Perceived Risk: Effects on Reaching and Placing Performance in Persons With Cerebrovascular Accident

Holly M. Fuller, Julie Jepsen Thomas, Martin S. Rice

OBJECTIVE. Developing useful movement with the affected extremity in persons with cerebrovascular accidents (CVAs) is a common occupational therapy goal. The purpose of this study was to examine the effects of perceived risk in an occupational form on upper-extremity movement dynamics in persons who have had CVAs.

METHOD. Twenty-eight persons (M = 69.6 years, SD = 15.6 years) with post-CVA participated in the randomly assigned, repeated measures counterbalanced study. In the higher risk condition, participants reached for and grasped a raw egg in an egg carton, transported it, and placed it in a bowl with other raw eggs. The same procedure was completed in the lower risk condition with weight-matched plastic eggs. Participants completed both conditions with their affected and unaffected upper extremities. Dependent variables included total movement time and movement units.

RESULTS. The higher risk condition produced statistically significantly longer movement times (p ≤ 0.001), but no difference in movement units (p > .05) compared to the lower risk condition. The affected extremity had significantly longer overall movement times (p ≤ .001), but no difference in movement units (p > .05) compared to the unaffected extremity.

CONCLUSION. When higher levels of perceived risk are present in an occupational form, slower movements are elicited among persons who have had a CVA. The occupational therapist can grade tasks from relatively lower risk to tasks with relatively higher risk to help patients achieve desired variability in their movement patterns. By doing this, the patient will be better prepared for everyday situations that vary widely in degree of risk.


M}oving and placing objects during daily tasks is an important component for successful and independent occupational performance. For many persons who have sustained a cerebrovascular accident (CVA), skillful manipulation of everyday objects presents a challenge. A number of variables contribute to the smooth and harmonious use of one’s hands, including the motor and sensory systems as well as cognitive processes. Because each of these is intimately controlled by the central nervous system, it is important to investigate symptoms and processes in clients with compromised neurological systems, such as those who have had a CVA.

The process of perception forms much of the basis for the meaning that we find in our everyday surroundings. Once we find meaning or make sense of a situation, we create purposes and decide on courses of action that result in patterns of thoughts or behaviors. Meaning is formed through our perceptions and is influenced by our past experiences. Perceptions are multisourced and multidimensional. For example, we perceive the relative distances among objects. We also can perceive the degree of risk of breaking objects, taking into consideration their relative fragility. Meaning requires interpretation and making sense out of a situation (Nelson & Thomas, 2003). Meaning fuels performance; in the case of this study, moving eggs. Occupational therapy researchers have examined the effect that differing degrees of meaning have on occupational performance (Beauregard, Thomas, & Nelson, 1998; Kircher, 1984; Rice, Alaimo, & Cook, 1999; Ross & Nelson, 2000; Trombly & Wu, 1999; Wu, Trombly, & Lin, 1994). Whereas these studies focused on comparing the effects that occupational embeddedness versus
rote exercise have on performance, this study investigated an emerging variable in the form of perceived risk and its effects on occupational performance in persons who sustained a CVA (Rice & Thomas, 2000; Thomas & Rice, 2002).

Several studies have shown that a way to determine the effect of an occupational form on performance when reaching is to measure movement dynamics (Beauregard et al., 1998; Ric et al., 1999; Rice & Thomas, 2000; Ross & Nelson, 2000; Thomas & Rice, 2002; Trombly & Wu, 1999; Wu et al., 1994). Movement dynamics include, but are not limited to, movement time (speed), movement units (smoothness), peak velocity, and percentage of movement time to peak velocity. Because occupational therapy focuses on goals to improve or regain movement, it is important to know the type of movement dynamics that contribute to the best possible reaching movements. A simple reach can be defined as a reach for a target (i.e., a cup). An efficient simple reach is represented by a relatively small number of movement units, a relatively short amount of movement time (Beauregard et al., 1998; Wu et al., 1994), and a relatively low peak velocity (Wu et al., 1994), and with peak velocity occurring within the first 50% of movement time in a reach (Jeannerod, 1984; Marteniuk, MacKenzie, Jeannerod, Athenes, & Dugas, 1987). Several occupational therapy studies have been conducted that involve a simple reach (i.e., reach for a target) and the measurement of its associated movement dynamics. Ross and Nelson (2000) and Wu et al. (1994) investigated typical college-age students and found that the materials-based condition (e.g., reaching for a pencil) produced a more efficient movement than in the rote or imagery conditions. In studies of persons with disabilities, Beauregard et al. (1998) showed that children with cerebral palsy and Trombly and Wu (1999) showed that persons post-stroke also had more efficient simple reaching patterns during materials-based conditions (e.g., reaching for a doll, reaching for food) than during the rote and imagery conditions.

In a non–occupational therapy study of a simple reach, Marteniuk et al. (1987) had participants grasp and lift a lightbulb (fragile condition) or a tennis ball (resilient condition). They found that movement time was longer for the lightbulb condition than the tennis ball condition. Participants appeared to perceive more risk in grasping the lightbulb than the tennis ball; thus, more care had to be taken when planning the movement to pick up the lightbulb than the tennis ball.

The previously mentioned studies measured movement dynamics associated with a simple reach (reach for a target). Occupational therapists also need research on more complex upper-extremity movements (i.e., manipulating eggs for cooking). A relatively more complex upper-extremity movement, as defined and investigated in this study, consists of reaching toward, grasping, transporting, and placing an object. Studies have measured movement dynamics associated with more complex upper-extremity movements (Rice et al., 1999; Rice & Thomas, 2000; Thomas & Rice, 2002) and have found that the different levels of occupational embeddedness, or meaning, in complex upper-extremity tasks affect one’s motor response by influencing the range and smoothness of motion. For example, Rice et al. (1999) compared participants reaching for a labeled soup can, an unlabeled soup can, and a piece of clay, transporting them, and placing them in a cupboard. They found no significant differences in movement time among the three conditions, but they did find significantly more angular displacement when moving the clay than when moving the unlabeled soup can and significantly more movement units when moving the clay versus the labeled soup can.

The previous research lends support to the belief that different occupational forms elicit different occupational performances. The different occupational performances are due, in part, to the type of meaning and purpose that people attach to the occupational form. Prior research in the field of occupational therapy has concluded that varying the occupational form by adding meaning and purpose through the use of games, imagery, and the opportunity to complete a project affects occupational performance (Beauregard et al., 1998; Riccio, Nelson, & Bush, 1990; Ross & Nelson, 2000; Sietsema, Nelson, Mulder, Mervau-Scheidel, & White, 1993; Trombly & Wu, 1999; Wu et al., 1994).

Another way to change the occupational form is to vary the degree of risk associated with the form. In a study done by Rice and Thomas (2000), young adults performed a relatively complex reach involving pouring hot water and cold water from a pitcher into a cup to make a beverage. The two conditions had different degrees of risk with the hot-water pouring being a higher risk occupation than the cold-water pouring. Displacement, movement time, and movement units were significantly greater in the hot condition than the cold condition from the beginning to the end of the movement. In an extension of the Rice and Thomas (2000) study, well-elderly participants completed the hot-water and cold-water pouring tasks (Thomas & Rice, 2002). The results for well-elderly persons were similar to those for younger persons in that performance in the higher risk condition (pouring hot water) elicited longer total movement times, greater displacements, smaller percentages of movement time to peak velocity, and more movement units than the lower risk, cold-water pouring condition. Both age groups appeared to perceive the hot-water condition as having a higher level of risk, thus requiring more careful, slower, and frequently adjusted movements to avoid potentially...
burning themselves (perceived as a higher risk). Thus, the quality of movement in the hot-water condition reflected a more cautious and guarded movement than the quality of movement that occurred in the cold-water condition.

This study is an extension of the Rice and Thomas (2000) and Thomas and Rice (2002) studies on the effects of perceived risk on occupational performance of relatively complex upper-extremity movements involving reaching, transporting, and placing a common object. The current study investigates how perceived risk affects movement dynamics for persons who have had a CVA. Different tasks (unilateral grasping, transporting, and placing tasks using raw and plastic eggs) are used as higher and lower risk conditions in order to generalize results from previous research on water pouring, which required bilateral grasping of a pitcher and cup, pouring, and replacing pitcher and cup with water. The movement dynamics of total movement time, as well as movement units, are used to compare the higher and lower risk conditions. The purpose of this study is to investigate the effects of different levels of perceived risk (handling real fragile eggs compared to handling plastic eggs) on upper-extremity movement in persons who have sustained a CVA. The primary hypothesis is that the higher risk condition will elicit different movement dynamics for persons with a CVA than the lower risk condition. The secondary hypothesis is that the affected extremity will generate different movement dynamics than the unaffected extremity.

Methods

Participants

The Institutional Review Board approved the study and participants gave informed consent before data collection. Over a 6-month period, 28 participants who had recovered from unilateral CVA were recruited by verbal invitation from inpatient and outpatient therapy clinics and nursing homes in the midwestern United States. Although the sample varied widely in ability level, we asked the referring therapist or nurse to judge and assure that the participants had (a) the cognitive ability to both understand and follow data collection procedures and (b) the physical ability to reach forward one arm’s length, grasp an object the size of a chicken egg, and horizontally adduct both the affected and unaffected shoulders.

Design

A repeated measures, counterbalanced design was used where participants acted as their own controls and experienced both conditions (higher and lower risk) using both the right and left upper extremities. The participants were randomly assigned to one of two orders (unaffected extremity–affected extremity, or affected extremity–unaffected extremity). The participants were also randomly assigned to one of two conditions (higher risk–lower risk, or lower risk–higher risk). A $2 \times 2$ (risk $\times$ arm) analysis of variance (ANOVA) with repeated measures on both factors was used to analyze the data for movement time and movement units. The alpha level was set at .05. Effect sizes ($f$) were calculated for the main effects and interactions for each ANOVA (Cohen, 1988). Cohen defined criteria for labeling effect sizes ($f$) as small (.1), medium (.25), and large (.4).

Instruments and Apparatus

We administered the modified Ashworth scale of muscle spasticity (Bohannon & Smith, 1987), Rankin’s level of disability scale (Rankin, 1957), and a line bisection test (Lin, Cermak, Kinsbourne, & Trombly, 1996) for the purpose of gathering descriptive characteristics of the participants. The modified Ashworth scale of muscle spasticity uses an ordinal scale to describe degree of muscle spasticity. This scale has face validity because it gives a grade that reflects the resistance of a passively stretched muscle (spasticity). Bohannon and Smith (1987) report that the scale has good interrater reliability (.847, $p < .001$). The Rankin’s level of disability scale was used to describe the participants’ abilities to carry out their daily tasks. Level one specifies that the person is “able to carry out all usual duties” and level four specifies that the individual is “unable to walk without assistance and unable to attend to own bodily needs without assistance” (Rankin, 1957, p. 210). There are no reliability or validity data for this scale. In the line bisection test (Lin et al., 1996), the participant is asked to place a pencil mark indicating the center of a 100 mm line. The purpose of the line bisection test is to describe the level of unilateral neglect.

The portable experimental apparatus is illustrated in Figure 1. It consisted of a board (24 in. by 35.75 in.) on which an infrared photoelectric eye (Safe House, Model #49-307, Fort Worth, Texas 76102), a reflector, a commercially purchased egg carton, and clear glass bowl were mounted. A force-sensing resistor (Interlink Electronics, 546 Flynn Road, Camarilla, California 93012) was attached to the base of one section of the egg carton to mark the time when the egg was lifted from the egg carton. The photoelectric eye marked the time when the egg was placed in the bowl.

White, jumbo-size raw eggs were used in the higher risk condition because their relative fragility and the potential for breakage when placed on one another adds an element of risk when moving them. This perception of risk is
assumed to be a substantial component in the interpretive process as one develops meaning and purpose for this task.

Yellow-colored, plastic eggs of matched weight and size to the raw eggs were used in the lower risk condition because of their relative sturdiness and low risk of breakage when placed on top of one another. One egg rested on the force-sensing resistor in the egg carton, and eight additional eggs were arranged in two layers in the glass bowl. A marked starting position for the participant's hand was used for each condition. Two electrogoniometers (one for each elbow) (Penny and Giles Biometrics Ltd., Unit 25, Nine Mile Point Industrial Estate, Cwmfelinfach Gwent NP1 7HZ, United Kingdom) provided angular data during the conditions. The manufacturer reported repeatability to be better than ± 1° and accuracy of ± 2° measured over a range of 90°. The goniometers, photoelectric eye, and force-sensing resistor were interfaced with a 16-bit analogue to digital board (Keithly Instruments, Inc., 28775 Aurora Road, Cleveland, Ohio 44139) that was based in a 166 MHz computer. All data were sampled at 60 Hz. The Testpoint data acquisition software, version 3.4 (Capital Equipment Corp., 900 Middlesex Turnpike, Building 2, Billerica, Massachusetts 01821), was used to collect the data.

Procedure

The researcher collected demographic data including gender, age, date of CVA, hemiplegic side, and hand dominance (pre-CVA and post-CVA). Next, the researcher administered Rankin's level of disability scale (1957), the line bisection test (Lin et al., 1996), and the modified Ashworth scale (Bohannon & Smith, 1987). The electrogoniometers were attached across the lateral side of the participants' elbows and were zeroed. The participant sat as close as possible to a table with the egg carton in front of the participant and with his or her hand on the starting position (see Figure 2). The researcher explained and demonstrated the procedure for moving the egg from the egg carton to the glass bowl. The participants practiced the procedure before trials were recorded by moving the plastic egg and then the raw egg with the unaffected extremity and then the affected extremity. The researcher read the following instructions for the higher and lower risk conditions:

When I say begin, move the egg from the egg carton to the bowl of eggs and place it here (point to spot). When you are done, place your hand back on the starting position. Do you have any questions? Are you ready? Begin.

Participants completed three trials in each condition.

Data Reduction and Dependent Variables

Positional time series data were smoothed using a dual-pass fourth order Butterworth low-pass filter with a cutoff frequency of 7 Hz. Data smoothing is a technique that rids data of unwanted noise. Noise occurs from a number of sources (e.g., radio frequency from fluorescent lighting) and introduces artifacts into the data. Because human movement is relatively slow (less than 10 Hz) compared to radio frequency (60 Hz), we chose to use a low-pass smoothing technique that attenuated frequencies in the data higher than 7 Hz. The dependent variables included movement time (MT) and movement units (MU). MT data were analyzed from the point at which the egg was lifted from the sensor in the egg carton to the point at which the hand

![Figure 1. The force-sensing resistor located in the egg carton, with the bowl of eggs between the photoelectric eye (right) and reflector (left).](image1)

![Figure 2. Participant wearing the electrogoniometer, grasping egg in egg carton in order to transport it to the bowl.](image2)
placing the egg in the bowl broke the infrared beam of the electric eye. Although participants were positioned in a way that minimized the use of trunk movements when moving the egg, some participants relied on both trunk and elbow movements to complete the task. Because MU were reduced from the elbow goniometer positional time series, we calculated the portion of MT that incorporated elbow movement. Elbow MT started at the time the elbow began to move and ended when the elbow stopped moving. The elbow start and stop times were visually identified on the positional time series by two of the investigators. Interrater reliability was high, with $r$-values ranging from .989 to .999. Movement units were calculated by custom software with algorithms that counted the number of times the acceleration profile crossed the zero line from negative to positive and back to negative within the elbow MT. The data from the three trials in each condition were averaged into a single score for each dependent variable within each arm (affected, nonaffected) within each condition (higher risk, lower risk).

**Results**

Participants included 12 men and 16 women ($M = 69.6$ years, $SD = 15.6$). Descriptive characteristics—including sex, age, status post-CVA time, and affected side, along with the results of the line bisection test, modified Ashworth scale of muscle spasticity, and Rankin’s level of disability scale—are presented in Table 1. Participants varied in their degree of unilateral neglect. The mean deviation for the unaffected extremity was 4.88% with a range of 16.20% deviation from the left of center to 11.70% deviation from the right of center. The mean deviation for the affected extremity was 6.61% with a range of 12% deviation from the left of center to 33.57% deviation from the right of center. In Table 1, a deviation that is positive indicates deviation to the right, whereas a negative deviation indicates deviation to the left.

The muscle spasticity grades ranged from zero to plus one (see Table 1). Thirteen participants had a muscle grade of zero, 10 participants had a grade of one, and 5 participants had a grade of plus one. These grades indicate that the participants’ muscle tone varied from “no increase in muscle tone” when tested to a “slight increase in muscle tone, manifested by a catch, followed by minimal resistance throughout the remainder (less than half) of the ROM” (Bohannon & Smith, 1987, p. 207).

The scores for Rankin’s (1957) level of disability scale ranged from one to four (see Table 1). The majority of participants were ranked at level four. Level four is the first level

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Sex</th>
<th>Age</th>
<th>Status, Post CVA</th>
<th>Affected Side</th>
<th>Unaffected Extremities</th>
<th>Affected Extremities</th>
<th>Ashworth Scale of Muscle Spasticity</th>
<th>Rankin’s Level of Disability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>88</td>
<td>12 yr 3 mo.</td>
<td>R</td>
<td>8.30</td>
<td>8.83</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>F</td>
<td>69</td>
<td>2 mo.</td>
<td>L</td>
<td>10.97</td>
<td>12.77</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>53</td>
<td>1 mo.</td>
<td>R</td>
<td>0.10</td>
<td>4.70</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>M</td>
<td>74</td>
<td>40 yr</td>
<td>R</td>
<td>–0.83</td>
<td>0.47</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>75</td>
<td>10 mo.</td>
<td>R</td>
<td>–1.50</td>
<td>–1.83</td>
<td>1+</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>81</td>
<td>33 yr 1 mo.</td>
<td>L</td>
<td>7.00</td>
<td>3.57</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>F</td>
<td>73</td>
<td>23 yr</td>
<td>R</td>
<td>–4.43</td>
<td>0.43</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>87</td>
<td>24 yr</td>
<td>L</td>
<td>–1.13</td>
<td>3.80</td>
<td>1+</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>83</td>
<td>2 yr</td>
<td>L</td>
<td>1.53</td>
<td>1.37</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>86</td>
<td>1 yr 5 mo.</td>
<td>R</td>
<td>4.50</td>
<td>1.07</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>M</td>
<td>74</td>
<td>2 yr</td>
<td>R</td>
<td>6.53</td>
<td>1.77</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>72</td>
<td>1 yr 2 mo.</td>
<td>L</td>
<td>1.03</td>
<td>9.40</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>F</td>
<td>47</td>
<td>22 yr 10 mo.</td>
<td>L</td>
<td>0.83</td>
<td>12.13</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>14</td>
<td>F</td>
<td>43</td>
<td>2 yr</td>
<td>L</td>
<td>–0.27</td>
<td>3.83</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>F</td>
<td>64</td>
<td>3 mo.</td>
<td>L</td>
<td>–7.57</td>
<td>4.90</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>M</td>
<td>75</td>
<td>3 mo.</td>
<td>L</td>
<td>–2.80</td>
<td>3.13</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>17</td>
<td>M</td>
<td>22</td>
<td>1 mo.</td>
<td>L</td>
<td>6.63</td>
<td>9.60</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>M</td>
<td>73</td>
<td>3 mo.</td>
<td>L</td>
<td>2.70</td>
<td>2.13</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>19</td>
<td>F</td>
<td>59</td>
<td>4 mo.</td>
<td>L</td>
<td>3.83</td>
<td>6.53</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>F</td>
<td>84</td>
<td>&lt;1 mo.</td>
<td>L</td>
<td>–3.63</td>
<td>33.57</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>21</td>
<td>F</td>
<td>55</td>
<td>&lt;1 mo.</td>
<td>L</td>
<td>10.50</td>
<td>–2.13</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>22</td>
<td>M</td>
<td>83</td>
<td>&lt;1 mo.</td>
<td>L</td>
<td>–16.20</td>
<td>–12.00</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>23</td>
<td>F</td>
<td>64</td>
<td>&lt;1 mo.</td>
<td>L</td>
<td>0.27</td>
<td>4.50</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>24</td>
<td>M</td>
<td>87</td>
<td>1 mo.</td>
<td>L</td>
<td>7.00</td>
<td>12.17</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>25</td>
<td>M</td>
<td>74</td>
<td>3 mo.</td>
<td>L</td>
<td>3.43</td>
<td>–4.77</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>26</td>
<td>F</td>
<td>75</td>
<td>5 yr</td>
<td>L</td>
<td>11.70</td>
<td>–10.90</td>
<td>1+</td>
<td>4</td>
</tr>
<tr>
<td>27</td>
<td>F</td>
<td>60</td>
<td>11 mo.</td>
<td>R</td>
<td>2.10</td>
<td>2.20</td>
<td>1+</td>
<td>4</td>
</tr>
<tr>
<td>28</td>
<td>F</td>
<td>86</td>
<td>2 mo.</td>
<td>R</td>
<td>–9.27</td>
<td>–10.63</td>
<td>1+</td>
<td>4</td>
</tr>
</tbody>
</table>

* A record of the month in which the CVA occurred was not available for all participants.
that includes the criteria of being unable to walk without assistance and not being able to take care of bodily needs without assistance. This is a broad category and some participants were ranked as a level four due to their use of a cane or walker as an assist with ambulation, even though they were able to take care of their own bodily needs.

Because elbow MT was a subset of total MT, we anticipated that these two variables could be correlated, and the Pearson correlation coefficient resulted in an \( r \) of .65. Because these two variables were not independent, we did not include the elbow MT in further analyses. We performed multivariate analyses of variance (MANOVA) on gender and order across MT and MU. There were no significant differences on the factors of gender and order for MT or MU (\( p > .05 \)). Additionally, the D’Agostino-Pearson omnibus normality test indicated that the data followed a Gaussian distribution.

The results of the repeated measures ANOVA for MT revealed a significant difference for the main effect of Arm \( F(1, 28) = 5.07, p = .032 \), with a medium effect size \( (f = .21) \). The mean MT for the affected arm was greater than the mean MT for the unaffected limb (see Table 2 for the descriptive statistics). There was a significant difference for the main effect of Risk \( F(1, 28) = 8.77, p < .006 \), with a large effect size \( (f = 5.05) \). The MT for the higher risk condition was greater than the MT for the lower risk condition (see Table 2). There was no significant Risk by Arm interaction \( F(1, 28) = 3.25, p = .082 \), with a large effect size \( (f = .95) \). The change in the mean MT from the higher risk condition to the lower risk condition for the affected limb was not significantly different for the same comparison with the unaffected limb (see Figure 3 for the interaction plot).

The results of the repeated measures ANOVA for MU revealed no significant difference for the main effect of Arm \( F(1, 28) = .88, p = .355 \), with a small effect size \( f = .10 \). There was no significant difference for the main effect of Risk \( F(1, 28) = .88, p = .357 \) with a small effect size of \( f = .03 \). There was no significant Risk by Arm interaction \( F(1, 28) = .39, p = .536 \) with a large effect size \( (f = .71) \). Refer to the interaction plot for MU in Figure 4.

### Table 2. Movement Time and Movement Units for High Risk and Low Risk Conditions for the Affected and Unaffected Arm

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Condition</th>
<th>Minimum values</th>
<th>Maximum values</th>
<th>Median</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement Time (in seconds)</td>
<td>High Risk</td>
<td>0.54</td>
<td>3.51</td>
<td>1.23</td>
<td>2.69</td>
<td>2.08</td>
</tr>
<tr>
<td></td>
<td>Unaffected</td>
<td>0.51</td>
<td>7.77</td>
<td>1.34</td>
<td>2.52</td>
<td>2.15</td>
</tr>
<tr>
<td></td>
<td>Affected</td>
<td>0.54</td>
<td>3.51</td>
<td>1.23</td>
<td>1.57</td>
<td>0.81</td>
</tr>
<tr>
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<td>Low Risk</td>
<td>0.63</td>
<td>6.61</td>
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<td>1.37</td>
</tr>
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<td>18.00</td>
<td>4.33</td>
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<td>4.05</td>
</tr>
<tr>
<td></td>
<td>Affected</td>
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<td>18.00</td>
<td>5.33</td>
<td>6.33</td>
<td>4.22</td>
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<tr>
<td>Movement Units</td>
<td>High Risk</td>
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<td>22.67</td>
<td>4.00</td>
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<td>4.24</td>
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<td>15.33</td>
<td>4.33</td>
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<td>3.89</td>
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</table>

### Figure 3. Mean movement times (in seconds) and standard deviation for the unaffected and affected arms across the lower risk and higher risk conditions.

### Figure 4. Mean movement units and standard deviation for the unaffected and affected arms across the lower risk and higher risk conditions.

### Discussion

Overall, the results of this study suggest that varying the level of perceived risk does affect the reaching performance of persons who have had a CVA in terms of the amount of time to complete the task, but not in the number of adjustments made or smoothness of the movements. The first hypothesis was that the higher risk condition would elicit different movement dynamics than the lower risk condition and was supported by the MT results. The total MT was significantly greater in the higher risk condition than the lower risk condition. Because there was not a significant interaction between risk and arm used, it appears that perception of risk, as processed by the central nervous system, influences both the affected and nonaffected extremities in
similar ways. Regardless of which arms participants were using, they perceived moving the raw eggs to be riskier than moving the plastic eggs. They took longer to move the raw eggs while transporting and placing them in the bowl than when they were moving the plastic eggs. This perception was reflected in participants adjusting their movement strategies in terms of MT in a similar manner for both arms. This strategy helped them accommodate to the increased perception of risk and it reflected a more cautious approach during the higher risk condition compared to the lower risk condition. The findings for MT are consistent with the previous research done by Rice and Thomas (2000) and Thomas and Rice (2002). In these previous studies, younger and older adults without disabilities also took a longer time to accomplish their pouring tasks during the higher risk conditions than during the lower risk conditions. In addition, Marteniuk et al. (1987) found similar results with longer MT when participants reached for a lightbulb than when they reached for a tennis ball. Based on these previous studies and the results of this study, level of perceived risk appears to influence movement strategies.

The results did not support the hypothesis for the smoothness of movement variable (MU). There were no differences between higher and lower risk conditions for the number of MU that participants used to move the eggs, regardless of which arm they were using. This finding for MU differed from previous studies (Rice & Thomas, 2000; Thomas & Rice, 2002), which have found that the higher risk condition (pouring hot water) results in more adjustments and, hence, more MU than the lower risk condition (pouring cold water). These previous studies, like the current study, examined a more complex upper-extremity movement (water pouring) involving reaching toward an object, and grasping, transporting, and placing it. However, the tasks in the previous and current studies did differ in important ways. In the previous studies, the pouring tasks were bimanual, requiring participants to grasp a pitcher with one hand, manipulate the pitcher into position, and pour water into a cup held with the other hand. The present study required unilateral action rather than bimanual action. It emphasized grasping, transporting and placing with one hand rather than manipulation and interaction of objects held in both hands. Each task required use of different muscle groups and required different movement strategies. One could also argue that pouring hot water could be perceived as “riskier” than manipulating eggs, which could result in the need for more adjustments (MU) when pouring hot water. These differences in the tasks and task demands could account for differences in MU results. The previous studies found that both healthy young adults and well-elderly persons exhibited overall longer MT and more MU in the higher risk condition when compared to the lower risk condition. It appears that groups of people who differ in age and neurological status used similar movement strategies of taking more time with both higher risk conditions but smoothness of movement may be more affected with increasing task complexity.

Another difference between the previous studies and the current study is that they focused on different populations (i.e., young adults, older adults, and persons with CVAs). Because similar MT results were found across two different tasks and among different populations, confidence is added to our belief that predictable patterns of movement or movement strategies will be used when confronted with tasks of high and low risk. Persons who encounter tasks that they perceive as being riskier will tend to move more slowly in order to express a higher level of caution and ensure successful task completion.

Significant differences were found between the higher risk and lower risk conditions for MT, and the effect sizes for MT were medium to quite large. However, it should be noted that the effect sizes for MU in both the risk and arm conditions were quite small. The differences in movement dynamics between the conditions may have been subtle relative to the magnitude of variability in the data. Although the referring therapists and nurses screened participants to control for basic ability to grasp and reach, there was still large variability in the movement dynamics. Previous studies have also reported large variability in movement dynamics with this population (Lough, Wing, Fraser, & Jenner, 1984; Rice & Newell, 2001; Trombly, 1993; van Vliet, Kerwin, Sheridan, & Fentem, 1995; van Vliet, Sheridan, Kerwin, & Fentem, 1995). In the current study, the large amount of variability of performance in the higher and lower risk conditions may have made it more difficult to show larger effect sizes for MU. Despite the variability that may have affected the effect sizes for MU, significant differences and larger effect sizes were found for MT between the higher and lower risk conditions. This may be due, in part, to the sensitivity of the electrogoniometers used to measure movement dynamics.

The second hypothesis was that the affected extremity would elicit different movement dynamics than the unaffected extremity, and this hypothesis was supported by the MT results but not the MU results. Total MT was greater for the affected extremity compared to the unaffected extremity. The significant differences for this dependent variable document the effects of CVAs on motor performance. An upper-motor neuron lesion resulting from a stroke is characterized by absent or weaker voluntary movements of the affected muscles along with some level of spasticity (Kiernan, 1998). Because motor control largely occurs...
through inhibition, the movements of a person after a stroke often have greater variability with decreased spatial and temporal accuracy. The majority of participants (15 of 28) had an increase in muscle tone when the affected upper extremity was moved from a flexed to an extended position. Even those whose affected extremity did not meet the criterion for increased muscle tone on the Ashworth scale probably had subtle neurological effects that were reflected in longer MT when using their affected extremity compared to their unaffected extremity. The medium effect size for MT in this comparison reflects the substantial effect that stroke has on sensitively measured movement dynamics.

The results of this study are beneficial to occupational therapists because they show that different levels of risk perceived in everyday tasks can affect how a person with a disability such as stroke moves. More cautious movements (longer MT) occur in a task with relatively higher risk when compared with the movements in a task with relatively lower risk (shorter total MT). These findings show that occupational forms with different types of perceptual meaning (relatively high and low risk) influence one's occupational performance. Therefore, if the occupational therapist is trying to help a patient achieve an efficient movement, she or he could initially manipulate the occupational form so that the patient perceives a relatively low amount of risk. As the patient progresses, the occupational therapist may grade the occupation by increasing the level of risk in the occupational form to give the patient opportunities to experience more challenging situations requiring progressively more careful movements. The knowledge that longer MT typically accompanies situations of increasing perceived risk could be used to encourage persons with poor motor control or impulsivity to slow the pace of movement when risk is increased. Given the variability of risk in the daily tasks one must accomplish, occupational therapists need to provide experience in tasks reflective of the potential range of risk to better prepare patients for the realities of life. Further research needs to be done using other tasks and settings before the results can be confidently generalized beyond the laboratory.

Although participant positioning and verbal directions encouraged participants to use only the upper extremity when moving the eggs, some participants relied on a combination of both trunk movements and elbow extension to place the egg in the bowl. However, whatever strategy was initially used, participants tended to use the same strategy on the subsequent trials. Therefore, although there were individual differences in the movements used to move the eggs, these differences were minimized by the repeated measures, counterbalanced design.

To date, research on perceived risk has been conducted with healthy young adults, older adults, and persons with stroke. Because many occupational therapists work with children, it would be helpful to see whether a study with children would yield similar results. Children may perceive risk differently than adults, and researchers should document the effects of children’s developmental maturity on how they tend to move. There are many possibilities for replication of the current study. Studying additional daily tasks that involve varying levels of perceived risk would assist in generalizing this phenomenon beyond the two tasks studied to date. For example, one could investigate how perceived risk varies with tool use. We have contrasted dichotomous conditions with two levels of risk, high and low, but have not documented whether there is a continuum of risk with accompanying modifications in movement strategies. Future research could investigate this possibility.

Conclusion

This study examined the effects of two levels of perceived risk in an occupational form on movement dynamics. We found that persons who had a diagnosis of stroke used more cautious movement patterns reflecting more movement time in the higher risk condition than in the lower risk condition. There was no difference in smoothness of movement between the two conditions. This knowledge is beneficial to occupational therapists because it shows that occupational forms with different levels of perceived risk elicit different types of movement in persons with a CVA. For a patient to achieve the desired type of movement, the occupational therapist can grade tasks from relatively lower risk to tasks with relatively higher risk, as patients need more challenges. By doing this, the patient will be better prepared for everyday situations that vary widely in degree of risk. ▲

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References


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