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(contextual constraints)

(Part I)
(Part II)

motion analysis system

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(client-centered)
(evidence-based stroke rehabilitation)

Abstract

Current theories of motor control in rehabilitation focus on how the nervous system responds to many types of external and internal constraints to execute motor behavior for accomplishing a task. This study examined the impact of some aspects of internal (personal preference) and external constraints (functional goal) on motor performance in persons with stroke.

Twelve left cerebral vascular accident (LCVA) patients and 15 right cerebral vascular accident (RCVA) patients used the uninvolved arm to perform an upper extremity reach task under four experimental conditions.

Four testing conditions were formed by the crossing of functional goals and personal preferences. Under the higher level of a functional goal, participants took a drink from a can of beverage. The lower level of a functional goal, participants involved bringing the beverage to the mouth without drinking. The level of personal preferences was determined by the degree of predilection for a beverage. The participant selected his or her most and least preferred beverages among five options for task performance.

The results show that performing a preferred task with a higher functional goal enhances motor performance in temporal aspect. This finding suggested that providing patients with choices for preferred activities and incorporates functional goal-directedness to therapeutic tasks enhance response rate or movement efficiency.

Keywords: Functional goals, personal preferences, cerebral vascular accident, kinematic analysis

Current theories of motor control used as a basis for predicting motor response during assessment and treatment for neurological patients focus on how the nervous system responds to various external and internal constraints to develop and execute motor behavior that is efficient to accomplish a task (Charlton, 1992; Newton, 1995). External constraints are the limitations or demands imposed by the environment and the task. Internal constraints arise from the actor's characteristics, being psychological, physiological, or biomechanical (Adam, 1992). The internal and external constraints do not stand alone to explain motor control in the individual with neurological dysfunction. Rather, they interact and interrelate (Newton, 1995). Despite the emphasis of interplay between internal and external constraints to produce movements, the potential contributions of the systemic relation between these two categories of constraints in evaluation and intervention of clinical populations has been little studied (Dunn, Brown, & McGuigan, 1994). This study examined the impact of some aspects of internal and external constraints on motor performance in persons with cerebral vascular accident (CVA).

Functional goals

Among various types of external constraints, goals which represent what an individual attempts to achieve are proposed to be an important factor to affect movement performance (Jeannerod, 1994; Newell, 1986). Davis and Burton (1991) suggested that task goals interact with the environment surrounding the performer and the performer's attributes to determine the pattern of movement coordination. Reed (1982) further suggested that as the functional importance or the functional level of the task goal increases, the precision of performance or the performance of movements may enhance.

The present study attempts to examine the reaching performance using the task of drinking a can of beverage (the higher level of functional goal) and the task of bringing a can of beverage to the mouth without drinking it (the lower level of functional goal) in persons with stroke using the "unaffected" arm. The arm ipsilateral to a unilateral hemisphere stroke is often clinically described as being "unaffected," but substantial evidence indicates that ipsilateral function may be abnormal. Interventions that focus on specific motor control deficits

through practice with the ipsilesional upper extremity may result in functional improvements in both limbs and test of the ipsilesional arm will help us obtain useful information for physical rehabilitation in patients with stroke.

Personal Preferences

A further aim of this study is to examine the effects of internal constraints on movement performance. Previous research on internal constraints focused on the neurological or biomechanical factors of an individual. The psychological factors have yet to be investigated. The present study used computerized recordings such as kinematic analysis to investigate movement performance when the participant chooses the most preferred and least preferred beverage for performing the drinking task.

Movement kinematics

Kinematics describe the spatio-temporal characteristics of movement which are planned by the central nervous system (Geogopoulos, 1986). Such instrumental measures could minimize variation between examiners and participants, and add power to statistical comparisons by providing a degree of quantitative precision greater than that of rating scales. Measuring the kinematics of movement can detect whether the central nervous system organizes one movement differently from another (e.g., Mathiowetz, & Wade, 1995). Kinematic variables used to measure reaching movement in the present study include reaction time (RT), movement time (MT), total displacement (TD), the amplitude of peak velocity (PV), percentage of movement where peak velocity occurs (PPV), and the number of movement units (MU).

Hypothesis

The condition of higher functional goal with most preferred task object was hypothesized to elicit the best performance of movements and that of lower functional goal with least preferred task object the worst performance among the four conditions. The condition of higher functional goal with the least preferred object would lead to better performance relative to the condition of lower functional goal with most preferred target. The latter prediction was made based on the position that engagements in tasks directed to a goal of functional meaningfulness would considerably enhance task performance. Enhanced performance of movements would be evident on kinematic variables including shorter reaction time, shorter movement time, less total displacement, higher peak velocity, greater percentage of reach where peak velocity occurs, and less movement units.

Due to the fact that the data trends varied according to presence of neglect and side of lesion. Table 1 shows the means and standard deviations associated with some of the dependent variables and experimental conditions by types of stroke patients.

The contrast analysis was performed based on the obtained omnibus $\underline{F}$. Results of the contrast analysis testing the a priori hypotheses described earlier showed significant and large effects for reaction time and movement time for three types of stroke patients. Non-significant and small effects were found for the other dependent variables.

However, the means of reaction time and movement time for the four conditions, shown in table 1, were not fully congruent with the hypotheses. To search for a more robust theory, further exploratory analysis of the data was attempted. Table 2 summarizes the results of the post hoc contrast analysis. Large effects in favor of the new direction in the group of RCVA patients without neglect were found: for reaction time, focused $\underline{F}$ (1, 12) = 4.43, $\underline{r}$ = .72; for movement time, focused $\underline{F}$ (1, 12) = 5.72, $\underline{r}$ = .77. Results for the group of RCVA with neglect showed large effects for reaction time, focused $\underline{F}$ (1, 9) = 5.38, $\underline{r}$ = .80 ; and movement time, focused $\underline{F}$ (1, 9) = 8.18, $\underline{r}$ = .86. Results for the group of LCVA patients are as follows: reaction time, focused $\underline{F}$ (1, 24) = 7.26, $\underline{r}$ = .69; and movement time, focused $\underline{F}$ (1, 24) = 6.90, $\underline{r}$ = .68.

This study supports the idea that the external and internal constraints play a role in

movement planning and production. It shows that functional goal and personal preference have an impact on the temporal aspects of movement output. These findings suggested that subtle changes in instructions relevant to functionality of task goal and preference of the task object can lead to very different results related to reaction time and movement time.

For the groups of RCVA patients without neglect and LCVA patients, the condition of providing a preferred task with functional goal facilitated more efficient movement than the other conditions, as shown by MT. A functional task perceived as familiar might evoke efficient completion of the task movement, which can not be achieved when the goal was less functional. The conditions of higher functional goal with least preferred task and lower functional goal with most preferred task yielded the same movement time, suggesting that functionality and preference of task play equal roles in temporal control of movement. Reversed trends were found in the variable of reaction time. It seems that there is reaction time-movement time trade off when the tasks to be performed keep similar.

For the RCVA patients with neglect, the task with higher functional goal and most preferred target elicited the least reaction time and that with lower functional goal and least preferred target the most RT among four conditions. Neglect patients were defined as failure to oriented to stimuli presented to the side opposite to a brain lesion. Although the target was presented at the midline of the participant in this study, patients with neglect may be still difficult in attending to the target, which lead to slow initiation of movement. Functional goal and preferred task may provide strong motivation to attend the task, and, therefore, lead to shorter reaction time.

This report provides a detailed description of Part I of the study program and a brief sketch of the Part II study in the Chinese Abstract section. This preliminary work was motivated by the findings of Part I study and the dynamic systems theory of motor control. Continued inquiry is underway.

The unique contribution of the Part I study is to reveal the differential improvement in temporal control of reaching of various subtypes of stroke patients. The implication of this study in stroke rehabilitation is enormous. Similar treatment strategies may have different impacts on stroke patients with different symptoms. One of the undesirable characteristics of neglect patients, difficulty initiating a movement, may be reduced by use of functional goal and preferred task. In contrast, the application of functional goal and preferred task in LCVA patients and RCVA patients without neglect cannot reduce response time. Rather, they may facilitate the movement efficiency in terms of shortening time for execution.

Part II of this research program provides further insights into the interplay of internal and external constraints of task contexts. Stroke rehabilitation can be streamlined in light of the findings. Further research is needed to investigate the complexity of interplay between various constrain factors. Continued research is underway based on findings of this pilot work.

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Table 1. Means and standard deviations for the kinematic variables for each condition for patients with RCVA without neglect, RCVA with neglect, and LCVA

Kinematic variables/ conditions	Mean (standard deviation)		
	RCVA without neglect	RCVA with neglect	LCVA
Reaction time			
Condition A	0.683 (0.14)	0.564 (0.16)	0.776 (0.18)
Condition B	0.550 (0.15)	0.654 (0.17)	0.654 (0.14)
Condition C	0.587 (0.072)	0.595 (0.18)	0.657 (0.17)
Condition D	0.522 (0.12)	0.714 (0.17)	0.645 (0.17)
Movement time			
Condition A	1.511 (0.47)	1.885 (0.72)	1.295 (0.40)
Condition B	1.623 (0.36)	1.825 (0.60)	1.351 (0.37)
Condition C	1.592 (0.39)	1.686 (0.65)	1.368 (0.36)
Condition D	1.767 (0.42)	1.534 (0.46)	1.620 (0.51)

Table 2. Results of post hoc contrast analysis

Kinematic variables/ types of stroke group	Post hoc hypotheses	Effect size r
RCVA without neglect		
Reaction time	A>B=C>D	.72
Movement time	A<B=C<D	.77
RCVA with neglect		
Reaction time	A<B=C<D	.80
Movement time	A>B=C>D	.86
LCVA		
Reaction time	A>B=C>D	.69
Movement time	A<B=C<D	.68