Object familiarity in a reach and placing task with a 24-hour delay

Kyle Sterling
Medical College of Ohio

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FINAL APPROVAL OF SCHOLARLY PROJECT
For the Degree of
Master of Occupational Therapy

Title of Scholarly Project: Object Familiarity in a Reach and Placing Task with a 24-Hour Delay

Submitted by
Kyle Sterling

(Name)

In partial fulfillment of the requirements for the degree Master of Occupational Therapy

APPROVED

Name

Martin S. Rice, Ph.D., OTR/L
Major Advisor

Julie J. Thomas, Ph.D., OTR/L, FAOTA
Department Chair

Christopher E. Bork, Ph. D.
Dean, School of Allied Health

Keith K. Schlander, Ph.D.
Dean, Graduate School

Signature

Date

5/6/05

Final Approval of SP MOT
Object Familiarity in a Reach and Placing Task with a 24-Hour Delay

Kyle Sterling

Department of Occupational Therapy

Medical College of Ohio at Toledo
Abstract

Objective

The purpose of this study was to investigate if using a familiar object (metal cup) or an unfamiliar object (clay mass) would elicit differences in movement kinematics in a reaching and placing occupation among trials separated by a 24-hour delay.

Method

This study was a mixed experimental design. 72 healthy participants between the ages of 18-65 were recruited and randomly assigned to either the high familiarity (HF) condition with the metal cup or the low familiarity (LF) condition with the clay mass. The participants were then asked to perform trials on day-1 and return in 24-hours for follow-up trials. Participants opened a door and moved an object from a shelf to a target on a shelf. The movement was analyzed in terms of movement time, movement units, displacement, average absolute velocity, peak velocity, and percent of movement time to peak velocity.

Results

There were no differences in movement dynamics between the two object familiarity groups on the second day. There were differences between the two groups when comparing the final trial of day-1 to initial trial of day-2 in terms of peak velocity. There were also differences between the two groups when comparing the initial trial of day-1 to the initial trial of day-2 in terms of percent of movement time to peak velocity. Differences were found on the final trial of day-1 and the initial trial of day-2 in terms of displacement and peak velocity. Similarly, comparison of the initial trials of both days showed differences in movement in terms of movement time, displacement, average absolute velocity, peak velocity, and percent of movement time to peak velocity. Significant differences in movement were also found when
investigating the interaction between object familiarity and trial. Specifically, there was a
difference from the final trial of day-1 to the initial trial of day-2 in terms of movement units. On
the initial trials of both days, significance in the interaction between object relevancy and trial
reached significance in both movement units and displacement.

Conclusion

Differences in movement are hypothesized to be the result of how the participant
perceived the occupation at the different times of the experiment. The results of this study show
that quality and rate of a reach and place occupation changes over time and may be influenced by
objects in the person’s environment. Investigation of how a person perceives an occupation over
time is important to the profession of occupational therapy because therapists often use repetition
to gain skill, strength, and endurance, and usually receive therapy several times a week.
Therapeutic benefit can be maximized when an occupation is designed in the most appropriate
duration, frequency, and variety.
Introduction

A person, by his or her own nature is a being of occupation. A person engaged in occupation is not just engaged in that of vocation, but in anything that involves “doing.” The health of a person is supported and maintained when individuals are able to engage in occupations and in activities that allow desired or needed participation in home, school, workplace, and community life (The Commission of Practice, 2002). Occupational Therapists’ role is to help people regain or retain those abilities and skills to allow them to have a healthy and productive life by their own terms. Occupation is defined as the “doing of something,” but this “doing” actually involves several components: the performer, the actual performance, and the environmental context.

According to Nelson’s Conceptual Framework of Occupational Therapy, occupation involves a relationship between an occupational form (the situation) and occupational performance. He further explains that the subjective way that a person perceives the occupational form is termed meaning. The meaning a person derives from any given situation will vary because of individuality and experience, and perhaps whether or not the person has a disability. The meaning a person derives from the situation will then affect the desire to act. This desire to act or to “do” is termed the person’s purpose. This purpose is how the person wants to do the occupation, which will inherently influence the occupational performance or the “doing” of the occupation (Nelson, 1994).

The focus of this study is the relationship between the ways an individual perceives the occupational form, and how that perception will change or enhance his or her performance. This relationship has been studied in terms of added-purpose (Yoder & Nelson, 1989), contextual relevance (Ferguson & Rice, 2001), and occupational embeddedness (Lin, Wu, Tickle-Degnen,
& Coster 1997). In several instances, the difference in whether an occupational form is determined to be occupationally embedded or not is based upon the familiarity of the object. For instance, in Rice, Alaimo, and Cook (1999) and Gasser-Weiland and Rice (2002), the object with greater familiarity, (e.g. a soup can) was assumed to have greater meaning than the object with relatively less familiarity (e.g. an unformed mass of clay). Regardless of the variability in the terminology, the condition with the enhanced occupational form was often compared to a rote condition in which little or no meaning was assumed. The clinical application of the findings of the Lin, et al. (1997) meta-analysis is that if a patient finds enhanced meaning or purpose in certain occupations, there will be more motivation to take part in these occupationally embedded therapeutic sessions and more motivation to regain the abilities required to do those occupations.

Yoder and Nelson (1989) explored this idea with a cookie dough stirring task. Participants in the added-purpose group were told that the dough was best if it was stirred a lot. The rote-exercise group was simply told to stir the dough for exercise; otherwise, both the groups received the same instructions. This study found that there were significantly greater rotations in the embedded condition than in the rote condition. Duration of the task in the added-purpose situation was also significantly greater. It was concluded that the simulated process of making cookies created an occupational form which brought about the desire to exert more effort than in the exercise condition.

Although this finding is significant to the theoretical base of occupational therapy, many of the tasks that occupational therapists and patients focus include other aspects of movement, for example, coordination. Several studies have explored the idea that an occupational form can affect occupational performance in terms of movement efficiency. For instance, Wu, Trombly, and Lin (1994) investigated the relationship between the occupational form and occupational
performance by analyzing the kinematics of participants when asked to pick up a pencil and write their name (materials based occupation). With a similar motion, participants were asked to pretend to pick up a pencil and sign one’s name (imagery-based occupation). Finally, the participants were asked to simply move their hand forward as in the other two conditions (rote occupation) with no materials or imagery used. The results revealed enhanced quality of movement in the materials-based condition as compared to the imagery-based and exercise conditions. However, contrary to the hypothesis, participants performed better in the exercise versus the imagery-based occupation. The practical implication that the materials-based occupation will show enhanced movement quality over imagery-based occupation and exercise is supported.

Mathiowetz and Wade (1995) studied the effects of different levels of task constraints, as he termed it, in three functional tasks: eating with a spoon, drinking from a cup, and turning pages in a book. There were two populations, 20 normal adult and 20 adults with Multiple Sclerosis. In the group with the highest level of task constraint (impoverished), the participant would have to mime a movement without any materials. In this experiment, the participants in the partial constraint group would mime the movement with some of the materials normally used, and in the natural group, the participant would perform the actual functional task. Movement time, maximum displacement, and velocity variability were significantly different between the three levels of task constraint. In addition, the healthy participants and the participants with MS responded to each condition similarly.

The Hall and Nelson (1998) study was a replication of Mathiowetz and Wade (1995). This replication study explored the effects of materials on occupational performance in a materials-based, partial imagery-based and imagery-based occupation. Although this study was a
repeated measure counterbalanced design, it did not use a population with disability. The participants were 47 college-aged females. This was done because Mathiowetz and Wade (1995) failed to see improvement in the population with MS that was equal to the healthy population. Hall and Nelson (1998) found differences that were similar to Mathiowetz and Wade (1995) in that there was a difference between all the conditions. The materials-based condition elicited slower, less smooth movement with a lower peak velocity when compared to the other conditions. Similarly, the partial imagery-based occupation elicited slower, less smooth movement with less maximum displacement and lower peak velocity.

Rice, Alaimo, and Cook (1999) explored the effects of different levels of occupational embeddedness on a grasping and placing task. These three levels of embeddedness; a labeled soup can (occupationally embedded), a can with no label (limited occupational embeddedness), and a mass of modeling clay (non-occupationally embedded), represented different occupations that would be more or less interesting to a person. While standing, the subjects moved an object from the counter into the cabinet above. There was significantly less displacement and fewer movement units in the limited occupationally embedded condition than the non-occupationally embedded condition.

The results of the Wu et al. (1994), Mathiowetz and Wade (1995), Hall and Nelson (1998), and Rice et al. (1999) support the premise that enhanced occupations may enhance motor performance. Previous research has also explored the effects of enhanced occupations on skill acquisition and transfer after a 24 hour delay period (Ferguson & Rice, 2001; Ma, Trombly, & Robinson-Podolski, 1999).

The effects of context on skill acquisition and transfer had been explored by Ma, Trombly, and Robinson-Podolski (1999). Participants were asked to use chopsticks in either a
natural or simulated context. The 40 right-handed college students without disabilities were asked to either pick up 10 pieces of cheese and eat it (natural) or pick up 10 chunks of eraser and bring it to the mouth (simulated context) with a pair of metal chopsticks. The participants were asked to come back 1 day later, without practicing the use of chopsticks. In the transfer phase, the participants were asked to use wooden chopsticks to pick up 10 cooked pasta shells to eat. The participants were rated not only on their kinetics, but also on their rate of success. While success rate between the two groups was significantly different in the acquisition and transfer phases, the kinematic findings were not. Several reasons for this were suggested.

First, in the Ma, Trombly, and Robinson-Podolski (1999) study, the researchers had considered that the manipulation of the context variances may not have been strong enough to elicit a large effect size. Both groups had concrete materials, where previous research had shown larger differences if the contexts were theoretical (imagery) versus concrete (materials-based) (e.g., Sietsema, Nelson, Mulder, Mervau-Scheidel, & White, 1993; Wu et al., 1994; Yuen, Nelson, Peterson, & Dickerson, 1994). Second, the researchers took into consideration that the context in which the trials were carried out was not a match to the occupation being done (they were not in an oriental restaurant). The participants would not normally use chopsticks to eat cheese, and hence the naturalistic context in this occupation was not very naturalistic after all. Third, the researchers had considered how the participants perceived the purpose of this task. If the participant thought that the task was that of using the chopsticks as fast as they could (which was not specified), then the possibility of the speed-accuracy trade-off emerges. The speed-accuracy trade-off is that when a motion occurs quickly, the accuracy of the movement is reduced. Finally, the homogeneous nature of the population was in question. The Lin et al. (1997) meta-analysis showed larger effect sizes for those populations with neurological
impairment than those who were neurologically intact. If the healthy adults in this study were not as sensitive to the subtle influences of the contexts as those of previous studies who had some neurological impairment, this would have reduced the effect size.

In a motor skill learning and transfer study by Ferguson and Rice (2001), there was a neck-tying occupation that investigated the effects of contextual relevance on the ability to transfer acquired skill from one day to an occupation after a 24 hour rest period. In the acquisition phase of learning, the contextually relevant condition was that of learning to tie a necktie on a mannequin while the non-contextually relevant condition involved tying the same style of knot with a rope around a wooden post. After 24 hours, the contextually relevant and non-contextually relevant groups were asked to transfer what they learned in the acquisition phase to tying a necktie on themselves. The control group did not undergo an acquisition phase and was simply asked to tie a necktie around their necks on the second day.

In the skill acquisition phase, there were significant differences in movement kinematics between the contextually relevant and non-contextually relevant groups in terms of movement time and movement units \( p<0.001 \). The contextually relevant group had greater movement time and movement units than the non-contextually relevant group. This may be attributed to the materials used because the contextually relevant group was a flat tie, where the non-contextually relevant group used a round rope. The orientation of the sides of the tie was pertinent to whether or not the knot was tied correctly, whereas the round rope did not have this variable.

In the first trial of the transfer phase, the differences among the groups marginally failed to reach significance \( p=0.06, p=0.07 \) in terms of movement time and movement units respectively. Because these \( p \) values were relatively close to significance, effect sizes were calculated and were found to be large for movement time and movement units. If the materials
used were equal in their ease of use, the kinematics of the contextually relevant group may have achieved significance, but because tying the flat tie required side-orientation, it was harder to tie. As hypothesized, movement time and movement units between the groups during the transfer phase were not significant. This indicates that the process of learning skill in the acquisition phase and used in the transfer phase was successful for both the contextually relevant and non-contextually relevant groups.

Occupational embeddedness has been shown, in multiple studies, to have an influence on various movement kinematics (Ferguson & Rice, 2001; Gasser-Wieland & Rice, 2002; Hall & Nelson, 1998; Rice et al. 1999; Trombly & Wu, 1999; Wu et al., 1994). Occupational embedded tasks have shown mixed results in skill transfer after a 24 hour period (Ferguson & Rice, 2001; Ma et al., 1999). What, though, occurs over time to the dynamic movements of a subject doing a task in a situation that either has meaning or does not have meaning to the person? With the exception of Ferguson and Rice (2001), the majority of previous studies exploring movement kinematics involved a seemingly simple reaching and placing tasks.

Although the reaching and placing task seems like a simple motor skill, but analysis of the underlying movements, kinetics, and kinematics reveal great variances when manipulating certain characteristics of the occupational form. For instance, a healthy person reaching for and grasp a familiar object as opposed to a non-representative object has been shown to improve movement dynamics (Rice et al., 1999). Quantitative measurement is necessary to show subtle differences in movement kinetics that are not directly observable. Efficiency of movement can be measured in terms of displacement, movement units, movement time, peak velocity, and percent of movement to peak velocity.
Displacement is the summative change in position during a movement. This can be linear, which is the distance a body part has traveled in a 3-dimensional space, or it can be angular which is the range displaced by a joint during the movement. Movement units are the amount of acceleration and deceleration cycles that occurs during a person’s movement. Movement units can also be viewed as the amount of correction the person made during the movement (the more movement units, the more acceleration and deceleration took place). Movement time is the total amount of time the movement took from the start position to the end position. Peak velocity will show how fast the person was able to move, but this will not always elicit a short movement time. Percent of movement time to peak velocity will reflect what proportion of the movement time it took the participant to reach his/her peak velocity in a specified segment of the movement. These different kinematic measurements yield a more complete picture of how the person moved.

Examining the movements of persons with neurological impairments can be helpful in investigating the complexity of simple movements. For example, the person with a unilateral lesion of the dorsal column medial lemniscus tract will inhibit all sensory information below that spinal level lesion on one side of the body, but will leave all pain sensation and motor tracts intact. Without proprioception, motor control is greatly altered (Schmidt & Lee, 1999). In studies trying to elicit performance differences from subtle changes in the occupational form, a more sensitive population may show these differences more overtly. Gasser-Weiland and Rice (2002) investigated the effects of occupational embeddedness on a reaching and placing in survivors of cerebral vascular accidents. The participants showed a significant difference between the occupationally embedded condition (can of soup) and the non-occupationally embedded
condition (mass of clay) in terms of motor time and movement units ($p<0.003$, $p<0.01$ respectively).

In the current study, we explore the lasting effects of meaning from the occupational form on motor control. There are two studies taking place at the same time, both investigating how meaning affects the movement kinematics of a reaching and placing task. One is investigating the effects of the subject’s perception of meaning in an occupationally embedded versus a non-occupationally embedded condition across multiple trials. This study will explore the effects of occupational embeddedness on motor control from those multiple trials to trials after a 24-hour delay. The idea of using a delay in an occupational embeddedness experiment is not novel (Ferguson & Rice, 2001; Ma, et al., 1999; Rice, 2003), but no study has investigated how movement kinematics may differ as a result of exposure to occupations with different intended levels of meaning.

The implications of this study go to the heart of occupational therapy where occupation is both the therapeutic means and ultimate goal of therapy. Knowledge about temporal influences upon meaning is important to the practice of occupational therapy because therapists ideally utilize more meaningful occupations to catalyze a patient’s recovery and make the therapy a “tailor-made” engaging experience for each individual client. If enhanced occupational embeddedness does have a temporal effect on a person’s meaning, purpose, and inevitably performance, then exploring the lasting effects of that change must be explored.

To operationalize the purpose of this study, the following hypotheses were developed:

1. On the initial trial after the 24-hour delay, the movement performance will be enhanced when exposed to the occupationally embedded condition (high familiarity object) compared to when exposed to the non-occupationally embedded condition (low familiarity object).
Hypothesis 2-4 will investigate the movement kinematics between the final trial of day-1 and the initial trial of day-2:

2. There will be a difference in movement kinematics on the main effect of object familiarity.
3. There will be a difference in movement kinematics on the main effect of trial.
4. There will be a significant interaction on the factor of object familiarity and trial.

Differences in movement kinematics will similarly be investigated in terms of object relevancy, trial, and the interaction of object familiarity and trial between the final trial of day-1 and the initial trial of day-2. Therefore, hypothesis 5-7 are as follows:

5. There will be a difference in movement kinematics on the main effect of object familiarity.
6. There will be a difference in movement kinematics on the main effect of trial.
7. There will be a significant interaction on the factor of object familiarity and trial.

Methods

Participants

Participants included 72 healthy male and female volunteers aged 18-65 years. They were recruited from Midwest universities and the surrounding community. Recruitment of participants occurred through poster, advertisements, and through word of mouth and email.

Apparatus

Kinematic data were collected at 120 Hz using a four-camera Qualysis ProReflex 3-dimensional system. This system records the 3-dimensional spatial coordinates of reflective markers that were affixed to bony landmarks on the participant’s upper extremity and upper body. Muscular activity for the movement of the shoulder, elbow, wrist, thumb, and finger was also recorded with a noninvasive surface electromyography (EMG) to assess reach and grasp.
The rationale for using EMG is that associated EMG profile, combined with the movement kinematics provides a window to understand movement planning and programming by the brain. Using an 8-channel Noraxon EMG system, electrodes were placed on the muscle bellies of the flexors and extensors. EMG data was collected and digitized at 1080 Hz in synchrony with the movement data. For off-line analysis, raw EMG signals were bandpass filtered, half wave rectified, and smoothed according to standard procedure (Cooke & Brown, 1986).

Randomization

This is a mixed experimental design. Therefore, participants were randomly assigned to one of two conditions using a customized computer random-number generator software program. The two conditions were the higher familiarity (HF) coffee cup condition and the lower familiarity (LF) mass of clay condition. Specifically, there were 7 blocks of 2 participants, 4 blocks of 4 participants, 3 blocks of 6 participants, and 2 blocks of 12 participants (for a total of 72 participants). In addition, the order in which the blocks present themselves were randomly assigned using a customized computer random-number generator software program. The data collection investigator entered the participant’s subject number in a computer program once the participant arrives at the data collection session. The computer program dated and time stamped the occurrence of accessing the participant’s subject number. In doing so, the investigator was not able to anticipate the participant’s group assignment prior to that participant’s data collection session. All participants returned in 24 hours for retention trials.

Procedures

This study was approved by the Institutional Review Board, IRB #104767. Informed consent was provided to all participants prior to any data collection. The data collection site consisted of a room that was approximately 40 feet by 30 feet. At one end of the room, an object
(either a metal coffee mug or a mass of clay wrapped in aluminum foil) was sitting upon a shelf that was attached to an adjustable-height table (see Figures 1 & 2). The object (either the mug or the clay) was sitting on the shelf, but behind a translucent door. The door was hinged on the bottom, and had a “knob” that was mounted on the side edge of the door (see Figure 3). To the right of the apparatus was a Big Red Switch® placed on a six inch pedestal. The initiation of the trial began with releasing this Big Red Switch®. When the door is open, the shelf, the object, and a portion of the table were unobstructed for the participant. There was a micro switch placed upon the bottom so that when the door is open, the micro switch was engaged and send a trigger to initiate data collection. This additionally standardized the starting location for the reach portion of the movement. The shelf had a micro switch plate upon which the metal coffee cup or mass of clay wrapped in aluminum foil rested. This switch signaled the computer when the participant touched the object. The target for where the object was placed by the participant consisted of another micro switch plate that standardized the end of the transport phase. Therefore, each portion of the upper extremity movement was “marked.” For instance, the “reach” portion started from when the door is latched from the bottom (open) position to when the hand touches the object. The “grasp” portion of the movement is from when the hand initially touches the object to when the object is lifted from the shelf. The “transport” portion of the motion is from when the object is lifted from the shelf to when the object is placed upon the target micro switch plate.

Once informed consent was obtained, the data collection investigator entered the participant’s subject number into the software program that indicated the order of presentation of conditions that the participant incurred. Obtaining informed consent was received in an adjacent room from where data collection occurred. Reflective markers were placed on the participant’s
acromion process, humerus, elbow, wrist, the metacarpal, and the finger nail of the thumb and index finger of the right upper extremity. EMG electrodes were placed on the muscle bellies of the flexors and extensors of the wrist, hand, and fingers. The following instructions were read to the participants:

When I say, “begin”; with your right hand I would like you to open the door so that the door is opened the whole way like this (the data collection investigator demonstrates). Then I would like you to move the object from the shelf and set it on the target plate. Once you set the object down, you can let your arm rest by your side. Do it like this (investigator demonstrates). When you move the object, just move at a rate that is comfortable to you. Do you have any questions? (If the participant has any questions, particularly procedural-type questions, the data collection investigator will answer them)

The instructor ensured that the correct object was placed on the shelf behind the closed door and then said “begin.” Once the participant opened the door, reached for, and placed the object from the shelf onto the target plate, then rested his or her arm back on the Big Red Switch®, the investigator reset the experimental unit for the next trial by returning the object to the shelf and closing the door. Each participant performed 3 trials.

*Dependent Variables*

Kinematic dependent variables for the “reach” and “transport” portion of the movement includes movement time, displacement, average velocity, peak velocity, percentage of movement time to peak velocity, and movement units. Movement time is calculated from the time the door is latched in the open position to the time the hand touches the object. Displacement is defined as the position to the position change in a 3-dimensional space. Velocity is defined as the change in position divided by the change in time. The percentage of movement time at peak velocity is calculated by dividing the time at which peak velocity occurred by the total movement time of the reach and transport portions. Movement units are defined as a crossing of the zero line on the
acceleration profile from a negative value to a positive value and back to a negative value again (Ferguson & Rice, 2001). These variables were derived from the marker affixed to the index and metacarpal area. Movement time is calculated as the time from when the object is lifted until the object hits the target plate.

Statistical Analysis

For the first hypothesis, a one way multiple analysis of variance (MANOVA) will be performed on the initial trial of day-2 for the main effect of condition. For the second through seventh hypothesis, a 2x2 (object relevance x time) analysis of variance (ANOVA) with repeated measures on the second factor will be performed for each of the dependent variables. Alpha will be set at $p<.05$ for all of the analyses.

The reduction and application of the EMG data will be a long and arduous process, and will be analyzed at a later date.

Results

While there were 72 subjects recruited, data from only 51 could be included for statistical analysis. This was due to the reflective markers disappearing from the camera, subjects not following the protocol set forth by the instructions, and/or subjects unexpectedly not being able to return for the second day of trials. Furthermore, the $dF$ for each hypothesis will be different because some subjects had incomplete data sets due to the markers disappearing in certain parts of either the reach or transport phase.

When analyzing the movements of each subject, the “reach” phase and “transport” phase were run separately. The reach phase is defined as starting when the door stopped opening thereby making contact with the shelf apparatus till when the subject first touched the object. The transport phase is defined from when the object started moving to when the object struck the
second target. This was done so that the potential differences in movement could be identified when the subject was moving without then with the object in his/her hand.

Hypothesis One stated that after the 24-hour delay, the movement performance will be enhanced when exposed to the high familiarity (HF) condition compared to when exposed to the low familiarity (LF) condition. For hypothesis one, the \( n=48 \). A one way MANOVA revealed no significance between the two conditions on the initial trial of the second day in any of the dependant variables in either the reach or transport phase \( p>0.05 \). Means and standard deviations are illustrated in Table 1.

Hypothesis Two stated that when comparing the final trial of day-1 to the initial trial of day-2, there would be a difference in movement kinematics in the main effect of condition. When analyzing the reach portion of the movement, there were no dependent variables that reached significance. Figure 4 illustrates that peak velocity was statistically different for the transport phase of the movement \( F(1,49) = 5.75, p=0.02 \). This means that on the final trial of day-1 and first trial of day-2, subject moving the mass of clay reached a higher peak velocity than that of subjects moving the cup.

Hypothesis Three stated that there would be a statistically significant difference across trials in movement kinematics, specifically comparing the final trial of day-1 to the initial trial of day. When analyzing the reach portion of the movement, there were no dependent variables that reached significance. However, the transport phase (object in hand) showed a significant difference in displacement between the trials separated by a 24-hour delay \( F(1,49) = 19.27, p<0.05 \). Both the subjects moving the cup and clay mass increased the amount of displacement shown in Figure 5. Peak velocity of the object transport also significantly increased across the two trials on the second day in both conditions \( F(1,49) = 8.67, p=0.005 \).
Hypothesis Four states that there will be an interaction between time and condition from the final trial of day-1 to the initial trial of day-2. A 2x2 ANOVA with repeated measures ($dF=49$) was conducted for the two conditions and two trials (repeated factor). There was a significant difference during the reach phase in the number of movement units on the factor of trial by condition $F(1,49) = 4.62, p=0.037$. This difference is illustrated in Figure 6, and shows that there were more movement units in the last trial of day-1 for those in the HF group, and after a 24-hour the movement efficiency increased as movement units decreased. Alternately, the reaching movement of the LF group initially elicited fewer movement units, but over time efficiency decayed and movement units increased. The transport phase of the movement revealed no significant differences in movement variables.

The previous three hypotheses explored the movements occurring between the final trial of day-1 and the initial trial of day-2 in an effort to observe the hypothetical effect of the 24-hour break on movement dynamics hypothetically reflecting perception of meaning from the respective objects. Hypotheses Five through Seven investigated the differences in movement in the same manner as hypotheses Two through Four, but comparing the initial trial of day-1 to the initial trial of day-2. This comparison investigates any significant differences that may have occurred between the movements at the first exposure to the occupation to movements in the trial that followed the subsequent 35 trials and the first trial after a 24-hour delay. For the sake of simplicity, the following three hypotheses will be presented in the same order as the previous three; object familiarity, trial, and then trial by object familiarity.

Hypothesis Five states that there will be a significant difference between the performance of the two condition groups when comparing the initial trial of day-1 and the initial trial of day-2. A 2x2 ANOVA with repeated measures showed no significant differences in the reach portion of
the movement. However in the transport phase, there was support for this inquiry in terms of percent of movement time to peak velocity $F(1, 48) = 5.23, p=0.027$. Figure 7 illustrates that the subjects transporting the cup reached peak velocity significantly earlier in the total movement than those moving the clay mass.

Hypothesis states that there will be a difference in performance of subjects in each condition when comparing the initial trial of day-1 to the initial trial of day-2. A 2x2 ANOVA shows support for this hypothesis with several movement kinematic variables. While there was no support for this hypothesis in the reach phase, there were significant differences during the transport phase across trials found including peak velocity $F(1,48) = 10.61, p=0.002$, average absolute velocity $F(1, 48) = 6.14, p=0.017$, percent movement time to peak velocity $F(1,48) = 7.28, p=0.01$, movement time $F(1,48)=37.54, p<0.001$, and displacement $F(1, 48) = 6.29, p=0.016$. More specifically, peak velocity increased in both conditions across the trials (Figure 8). Average absolute velocity was also higher on the second day in both conditions (Figure 9). Percent movement time to peak velocity was decreased in both conditions across the two trials (Figure 7). This means that peak velocity was reached significantly earlier in transporting the object in both the HF and LF conditions. Along with peak velocity increasing from day-1 to day-2, movement time of transporting the object was similarly decreased (Figure 10). While the movement occurred more quickly in almost every kinematic variable, displacement was also significantly lower on the trial of day-2 (Figure 11).

Hypothesis Seven stated that there would be an interaction between the factor of object relevance and time. This was investigated by comparing the initial trial of day-one to the initial trial of day-2. A 2x2 MANOVA ($dF=47$) for the initial trials of both days was conducted to observe these interactions. When considering differences between conditions across trials, the
movement units $F(1,47) = 5.96, p=0.018$ and displacement $F(1,47) = 5.77, p=0.02$ achieved significance in the reach phase of the movement. Movement units are the number of corrective cycles a person uses when approaching a target. This is a direct descriptor of efficiency. The LF group decreased in efficiency from the initial trial of day-1 to the initial trial of day-2 while the HF group initially performed worse, but improved on day-2 (Figure 12). Similarly, displacement was initially lower in the LF group, but was significantly higher on day-2, while those in the HF group initially performed less efficiently but improved on day-2. Displacement is clearly illustrated in Figure 13. There were no significant differences in the transport phase of the movement.

Discussion

Georgopoulos (1986) proposed that reaching is a seemingly simple physical movement with many steps that are planned and controlled with several neuronal hierarchical levels, all of which may influence a seemingly simple movement in a variety of ways. Explaining why movement of an object differed from movement of another object from one trial to the next could therefore become a seemingly endless task. Researchers systematically investigate influences on movement by altering one factor in a controlled environment and observe what happens in comparison to what happens in another controlled environment. From this comparison, researchers must make humble assumptions that the differences between the situations may have caused the difference in movement and hope that this difference in movement occurs in subsequent studies testing similar hypotheses thereby developing a line of research.

This study was conducted to observe the kinematic performance of a person in a reach and place occupation using either a mass of clay or metal cup. The objects used in this study were chosen in an effort to represent low (mass of clay) and high (metal cup) levels of familiarity
with objects in everyday life. Theoretically if the object was regarded with a higher level of familiarity, the person would be more engaged in moving the object by evidence of better movement efficiency. The results for Hypothesis One revealed that after 36 trials and a 24-hour delay, subjects had no significant differences between those using the mass of clay and those using the metal cup.

Lack of significance in movement kinematics after a delay is consistent with the findings of two other studies. Ferguson and Rice (2000) observed the skill acquisition and movement dynamics of persons tying a necktie or rope, and transferring that skill after a 24-hour, and they too found no significant difference in movement kinematics between the conditions after the delay. Ma et al. (1999) observed the skill acquisition and movement kinematics of using chopsticks and the transfer of that skill after a 24-hour delay. Again, they found significant differences in success of occupation, but no significant differences in any of the kinematic variables after the delay. It is possible that after the repeated trials and the 24-hour delay, the subject no longer found the object or context as novel as the initial interaction. If the person no longer perceived the object as a significant part of the occupation over time but focused on simply completing the task, it may explain why no difference in performance was observed between the conditions. Ferguson and Rice (2000) and Ma et al. (1999) found an increased success rate in the subjects who initially used the objects of higher occupational embeddedness possibly because they were more engaged in the early trials and transferred that skill to the next day.

Each group of the current study moved with similar levels of movement efficiency perhaps because both groups have engaged with the objects for the same duration and frequency, and may have similar levels of familiarity after the multiple trials and 24-hour delay. By the end
of 36 trials, any differences that there may have been initially on day-1 were diminished by the 36\textsuperscript{th} trial. Perhaps the memory of much repetition from the day earlier had not depleted and movement was therefore influenced by the reminiscent memory of repetition from day-1, not the object itself.

The use of an object with different levels of familiarity would be expected to elicit a difference in movement kinematics at some point in the experiment, which is why both the initial trial and final trial of the first day were compared to the initial trial of the next day.

Hypothesis 2 investigated the first set of hypotheses that there would be a significant difference between the movement of subjects in the HF and LF conditions. Support for this hypothesis was found in that those transporting the object in the LF condition, there was higher peak velocity than those in the HF condition. Refer to Figure 4 for an illustration of this difference. Higher peak velocity in the LF condition may be the reflection of one of two opposing explanations. On the one hand, the subject may be more excited about moving the clay mass on these particular trials by evidence of a higher speed. However, there were no significant differences in other movement kinematics to support the differences of condition in these trials. On the other hand, perhaps by the end of the multiple trials of day-1 and the initial trial of day-2 the subjects found very little value in the use of the clay mass and therefore wanted to simply complete the remaining trials as quickly as possible. While there is no way to determine what exactly made the subjects in the LF condition move more quickly, but this trend will resonate in the support of subsequent hypotheses.

Hypothesis 3 focuses on the differences in movement from the final trial of day-1 to the initial trial of day-2 to observe if the 24-hour delay may have had an effect on the perception of meaning from the objects. It is assumed that changes in perception of meaning would elicit
differences in movement kinematics. Although there were no significant differences in movement kinematics in the reach phase, there were significant differences when transporting the object.

At the end of the first day, subjects in both the LF and HF condition transported the object with more efficiency in terms of displacement than on the initial trial of day-2 as illustrated in Figure 5. Perhaps at the end of the multiple trials of day-1, the subjects were moving with more efficiency because of the practice, but after the 24-hour delay, subjects lost some efficiency because the time away from the occupation caused some of decay of skill. Figure 4 shows that when transporting the object, peak velocity was significantly lower on day-1 when compared to day-2. This increase in peak velocity could also be due to being at the end of much practice on day-1 when the subject was eliciting a higher level of skill, and when returning to the occupation the subjects showed a decline in efficiency after the elapsed time. The relationship between displacement and peak velocity is consistent with the speed-accuracy trade-off. As the movement is done more quickly, the ballistic portion becomes more pronounced with the correction at the end of the movement, which is indicative of a mature reach (Georgeopolus, 1986). Although accuracy of hitting a target was not the objective, in order to grasp, lift, and place the object, a certain minimal degree of accuracy was demonstrated in completion of the occupation.

Hypothesis 4 stated that there would be an interaction between the factor of object relevance and time from the final trial of day-1 to the initial trial of day-2. This means that when comparing trials separated by the 24-hour delay, performance is significantly different between the subjects in the respective familiarity conditions. Subjects in the HF group demonstrated fewer movement units when reaching for the object, thus greater movement efficiency than those
in the LF group on the final trial of day-1. Figure 6 clearly illustrates this trend. There was no
significance in movement kinematics when the subjects transported the object.

After the 24-hour delay, efficiency in the HF group decayed and more movement units were elicited. These changes in movement quality may be a result of a change in the way the person perceived the occupation across the trials. Perhaps by the final trials of day-1 the subjects using the cup were no longer focused on the object itself, but were possibly doing the trials on “autopilot.” If the person using the metal cup was more engaged in the initial trials, the subject may have set a higher standard of movement quality for themselves showing superiority to the LF condition. Then after the 24-hour delay, the subjects in the LF condition may have remembered the unique ambiguity of the object and as a result their level of object familiarity is heightened. Conversely, those in the HF group who performed well in the final trial of day-1 may have returned with the memory of the ordinary metal cup and hence interest in the occupation was lost. As previously cited in other studies with a 24-hour delay, the delay has been known to diminish the differences in movement kinematics between conditions.

Hypotheses 2-4 investigated differences in condition, trial, and trial by condition between the final trial of day-1 and the initial trial of day-2. Grouping these hypotheses together allowed the discussion of how the 24-hour delay may have influenced the movements. Hypotheses 5-7 will follow a similar order of inquiry for condition, trial, and then trial by condition, but will be comparing the initial trial of day-1 to the initial trial of day-2. In the next 3 hypotheses, the researchers observed the hypothetical cause of any changes in movement based on the influence of multiple trials as well as the 24-hour delay.

Hypothesis 5 stated that there would be a significant difference in performance between subjects in the main effects of condition when comparing the initial trial of day-1 to the initial
trial of day-2. Differences were found when transporting the object in that subjects in the HF condition reached that peak velocity significantly earlier (Figure 9) in the movement than those moving the clay mass. Georgeopoulos (1986) discussed the complexity of aimed movements with respect to acceleration and deceleration profiles. Specifically, humans and monkeys have adopted an optimal reaching pattern where acceleration is constantly changing and velocity is never constant with peak amplitude reached at approximately midway through the reach. He further specifies that with practice, the acceleration slope may be steeper and peak amplitude will be reached earlier in the reach. According to the Georgeopoulos paper, an earlier peak velocity shows enhanced skill from the multiple trials of practice, and perhaps an earlier peak velocity may be the result of the influence of the two object familiarity conditions. One caveat stated in the 1986 paper is that research had not yet been done in a 3-D environment and these assumptions may not hold for movements measured in 3-dimensions.

Hypothesis 6 states that there would be a difference in movement from the initial trial of day-1 to the initial trial of day-2. Support for this hypothesis came from several movement variables showing a general trend that on these trials, subjects reached peak velocity earlier in the movement (Figure 7), transported the object significantly faster (Figure 8 & Figure 9), in a shorter amount of time (Figure 10), and movement was relatively more efficient in terms of displacement (Figure 11). Schmidt and Lee (1999) have determined that a similar trend occurs in multiple trials of practice called the learning curve. They have not, however, determined how a 24-hour delay influences the characteristics of movement. The widespread support for time eliciting a difference in these movement variables may have been due to the events that occurred between the trials being compared, more specifically the multiple trials with a 24-hour delay.
Whatever changed in terms of meaning or motor planning, it is apparent that time influenced how subjects performed in the repeated trials of the occupation.

Hypothesis 7 investigated the interaction of the main effect of condition and time in the initial trial of day-1 to the initial trial of day-2. Significance was achieved in the reach portion of these trials in terms of movement units and displacement. As previously mentioned, movement units and displacement are descriptors of movement efficiency, and both kinematic variables followed similar trends that subjects in the LF condition moved with less efficiency and those in the HF condition performed more efficiently. These trends for movement units and displacement are clearly illustrated in Figure 12 and Figure 13 respectively. These results are somewhat unclear because the subjects using the mass of clay which was the LF condition initially displayed better performance on day-1 in the condition in which they were expected to perform less efficiently.

One manner of explaining this trend is that the individual’s level of meaning may have shifted for each object. Duration of exposure to the object and frequency of its use may have changed the way in which the object was perceived. It appears in Figures 12 and 13 that initially subjects reaching for the metal cup did so with more movement units and displacement than those reaching for the clay mass, but over time subjects using the metal cup decreased amount of movement units and displacement hence showing improvement in efficiency. Perhaps prolonged exposure to the metal cup enhanced the subject’s perception of the object and hence effecting movement by increasing efficiency. Conversely, subjects reaching for the mass of clay initially moved with significantly fewer movement units and displacement when compared to subjects reaching for the metal cup, but over time moved with greater movement units and displacement showing decay in efficiency.
Limitations

Several limitations in other studies investigating occupational embeddedness could also be applied to this study. The metal cup was in the shape of a mug, but had characteristics of a beerstein which could have confused the subject as to what the object precisely was. Conversely, the mass of clay was intentionally designed to not represent any common object, but it is possible that it could have been personally perceived as something meaningful without the investigators being aware of this. Participants were not asked their opinion of what they thought of the object. A qualitative data set could have been collected at the end of the experiment to assess how the subject perceived the object.

Next, there were several elements in the research environment that could have distracted the subject from the object and/or occupation. Before the subject could begin the trials each day, they had to be connected to an EMG apparatus and had seven reflective balls attached to the skin of the right arm and hand. When doing this occupation, the EMG leads and reflective markers may have been visual and tactile distractions from the subject’s interaction with the object itself.

The subjects of this study were healthy adults between the ages of 18 to 65. Some studies used a population that was medically impaired and found that this population may have been more sensitive to occupationally embedded situations (Trombly & Wu, 1999; Mathiowetz & Wade, 1995). The reasoning behind using persons with movement disorders usually have less efficient movement and therefore have a larger margin of efficiency to improve. Healthy adults move relatively more efficiently than those with movement disorders and therefore would not have as large of a margin for improvement. It is possible that a population with movement disorders in this experiment may have yielded a larger margin for improvement than that of this healthy population. However, one must take into account that the nature of a special population
is that it has more variability than a “normal” population. This variability will yield a higher degree of heterogeneity, and would therefore increase the amount of outliers in the data.

Finally, the nature of this experiment was to observe the potential effect of object relevancy on the efficiency of movement. One way to strengthen the occupational embeddedness would be to make the environment contextually relevant. The mass of clay was intended to have a lower familiarity to the general public, and a contextually appropriate environment may have been the lab environment with its lab equipment, machines, and wires. However, the subjects using the metal cup could have been placed in a simulated kitchen with some shelves to resemble placing the cup in the cupboard or on a rack. For this experiment, the more contextually matched environment may have been achieved in the LF group with the mass of clay. For future studies comparing the effects of object familiarity on movement kinematics, altering the environmental context to reinforce the intended object familiarity of each condition may aid in finding significance in multiple movement variables and more consistent results may be found.

Clinical Implications

This study provides information and insight as to how a person may perform when integrated into an intended occupationally embedded situation. Occupational therapists intend to provide environments for patients that will elicit some interest and meaning in an effort to enhance exerted effort, skill, and ultimately a more speedy recovery. In therapy, repetition for practice, skill acquisition, and strengthening is often used as a reinforcement tool so that the patient can apply the skill in a reliable and safe manner. Based on the findings of this study, if repetition is not integrated with an element of interest, the patient may not fully benefit from the therapeutic experience.
Furthermore, therapy is often conducted on multiple days during the week. This study shows that there were significant differences between the initial trials of day-1 versus day-2 when compared to the last trial of day-1 versus day-2. According to these results, some therapeutic benefit may be lost over time. It may therefore be beneficial for the therapist to alter the occupation from day to day and after multiple trials of practice if he or she intends to work on the same skill. This would benefit both the clinician and patient because goals may be achieved sooner and patients may go home earlier. Lastly and possibly most important, if the field of Occupational Therapy embraces the idea of client-centered practice as a core philosophy, then according to the results of this study the therapist is obligated to alter the therapeutic occupation from day to day in order to maximize the quality of movement and engagement of the patient.

The results of this study show that occupation and aspects of that occupation can change how a person moves and potentially how the person perceives the occupation itself over time. Much research has been done to observe the performance and skill improvement over multiple trials, but continuing to investigate the effects of context on occupational performance will have significant implications for the delivery of occupational therapy services in the most effective manner for the client. This line of research should continue in the quantitative investigation of a 24-hour delay on occupational performance while including an element of qualitative investigation as to how the person subjectively perceives the occupation and the intended level of object or contextual relevancy. A correlation between effect sizes and degree of affinity towards the object could strengthen the practical findings of this line of research.
Conclusion

The results of this study imply that over time there may be a change in how a person perceives an object by evidence of a change in his or her movement dynamics. The method of designing an environment and object that conveys the impression of occupational embeddedness or non-occupational embeddedness has yet to be perfected and more research must be done. Furthermore, implying that a change in movement dynamics is a direct result from how a person perceives an object or situation underestimates the complexity of the human mind. Additional information about how a person perceives his or her environment is needed to more reliably draw conclusions about how that environment impacts performance.

This study has investigated the effect of a 24-hour delay on performance dynamics, which is proposed to be an exemplification of perceived meaning. Although the results of this study do not succinctly explore all the elements of meaning, it does contribute to a growing body of knowledge about how persons interact with their environment. Knowledge of this interaction is vital to the field of occupational therapy because it not only focuses on how the clinician can most effectively be a therapeutic part of the person’s environment, but it ultimately contributes knowledge about how to help a person achieve a satisfying level of success in the combined occupations that make up one’s life.
Acknowledgements

Special thanks must be given to my research cohorts who helped with recruiting subjects, running trials, and spending countless hours in the lab finalizing data. Dr. Rice, thank you for your benevolence in this project and my scholarly development. Thank you Dr. and Mrs. James E. Getz for donating the metal cup to the experiment and Paint n’ Plates for firing our clay objects for free. I would also like to recognize the Medical College of Ohio Graduate School for the research grant I received.
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Table 1. Reach phase (I) and Transfer Phase (II) means and standard deviations of movement time, displacement, peak velocity, average velocity, percentage of movement time to peak velocity, and movement units for the initial trial of day-2.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Movement Time (s)</th>
<th>Displacement (mm)</th>
<th>Peak Velocity (mm/s)</th>
<th>Average Velocity (mm/s)</th>
<th>% Movement Time to Peak Velocity</th>
<th>Movement Units</th>
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<td></td>
<td>Mean</td>
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<td>304.58</td>
<td>47.19</td>
<td>1.46</td>
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<td>St. Dev</td>
<td>0.2162</td>
<td>154.27</td>
<td>541.09</td>
<td>231.79</td>
<td>20.39</td>
<td>0.721</td>
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<tr>
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<td>St. Dev</td>
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<td>119.85</td>
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<td>St. Dev</td>
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<td>639.40</td>
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<td>115.69</td>
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<td>1.50</td>
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n=48
Figure 3. Apparatus
Figure 1. Metal cup
Figure 2. Clay mass
Figure 4. Peak velocity of the transport phase for the final trial of day-1 vs. initial trial of day-2
Figure 5. Displacement of the transport phase for the final trial of day-1 vs. initial trial of day-2
Figure 6. Movement units of the reach phase for the final trial of day-1 vs. initial trial of day-2
Figure 7. Percent movement time to peak velocity for the transport phase of the initial trial of day-1 vs. the initial trial of day-2
Figure 8. Peak velocity for the transport phase of the initial trial of day-1 vs. the initial trial of day-2
Figure 9. Average absolute velocity for the transport phase of the initial trial of day-1 vs. initial trial of day-2
Figure 10. Movement time for the transport phase of the initial trial of day-1 vs. the initial trial of day-2
Figure 11. Displacement for the transport phase of the initial trial of day-1 vs. the initial trial of day-2
Figure 12. Movement units for the reach phase of the initial trial of day-1 vs. the initial trial of day-2
Figure 13. Displacement for the reach phase of the initial trial of day-1 vs. the initial trial of day-2