Effect of Instructions on Functional Reach in Persons With and Without Cerebrovascular Accident

Susan E. Fasoli, Catherine A. Trombly, Linda Tickle-Degnen, Mieke H. Verfaellie

KEY WORDS
• goal-directed action
• movement kinematics
• stroke

OBJECTIVE. Verbal instructions comprise an important element of clinical practice, however, their effectiveness in promoting movement organization in persons with cerebrovascular accident (CVA) has not been well investigated.

METHOD. A counterbalanced, repeated-measures design was used to examine the effects of externally focused (task-related) versus internally focused (movement-related) instructions on movement kinematics during three functional reaching tasks. Participants included 16 persons with stroke who were able to perform the tasks with their affected arm and 17 age-matched adults without neurological impairments.

RESULTS. Significantly shorter movement time and greater peak velocity were evident when reaching under the external-focus condition of all tasks than for the internal-focus condition.

CONCLUSION. One clinical implication is that internally focused instructions can contribute to slower and less forceful reach in adults with and without CVA. This research reinforces the need for therapists to consider their use of instruction during the evaluation and treatment of movement disorders.


Occupational therapists use many forms of verbal instruction to aid the recovery of motor control in persons after cerebrovascular accident (CVA). Instructions are used to direct a person's attention, influence sensory awareness, and establish goals for a particular motor action (Brooks, 1986; Carr & Shepherd, 1998). During therapy, instructions may be used in two ways to facilitate appropriate motor responses within the context of daily occupations. They can direct the performer's attention toward relevant information in the environment or focus one's attention internally toward the key elements of a particular movement pattern or sequence (Carr & Shepherd, 1987; Magill, 1998; Mathiowetz & Haugen, 1995).

Although verbal instructions comprise an important element of clinical practice, their effectiveness in promoting movement organization during therapeutic intervention has not been investigated. Research on the effects of instruction on motor action has primarily examined persons without neurological impairments during complex motor tasks. In these studies, instructions that directed one's attention toward the task characteristics or intended outcome appeared to enhance motor performance and learning (Singer, Lidor, & Cauraugh, 1993; Wulf, Höß, & Prinz, 1998; Wulf, Lauterbach, & Toole, 1999). Research with clinical populations is needed to determine whether these findings can be generalized to persons with neurological impairments or to the less complex motor tasks typically used to restore motor skills during therapy.

The purpose of this study was to examine the effect of verbal instructions on movement organization in persons with CVA and to compare their performance to that of age-matched, control participants without neurological impairments. Persons with stroke were chosen because they comprise the largest single popula-
tion of clients treated in occupational therapy (Trombly, 1995) and because they frequently receive therapy to improve motor performance. If the type of instruction is found to affect movement organization in persons with and without CVA, then rehabilitation therapists may need to consider more carefully their use of instructions during the evaluation and treatment of movement disorders.

Literature Review

Effect of Instructions on Movement in Adults Without Neurological Impairments

The effect of different types of instruction on motor performance and learning has been investigated in adults who are neurologically intact. This research examined the effects of externally focused versus internally focused instructions during novel, complex tasks, such as maneuvering a ski simulator apparatus (Wulf et al., 1998), hitting a golf ball (Wulf et al., 1999), and throwing a ball at a target (Singer et al., 1993).

The externally focused instructions directed participants to focus their attention on task-related variables, such as the force applied to the outer wheels of the ski simulator (Wulf et al., 1998), the movement of the golf club (Wulf et al., 1999), or the center of the target (Singer et al., 1993). These instructions appeared to emphasize the visual information available from the interaction with task objects. During the internal-focus conditions, instructions directed the performer’s attention to the movements necessary for task completion (e.g., “apply pressure on the outer foot”). Generally, the nature of internally focused instructions in these studies involved proprioceptive information about the amount of force exerted or the feeling of one’s movement.

Findings revealed significantly better motor performance and learning (exhibited by greater movement amplitude, higher accuracy, and less variability) in the external-focus condition of both acquisition and retention trials. If improved performance in the external-focus condition is replicated with clinical populations during acquisition trials, then this information may guide the way in which instructions are used during therapeutic practice.

Effect of Instructions on Movement After CVA

Research in the area of instructions and motor performance after CVA is extremely limited. Only one study by Spatt and Goldenberg (1997) examined the effect of instructions on motor performance in persons with CVA. In this experiment, participants with and without limb apraxia were asked to perform a novel task with their unaffected arm under two instruction conditions. In the first condition, externally focused instructions directed attention toward the task goal, which was to depress one, two, or three illuminated keys simultaneously with any fingers as quickly as possible. In the second condition, internally focused instructions required participants to depress the lit keys quickly with only the fingers indicated by a visual model of a hand, thereby drawing attention to specific motor responses. An analysis was performed on only the trials that had been performed identically in both conditions. During this experimental task, persons with and without CVA demonstrated significantly shorter reaction time and fewer movement errors under the external-focus condition. After ruling out alternative hypotheses related to variations in the cognitive and perceptual demands across conditions, the authors concluded that externally focused instructions, directed toward the task goal, positively influenced motor performance in the arm ipsilateral to the side of stroke lesion. To extend these findings to rehabilitation practice, researchers need to examine these effects on movement of the arm contralateral to the stroke lesion during familiar occupational tasks.

Research Hypothesis

The hypothesis in this study was that externally focused (task-related) and internally focused (movement-related) instructions would have significantly different effects on movement organization during reach. Specifically, reaching movements of adults with and without CVA would be characterized by significantly shorter movement time (faster), greater peak velocity (more forceful), fewer movement units (smoother), and a greater percentage of time to peak velocity (more preplanned) when externally focused instructions were provided than when internally focused instructions were given.

One research question also was proposed for which little empirical evidence exists: Do externally focused and internally focused instructions have a different effect on movement kinematics in persons with CVA when compared with persons without neurological impairments?

Method

Design

A counterbalanced repeated-measures design was used in this study to control for effects of sequence and order and for intersubject variability (see Rosenthal & Rosnow, 1991). Participants were randomly assigned to one of two sequences (AB or BA) in which either the externally focused or internally focused instructions were provided first. Three tasks were randomly presented: removing a can from a shelf, putting an apple into a basket, and moving a coffee mug
onto a saucer. Each participant performed all three tasks under his or her assigned sequence. Tasks were presented to a participant in the same order under both instruction conditions.

**Participants**

Based on a power analysis of pilot study results, we made a conservative decision to include 16 participants with CVA and 16 participants without neurological impairments in this study. In total, 19 persons with CVA were recruited from local stroke support groups and agreed to participate in the research study. Inclusion criteria included sufficient motor ability to reach forward and grasp task objects with the hemiparetic arm and no evidence of comprehension impairments or apraxia. These latter criteria ensured that any differences in reach among the instruction conditions would not be confounded by the participants’ inability to understand verbal instructions or by motor planning impairments. To determine that all participants with CVA met inclusion criteria, the shortened version of the Token Test for auditory comprehension (DeRenzi & Faglioni, 1978) and the Florida Apraxia Screening Test (Revised) (Rothi, Raymer, & Heilman, 1997) were administered before other experimental procedures. Although the reliability of these measures has not been reported, these tests commonly are used in the clinic to assess whether clients with stroke are able to understand and follow verbal instructions or have movement difficulties related to apraxia. Three persons with CVA demonstrated minimal to moderate auditory comprehension disturbances and were excluded from further participation in this study. One of these individuals also scored within the impaired range on the Florida Apraxia Screening Test.

Sixteen persons with stroke (10 men, 6 women) 32 to 79 years of age ($M = 61.12$ years) completed this study. The control group participants ($M = 61.19$ years) and 17 participants without neurological impairments ($4$ men, $13$ women) 31 to 79 years of age ($M = 61.12$ years) completed this study. The CVA group consisted of $6$ participants with left hemisphere damage, $9$ with right hemisphere stroke, and $1$ with bilateral infarcts. The time poststroke ranged from 6 months to 32 years, 3 months. Control group participants were matched with CVA group participants by age (within 2 years) and hand dominance.

**Clinical Tests**

To characterize the relationship between motor impairments and task performance and to screen for visual neglect in participants with CVA, several clinical assessments were administered. The Modified Ashworth Scale (Bohannon & Smith, 1987) was used to measure muscle spasticity in the involved upper extremity. The amount of resistance to passive stretch was rated on a 5-point scale in 14 muscle groups of the affected arm. This scale has been found to have significantly strong interrater reliability ($\tau = .847, p < .001$). Spasticity was negligible in this sample, except for 1 participant who exhibited mild to moderate spasticity of the elbow, wrist, and fingers.

The Perception of Joint Position Sense Test (Leo & Soderberg, 1981) was used to examine the participants’ proprioceptive awareness of the involved limb. With vision occluded, participants had to accurately touch a piece of tape affixed to the radial styloid of their affected arm when it was moved into six combinations of shoulder, elbow, and forearm placements. Moderate interrater reliability ($ICC = .54$) has been shown for this test. Severe impairment was not observed in this sample.

Letter cancellation and visual extinction tests examined the presence of visual neglect (see McGlinchey-Berroth et al., 1996). Three participants demonstrated significant impairment during the visual extinction test but compensated well during letter cancellation. Two of these 3 participants reported a history of cataracts that led to impaired peripheral vision not related to stroke. During kinematic testing, task objects were presented at midline to control for this impairment.

**Procedure**

After informed consent was obtained, the clinical tests were administered to study participants with CVA. Participants were then seated so that their midsagittal plane was aligned with the middle of the table, and a light-emitting diode (LED) was attached to the tested hand, as noted later.

Three experimental tasks were administered in a random sequence: (a) removing a can from a shelf and placing it on the table, (b) taking an apple off a shelf and putting it into a basket, and (c) moving an empty coffee mug from the table onto a saucer. The Index of Difficulty (Fitts, 1954) was 3.77 for the can task, 3.79 for the apple task, and 3.91 for the mug task. Tasks rated at an Index of Difficulty of 4.58 and below are expected to be accomplished via a pre-planned, continuous movement strategy (Wallace & Newell, 1983). Three tasks rather than one were chosen to test whether the effects of instruction were robust across tasks.

Before data collection began, participants demonstrated an understanding of the tasks to be performed by completing one practice trial of each task with only goal-directed instruction (i.e., “take this can from the shelf and place it on the table with your right hand”). After this trial, a questionnaire (see Appendix) was administered to examine whether participants thought that they attended more to the task characteristics or to the movement of their arm.
During this baseline trial. Full instructions that provided information about the task goal and focus of attention then were given before the first trial of each task condition. The instructions during the can task were as follows:

- **External-focus condition**: “Take this can from the shelf and place it on the table with your [right or left] hand. Pay attention to the can: Think about where it is on the shelf and how big or heavy it is. Later, I’m going to ask you some questions. Ready, begin.”
- **Internal-focus condition**: “Take this can from the shelf and place it on the table with your [right or left] hand. Pay attention to your arm: Think about how much you straighten your elbow and how your wrist and fingers move. Later, I’m going to ask you some questions. Ready, begin.”

Abbreviated instructions were given during the remaining trials. All three tasks were performed under one instruction condition before moving on to the next. Participants performed 8 trials under each task–condition combination for a total of 48 reaches.

**Procedure To Verify Experimental Effects**

After each task–condition combination was completed, the same questionnaire (see Appendix) was administered as a manipulation check to determine whether participants perceived that they followed the instructions as directed. In addition, total displacement (i.e., the limb’s movement path during reach) was measured during all trials to determine whether participants varied how directly they reached toward the task objects across instruction conditions. This second procedure was used to verify that any differences in the dependent variables (movement time, peak velocity) among conditions could be attributed to the focus of instruction rather than to changes in limb displacement.

**Instruments**

Kinematic measures indicative of the quality of motor performance were obtained from data collected by the OPTOTRAK 3020¹, a noncontact optoelectric motion measurement system. This system uses three infrared cameras (sensors), which are permanently mounted in a 5-ft long housing to track movement of infrared LEDs attached to the participant’s arm. The OPTOTRAK system is capable of recording high velocity motion in three dimensions with .1-mm accuracy at a distance of 2.5 m. The reliability of this system in measuring static positions has been established (ICC > .99) (Trombly, Wu, & Cope, 1994).

One LED was applied to the dorsal surface of the fifth metacarpophalangeal joint of a CVA group participant’s affected limb, or to the same hand of the age-matched control group participant, to allow an unobstructed view of the LED during movement. Each movement sample began when the participant raised his or her hand from a hand switch located on the table 2 in. from the edge and slightly lateral to the shoulder. When either the can or coffee mug was lifted, a switch attached to its base was activated to signal the end of reach. All switches were connected to the OPTOTRAK data acquisition unit. During the apple task, a second LED was placed next to the apple and used as a reference to detect the end of reach (i.e., the point when the distance between the two LEDs was minimal). This information was used to determine the movement time, or duration, of each reach.

The LEDs were fired sequentially by the central controller unit and strobed at a rate of 2000 Hz. The position of the LEDs was tracked continuously by the OPTOTRAK sensors, which collected two-dimensional displacement data during each trial at a sampling rate of 100 Hz. Data were stored for offline analysis.

**Data Reduction**

The OPTOTRAK data acquisition program was used to convert two-dimensional kinematic data into three-dimensional coordinates through a direct linear transformation algorithm. The Northern Digital Data Analysis Package (DAP)² was used to filter the data at a frequency of 5 Hz, using a second-order Butterworth filter with a forward and backward pass. Trials with missing data of more than 10 consecutive frames (.10 sec) due to an obstruction of the hand LED during reach were not used. Trials with occluded data in 10 or fewer consecutive frames were flagged, and the missing data were interpolated linearly in DAP. Only eight trials (.5% of all reaches) required interpolation. The filtered data were then processed with a custom-written program to yield the following kinematic variables: total displacement, peak velocity, movement units, and percentage of time to peak velocity.

**Dependent Variables**

The four dependent variables of interest (indicative of movement organization during reach) were movement time, peak velocity, movement units, and the percentage of time to peak velocity. Movement time is the interval from the beginning to the end of reach and is a measure of the overall speed of movement. A typical, preplanned reaching movement to a large target comprises a single-peaked velocity profile with one acceleration phase and one deceleration phase (Brooks, Cooke, & Thomas, 1973; Brooks & Watts,

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¹Northern Digital, Inc., Waterloo, Ontario N2V 1C5, Canada
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Peak velocity corresponds to the changeover from acceleration to deceleration and is defined as the maximal instantaneous velocity associated with a given movement (Wing & Miller, 1984). Peak velocity reflects the amount of force elicited during reach (Nelson, 1983; Schmidt, 1982).

A single movement unit is characterized by one acceleration phase and one deceleration phase, or one zero crossing of the acceleration trace (Fetters & Todd, 1987). Sensory feedback is thought to occur only at the end of each movement unit: A more guided movement is indicated by a higher number of movement units (Brooks, 1986; Brooks & Watts, 1988; Fetters & Todd, 1987).

The percentage of total movement time to peak velocity (i.e., the acceleration phase) and the number of steps, or movement units, indicates the type of movement strategy selected for a particular motor action. A preplanned, continuous movement strategy typically is seen when reaching to a known target that does not require accuracy (Brooks et al., 1973; Brooks & Watts, 1988). This continuous movement strategy is characterized by a single movement unit and a percentage of time to peak velocity ranging from approximately 33% (Bullock & Grossberg, 1988) to 50% of the total movement time (Nagasaki, 1989). After stroke, a discontinuous or guided movement strategy often is seen when reaching with the affected limb, with a velocity profile that is more left-shifted (less than 33% of the movement time is spent in acceleration) and characterized by numerous movement units or acceleration and deceleration phases (Lough, Wing, Fraser, & Jenner, 1984; Trombly, 1992). Under optimal conditions, a preplanned reach to a known target will be of shorter duration (less movement time), more forceful (greater peak velocity), and smoother (less movement units) (Brooks & Watts, 1988; Wu, Trombly, Tickle-Degnen, & Lin, 2000).

**Data Analysis**

Descriptive statistics of the dependent variables were calculated, and means of the last five of eight trials for each task, condition, and dependent variable were used for subsequent data analyses. The last five trials were used because pilot data showed moderate variability in the dependent variables during the initial trials of each condition as participants became familiar with the instructions and task requirements.

The research hypothesis was addressed by separate 2 × 2 mixed analyses of variance (ANOVA) for each task, kinematic variable, and participant group, with one between factor (sequence) and one repeated factor (order). The effect of instructions (i.e., treatment effect) was found in the sequence by order interaction. This practice allowed the use of a more precise error term by controlling for the effects of sequence and order (Rosenthal & Rosnow, 1991).

The research question was addressed by three-way repeated-measures ANOVAs, with two between factors (group and sequence) and one within factor (order). Separate ANOVAs were calculated for each task and dependent variable. The sequence by order by group interaction indicated whether persons with and without CVA responded differently under the instruction conditions. The strength, or magnitude of all findings, was determined by calculating the effect size $r$ (Cohen, 1988).

Spearman rank-order correlations were performed between the clinical test scores and dependent variables to characterize further the relationship between motor impairments and reaching performance in participants with stroke. Additional post hoc analyses were performed to verify the experimental effect or to enhance the interpretation of the findings.

**Results**

Preliminary analyses were performed for all dependent variables to assess whether significant differences existed between participants with right CVA versus left CVA. Because none was found, subsequent analyses were performed for all participants with CVA as a group.

**Verification of Experimental Effects**

**Manipulation check questionnaire.** Significant and large effects of instruction were found in the manipulation check ratings of both participant groups during all tasks. Scores indicated that participants with and without CVA perceived that they attended to the instructions as directed.

When compared with the control group, participants with stroke perceived that they attended more to the task objects during the internal-focus condition. Post hoc analyses revealed significant differences between groups in the manipulation check ratings during the apple task, $F(1, 31) = 6.41$, $p = .017$, $r = .41$, and mug task, $F(1, 31) = 6.39$, $p = .017$, $r = .41$. This finding suggests that the participants with CVA were not as able to shift their focus of attention toward the movement of their arm during these reaching tasks.

**Total displacement.** No significant effects of condition were found for total displacement in either group. This finding indicates that the kinematic differences among instruction conditions could not be attributed to variations in limb displacement when participants reached for task objects. This finding also indicates that participants reached as accurately (i.e., as directly) toward objects during both instruction conditions.

**Effects of Instruction: CVA Group**

The research hypothesis was partially supported for participants with and without CVA. During all reaching tasks,
participants with CVA exhibited significantly shorter movement time and greater peak velocity in the external-focus condition than in the internal-focus condition. During the can task, significantly fewer movement units were found under the external-focus condition. These findings suggest that reaching movements were faster, more forceful, and smoother when externally focused instructions were given. During all three tasks, nonsignificant and small to moderate effects of instruction were found for the percentage of time to peak velocity, indicating that preplanning of reach was similar under both conditions (see Tables 1, 2, & 3).

A significant and large main effect of order was observed only for movement units during the can task, F(1, 14) = 4.48, p = .052, r = .49. However, the effects of the instruction condition (sequence by order) were obtained after controlling for any order effects and, therefore, were not confounded by this effect.

**Effects of Instruction: Control Group**

During all reaching tasks, control group participants also exhibited significantly shorter movement time and greater peak velocity in the external-focus condition. A significant and large effect of instruction on movement units was found only during the can task, with smoother, less guided reach apparent under the external-focus condition. In two of the tasks (can and mug), a significant and large effect of instruction was found for the percentage of time to peak velocity, which indicated that reaching movements were more preplanned under the external condition (see Tables 1, 2, & 3).

A significant and large main effect of sequence was only observed for the percentage of time to peak velocity during the apple task, F(1, 15) = 5.84, p = .029, r = .53. Reaches toward the apple were more preplanned in the external-focus condition than in the internal-focus condition when the externally focused instructions preceded the internally focused instructions (sequence AB). As in the CVA group, significant effects of the instruction condition were obtained after controlling for the effects of sequence and, therefore, were not confounded by this effect.

**Effects of Instruction: Comparison Between CVA and Control Groups**

The results of multiple three-way ANOVAs for each task and kinematic variable showed significant and moderate to large main effects for group during all tasks for movement time, peak velocity, and movement units. Participants with CVA displayed reaching movements that were significantly slower, less forceful, and more guided than participants without CVA.

The sequence by order by group interaction demonstrated that the instruction effects for the two groups were not significantly different from one another in any of the three tasks for movement time, peak velocity, or movement units. However, during the can task, the group difference was significant for the percentage of time to peak velocity, F(1, 29) = 4.55, p = .04, r = .37. Results indicated that the preplanning of reach was not significantly affected by the instruction condition in the CVA group, whereas the control group demonstrated movements that were significantly more preplanned under the external-focus condition.

**Correlation With Clinical Tests**

No significant correlations were found between scores on the Perceptual Task of Joint Position and any of the dependent variables in the CVA group.

**Discussion**

The results of this study partially supported the a priori hypothesis that movement organization would be influ-

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### Table 1. Results of Sequence by Order ANOVAs and Summary Statistics for Each Kinematic Variable and Condition for CVA and Control Groups During the Can Task

<table>
<thead>
<tr>
<th>Group and Kinematic Variable and Condition for CVA and Control Groups During the Can Task</th>
<th>External Focus</th>
<th>Internal Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M (SD)</td>
<td>M (SD)</td>
</tr>
<tr>
<td><strong>CVA (n = 16)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement time (sec)</td>
<td>2.04 (1.24)</td>
<td>2.39 (1.13)</td>
</tr>
<tr>
<td>Peak velocity (mm/sec)</td>
<td>677.36 (201.61)</td>
<td>589.01 (181.17)</td>
</tr>
<tr>
<td>Percentage of reach where peak velocity occurs (%)</td>
<td>22.80 (5.92)</td>
<td>23.63 (8.43)</td>
</tr>
<tr>
<td>Movement units</td>
<td>4.10 (4.67)</td>
<td>5.08 (3.95)</td>
</tr>
<tr>
<td><strong>Control (n = 17)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement time (sec)</td>
<td>1.17 (0.44)</td>
<td>1.54 (0.90)</td>
</tr>
<tr>
<td>Peak velocity (mm/sec)</td>
<td>896.56 (154.77)</td>
<td>784.91 (190.82)</td>
</tr>
<tr>
<td>Percentage of reach where peak velocity occurs (%)</td>
<td>28.43 (5.32)</td>
<td>25.02 (4.80)</td>
</tr>
<tr>
<td>Movement units</td>
<td>1.60 (0.80)</td>
<td>2.30 (1.20)</td>
</tr>
</tbody>
</table>

Note. ANOVAs = analyses of variance; CVA = cerebrovascular accident. The reported F is for the sequence by order interaction, which is the effect of the instruction condition with effects of order and sequence removed. The df is 1, 14 for CVA group and 1, 15 for control group. The effect size r is calculated from the F (Rosenthal & Rosnow, 1991). According to Cohen (1988), r = .10 is a small effect; r = .30 or greater represents a moderate effect; and r = .50 or greater is a large effect. Negative values of r indicate that findings were opposite to the expected direction.
enced by the type of instruction provided. Participants with and without CVA displayed significantly shorter movement time and greater peak velocity during all three tasks when given externally focused instructions versus internally focused instructions. These findings agree with those of previous research that demonstrated a significant relationship between instructions and motor performance during novel tasks in adults without neurological impairments (Adam, 1992; Fisk & Goodale, 1989; Singer et al., 1993; Wulf et al., 1998; Wulf et al., 1999). Furthermore, the current results begin to extend the benefit of externally focused instructions to familiar motor tasks commonly used in occupational therapy. The present findings are in concert with a key assumption of contemporary theories of action: that variables external to the performer, such as a therapist’s instructions, can affect motor performance in persons with and without neurological impairments (Horak, 1991; Kamm, Thelen, & Jensen, 1990; Mathiowetz & Haugen, 1995; Newell, 1986; Newell & Valvano, 1998).

It was further proposed that persons in both groups would demonstrate more preplanned and less guided movements under the external-focus condition, as indicated by a significantly greater percentage of time to peak velocity and fewer movement units. Greater preplanning of movements under the external-focus condition was not found in the control group during the apple task or in the CVA group in any of the three tasks. The externally focused instructions appeared to have a greater effect on how quickly and forcefully reaching movements were executed (movement time and peak velocity) than on the type of movement strategy used during reach (percentage of time to peak velocity and movement units).

One explanation for these findings is that the effects of instruction on movement time and peak velocity are related to the type of sensory processes emphasized under each condition. The externally focused instructions directed visual attention toward object affordances that were relevant for shaping the desired motor action (e.g., “think about the size of the mug and the shape of the handle”). In contrast, the internally focused instructions emphasized proprioceptive feedback (e.g., “think about the movement of your wrist and hand as you reach”). Although proprioception

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**Table 2. Results of Sequence by Order ANOVAs and Summary Statistics for Each Kinematic Variable and Condition for CVA and Control Groups During the Apple Task**

<table>
<thead>
<tr>
<th>Group and Kinematic Variable</th>
<th>Condition</th>
<th>M (SD)</th>
<th>M (SD)</th>
<th>F</th>
<th>p</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVA (n = 16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement time (sec)</td>
<td>External Focus</td>
<td>1.68 (0.80)</td>
<td>1.89 (0.97)</td>
<td>4.43</td>
<td>.054</td>
<td>.49</td>
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<td></td>
<td>Internal Focus</td>
<td>1.89 (0.97)</td>
<td>2.32 (1.25)</td>
<td>5.47</td>
<td>.035</td>
<td>.53</td>
</tr>
<tr>
<td>Peak velocity (mm/sec)</td>
<td>External Focus</td>
<td>700.86 (208.10)</td>
<td>641.60 (192.74)</td>
<td>5.47</td>
<td>.035</td>
<td>.53</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>641.60 (192.74)</td>
<td>700.86 (208.10)</td>
<td>5.47</td>
<td>.035</td>
<td>.53</td>
</tr>
<tr>
<td>Percentage of reach where peak velocity occurs (%)</td>
<td>External Focus</td>
<td>28.70 (7.43)</td>
<td>28.33 (8.97)</td>
<td>0.06</td>
<td>.807</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>28.33 (8.97)</td>
<td>28.70 (7.43)</td>
<td>0.06</td>
<td>.807</td>
<td>.07</td>
</tr>
<tr>
<td>Movement units</td>
<td>External Focus</td>
<td>2.99 (2.25)</td>
<td>3.20 (2.91)</td>
<td>0.32</td>
<td>.583</td>
<td>0.15</td>
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<tr>
<td></td>
<td>Internal Focus</td>
<td>3.20 (2.91)</td>
<td>2.99 (2.25)</td>
<td>0.32</td>
<td>.583</td>
<td>0.15</td>
</tr>
<tr>
<td>Control (n = 17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement time (sec)</td>
<td>External Focus</td>
<td>1.08 (0.42)</td>
<td>1.12 (0.55)</td>
<td>6.96</td>
<td>.019</td>
<td>.56</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>1.12 (0.55)</td>
<td>1.08 (0.42)</td>
<td>6.96</td>
<td>.019</td>
<td>.56</td>
</tr>
<tr>
<td>Peak velocity (mm/sec)</td>
<td>External Focus</td>
<td>887.70 (166.31)</td>
<td>817.50 (187.17)</td>
<td>9.76</td>
<td>.007</td>
<td>.63</td>
</tr>
<tr>
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<td>.007</td>
<td>.63</td>
</tr>
<tr>
<td>Percentage of reach where peak velocity occurs (%)</td>
<td>External Focus</td>
<td>33.57 (6.07)</td>
<td>31.73 (5.36)</td>
<td>1.76</td>
<td>.205</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>31.73 (5.36)</td>
<td>33.57 (6.07)</td>
<td>1.76</td>
<td>.205</td>
<td>.32</td>
</tr>
<tr>
<td>Movement units</td>
<td>External Focus</td>
<td>1.20 (0.80)</td>
<td>1.30 (0.50)</td>
<td>0.15</td>
<td>.700</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>1.30 (0.50)</td>
<td>1.20 (0.80)</td>
<td>0.15</td>
<td>.700</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Note: ANOVAs = analyses of variance; CVA = cerebrovascular accident. The reported F is for the sequence by order interaction, which is the effect of the instruction condition with effects of order and sequence removed. The df = 1, 14 for CVA group and 1, 15 for control group. The effect size r is calculated from the F (Rosenthal & Rosnow, 1991). According to Cohen (1988), r = .10 is a small effect; r = .30 or greater represents a moderate effect; and r = .50 or greater is a large effect.

**Table 3. Results of Sequence by Order ANOVAs and Summary Statistics for Each Kinematic Variable and Condition for CVA and Control Groups During the Mug Task**

<table>
<thead>
<tr>
<th>Group and Kinematic Variable</th>
<th>Condition</th>
<th>M (SD)</th>
<th>M (SD)</th>
<th>F</th>
<th>p</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVA (n = 16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement time (sec)</td>
<td>External Focus</td>
<td>2.02 (0.87)</td>
<td>2.35 (1.22)</td>
<td>6.15</td>
<td>.027</td>
<td>.55</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>2.35 (1.22)</td>
<td>2.02 (0.87)</td>
<td>6.15</td>
<td>.027</td>
<td>.55</td>
</tr>
<tr>
<td>Peak velocity (mm/sec)</td>
<td>External Focus</td>
<td>402.60 (112.48)</td>
<td>372.37 (111.58)</td>
<td>8.21</td>
<td>.013</td>
<td>.61</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>372.37 (111.58)</td>
<td>402.60 (112.48)</td>
<td>8.21</td>
<td>.013</td>
<td>.61</td>
</tr>
<tr>
<td>Movement units</td>
<td>External Focus</td>
<td>19.65 (6.65)</td>
<td>20.75 (8.21)</td>
<td>0.75</td>
<td>.400</td>
<td>.23</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>20.75 (8.21)</td>
<td>19.65 (6.65)</td>
<td>0.75</td>
<td>.400</td>
<td>.23</td>
</tr>
<tr>
<td>Control (n = 17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement time (sec)</td>
<td>External Focus</td>
<td>1.19 (0.45)</td>
<td>1.37 (0.56)</td>
<td>12.76</td>
<td>.003</td>
<td>.68</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>1.37 (0.56)</td>
<td>1.19 (0.45)</td>
<td>12.76</td>
<td>.003</td>
<td>.68</td>
</tr>
<tr>
<td>Peak velocity (mm/sec)</td>
<td>External Focus</td>
<td>555.32 (110.76)</td>
<td>501.56 (118.52)</td>
<td>12.91</td>
<td>.003</td>
<td>.68</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>501.56 (118.52)</td>
<td>555.32 (110.76)</td>
<td>12.91</td>
<td>.003</td>
<td>.68</td>
</tr>
<tr>
<td>Percentage of reach where peak velocity occurs (%)</td>
<td>External Focus</td>
<td>29.25 (5.95)</td>
<td>26.91 (7.34)</td>
<td>4.87</td>
<td>.043</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>26.91 (7.34)</td>
<td>29.25 (5.95)</td>
<td>4.87</td>
<td>.043</td>
<td>.50</td>
</tr>
<tr>
<td>Movement units</td>
<td>External Focus</td>
<td>2.00 (1.00)</td>
<td>2.40 (1.50)</td>
<td>3.71</td>
<td>.073</td>
<td>.45</td>
</tr>
<tr>
<td></td>
<td>Internal Focus</td>
<td>2.40 (1.50)</td>
<td>2.00 (1.00)</td>
<td>3.71</td>
<td>.073</td>
<td>.45</td>
</tr>
</tbody>
</table>

Note: ANOVAs = analyses of variance; CVA = cerebrovascular accident. The reported F is for the sequence by order interaction, which is the effect of the instruction condition with effects of order and sequence removed. The df = 1, 14 for CVA group and 1, 15 for control group. The effect size r is calculated from the F (Rosenthal & Rosnow, 1991). According to Cohen (1988), r = .10 is a small effect; r = .30 or greater represents a moderate effect; and r = .50 or greater is a large effect. Negative values of r indicate that findings were opposite to the expected direction.
and vision both contribute a great deal to the control of coordinated movement, researchers have shown that individuals spontaneously attend more to visual information than to proprioception during motor action (Kelso, 1982; Magill, 1998; Weiss & Jeannerod, 1998). This preference was apparent from the preinstruction questionnaire in the present study in which participants in both groups thought that they paid more attention to the characteristics of the task objects than to the movement of their arm. As such, instructions directed toward proprioceptive feedback may have contributed to longer movement time and lower peak velocity in both groups because they interfered with the automatic processing of visual information during reach.

Post hoc ANOVAs, which compared ratings by participants with and without CVA on the manipulation check questionnaire, provided additional information about the sensory processes attended to during the instruction conditions. These analyses revealed that participants with stroke thought that they paid more attention to task objects (i.e., visual information) during the internal-focus condition of the apple and mug tasks than control participants. Participants with stroke also demonstrated minimal to moderate impairments in proprioceptive awareness, as measured by the Perception of Joint Position Sense Test. Fisk and Goodale (1988) proposed that impaired processing of proprioceptive information after stroke may contribute to a greater reliance on visual information to monitor the position of the arm during goal-directed tasks. As such, CVA group participants possibly were less able to attend to the movement of their arm during the internal-focus condition. Therefore, they may have relied on visual information to compensate for impaired position sense when reaching for and grasping the apple or mug. Further research is needed to test this proposal.

The effects of instruction were not as consistent for the dependent variables used to depict the type of movement strategy used during reach. Significant effects of externally focused instructions versus internally focused instructions on the percentage of time to peak velocity and movement units were found only in the control group during the can and mug tasks. One possible explanation is that the presence of the task object across instruction conditions reduced the need to alter one's movement strategy. Several researchers have differentiated the effects of object availability on movement kinematics from the effects of task constraints (e.g., goal, target size, amplitude of movement) (Lin, Wu, & Trombly, 1998; van Vliet, Sheridan, Kerwin, & Fentem, 1995; Wing & Miller, 1984). Wing and Miller (1984) found that the acceleration phase of the velocity profile (the preplanned phase of movement) was relatively invariant when participants moved a cursor toward targets on a computer screen, even though the task constraints, such as the target size and distance, were altered. Other studies reported that the percentage of time to peak velocity was not significantly affected by changes in the functional goal when the task object was present across conditions (Lin et al., 1998; van Vliet et al., 1995). The results of these studies are similar to the present findings in that the presence of task objects, rather than changes in task constraints (goal or instructions), appeared to influence the preplanning of reach across experimental conditions.

If object availability accounted for the lack of instruction effects on the movement strategy used during reach, then the same findings would be expected in persons with and without CVA. This was not the case. The effects of instruction on the percentage of time to peak velocity and movement units were greater in the control group. An alternate explanation is that the participants with stroke were less able to produce more preplanned and less guided movements in response to instructions because of impaired force generation in the affected limb. Previous studies have suggested that reduced force generation may contribute to the slow, discontinuous movements seen after CVA (Lough et al., 1984; Trombly, 1992, 1993; Wu et al., 2000). Compared with the control participants, reaching movements of the CVA group participants were slower, less forceful, less preplanned, and more guided across instruction conditions. The CVA group participants were less able to vary their movement strategy in response to instruction, as seen by smaller differences between conditions in the average percentage of time to peak velocity and number of movement units. Also evident was that the effects of instruction in the CVA group were smaller for the percentage of time to peak velocity variable than for the other dependent variables. This finding suggests that the percentage of time to peak velocity is not a sensitive outcome variable for detecting the effects of instruction on reach in persons with stroke. Future studies are needed to validate this proposal.

**Implications for Occupational Therapy Practice**

These findings reinforce the strong relationship between therapeutic context, particularly verbal instruction, and motor performance. The results indicate that persons with and without stroke can benefit from externally focused instructions that emphasize visual information during the interaction with task objects. Therapists may find instructions that highlight relevant task affordances, such as the size or shape of the object, to enhance the automatic shaping of reach to grasp movements. The evidence from this study suggests that internally focused instructions (e.g., “straighten your elbow…open your fingers”) may actually deter motor performance during therapy by contributing...
to less efficient (slower) and less forceful reach in persons with CVA and in older adults without neurological impairments.

**Directions for Future Research**

Further kinematic research is needed to confirm and expand the present results. Replication of this study may be enhanced by the use of a consistent method to determine the end of reach (e.g., switch only); by comparing the effects of simple, goal-directed instruction (“put the can on the shelf”) with both externally focused and internally focused instructions; and by using novel and more challenging reaching tasks.

**Conclusion**

This study was the first to examine the effect of instructions on motor performance in persons with and without CVA during occupational tasks. The beneficial effect of externally focused instruction during familiar tasks extends previous motor research of complex, novel tasks (Wulf et al., 1998; Wulf et al., 1999). The findings provide preliminary evidence that movement time and peak velocity during reach are significantly influenced by the focus of instruction in persons with and without CVA.

In this study, motor performance of the affected limb was analyzed during the performance of daily occupational tasks. The results support the use of externally focused instructions directed toward naturalistic task performance to improve movement speed and force in the hemiparetic arm after stroke. This research reinforces the need for therapists to consider their use of instructions when evaluating and treating movement disorders after stroke (Newell & Valvano, 1998).

**Acknowledgments**

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**Appendix: Manipulation Check Questionnaire**

I would like you to answer some questions by using the scale here [explain]. While you did these things (took the can or apple from the shelf, moved the coffee mug), how much did you pay attention to:

**Movement-Related Questions:**

- The movement in your arm?
- The movement in your elbow?
- The movement in your wrist or hand?

Mean Rating—Movement

**Task/Object-Related Questions:**

- The object—the can, apple, or mug?
- The size or weight of the object?
- Where you would put it after you picked it up?

Mean Rating—Task/Object

Did you pay attention to anything I did not mention?

Check one:  
Baseline ______  
External focus ______  
Internal focus ______

Note. Participants used a 5-point Likert scale to answer questions:  
1 = None of the time  
2 = A little of the time  
3 = Some of the time  
4 = Most of the time  
5 = All of the time

Ratings of the movement-related questions were inverted by using a 5-point scale (1 = least attention toward task objects, 5 = most attention toward task objects) before data analysis. The same questions were administered during practice trials (preinstruction baseline) and as a manipulation check during the internal and external focus conditions.
References


Lin, K.-C., Wu, C.-Y., & Trombly, C. A. (1998). Effects of task goal on movement kinematics and line bisection perfor-

The American Journal of Occupational Therapy 389


