s movement compared to conventional measures.

Furthermore, it has been shown that conditions with added purpose can specifically enhance motor learning. Wu, Trombly, and Lin (1994) found that participants who performed a reaching task (picking up a pencil in preparation to write one’s name) under a materials-based condition performed with higher quality of movement than those in imagery-based and exercise conditions. Kinematic variables analyzed included reaction time, movement time, number of movement units, and total displacement among others.
Yuen, Nelson, Peterson, and Dickinson (1993) found that those who were trained to use an above-elbow training prosthesis in an added-materials method scored significantly better on a tracing test compared to those in the control group. Fifty-two college-aged males were randomly assigned to either an added-purpose group or control group. In each group, a flashlight was attached to a farmer’s hook at the distal end of the prosthesis. The added-materials group was trained to use the prosthesis by practicing connecting dots on the wall in front of them with the light beam as accurately as possible. Those in the control group were simply asked to move the forearm component of prosthesis however they could while trying to be as steady as possible. In this condition, the flashlight was fixed to the prosthesis in a non-functional way (toward the hook of the prosthesis) to ensure equal weight in each condition. Both groups then completed a tracing task, where it was found that the added-material’s group deviated from the line significantly less compared to the control group, demonstrating better motor learning of use of the prosthesis.

Ferguson and Trombly (1996) conducted a study to test skill acquisition under purposeful and non-purposeful conditions. All participants (healthy university students) were taught three five-note sequences on a keyboard. In the added-purpose condition, musical notes were produced when the participant would press the keys on the device when performing the sequence, while those in the rote exercise condition performed the same movement pattern without the production of sound. All participants were given time to practice all three sequences in multiple acquisition trials, a thirty minute rest period, and then were tested for recall of the skill in several retention trials. Transfer of skill was tested as subjects in both groups were asked to play a new five-note tune. Number of errors was measured for each participant, defined by inaccurate finger placement on the keys and inaccurate sequencing of keys. Although there was no significant difference in the number of errors produced in the skill transfer trials, there was a significant
difference in the retention trials. This shows that occupations with added purpose can elicit better motor skill retention.

Both skill acquisition and transfer were found to be enhanced based on context in a study by Ma, Trombly, and Robinson-Podolski (1999). College-aged students without disability learned the task of using chopsticks in a natural environment or simulated environment. During the acquisition phase, the natural environment consisted of reaching for and picking up a piece of cheese with the chopsticks, bringing it back to the mouth, and eating; the simulated environment involved picking up an eraser and bringing it to the mouth. The transfer phase required participants to use the chopsticks to pick up a piece of pasta followed by bringing it back and placing it into one’s mouth. Results show a significantly higher success rate among those in the natural context for both the acquisition and transfer phases. These results further represent better transfer of skill among those in the natural versus simulated context.

Limitations in motor control can be addressed by occupational therapy. A common strategy to compensate for the lack of motor control is to employ the use of assistive devices. In particular, assistive devices are often suggested for those with decreased range of motion, strength, and mobility with the goal to increase independence and function for those who use them. It is important to consider the potential functional impairments introduced by the nature of certain assistive devices that may negatively influence one’s success in use of the device. Maitra, Philips, and Rice (2010) examined various components of grasp (maximal grasp aperture, peak velocity of finger aperture, time to achieve maximal velocity), reach (reach time, peak velocity of reach, percentage of time to reach peak velocity) and muscle activation patterns involved when using a reacher. Data were then compared against that for the non-aided hand. Results showed the characteristics of a natural grasp were indeed different from those of a reacher grasp,
with the natural grasp demonstrating a faster reach and larger grasp aperture with higher peak velocity. Analysis of muscle activation patterns revealed that muscle activation related to size of the object (i.e. more activation when reaching for larger objects); also, less combined muscle activations were seen when reaching naturally compared when reaching with the reacher. Suggestions for the explanation of these results were an insufficient amount of kinesthetic feedback received from the unstable reacher-object interface, the stability of the arm-object interface, and force requirement of the task.

Assessment of one’s level of skill acquisition regarding motor control is an important consideration within the clinical setting. There are many indicators of skill acquisition, with the more traditional method being the observation of the learning curve. This can be done by analyzing various dependent variables, such as movement time, velocity of movement, percentage of movement time to peak velocity, movement units, and error. Fitts and Posner (1967) presented a model which breaks learning into three phases: cognitive, associative, and autonomous. Dramatic gains in performance are seen in the cognitive phase, in which the individual learns what is to be done and tries various attempts at solving the problem. This variability may, however, lead to inconsistent performance. Significant cognitive activity is necessary in this phase in order to develop effective strategies to solve the problem and reject those which are less valid. In the associative phase, the learner has decided upon the best way of doing the task and continues to make more minor adjustments. Small changes made gradually over time lead to enhanced, more consistent motor performance. The learner enters into the autonomous phase after much practice of the skill. In this phase, performance of the skill becomes automatic, in that simultaneous activities will pose less interference to the primary task.
It should be noted, however, that learning can still be achieved in any phase. Crossman (1959) found improvements in factory workers even after seven years of practice.

An example within the occupational therapy literature that illustrates this classic learning curve can be found in a study by Ferguson and Rice (2001), which measured rate of performance change in college-aged women over acquisition, rest, and transfer phases. Subjects participated in a neck-tie tying task in contextually relevant and non-contextually relevant conditions. Participants in both conditions made their largest improvements in performance in the earlier acquisition trials; by the end of the acquisition phase, the change in improvement from trial to trial was markedly reduced, however, improvement was still noted.

There is an important need to study skill acquisition specifically in fine-motor tasks as it is related to the ability to perform self-care occupations. One of the fine-motor tasks that clients of occupational therapy often struggle with is the self-administration of pharmaceuticals. Picking up and manipulating pills can be a formidable challenge, especially for those with decreased hand function secondary to arthritis in the joints of the hand. To address this problem within the clinic, an occupational therapist may recommend the use of an assistive device that may make handling the pills easier. However, little is known about the ability of persons with arthritis to acquire fine motor skills using such an assistive device.

Arthritis of the hands can present clients with great difficulty in performing fine-motor tasks. Clients may experience declines in occupational functioning due to pain, stiffness and decreases in strength, endurance, and range of motion. Furthermore, deformities of the wrist, hand, and/or fingers make manipulating joints in a functional way increasingly difficult (Radomski & Latham, 2008). Occupations requiring repetitive movements may exacerbate
symptoms, leading individuals to avoid such tasks. Without proper compensations, individuals may find themselves no longer able to independently perform many self-care occupations.

The purpose of the present study is to examine the rate of learning of a fine motor task involving the use of a novel tool in occupational (occupationally embedded) versus rote (non-occupationally embedded) conditions in an elderly population with arthritis. The fine motor task used in this study is the manipulation a small pair of modified pliers to pick up either aspirin tablets or similarly-shaped pieces of wood. We compared the kinematic variables of movement time, displacement, movement units, and movement velocity in both conditions. Generally, greater movement efficiency is associated with movements that have the following: smaller movement time, smaller displacement, greater velocity, and fewer movement units (Rice, Davies, & Maitra, 2009). The hypothesis is that the occupationally embedded condition will elicit greater movement efficiency than the non-occupationally embedded condition.

Methods

Participants

Twenty-six male and female participants aged 50 to 99 years of age were recruited for this study. Inclusion criteria required that they be 18 years or older and have any type of arthritis affecting the hand. Participants could have either hand dominance and they were required to have at least 3 pounds of pad-to-pad pinch force as measured by a pinch meter. This criterion was chosen as it is 3 times the force needed to operate the pliers. They were also required to have a driver’s license or demonstrate at least 20/40 vision to ensure that vision did not limit their ability to watch the video instruction and complete the task. Additionally, participants were required to score at least a 23 on the Mini Mental State Exam (MMSE). Data were collected at
The University of Toledo and at two local YMCAs. Participants were recruited from senior organizations, hospital arthritis programs from the general community, through advertisement, flyers, networking with pertinent organizations in the Toledo area, and through word of mouth.

Study Design

The study employed a 2 X 2 design of four conditions. The conditions included action observation-occupationally embedded (AO/OE), action observation-rote (AO/R), verbal-occupationally embedded (V/OE), and the verbal-rote (V/R) condition. Participants were randomized to one of the four conditions using permutated blocks. The action observation/verbal independent variable was part of another experiment.

Apparatus

In all conditions, a modified pair of reverse action, mini snap ring pliers was used, 3” long by 11/16” max opening, with tips angled at 45 degrees (model number, manufacture and city of manufacture—if available). After consultation with an expert in ergonomics and arthritis, the pliers were modified with a rectangular piece of EZForm® splinting material wrapped over the handles to increase the finger/thumb contact surface. See Figure 1 for an image of the pliers.

Video data were collected using a Basler B94 black and white 100 Hz digital camera, suspended from a wooden frame 28.5 inches above the working surface. MaxTraq motion analysis software (version 2.2.2.2, Innovision Systems Inc) was employed for both data collection and data analysis and was installed on a Dell Latitude E6510 laptop computer. The MaxTraq software used a window resolution of 460 X 344 (Y and X pixels). To aid in digitizing motion, reflective tape was placed on the tips of the pliers to allow for detection of movement of the tool in the work area and changes in the aperture of the tool. A separate computer was used to
show participants video for instruction on the task.

**Procedure**

This study was approved by The University of Toledo Biomedical Institutional Review Board. Data were collected from February, 2011 to September, 2011. Participants were screened for eligibility. After obtaining informed consent, participants were given instructions as per their randomly assigned condition. Those assigned to the V condition viewed a video clip of the materials to be used in which the audio track was the voice of a researcher giving verbal instructions for the task. Those assigned to the AO condition viewed a video clip that begins with the same viewing angle of the materials and the same verbal instructions but also includes video footage of an individual completing the task proficiently. See Appendix A for the verbal instructions that were included in the video clip.

Participants picked up either 81-mg safety-coated aspirin tablets (5/16” in diameter) with the pliers, or pieces of a wooden dowel of the same diameter cut to the same size as the aspirin tablets in the OE and the R condition, respectively. Each item (pill or dowel segment) was placed in a plastic box divided into seven wells. In the OE condition, each box was labeled with a letter denoting each day of the week (a common pill organizer). In the R condition, the box was identical but unlabeled. See Figure 2 for images of the OE and R materials.

In all four conditions, each trial consisted of moving seven items, one into each of seven wells. Participants completed 10 trials, resting for 30 seconds between trials. During the rest, the video segment corresponding to the experimental condition was shown again. Participants were seated at an adjustable table and chair to complete the task. The table, chair, and foot stools (as needed) were adjusted appropriately to the height of each participant, so that his or her
elbows were at table height and his or her feet were supported.

**Dependent Variables and Statistical Analysis**

Motor performance was assessed through the motion analysis variables of movement time, movement displacement, velocity, and movement units. Learning was assessed through the rate of change in these variables across trials. Motion variables were derived from the digitized X-Y position/movement trajectories of key points. The positional data were collected using a 2-dimensional system that recorded data in the X and Y plane. The set up was such that the X-axis ran medial and lateral while the Y-axis ran anterior and posterior and used a pixel resolution of 460 (y) by 344 (x). The dependent variables were calculated from the time the participant initially moved past a standardized position on the Y–axis on his or her way to dropping the first object into the first container box to the time when the participant crossed the same point on the Y-axis on his or her way back to the starting point after dropping the final object in the container. This standardized point on the Y-axis was at the 250th pixel. This point was chosen as it was deemed a reliable point at which all participants crossed regardless of the exact position where they initially picked up their first object and finished the entire task which varied from participant to participant. The resolution of the X and Y position data was calculated for each sample. Displacement was then calculated by summing the absolute position difference from sample to sample from the start to the stop points of the trial.

**Data Analysis**

A 2x2 multivariate analysis of variance (MANOVA) was used to assess both the main effects (Action Observation/Verbal instruction and Occupational Embedment/Rote) and interactions. Significance was determined with α set at <0.05. A t-test for independent measures
was used to compare the improvement in performance from trials one to 10 between conditions (i.e., OE versus RE). Finally, a MANOVA was used to compare the improvement in performance from trials one to 10 between all (i.e., OE/RE and AO/V) as well as to ascertain any interaction between the two independent variables.

Results

While 26 participants were recruited for this study, data from six participants were discarded due to missing or unclear segments in the motion analysis data. Of the remaining 20 participants included in the statistical analysis, 4 were male and 16 were female. One participant was African American and the remaining were Caucasian. The mean age of the participants included in the data analysis was 67.78 years with a standard deviation of 6.43 years. See Table 1 for complete demographic results.

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Insert Table 1 here

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Overall, the hypothesis was not supported in that there was no statistically significant improvement in movement efficiency between the occupationally-embedded and rote conditions for any of the dependent variables except for the variable of displacement. Those in the OE condition did have significantly less movement displacement, demonstrating improved efficiency of movement. However, there were no other significant changes for the other variable in terms of condition. See Table 2.

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There was significant improvement for the repeated factor of trial. When comparing the mean values for the variables at trial 1 and trial 10, significance was found for movement time, displacement, and movement units, but not for average velocity. See Table 3. The mean values for each variable for trials 1 and 10 are show in Table 4. The mean average velocity shows a trend toward improvement between the trials, but the change was not statistically significant. These results show that significant motor learning took place over time. See Table 4.

In order to more closely ascertain whether the change in performance improved from trial one to trial 10, a ratio score was calculated by dividing the performance on trial 10 by the performance on trial one. Using this ratio, a result less than one indicates there was improvement in the variables of displacement, movement units, and movement time where one would expect the values of these variables to decrease with repetition; a result greater than one would denote improvement in the variable of velocity, it is expected that velocity would increase with repetition. A 2-tailed independent samples \( t \)-test was done which showed no significant differences between groups for all dependent variables. No significance was found between the
OE and rote groups for movement time, displacement, average velocity, or movement units (Table 5).

A 2 x 2 (OE/RE x AO/V) MANOVA was also performed to analyze improvement from trial 1 to trial 10 (using the same ratio of trial 10:trial 1 described above) in the OE group versus the rote group, the action-observation group versus the verbal group, as well as the interaction between the two sets of independent variables. There were no significant differences in any of the dependent variables for any of the 4 groups, however there was significance found in the interaction of the 4 conditions for movement time, average velocity, and movement units. See Table 6.

Insert Table 6 here

These results are graphically represented and are shown in Figure 3.

Insert Figure 3 here

**Discussion**

The purpose of this study was to examine the rate of learning of a fine motor task involving the use of a novel tool in occupational (occupationally-embedded) versus rote (non-occupationally embedded) conditions in an elderly population with arthritis. The results of this study did not support the hypothesis that those in occupational condition would show
significantly improved rates of learning than those in the rote condition. The occupationally-embedded group did not significantly improve movement efficiency compared to the rote condition for any of the dependent variables except for the variable of displacement. The significant improvement in movement displacement might be explained by the familiarity of using the more naturalistic materials during the task, which could have elicited participants’ motivation and a sense of purpose for the task, contributing to greater movement efficiency in the OE condition, a theory supported by relevant literature (Wu, Trombly and Lin, 1994; Yuen, Nelson, Peterson, and Dickinson, 1993; Ferguson and Trombly, 1996).

In addition, the wooden pieces used in the rote condition were slightly irregular in shape compared to the uniform shape of the aspirin tablets. To successfully grasp the wooden pieces between the tips of the tool, one would have to make slight adjustments in the operation of the tool to manipulate its aperture to accommodate for the different sized pieces. The variations in motor patterns required to do this may have made the task more difficult to learn than in the OE condition. The aspirin tablets used in the OE condition were uniform in shape. This would have required the same exact movement pattern while operating the tool to successfully pick up and transport each of the objects. This would have allowed for a more repetitive movement pattern, perhaps making it easier to learn. This difference in object shape may have decreased the rate of motor learning in the rote condition while facilitating a faster rate of learning in the OE condition, yielding a significant difference between conditions for this variable.

The remaining dependent variables of movement time, and movement units did improve significantly over time, with the exception of movement velocity. However, these variables did not yield statistically significant results when comparing conditions. This suggests that the motor learning that took place was most likely due to practice and the passage of time as opposed to the
environments of the respective conditions. These results are similar to those found by Rice, Davies, and Maitra (2009) where there were no significant differences for any measures of movement efficiency during the reaching phase of a task when comparing the use of relevant and irrelevant objects.

The results of this study also, however, conflict with the general results of other similar studies (Rice, Alaimo, & Cook, 1999; Gasser-Wieland & Rice, 2002) which found that conditions with higher object relevancy elicit great movement efficiency than conditions with lower object relevancy. Specifically, Rice, Alaimo, and Cook (1999) studied movement efficiency in a reaching and placing task with three levels of object relevancy among a healthy adult population. The kinematic variables analyzed were movement displacement, movement units, and movement time. Results showed significantly decreased movement units in the occupationally embedded condition compared with the non-occupationally embedded condition. Significance was also for the variable of angular displacement, with the limited occupationally embedded condition showing significantly reduced displacement than the non-occupationally embedded condition.

Gasser-Weiland and Rice (2002) also studied the movement kinematics in occupationally embedded and non-occupationally embedded conditions in a reaching and placing task in a population consisting of survivors of a cerebral vascular accident. The variables examined in this study were movement time, displacement, movement units, peak velocity, and percentage of movement time at which peak velocity occurred. Of these variables, significance was found in favor of the occupationally embedded condition for movement units and movement time.

There are notable differences between the two studies reviewed above (Rice, Alaimo, & Cook, 1999; Gasser-Weiland & Rice, 2002) and the current study that may have contributed to
conflicting overall results. First, the task in the current study analyzed more fine motor movement, while the tasks in the other studies involved more gross motor grasp and reach movements. Also, the task in the current study involved the use of a tool, whereas there was no tool used in the other studies. This suggests that the results found by Rice, Alaimo, and Cook (1999) and Gasser-Weiland and Rice (2002) cannot be generalized to fine motor tasks involving the use of a tool. Lastly, these studies involved three different populations, so it may not be possible to generalize results across populations.

Data were also analyzed that compared the occupationally-embedded/rote variable with the action observation/verbal independent variable which was part of another experiment. Recall that this comparison was based on the four separate conditions of 1) action observation-occupationally embedded (AO/OE), 2) action observation-rote (AO/R), 3) verbal-occupationally embedded (V/OE), and 4) verbal-rote (V/R). While there were no significant differences in any of the dependent variables for any of the 4 groups, statistical significance was found in the interaction of the 4 conditions for movement time, average velocity, and movement units (see Table 3).

Figure 2 shows two interesting trends in this data. Conditions one and four, AO/OE and V/R respectively, show stronger differences among the variables than conditions two and three, AO/R and V/OE respectively. The AO/OE condition represents a naturalistic task environment with a demonstration of the task to be completed, while the V/R condition represents a more simulated task with alternative materials, no demonstration of the task, and verbal instruction only. The type of task environment in the V/R condition would be assumed to elicit a relatively lesser level of meaning and purpose for the individual, compared with the more naturalistic environment of the AO/OE condition. Research supports that a task with added meaning and/or
purpose can lead to enhance performance of the task (Hsieh, Nelson, Smith, & Peterson, 1996; Bakshi, Bhambhani, & Madill, 1991; Keh-chung, Lin et al., 1997), yet the more rote condition in this study with no instructional demonstration yielded a similar trend in results. This suggests that two types of environments can yield similar results: an environment that is as close to the actual task with the most meaning and purpose for the individual as possible, or one that is completely simulated with very little or no meaning attached. It is also suggested that a mix of naturalistic elements will not produce the same improvement in movement efficiency and fine-motor learning as a completely naturalistic task or one that is completely simulated.

It is possible that there was an element of congruency in the AO/OE and V/R conditions which translated into a participants’ perception of authenticity of the task. The naturalistic materials paired with instructional demonstration in the AO/OE condition could have been perceived as being congruent. The rote materials paired with the verbal instructions in the V/R condition could have similarly been perceived as being congruent. The participants’ sense of congruency in these task environments could have helped to organize their motor outcomes. This resulted in more efficient movement patterns, thus demonstrating an increased rate of motor learning compared to the V/OE and AO/R conditions.

In contrast, participants in the V/OE and AO/R conditions may have perceived their experiences as being incongruent. The naturalistic materials paired with verbal instruction in the V/OE condition might have elicited a sense of incongruence. Likewise, the rote materials paired with the instructional demonstration in the AO/R condition also could have elicited this sense of incongruence. Because of this incongruence, participants might not have been able to believe in the authenticity of the task. This implication did not produce the same organizational effect of participants’ motor outcomes as was done in the AO/OE and V/R conditions, resulting in less
efficient movement patterns and thus a decreased rate of motor learning compared with those conditions.

This concept of congruency was also suggested by Holubar and Rice (2006). In their study, participants engaged in a reaching and placing task using their own mug or one that they did not own in either their own kitchen or a laboratory environment. Movement dynamics were analyzed by gathering data on the variables of movement time, peak velocity, percentage of movement time at peak velocity, displacement, and movement units. No significance was found for any of these variables for the factor of location when analyzing the relationship between natural and simulated environments (i.e. home and laboratory, respectively). When looking at the factor of ownership (i.e. own mug and not own mug), there was significance found for movement time only. Finally, there was a significant interaction found between the factors of location and ownership for movement units only. The authors suggest that the match, or compatibility, in contextual relevancy between location and ownership could have influenced how efficient movement occurred. Furthermore, they suggest that it was the more incompatible conditions that elicited the most efficient movement. For example, it was found that the influence of mug ownership in the laboratory setting resulted in fewer motor units than when performed in the home. The authors propose that this could be explained by the idea that one’s own mug would seem more unique in the laboratory setting, and therefore more meaningful, than it was perceived in one’s home resulting in more efficient movement.

This concept of compatibility could be applied to the results found in this study. While Holubar and Rice (2006) found that incompatibility resulted in enhanced motor performance, this study shows that conditions that are compatible result in enhanced performance. As explained previously, the combinations of naturalistic materials and instructional demonstration
as well as rote materials with verbal instruction only were perhaps perceived as being more compatible. When conditions were perceived as being compatible, it is possible that more meaning was ascribed to the task that resulted in the display of greater movement efficiency.

These results have implications for occupational therapy practice. Our results did not show significant differences between OE and R conditions, but there was significance found when comparing conditions that were congruent, or compatible, against those that were not. This shows the importance of authenticity on the part of the occupational therapist. In other words, occupational therapists need to be genuine in their interactions with clients.

This translates to the authenticity of therapeutic occupations as well as the overall therapeutic experience. Occupations used in therapy pertaining to fine motor learning should have an occupational form that is either as naturalistic and meaningful as possible, or one that is completely simulated with rote and meaningless elements. This could have different implications for different practice settings. For example, in the home health setting, it is much easier to incorporate naturalistic materials during therapy because the therapist and client are in the client’s most relevant environment and the goal is the increased function using the client’s own materials in his or her home. In more clinical settings such as acute care, there may be a lack of naturalistic materials to use in therapy. In this case, therapists may be just as effective by creating a completely simulated environment with the rote materials more commonly found in clinical settings. Therapists in out-patient rehabilitation settings often have increased access to more naturalistic materials than those in acute settings might tend to have, but still not in the abundance that therapists can utilize when carrying out therapy in the client’s home. According to the results of this study, caution is warranted in mixing naturalistic and rote materials as this may not elicit the highest efficiency of movement. To promote fine motor performance in the
out-patient setting, therapists might strive to gather the necessary materials and supplies to complete the naturalistic environment for given occupations, or otherwise remove the naturalistic elements of those occupations altogether.

This concept also applies to the broader scope of therapy beyond a single occupational form of a specific therapeutic occupation. Perhaps a client’s perceptions of meaning is not so much based on the level of meaning in a single task, but on the whole picture of the environment. This broad application of congruency takes into consideration the overall goal of a specific task and how that goal fits into a client’s own personal goals. If any element of the therapeutic environment is perceived to be contrived or incongruent, this may result in inferior therapeutic value for that person. This could lead to decreased performance in therapy and limited progress towards desired goals.

There are limitations inherent to this study that could have produced statistical error. The sample was relatively small and homogenous, therefore preventing the results from being generalized to other populations. Another limitation was the slight irregularities in the shape of the wooden pieces compared with the uniformity in all of the aspirin tablets, making picking up the wooden pieces slightly more challenging and unpredictable than picking up the aspirin tablets. The difference in size of the maximum aperture of the tool and the diameter of the pieces was relatively small. If the aperture were larger compared to the size of the pieces, more fine-motor precision would have been required to successfully pick up each piece with the tool, making it easier to detect changes in fine-motor learning. Another limitation is that some data were lost due to operator error. Lastly, a larger sample size may more accurately reflect a representative sample of this special population.
Conclusion

The purpose of the present study was to examine the rate of learning of a fine motor task in occupationally embedded versus non-occupationally embedded conditions in an elderly population with arthritis. Our results are not in support of the hypothesis and instead show that occupational embeddedness alone does not significantly increase the rate of fine motor learning. However, we did, interestingly, find that occupational embeddedness paired with action-observation can result in significantly improved rates of fine motor learning. Also, it is supported that non-occupational embeddedness paired with verbal instruction can also result in significantly improved rates of fine motor learning. This translates to the fundamental importance and necessity of effectively manipulating occupational forms to elicit the best motor performance and subsequent therapeutic benefits. More research is needed on the concept of congruency of task conditions. Until then, generalization of results of this study should be done conservatively.
Acknowledgements

I would first like to sincerely thank my research advisor, Martin Rice, Ph.D., OTR/L. Without his expertise, guidance, and encouragement throughout the research process, the success of this study would not have been possible. I would also like to express appreciation to Alexia Metz, Ph.D., OTR/L for all of her generous contributions to the design, implementation, and data analysis of this study. A special thanks is due to Alexis Misko for her willingness to collaborate throughout the development of this study, as well as with participant recruitment and data collection. In addition, I would like to thank Julie Thomas, Ph.D., OTR/L, FAOTA for sharing her expertise in the development of the tool used in the study. Finally, I would like to express gratitude to the participants who willingly and enthusiastically participated in this study. All of these contributions are deeply appreciated as they not only supported the completion of this study, but will ultimately serve to promote the field of occupational therapy.
References


doi:10.1002/oti.103.


Table 1

_Demographics Information for Study Participants_

<table>
<thead>
<tr>
<th>Condition</th>
<th>Gender</th>
<th>Hand Dominance</th>
<th>Age</th>
<th>Ethnicity</th>
<th>MMSE Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
<td>Left</td>
<td>Right</td>
<td>Mean</td>
</tr>
<tr>
<td>AO/OE (n=5)</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>62.4</td>
</tr>
<tr>
<td>AO/R (n=6)</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>68.5</td>
</tr>
<tr>
<td>V/OE (n=4)</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>4</td>
<td>62.5</td>
</tr>
<tr>
<td>V/R (n=5)</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>69.8</td>
</tr>
<tr>
<td>Total Participants (n=20)</td>
<td>4</td>
<td>16</td>
<td>4</td>
<td>16</td>
<td>67.78</td>
</tr>
</tbody>
</table>

*Note. AO/OE = Action observation/Occupational embedment; AO/R = Action observation/Rote materials; V/OE = Verbal instructions/Occupational embedment; V/R = Verbal instructions/Rote Materials.*
Table 2

*Statistical Analysis for the Dependent Variable of Displacement by Condition*

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III SS</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.021E7</td>
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<td>8.021E7</td>
<td>1261.530</td>
<td>.000</td>
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<tr>
<td>AOvVER</td>
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<td>1</td>
<td>35943.421</td>
<td>.565</td>
<td>.463</td>
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<tr>
<td>OEvRT</td>
<td>402082.689</td>
<td>1</td>
<td>402082.689</td>
<td>6.324</td>
<td>.023</td>
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<tr>
<td>AOvVER*OEvRT</td>
<td>909.502</td>
<td>1</td>
<td>909.502</td>
<td>.014</td>
<td>.906</td>
</tr>
<tr>
<td>Error</td>
<td>1017354.975</td>
<td>16</td>
<td>63584.686</td>
<td></td>
<td></td>
</tr>
</tbody>
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Table 3

ANOVA Table for Within-Subjects Effects for Movement Time, Displacement, Average Velocity, and Movement Units Across the Four Conditions of Occupationally-Embeddedness/Action Observation, Rote/Action Observation, Occupationally-Embeddedness/Verbal, and Rote/Verbal

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Source</th>
<th>Type III SS</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement Time</td>
<td>Trial</td>
<td>382.81</td>
<td>1</td>
<td>382.81</td>
<td>15.00</td>
<td>.001</td>
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<tr>
<td></td>
<td>Trial * Condition</td>
<td>88.37</td>
<td>3</td>
<td>29.46</td>
<td>1.154</td>
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<td>Error</td>
<td>408.42</td>
<td>16</td>
<td>25.53</td>
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</tr>
<tr>
<td>Displacement</td>
<td>Trial</td>
<td>430859.99</td>
<td>1</td>
<td>430859.99</td>
<td>4.56</td>
<td>.049</td>
</tr>
<tr>
<td></td>
<td>Trial * Condition</td>
<td>222306.097</td>
<td>3</td>
<td>74102.032</td>
<td>.785</td>
<td>.520</td>
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<tr>
<td></td>
<td>Error</td>
<td>1511298.315</td>
<td>16</td>
<td>94456.145</td>
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<tr>
<td>Average Velocity</td>
<td>Trial</td>
<td>2.147E18</td>
<td>1</td>
<td>2.147E18</td>
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<td>.317</td>
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<tr>
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<td>Trial * Condition</td>
<td>3.985E18</td>
<td>3</td>
<td>1.298E18</td>
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<td>.597</td>
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<td></td>
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<td>3.215E19</td>
<td>16</td>
<td>2.009E18</td>
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<tr>
<td>Movement Units</td>
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<td>19333.035</td>
<td>1</td>
<td>19333.035</td>
<td>10.754</td>
<td>.005</td>
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<tr>
<td></td>
<td>Trial * Condition</td>
<td>7610.125</td>
<td>3</td>
<td>2536.708</td>
<td>1.411</td>
<td>.276</td>
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</table>
Error   28764.150   16   1797.759
Table 4

*Mean Values for Each Dependent Variable at Trial 1 and Trial 10 and Levels of Significance for the Repeated Factor of Trial*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Mean Trial 1</th>
<th>Mean Trial 10</th>
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<tbody>
<tr>
<td>Movement time (sec)</td>
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<td></td>
</tr>
<tr>
<td>OE, AO</td>
<td>22.46</td>
<td>12.62</td>
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<tr>
<td>RT, AO</td>
<td>22.76</td>
<td>18.57</td>
</tr>
<tr>
<td>OE, V</td>
<td>18.21</td>
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<tr>
<td>RT, V</td>
<td>20.74</td>
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<tr>
<td>Displacement (pixels)</td>
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<td></td>
</tr>
<tr>
<td>OE, AO</td>
<td>1501.01</td>
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</tr>
<tr>
<td>RT, AO</td>
<td>1629.44</td>
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<tr>
<td>OE, V</td>
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<td>1299.96</td>
</tr>
<tr>
<td>RT, V</td>
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<td>1289.89</td>
</tr>
<tr>
<td>Average velocity (pixels/sec)</td>
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<td></td>
</tr>
<tr>
<td>OE, AO</td>
<td>1.23E9</td>
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</tr>
<tr>
<td>RT, AO</td>
<td>2.05E4</td>
<td>1.87E4</td>
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<td>OE, V</td>
<td>7.79E8</td>
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</tr>
<tr>
<td>RT, V</td>
<td>1.86E4</td>
<td>3.47E4</td>
</tr>
<tr>
<td>Movement units</td>
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</tr>
<tr>
<td>OE, AO</td>
<td>136.33</td>
<td>56.83</td>
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<tr>
<td>RT, AO</td>
<td>114.60</td>
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<tr>
<td>OE, V</td>
<td>117.50</td>
<td>96.50</td>
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<tr>
<td>RT, V</td>
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</table>
Table 5

Means, standard deviations and t-statistics for the trial10/trial1 ratio.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Condition</th>
<th>Mean</th>
<th>Standard Deviation</th>
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<th>p</th>
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<td>MT</td>
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<td>.32</td>
<td>10</td>
<td>-</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Rote</td>
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<td>.48</td>
<td>10</td>
<td>-.51</td>
<td>18</td>
<td>.62</td>
</tr>
<tr>
<td>Displacement</td>
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<td>.90</td>
<td>.19</td>
<td>10</td>
<td>.26</td>
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<td>.80</td>
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<tr>
<td></td>
<td>Rote</td>
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<td>.28</td>
<td>10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Velocity</td>
<td>OE</td>
<td>1.61</td>
<td>.55</td>
<td>10</td>
<td>.45</td>
<td>18</td>
<td>.66</td>
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<tr>
<td></td>
<td>Rote</td>
<td>1.50</td>
<td>.54</td>
<td>10</td>
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<tr>
<td>Movement Units</td>
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<td>-.43</td>
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<td>.67</td>
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</table>
Table 6

*ANOVA Showing Results of Interaction of the Four Conditions*

<table>
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<tr>
<th>Dependent Variable</th>
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<th>Mean Square</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOvER*OEvRT</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MT10by1</td>
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<td>1</td>
<td>.903</td>
<td>6.832</td>
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<td>Disp10by1</td>
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<td>1</td>
<td>.142</td>
<td>2.579</td>
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<tr>
<td>Vel10by1</td>
<td>1.800</td>
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<td>1.800</td>
<td>8.157</td>
<td>.011</td>
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<tr>
<td>MU10by1</td>
<td>1.763</td>
<td>1</td>
<td>1.763</td>
<td>7.985</td>
<td>.012</td>
</tr>
</tbody>
</table>
Figure 1. Image of the pliers used by all participants.
Figure 2. Images of the materials used in the OE condition (a) and rote condition (b).
Figure 3. Graphical representation of data comparing all four conditions (e.g. 1 = AO/OE, 2 = AO/R, 3 = V/OE and 4 = V/R).
Appendix A

Verbal task instructions given to those in the OE and R conditions

The following script will be read aloud by an unseen person during the video segments to be shown for participant instruction in each of the two conditions.

**Occupationally Embedded instructions**

“On the table in front of you is a pair of pliers, seven aspirin tablets, and a pill organizer. Please use the pliers to move each pill into a section of the box. Put only one pill in each section. Move one pill at a time. Thank you.”

**Rote instructions**

“On the table in front of you is a pair of pliers, seven wooden pellets, and a divided plastic box. Please use the pliers to move each pellet into a section of the box. Put only one pellet in each section. Move only one pellet at a time. Thank you.”