Effects of Task Instructions and Target Location on Reaching Kinematics in People With and Without Cerebrovascular Accident: A Study of the Less-Affected Limb

Keh-chung Lin, Ching-yi Wu, Kwan-hwa Lin, Chein-wei Chang

OBJECTIVE. We investigated how verbal instructions and target location interacted to influence reaching movement of the less-affected limb in participants with and without unilateral cerebrovascular accidents (CVAs).

METHOD. Using a counterbalanced repeated-measures design, 26 people with CVA and 24 age-matched healthy people performed the reaching tasks under 4 conditions formed by the crossing of verbal instructions (speed and accuracy emphasis) and target locations (ipsilateral and contralateral to the performing hand).

RESULTS. In the control groups, speeded instructions and ipsilateral reaches elicited significantly more preprogrammed movements than did accuracy instruction and contralateral reaches, respectively. Similar patterns of performance in response to task constraints were found in the CVA groups except for movement initiation in the right CVA group.

CONCLUSION. Instruction and locations interacted to constrain reaching movements in both control and CVA groups. The combination of speeded instruction and ipsilateral reach may optimize movement performance of the less-affected limb in stroke patients.


Occupational therapists incorporate different types of task constraints into practice schedules when designing treatment programs for people with cerebrovascular accident (CVA; Mathiowetz & Bass-Haugen, 2008; Pendleton & Schultz-Krohn, 2006). Task constraints refer to limitations imposed on purposeful movement (Trombley Latham, 2008), which may facilitate desired movement organization in people with CVA (Newell, 1998; Shumway-Cook & Woollacott, 2007). Two general sources of task constraints in the context of stroke rehabilitation have been identified: augmented information (e.g., verbal instructions for movement preparation and execution) and physical demands such as target location and relevance of target to be reached (Lin, Wu, & Trombley, 1998; Ma & Trombley, 2004; Newell, 1998; Trombley & Wu, 1999; Wu, Trombley, Tickle-Degnen, & Lin, 2000). Appropriate integration of verbal instruction and target location may be used to optimize movement performance by people with CVA. This assumption awaits experimental study to improve knowledge about the effects of task constraints on movement organization during goal-directed reaching. We designed this study to investigate how verbal instruction and target location may interact to influence movement performance by people with and without CVA.
Task Instructions and Reaching Kinematics

One of the noted examples of task constraints in biomechanical analysis of movements would be the trade-off between speed and accuracy in goal-directed reaching (Duarte & Freitas, 2005; Fitts, 1954). On the basis of the speed-accuracy paradigm, previous studies of the effects of instruction involved healthy people (e.g., Rival, Olivier, & Ceyte, 2003) and clinical populations such as people with Parkinson’s disease (Rand, Stelmach, & Bloedel, 2000). Research on people with CVA is needed to determine the effects of task instructions on reaching performance during motor tasks. Such research will provide information relevant for task-specific practice of motor actions important for daily occupations.

One theme of the speed-accuracy research (Adam, 1992; Fisk & Goodale, 1984; Rival et al., 2003) is the use of temporal and spatial instructions to study the speed-accuracy trade-off of reaching in pointing movements. In this situation, target characteristics (e.g., target size, distance) and the environment remain constant, and the emphasis on speed and accuracy is varied by changing the verbal instructions to the task performer. These instructions involve reaching for a target as quickly as possible or as accurately as possible. Several studies involving healthy adults (Adam, 1992; Fisk & Goodale, 1984; Rival et al., 2003) and people with Parkinson’s disease (Rand et al., 2000) have indicated that with speed instructions, participants initiated faster and produced more efficient reaching movements with greater force. These findings suggest that the speed-accuracy information provided by verbal instructions can direct a person’s attention toward the temporal or spatial aspect of the reaching movement. The speed-accuracy instructions thus influence the motor planning and strategies used to perform the task (Fasoli, Trombly, Tickle-Degnen, & Verfaellie, 2002; Hermsdorfer et al., 1996; Ma, Trombly, Wagenaar, & Tickle-Degnen, 2004).

Speed-emphasized tasks demand more efficient performance of the task in the temporal domain than do accuracy-emphasized tasks, and they demand a shorter time to complete the task and require more ballistic-like or more continuous movements. The more ballistic reaching movements depend more on advanced motor programming (i.e., more preplanning of the reaching movement) and less on direct sensory feedback, as reflected by less time for movement initiation (shorter reaction time [RT]), higher efficiency of movement execution (less movement time [MT]), and greater smoothness during performance (fewer movement units [MUs]; Haaland, Prestopnik, Knight, & Lee, 2004; Milner, 1992; Trombly, 1992). To complete the task more quickly, the performer needs greater force or impulse at movement initiation to quickly bring the hand to the target. The greater force or impulse at movement initiation can be reflected by a higher amplitude of peak velocity (PV; Ma et al., 2004).

Location Constraints

The dimension of movements studied in the literature related to the speed-accuracy instruction is limited to the sagittal plane. It remains unclear whether those effects hold true in other spatial planes. In addition, target location is another important constraint to consider in people with unilateral CVA. Previous research has described the effects of the laterality of the target position on movement kinematics in healthy adults (Fisk & Goodale, 1984; Ghozlan, 1998; Wu, Lin, Lin, Chang, & Chen, 2005) and in people with neurological impairment (Beer, Dewald, & Rymer, 2000; Castiello, Bennett, Bonfiglioli, Lim, & Peppard, 1999; Roy, Kalbfleisch, Bryden, Barbour, & Black, 2000; Trombly, 1993). The general findings suggest that ipsilateral reaches (i.e., the target position and the hand used to reach for the target are on the same side) were more efficient in movement planning and execution than contralateral reaches (i.e., target position on the opposite side from the limb). Planning and execution efficiency were reflected by RT and MT, respectively. Ipsilateral reaches are also more preprogrammed with less error correction (fewer MUs), more forceful (higher PV), and more accurate than contralateral reaches. The information on targets located on the same side of the body as the reaching limb is processed initially in the same hemisphere that controls the reaching limb (Barthelemy & Boulinguez, 2002). The advantage for reaches made into the ipsilateral space could be a consequence of more efficient within-hemisphere visuomotor transmission of target information and visual feedback from the reaching limb (Fisk & Goodale, 1984).

One alternative explanation for the ipsilateral reaching advantage lies in biomechanical factors. Differences between ipsilateral and contralateral reaches could be accounted for by differences in the inertial forces operating on the hand for movements in different directions. When a person performs abductive movement into the ipsilateral space, the hand path direction is parallel to the long axis of the upper arm. Such ipsilateral reaches require lower inertial loads or less strength, which results in shorter MT and higher PV than contralateral reaches, in which the hand path is more perpendicular to the axis of the upper arm (Carey, Hargreaves, & Goodale, 1996; Carey & Otto-de Haart, 2001; Trombly, 1993; Wu et al., 2005). It remains unclear whether and how the effect of location constraint may interact with the instructional
demand to constrain targeted movements of the less-affected limb after stroke.

**Study of the Less-Affected Limb**

Although deficits in the affected limb after stroke are pronounced, motor deficits may also appear in the less-affected limb (Haaland et al., 2004; Wetter, Poole, & Haaland, 2005). Reaching movements by the less-affected limb have been of growing interest to researchers and practitioners (e.g., Hermsdorfer, Blankenfeld, & Goldenberg, 2003). Therapists working with people with stroke often teach compensatory strategies using the less-affected limb for fine motor activities (Shumway-Cook & Woollacott, 2007). In addition, recent stroke rehabilitation literature has suggested that repetitive training involving paired movements of the affected and less-affected limbs results in a facilitation effect from the less-affected limb to the affected limb (Goble, 2006; Whitall, Waller, Silver, & Macko, 2000). Understanding the reaching performance of the less-affected limb in response to task constraints may provide relevant information for stroke rehabilitation that involves compensatory training of the less-affected limb or practice of bilateral movements.

**Research Questions and Hypotheses**

To clarify the effects of task constraints on reaching performance of the less-affected limb, we investigated the effect of task instructions and target location on reaching in people with left and right CVA (LCVA and RCVA, respectively) and healthy control participants. Specifically, we looked at reaching kinematics when people with and without stroke reached for an ipsilateral target (i.e., the target ipsilateral to the less-affected hand used for performance) and a contralateral target (i.e., the target contralateral to the responding hand) under speed and accuracy instructions. Healthy people were studied to provide a basis on which to establish normal patterns in task performance under different task constraints (Wu, Trombly, Lin, & Tickle-Degnen, 1998; Wu et al., 2000). Studying people with LCVA and RCVA would reveal specific movement responses to task constraints and provide insights into the role each hemisphere plays in movement organization (Elliott & Carson, 2000; Wu, Wong, Lin, & Chen, 2001).

The four experimental conditions, formed by the crossing of task instructions (speed and accuracy emphasis) and target locations (ipsilateral and contralateral to the less-affected hand used for performance), are (1) speed-emphasized reaching for an ipsilateral target (SI), (2) accuracy-emphasized reaching for an ipsilateral target (AI), (3) speed-emphasized reaching for a contralateral target (SC), and (4) accuracy-emphasized reaching for a contralateral target (AC). Participants with stroke performed the reaching tasks with their less-affected limbs.

We hypothesized that, for people with and without stroke, the movement would be more programmed (shorter RT and MT, fewer MUs), with higher force generation (higher PV) for speed-emphasized tasks than for accuracy-emphasized tasks and for ipsilateral reaches than for contralateral reaches. Instruction effects were further proposed to override location effects, based in part on the findings of Adam (1992) and Fasoli et al. (2002) that speed–accuracy or instruction effects remain robust when the target location is changed or when different task conditions are performed. That is, the more programmed movements with higher force generation would be elicited by the testing conditions in the following order: SI, SC, AI, and AC. We also predicted that differential responses to task manipulations may arise in accord with laterality of stroke lesion.

**Method**

**Participants**

The participants with stroke were recruited from two medical centers, and stroke location was identified by computed tomography or magnetic resonance images of the brain. The patients were able to understand or respond to directions given by the experimenter and had no clinical signs of motor apraxia and visuospatial neglect. They had no history of prior CVA or visual deficit that would prevent participation. The participants in the control group had no prior history of neurological or psychiatric disease, determined by self-report. All participants signed informed consent forms approved by the Institutional Review Board of National Taiwan University Hospital. The participants with CVA used the less-affected limb, and the matched control participants used the same limb as did the participants with CVA.

**Materials and Instrumentation**

The target object was a desk bell with a diameter of 9.65 cm and a height of 4.75 cm. The start and the end of the reach event were determined through the use of a hand switch and the desk bell. Before movement initiation, the participant’s hand rested on a switch. The beginning of movement was recorded when the hand moved off the switch. The end of movement was obtained when the participant pressed the desk bell.

A six-camera motion analysis system (VICON 370 3-D; Oxford Metrics Inc., Oxford, England) was used in conjunction with one personal computer (IBM clone) to capture the movement of the marker attached to the styloid process of
the ulna during reaching to press the bell and to collect two channels of analog signals simultaneously. The analog signals, connected with the hand switch and the desk bell, were used to determine the start and the end of the reach. The VICON system was shown to accurately and reliably measure distances ranging from 25 mm to 500 mm between markers statically and the motion of markers up to speeds of approximately 15 m per second. This precision is more than sufficient when measuring motions during reaching or gait (Bhimji, Deroy, Baskin, & Hillstrom, 2000). This system was calibrated to have averaged residual errors not exceeding 3 mm for each camera before data acquisition. As the participant moved, the instantaneous position of the marker was digitized at a sampling rate of 60 Hz. After data acquisition, we used the VICON system analysis software to save the three-dimensional location of the marker together with analog data in binary format. The obtained positional data were digitally low-pass filtered at 5 Hz using a second-order Butterworth filter with forward and backward pass.

Design and Procedures

We used a counterbalanced repeated-measures design. Each incoming participant was randomly assigned to one of four sequences for executing the reaching task: SI–AI–SC–AC, AI–SC–AC–SI, SC–AC–SI–AI, or AC–SI–AI–SC (see Table 1).

During the experiment, each participant sat on a chair 40.00 cm high in front of a table adjusted to 5.00 cm above the elbow. The participant’s performing hand rested on a pressure-sensitive switch that was located on the edge of the table in line with the participant’s midsagittal plane. Two target locations were used: the left and right hemispace located on a meridian 45° relative to the start position. The target object was placed 38.00 cm from the starting position for each task location. The verbal instruction involved an emphasis on rapid (i.e., as quickly as possible) or accurate (i.e., as accurately as possible) execution of the experimental task. The start of a trial was prompted by a randomly timed verbal instruction, “go,” to prevent participants from expecting when to initiate the movement. Under the speeded conditions (i.e., SI, SC), the participants missed the targets in some trials, and these were not included for analysis. Each participant performed three successful trials for each condition. One practice trial was performed before the participant executed the task for each condition.

Data Analysis

We used an analysis program coded by LabVIEW (National Instruments, Inc., Austin, TX) to process collected data. Information on reaching performance including RT, MT, MU, and PV was obtained. We conducted the analyses separately for the participants with LCVA and RCVA and for the healthy control participants. To test the effects of both constraints, we used contrast analyses (i.e., focused analyses of variance [ANOVA]) in which specific predictions were tested by contrasting them with the obtained data (Rosenthal & Rosnow, 1985). We first performed 4 × 4 mixed ANOVAs for each dependent variable to obtain the omnibus F of the Sequence × Order interaction. There was one between-subjects factor, sequence, and one repeated or within-subjects factor, order, in this mixed ANOVA. The effects of the task constraints (i.e., the omnibus F) were embedded in the Sequence × Order interaction (Rosenthal & Rosnow, 1991). This practice is more powerful than the commonly used two-way ANOVAs with repeated factors because it removes the confounding effects of sequence and order from the error term.

We then obtained the focused F for our contrast analysis from the omnibus F as follows: F_{contrast} = (r^2) \frac{\text{omnibus} F_{\text{treatment} \times \text{df numerator}}}{\text{omnibus} F_{\text{treatment} \times \text{df denominator}}}, where r^2 is the square of the correlation between the contrast weights and the residualized means (Rosenthal & Rosnow, 1991). For the present study, we assigned contrast weights numerically reflecting the hypothesis. For example, in this study's SI, SC, AI, and AC conditions, the contrast weights for predicting the trend of MT were −3, −1, 1, and 3, respectively. To indicate the magnitude of the effect of interest, we calculated the effect size r for each dependent variable for each group (Rosenthal & Rosnow, 1985).

Results

The participants in this study included 26 people with unilateral CVA (18 men and 8 women, 42–83 years old, mean age 63.4 years) and 24 age-matched healthy people (7 men and 17 women, 42–80 years old, mean age 62.3 years), who were right handed by self-report. Average time following stroke onset was 2.62 months (SD = 3.12; range = 0.13–12.90 months). Eleven participants with RCVA and 12 control participants used their right limbs to perform the tasks; 15

Table 1. A Counterbalanced Repeated-Measures Design

<table>
<thead>
<tr>
<th>Sequence</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>SI</td>
<td>AI</td>
<td>SC</td>
<td>AC</td>
</tr>
<tr>
<td>2</td>
<td>AI</td>
<td>SC</td>
<td>AC</td>
<td>SI</td>
</tr>
<tr>
<td>3</td>
<td>SC</td>
<td>AC</td>
<td>SI</td>
<td>AI</td>
</tr>
<tr>
<td>4</td>
<td>AC</td>
<td>SI</td>
<td>AI</td>
<td>SC</td>
</tr>
</tbody>
</table>

Note. Order refers to the order of administration of the treatment. SI = speed-emphasized reaching for an ipsilateral target; AI = accuracy-emphasized reaching for an ipsilateral target; SC = speed-emphasized reaching for a contralateral target; AC = accuracy-emphasized reaching for a contralateral target.
participants with LCVA and 12 control participants used their left limbs.

Figures 1 through 4 present the means and standard deviation bars associated with RT, MT, MU, and PV under each experimental condition for the four groups. Table 2 shows the results of the contrast analyses. For both control groups (one group using the left hand and the other using the right hand), speeded instructions and ipsilateral reaches elicited more preprogrammed movements than did accuracy instruction and contralateral reaches, respectively. Both control groups initiated the movement faster (shorter RT) and performed the movement more efficiently (shorter MT) and smoothly (fewer MUs) for speed-emphasized versus accuracy-emphasized tasks and for ipsilateral versus contralateral ones. The instructional effects overrode the target location effects for these three variables, which is consistent with the a priori hypotheses. However, a scrutiny of the raw data showed that the direction of constraint effects on force generation (PV) was not fully consistent with the a priori hypothesis. We performed a post hoc analysis, which showed that higher force was generated for speed-emphasized versus accuracy-emphasized movements and for ipsilateral versus contralateral reaches. Inconsistent with the a priori hypotheses, the location effects overrode the instructional effects (Table 3).

Results for the CVA groups using the less-affected limb showed significant and large effects of the task constraints for all variables (RT, MT, MU, PV) for the LCVA group and for three of the four variables (MT, MU, PV) for the RCVA group. Nonsignificant and modest task-constraint effects were found in RT for the RCVA group. Both groups showed more efficient (shorter MT) and smoother (fewer MUs) performance for speed-emphasized versus accuracy-emphasized movements and for ipsilateral
versus contralateral movements. Moreover, the instructional effects overrode the location effects, which is consistent with the a priori prediction.

However, the raw data showed that the effects on movement initiation (RT) for the LCVA group and on force generation (PV) for both groups were not fully consistent with the a priori hypotheses. We conducted post hoc analyses of the data for the stroke groups. Large effects were obtained in favor of the post hoc hypotheses for movement initiation in the LCVA group and for force generation in both groups (Table 3). Speed-emphasized conditions required less time to initiate the movement for the LCVA group than did the accuracy-emphasized conditions. Target location did not affect the time to initiate movement in this group under either type of task instruction (i.e., SI–SC; AI–AC). On the other hand, constraint effects on force generation were found for the RCVA and the LCVA groups. Target location effects overrode the instructional effects, in which ipsilateral reaches generated higher force than contralateral reaches. Speed requirements generated higher force, relative to accuracy demands, for either type of reach.

Table 3. Results of Post Hoc Contrast Analysis

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Post Hoc Hypotheses</th>
<th>Effect Size r</th>
</tr>
</thead>
<tbody>
<tr>
<td>NL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>SI &gt; AI &gt; SC &gt; AC</td>
<td>0.78</td>
</tr>
<tr>
<td>NR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>SI &gt; AI &gt; SC &gt; AC</td>
<td>0.85</td>
</tr>
<tr>
<td>LCVA</td>
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<td></td>
</tr>
<tr>
<td>RT</td>
<td>SI = SC &lt; AI = AC</td>
<td>0.81</td>
</tr>
<tr>
<td>PV</td>
<td>SI &gt; AI &gt; SC &gt; AC</td>
<td>0.82</td>
</tr>
<tr>
<td>RCVA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV</td>
<td>SI &gt; AI &gt; SC &gt; AC</td>
<td>0.94</td>
</tr>
</tbody>
</table>

Note. NL = controls using the left hand; NR = controls using the right hand; LCVA = participants with left cerebrovascular accidents; RCVA = participants with right cerebrovascular accidents; RT = reaction time; MT = movement time; MU = movement units; PV = peak velocity.

Discussion

The results of the study are partially consistent with the a priori hypotheses and support the notion that task constraints modulate movement preparation and execution (Newell, 1998; Shumway-Cook & Woollacott, 2007). Healthy people used more programmed movements (as suggested by RT, MT, and MU) with higher force generation (higher PV) for speed-emphasized versus accuracy-emphasized tasks and for ipsilateral versus contralateral movements. The instructional effects significantly overrode the target location effects on movement initiation (RT), efficiency (MT), and smoothness (MU) but not on force generation (PV). We found similar patterns of performance in response to task constraints in the CVA groups except for movement initiation in the RCVA group. Therefore, we concluded that the integration of speeded instruction and ipsilateral reach (SI condition) optimized movement execution for healthy adults and people with CVA. A major deficit of people with CVA in response to task constraints lies in movement initiation because we found no differential or gradient differences in RT among various task conditions. However, the consistent effects of task constraints on movement efficiency, smoothness, and force generation in the healthy participants and those with CVA suggest that some aspects of movement kinematics may be relatively unaffected by stroke.

Findings for both control groups were consistent with those of previous studies on speed–accuracy instruction constraints (Adam, 1992; Fasoli et al., 2002; Fisk & Goodale, 1984; Rival et al., 2003). Speeded instructions and ipsilateral reaches elicited more preprogrammed movements (faster initiation and more efficiency and smoothness) than the accuracy instruction and contralateral reaches, respectively. This study extended previous research by showing the benefit of speeded instruction in a simple, functionally relevant task. The instructional effect may arise because the demand for speed can direct the performer’s attention toward the temporal organization of movement and activate predominantly the preprogrammed strategies (i.e., the ballistic
movements; Hermdsorfer et al., 1996; Ma et al., 2004). Another possibility is that instructions for speed versus accuracy indicate different goals to be accomplished. Task goal has been shown to be a powerful organizing factor in simple motor tasks (Lin et al., 1998; Shumway-Cook & Woollacott, 2007; Trombly & Wu, 1999; Wu et al., 2000, 2001). The goal of reaching quickly may organize the motor system to perform faster and more smoothly to achieve the task requirement, whereas the goal of reaching with accuracy possibly directs the performer’s attention toward endpoint precision, which may compromise movement efficiency and smoothness.

The results of location effects on movement initiation, efficiency, and smoothness in both control groups agree with those of previous research (Fisk & Goodale, 1984; Ghodzlan, 1998; Wu et al., 2005) demonstrating the advantages of ipsilateral reaches. Such advantages possibly lie in the efficiency of intrahemispheric processing for visuomotor information on target or visual feedback from the reaching limb (Barthelemy & Boulinguez, 2002; Fisk & Goodale, 1984). Some positron emission tomography studies (Carey, Abbott, Egan, Tochon-Danguy, & Donnan, 2000; van Mier, Tempel, Perlmutter, Raichle, & Petersen, 1998) have shown greater brain activations in the hemisphere contralateral to the hand used than in the other hemisphere for ipsilateral reaches. By contrast, comparable brain areas were activated in both hemispheres for contralateral reaches. These findings further support the notion of the advantage of intrahemispheric processing for ipsilateral reaches. The results might also be accounted for by the biomechanical characteristics of the movement. As mentioned earlier, inertial force operating at the hand for ipsilateral reaches was lower than for contralateral reaches. Ipsilateral reaches may engender faster movement initiation and higher movement efficiency than contralateral reaches (Carey et al., 1996; Carey & Otto-de Haart, 2001).

In agreement with the findings of Adam (1992) and Fasoli et al. (2002), speed–accuracy effects overrode location effects. This study extended the robust effects of speed–accuracy from reciprocal movements to simple aiming movements and from the sagittal plane to the spatial planes ipsilateral and contralateral to stroke lesion. This may be because the nature of the auditory information from the verbal instruction provided strong constraints that captured the intrinsic dynamics of the performer’s movement system and overrode the effects of target location (Kail & Salthouse, 1994).

The effects of task constraints on force generation were not fully consistent with the a priori hypotheses. The control participants exerted more force for executing the task of speeded and ipsilateral reaches than for accurate and contralateral reaches, respectively, supporting the notion that tasks with speeded emphasis and ipsilateral reaches require greater inertial force or impulse at movement initiation for efficient movement (Beer et al., 2000; Ma et al., 2004; Rand et al., 2000; Roy et al., 2000). Inconsistent with the a priori hypothesis, location effects overrode speed–accuracy effects. The dominant effects of target location suggest that force generation may be more sensitive to within-hemisphere processing and biomechanical control than to preprogrammed strategies.

The results for the CVA groups were consistent with those for the control groups in movement efficiency, smoothness, and force generation, suggesting that these aspects of movement kinematics of the less-affected limb may be relatively unaffected by stroke. Moreover, the findings on movement efficiency and smoothness are consistent with those of the previous studies (Beer et al., 2000; Castiello et al., 1999; Roy et al., 2000). The deficits of people with CVA in response to task constraints (verbal instruction and target location) occur primarily in movement planning. The LCVA group exhibited shorter time for movement planning or preparation under speeded instructions than under accuracy instructions for reaching to either location. By contrast, the RCVA group did not demonstrate significant effects of task constraints on movement initiation. A possible reason for differences in effects of task constraints between the LCVA and RCVA groups might be that the right hemisphere is dominant for processing visuospatial or positional aspects of goal-directed movements, whereas the left hemisphere subserves nonspatial or nonpositional aspects of preplanning (Haaland et al., 2004; Winstein & Pohl, 1995). The task used in this study required position control to accurately press the bell under either type of instruction and scale the spatial relationship between the target and the performer (Heath, Hodges, Chua, & Elliott, 1998). Accordingly, once the right hemisphere is lesioned, the ability to preplan or program the motor act for a visual target such as that used in the present study is decreased, and the pattern of RT in response to instructional or location constraints is impaired.

A scrutiny of the kinematic performance between the control and the CVA groups showed that the participants with CVA generally produced fewer programmed movements (slower movement initiation, less movement efficiency and smoothness) with lower force generation than the control participants. These findings suggest that occupational therapy for stroke should consider motor deficits of the less-affected limb (Haaland et al., 2004; Kim, Pohl, Luchies, Stylianou, & Won, 2003; Quaney, Perera, Maletsky, Luchies, & Nudo, 2005; Wetter et al., 2005). This consideration is necessary because compensatory use of the less-affected limb after stroke is common for precision tasks in daily life situations. To facilitate enhanced movement performance, occupational therapists may incorporate task
constraints (e.g., verbal instructions and target location) into practice of goal-directed actions by people with CVA.

This study’s findings may have implications for task-specific practice of compensatory use of the less-affected limb after stroke. Task demands for speeded movement or for ipsilateral reach might facilitate movement efficiency, smoothness, and force generation. The combination of speeded instruction and ipsilateral reach may elicit the most preprogrammed movements and optimize movement performance when the less-affected limb is used for target reaching. The speeded instruction might have greater benefit than ipsilateral reaches for enhancing movement efficiency and smoothness. By contrast, if generation of greater force is the goal, use of the less-affected limb for practice of ipsilateral reaches might be more advantageous than speeded instructions. If fast response to the task demand is the goal, speeded demands may be helpful for people with LCVA but not for those with RCVA.

One limitation of this study is that the effect of stroke severity was not studied and warrants future research. Future research may also investigate the response patterns of the more-affected hand in response to the constraints to update motor control rehabilitation interventions for clients with hemiplegia. Additional constraint factors are relevant for study to elucidate the dynamic interplay between task constraints and people with CVA. Examples are task difficulty and complexity (e.g., target size and task distance; Hermsdorfer et al., 2003; Kim et al., 2003; Ma & Trombly, 2004), position of the hand relative to target location, presence of distracting objects, and motivational relevance of the motor act for individual performers. Further study that elucidates these issues will improve understanding of the organization of aiming movements and inform task-specific approaches to stroke rehabilitation.

Conclusions

Our findings reveal the confluence of instructional constraints of speed–accuracy and target location during reaching movements by people with and without CVA. The study demonstrated that instructions for speeded reaching for an ipsilateral target elicited the most preprogrammed movement. Moreover, some aspects of movement performance—such as movement efficiency, smoothness, and force generation of the less-affected limb in response to the task constraints—may be relatively unaffected by unilateral stroke. The RCVA group, but not the LCVA group, failed to respond to the instruction and location constraints in movement preparation during the desk bell task. The differential responses to task constraints in the hemispheric groups suggest that the right hemisphere may be responsible for the programming and planning of motor acts involving space coding. Such information might facilitate rehabilitative treatment planning for the less-affected limb that incorporates constraint factors into compensatory strategy practice. Therapeutic activities that involve instructional demands for fast movement and ipsilateral reaches may be used to facilitate movement efficiency, smoothness, and force generation of the less-affected limb. Further research may also study whether practice on these activities may enhance performance of the affected limb during bilateral movements involving both upper limbs (e.g., opening a drawer with the affected hand and retrieving a target object with the less-affected hand; Wu, Lin, Chen, Chen, & Hong, 2007).

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