The influence of speech on upper extremity movement in older adults

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Submitted by
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The Influence of Speech on Upper Extremity Movement in Older Adults

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Abstract

Objective: To investigate whether pre-reading an action word has a priming effect on a semantically congruent motor task in older adults and whether pre-reading the action word aloud influences the task performance differently compared to pre-reading the word silently.

Method: Twenty-eight right-handed participants between 60 and 76 years of age participated in the present study. The task involved reaching for a bottle, grasping the bottle, lifting and placing the bottle on a shelf, and returning to their starting position. At the beginning of each task the participants either read aloud or read silently a word that was displayed on a monitor in front of them. Five task-related words (reach, grasp, lift, place, and return) were randomly displayed, along with a control condition. Before each word appeared, a slide instructed the participant to read the word aloud or silently. Dependent variables were movement time and peak velocities of reaching, grasping, lifting and placing, and returning components. It was hypothesized that, a) specific segment of movement time will be shorter, and the segment peak velocity will be higher when participants concurrently read a word congruent to the meaning of the segment performance compared to movement time and peak velocity when participants do not read during movement. For example, reaching velocity will be faster and time will be shorter while reading the word “reach” and reaching for a bottle, compared to not reading while reaching for a bottle; b) specific segment of movement time will be shorter, and the segment peak velocity will be higher when participants concurrently read aloud a word congruent to the meaning of the segment performance compared to movement time and peak velocity when participants read silently a word congruent to the movement; c) grasp aperture velocity will be higher while reading the word “grasp” and grasping for a bottle, compared to not reading while grasping for the bottle; d) grasp aperture velocity will be higher when reading aloud the word.
“grasp” while grasping for a bottle, compared to silently reading the word “grasp” while grasping for a bottle.

Results: Reading a task-related word did significantly affect the reach and grasp component but not the lift and return component. Movement times were significantly shorter and reach velocity were significantly higher when the participants read the word ‘reach’ either silently or aloud (p<0.05). Likewise, grasp times were shorter and grasp velocity were higher when the participants read ‘grasp’ either silently or aloud (p<0.05). No statistically significant differences were found between the parameters of read silently and read aloud conditions.

Discussion: The results suggest that in older adults, the semantic effect of task related words were reflected in the initial movement components like reach and grasp and not on the later components of the movements like place or return. Earlier studies have found word effects on the lift components also but in younger adults. Thus, it appears that semantically congruent words like ‘return’ and ‘place’ were not influential in affecting cognitive programming of later movement components if those words were spoken early. Decline in cognitive and sensorimotor processing capacity in older adults could be a possible reason. This result further implies that in designing occupational therapy treatment with older adults, cognitive and sensorimotor decline in memory should be taken into consideration when a semantically congruent action word is considered a vehicle to influence the occupational performance.
The Influence of Speech on Upper Extremity Movement in Older Adults

Occupational therapists use occupational form to facilitate the meaning of an occupation and to encourage successful completion of an occupational performance (Nelson, 1996). Research has found that when an occupation is more meaningful to a patient, the patient’s occupational performance is more successful. Based on a person’s unique developmental structure and the occupational form, a meaning is asserted and an occupational performance is facilitated (Nelson, 1996). Meaning is an interpretative process a person engages in when encountering an occupational form. A person extracts information from the occupational form through vision, hearing, smell, kinesthesia, proprioception, or through touch (Nelson, 1996). This interpretation is generally language-based. In other words, a person assigns particular words to describe the components of the occupational form, i.e. clock, couch, coffee table, etc., or to describe actions, i.e., reaching, quickly reaching, etc.

From a neurological and motor control point of view, the central nervous system (CNS) undergoes a process of cognitive programming before performing a motor task. Recently, a series of studies described in the review of literature have found that priming of this cognitive programming is possible through the use of language/words, and the effect can be reflected in occupational performance (Gentilucci, 2000, 2003; Bates et al., 1989; Floel et al., 2003; Maitra et al., 2003).

Another line of research has shown that when a person speaks, the area of the brain that is responsible for movement (motor cortex) becomes activated at the same time (Rizzolatti and Arbib 1998; Binkofski et al, 1999). Thus, the first set of studies (Gentilucci, 2000, 2003; Bates et al., 1989; Floel et al., 2003; Maitra et al., 2003) showing that language can be used to change properties of an occupational form and the second set of studies demonstrating that speech can
Influence of Speech lead to an important question: is it possible to use speech and language to alter contextual properties and to influence performance?

Review of Literature

Behavioral studies have found that reading meaningful action words influences movement, and that comprehension skills are more accurate when speech and gesture agree (Gentilucci, 2003; Bates et al., 1989), thus showing a relationship between speech comprehension and movement. Gentilucci (2003) applied the idea of using words to influence movement when he presented participants with a target object (white parallelepiped) marked with a word or a non-word on the front visible to the participant. The words used were either adjectives (“high”, or “lateral”) or verbs (“place” or “lift”). The participants were instructed to reach out and grab the object, and move it to the opposite side of the table as fast as they could without compromising accuracy. For the reach component, peak velocity was significantly increased when the word “place” was presented on the target, in comparison with “lift” or the non-word. The participants’ arm movements showed a facilitatory effect in the lifting component when the word “lift” was printed on the target in comparison to the word “place” and the non-word, while no effect was found for adjectives or nonsense words. This was evidenced by an increase vertical peak velocity and maximal height when the word “lift” was printed on the target.

Furthermore, automatic reading of words related to target properties has been found to affect control of reaching-grasping movement. Gentilucci, Benuzzi, Bertolani, Daprati, and Gangitano (2000), had participants reach and grasp a white, wooden, parallelepiped with one of six words on them: “near”, “far”, “small”, “large”, “high”, or “low”. It was found that participants automatically associated the printed word’s meaning with the object, and they
developed a motor program for reaching and grasping based on that word. For example, in the reach component, participants’ arm peak acceleration and arm peak velocity were higher for the object with the word “far” printed on it compared to the object with the word “near” printed on it (Gentilucci et al., 2000). Thus, research has shown that a relationship between language and motor-planning exists. Words can be used to interpret and extract information from the occupational form, which can affect the motor planning and the occupational performance.

A recent study recorded the activity of the hand area of the cortex using transcranial magnetic stimulation, while participants were asked to read aloud a paragraph from a physiology textbook, read silently a paragraph from a physiology textbook, speak spontaneously, and produce phonemes (‘lala’). It was discovered that speech production as well as speech perception activates the hand motor cortex (Floel et al., 2003).

A number of brain-imaging studies have shown that there is a link between the different parts of the brain that involve speech production, speech comprehension, and hand movement. In fMRI studies done on monkeys, the area of the brain that correlates to human’s area of speech production (Broca’s area) showed activation both when the monkey grasped or manipulated objects and observed the experimenter making similar actions (Rizzolatti and Arbib 1998). In a fMRI study done on humans, it was found that activations of the main speech area occurred during manipulation of complex three-dimensional objects (Binkofski et al, 1999), further suggesting a relationship between movement and speech.

Bates, Thal, Fenson, Whitesell, and Oakes (1989) investigated early language development in children ages 13-15 months. In this study, the experimenters used a wooden block as a placeholder for a particular object (e.g., for the phone gesture, the block was tilted to the ear to simulate a receiver). Each of the nine gestures was modeled in one of three language...
support conditions: supportive, neutral, or contradictory. In the supportive condition, the experimenters referred to the object supported by the gesture, “Look! This is a cup!”. For the neutral condition, the experimenter made a non-specific comment, “Look! Watch this!”, and in the contradictory condition, the experimenter misnamed the object by saying, “Look! This is a shoe!”, while modeling the phone gesture. Results showed that children were more likely to imitate a familiar gesture using a wooden block if it was modeled, with the experimenter calling it by its correct name, versus incorrect, or no name at all. This demonstrates that there is a link between language and gestural movement, even in the early stages of language development.

McNeil et al., (2000), examined how gesture influenced language comprehension of preschool and kindergarten children, specifically if the role of gesture depends on the complexity of a message. The children played a communication game in which they were asked to find specific blocks from a stack of blocks. In the first part of the game, participants were asked to find specific blocks with animal pictures on them. The second part involved the participants selecting blocks with specific features on them, such as a smile face in the center of the block, with a rectangle on one side and an arrow on the other side of the smile face. The rectangle was positioned either above or below the face, and the arrow was at the right of the smile face, pointing up or down. Children selected six blocks according to the instructions. On each trial, the experimenter used a reinforcing gesture (e.g., saying “up” while gesturing up), no gesture at all while saying the word, or used a conflicting gesture (e.g., saying “up” while pointing down). It was found that in younger children, the spoken messages were more complex and the reinforcing gestures facilitated speech comprehension, while conflicting gestures did not. For older children, the reinforcing gestures did not influence comprehension,
but the conflicting gestures hindered comprehension. It was concluded that speech and gesture can be used to facilitate complex messages. Since both speech and gestures are involved during complex messages, combining the two could be effective in facilitating the learning of new information.

Maitra, et al. (2003) compared the effect of vocalization on a daily motor task. In this study, participants reached for a cup and placed it on a shelf during four conditions: no vocalization, synchronized self-vocalization, external (experimenter) vocalization, and imagery vocalization. The results showed that movements made during the self or external vocalization conditions were faster and smoother, which demonstrates that speech production (vocalization) does effect motor performance.

What is most effective to facilitate an occupational performance: speech comprehension alone with motor movement, speech production alone with motor movement, or speech production along with simultaneous speech comprehension with motor movement? The aim of the present study is to investigate these questions further in the older adult population. The older adult population was chosen because its numbers are rising, and occupational therapists will likely see their older adult patient load increase as well. Also, as a person ages, there is a predictable decline in cognitive, physical, sensory, and psychosocial performance (Chodzko-Zajko, 2001). Thus, the functional capacity of a person is usually slower and less precise as age increases. The aging body exhibits reduced strength, stability, and coordination resulting in a decline of occupational performance (Chodzko-Zajko, 2001). A decrease in cognitive ability can affect memory, attention, and central information processing (Ekelman, Mitchell, & O’Dell-Rossi, 2001). The natural decline in cognitive function makes it hard for an older adult
to plan and program occupational performance. Thus, it would be beneficial to find a way to enhance cognitive ability in order to facilitate occupational performance in older adults.

Once an effect of language and movement is found in a healthy sample of older adults, then further studies can be done in older adult patients who need rehabilitation due to some loss of function. Using meaningful language could prove useful in teaching patients new techniques in therapy. OT treatment is often a teaching-learning process (Mosey, 1986) in which the therapist teaches the patient to adapt and re-learn lost abilities (remediation), attain abilities that they never had before (developmental promotion), and to compensate for “intractable problems” (Nelson, 1996).

The purpose of the present study is two-fold: a) To investigate if reading a printed task-related word while performing the task influences the performance in older adults; b) Whether reading the task-related word aloud influences the performance differently than performing the task while reading the word silently in older adults.

To explore these issues discussed, the following hypotheses were formulated: a) In a sequential reaching-placing task, a specific segment of movement time will be shorter, and the segment peak velocity will be higher when participants concurrently read a word congruent to the meaning of the segment performance compared to movement time and peak velocity when participants do not read during movement. For example, reaching velocity will be faster and time will be shorter while reading the word “REACH” and reaching for a bottle, compared to not reading while reaching for a bottle; b) In a sequential reaching-placing task, a specific segment of movement time will be shorter, and the segment peak velocity will be higher when participants concurrently read aloud a word congruent to the meaning of the segment performance compared to movement time and peak velocity when participants read silently a
word congruent to the movement; c) In a sequential reaching-placing task, grasp aperture velocity will be higher while reading the word “GRASP” and grasping for a bottle, compared to not reading while grasping for the bottle; d) In a sequential reaching-placing task, grasp aperture velocity will be higher when reading aloud the word “GRASP” while grasping for a bottle, compared to silently reading the word “GRASP” while grasping for a bottle.

Method

Participants

Twenty-eight healthy older adults without disability, (eight males, 20 females) with ages ranging from 60-81 were voluntarily recruited in the present study from the local area. Inclusion criteria consisted of participants’ report that they had 20/20 vision with or without corrective lenses, were functionally independent, had no history of neurological or orthopedic conditions, and were at least 60 years old. Prior to recruitment and experimentation, the study received approval from the Medical College of Ohio- Institutional Review Board for human participant research. Each participant signed an informed consent form prior to participation. All participants were right handed according to self-report and were blind about the experimental hypotheses.

Task and Apparatus

All tests were performed in the Medical University of Ohio motor control laboratory of the occupational therapy department. This laboratory was located in the basement of the Collier Building. The laboratory staging area included a table, a chair for the participants, a coaster, a bottle, a shelf, and a red disc switch (DS). A laptop monitor was placed in front of the participant. Figures 1 & 2 depict the experimental set up.
A 3-D movement recording system based on infrared technology (Qualisys Version 3.0) was used to record arm, hand, and finger movements. The system used four cameras to read and detect infrared reflecting motion sensors at the sample rate of 120 Hz.

Seven motion markers were used in the present series of experiments. The first and second motion markers were placed on the base of the nail of the right thumb and index fingers respectively to monitor grasp; the third motion marker was placed on the second metacarpal bone of the right wrist 3 cm. proximal of the proximal interphalangeal (PIP) joint of the index finger to monitor wrist movement; the fourth motion marker was placed approximately 1 cm. proximal to the wrist on the right radial side of the forearm to monitor distal reach, and the fifth motion marker was placed on the right upper arm, approximately five cm proximal to the elbow joint to monitor upper extremity movement. A sixth motion marker was placed on the acromioclavicular joint to monitor shoulder stability during the action. The seventh marker was placed on the top of the bottle to track the bottle movement. For the purpose of the present study the movement of the wrist motion sensor was used to analyze the transport of hand actions during reach, lift, and return movements. The movements of the index and thumb motion markers were used to analyze the grasp. Other sensors were used to monitor stability of the hand-arm system and to isolate any confounding movements.

The participants were seated on a chair in front of a table, with their hips and knees placed in 90 degrees of flexion, and their trunks in neutral position. In their initial starting position (DS-SP) they placed their thumb and index finger in a pinch position on the middle of the DS located on the mid-saggital plane of the table. The middle of the DS to the table edge measured approximately 4 cm. A bottle filled with water measuring a circumference of 5.1 cm,
and weighing .3 kg was placed on a coaster. The bottle while resting on the coaster was approximately 12 cm from DS-SP.

An 11.7 cm high shelf was placed at a 30 degree elevation and 13.2 cm left from the coaster. These distances were modeled after Gentilucci et al. (1997). In pilot experiments we found that participants could perform the comfortably with the hand and arm without leaning forward during pilot experiments.

Five task-related words were randomly displayed on the laptop monitor, along with a control condition. Before each word appeared, there was a slide instructing the participant to read the word either aloud or silently. The control condition consisted of a white screen with a solid black box in the middle. There was a total of 11 conditions: a) read silently “reach”; b) read aloud “reach”; c) read silently “grasp”; d) read aloud “grasp”; e) read silently “lift”; f) read aloud “lift”; g) read silently “place”; h) read aloud “place”; i) read silently “return”; j) read aloud “return”; k) control. A custom-made computer generated randomization was used. Each participant had a unique counterbalanced randomization design of the 11 conditions. All conditions were performed three times, for a total of 33 times.

**Procedure**

Participants used their right arm and hand to perform the reaching-grasping task. Their left arm remained in their lap. The lights of the room were dimmed. After instructions were given to the participant, he or she was given one practice trial of each condition using the word “HI”, for a total of three practice trials. Participants were required to reach and grasp the bottle with their thumb and index finger and then lift, transport, place it on the shelf, and then return their hand to the DS-SP at their natural speed. On the computer monitor, the task-related word was displayed until the participant completed the movement.
Data Processing and Analysis

The marker data were digitized at a rate of 120 Hz, using the Qualisys Track Manager (QTM Version 3.0) motion capture system. This system has been found to be reliable and accurate for motion capture measurements within 1 mm. During acquisition, QTM took real time 2D camera information and processed and converted it into 3D using advanced algorithms. During the experiment the data was stored for off-line analysis with Visual 3D Origin analytical software Ver. 7.0 (OriginLab Corporation, One Roundhouse Plaza, Northampton, MA 01060).

The movement data was filtered by a custom routine build by the Visual 3D software (C-motion Analysis, Inc., 15821-A Crabbs Branch Way, Rockville, MD 20855). The routine was used to filter the data using a second-order Butterworth filter with forward and backward passes at a low-pas cutoff frequency of 6 Hz.

The movement data was digitally differentiated to obtain movement velocity profile. From the velocity data, each movement was divided and extracted into 3 segments: an initial reach segment, a middle lift and place segment, and a final return segment. Transverse (X), forward (Y), and upward (Z) movement components from each of these 3 segments were extracted. The start and stop of each segment was defined from the magnitude of the resolved vector of the movement. The resolved vector produced three defined velocity peaks for the three segments. From these 3 velocity profile, the start and stop of a segment is defined as the velocity of a segment exceeded and decreased to 4 mm/s. The velocity of the wrist was taken as criterion velocity to define the start and stop of a segment because in pilot analysis wrist
velocity was found to be maximal consistent to apply the custom routine. In case of missing data, a linear spline in the Qualisys program was applied to interpolate the missing data up to 10 points. Only 5% of analysed thumb data required interpolation. Other sensors data did not require interpolation. Trials with missing data of more than 10 points in the thumb data were not analyzed.

Once the X, Y, and Z components of the reach, lift/place, and return segments were isolated, peak velocities of each component were extracted for kinematic comparisons. The time required to reach, lift/place, and return was calculated by subtracting stop time from start time of each segments. For the present study, the dependent variables were each segment time and the principal components of velocities of each segment.

For the reach phase, the components were Y (forward movement), and Z (upward movement). For the lift phase, X (horizontal movement) and Z (upward movement was analyzed. In the return phase the X (horizontal movement), Y (forward movement), and Z (upward movement) were analyzed. The grip aperture phase was studied through the following kinematic parameters: maximal grasp aperture, and time to reach maximal grasp aperture.

A one-way repeated measure analysis of variance (ANOVA) was used to test the significance of kinematic parameters between the 11 levels of speech/language conditions to test hypotheses a) and b). Pairwise comparisons following significant findings from the ANOVA were performed to test hypotheses c) and d). Additionally, standard time series analysis of different components of reach and grasp action was performed to examine the performance.
Results

Reach component

Table 1 shows the effect of the ten task-related words and the control (non-word condition) on the mean values of reach movement time and peak velocity parameters. One way ANOVA results showed a significant effect of speech factors on reach time, and forward peak velocity components [PV (Y)]. Post hoc pair wise comparison revealed that compared to the control (no speech condition), time taken to complete reach component (reach time) was significantly decreased in the condition where the participants either read aloud or read silently the word ‘reach’ presented on the monitor (Table 1). Likewise, reach time also decreased significantly in the read silently condition of the word ‘return’ compared to the control condition. In addition, compared to the control, forward components of peak velocity significantly increased in conditions where the participants read aloud or silently read the word ‘reach’ presented on the monitor. Kinematic parameters in other speech conditions were not significantly different compared to control. There was no significant difference between the read aloud and read silently conditions of the word ‘reach’.

Lift/place component

Table 2 shows the effect of the ten task-related words and the control (non-word condition) on the mean values of lift time and peak velocity for the lift/place component. One way ANOVA results showed no significant effect of speech factors on lift/place time, lateral peak velocity components, or upward peak velocity components [Z]. There was also no significant difference between the read aloud and read silently conditions of the words ‘lift’ or ‘place’.
Return component

Table 3 shows the effect of the ten task-related words and the control (non-word condition) on the mean values of return time and peak velocity for the return component. One way ANOVA results showed no significant effect of speech factors on return time, lateral peak velocity components [PV X], forward peak velocity components [PV Y], or upward peak velocity components [Z]. There was no significant difference between the read aloud and read silently conditions of the word ‘return’.

Grasp Component

Table 4 shows the effect of the ten task-related words and the control (non-word condition) on the mean max grasp aperture, peak velocity of grasp, and grasp time of the grasp component. One way ANOVA results showed a significant effect of speech factors on maximum grasp time, and lateral peak velocity components [PV X]. Post hoc pair wise comparisons revealed that compared to the control (no speech condition), read silently word conditions ‘reach’, ‘place’, ‘return’, and ‘grasp’ and read aloud condition of the words ‘lift’, ‘place’, and ‘return’, produced significantly higher peak velocity compared to the no-word control condition. Additionally, post hoc pairwise comparisons discovered that compared to the control condition, the maximum grasp time was significantly decreased when the following words were read both silently and aloud: ‘reach’, ‘lift’, ‘place’, ‘return’, and ‘grasp’. There was no significant difference found between the read silently and read aloud conditions of the word ‘grasp’.

Discussion

The purpose of the present study was two fold: first, whether specific performance related words when read aloud or silently could influence that specific performance and second,
if there is a presence of word related influence on performance, whether reading aloud the word influences differently than reading silently the words in a sample of older adults. Based on these two purposes, first two hypotheses addressed the transport components (reach, place, return) and the third and fourth hypotheses addressed the grasp components of a reach-grasp task. Our first hypotheses is partially supported in that only the reaching component became efficient in terms of shorter movement time and higher forward velocity when the participants read the action congruent word ‘reach’. Lift/place components or return components were not affected by action congruent words ‘lift’ or ‘return’ respectively. Additionally, our second hypothesis was not supported in that there were no significant differences between movement parameters of reading aloud or reading silently conditions in influencing the action. Similar results were obtained in the grasp components. Grasp velocity became faster and grasp time became shorter with the word ‘grasp’ supporting our third hypothesis. However, like the transport phase, the reading aloud condition did not influence grasp differently than the read silently condition.

As discussed in the introductory section of this paper, past studies have shown that a word printed on a target can influence the movement towards the target (Gentilucci et al, 1997; Gentilucci & Gangitano, 1998; Gentilucci, 2003). The results of the present study in many ways support the findings of Gentilucci (2003). However, Gentilucci (2003) found that word can influence also the later section of the movement. For example, he found silently reading the word “lift” affected the lift portion of the movement in young adults. In our experiments with older adults, the effect of word reading was not evident after the reach and grasp components.
Gibson (1979) in his ecological theory of visual perception noted that objects found in the visual context may activate motor tendencies relevant to their use (Jeannerod, 1994). Glover et al. (2004) argued that a contextually relevant word in the visual scene was also capable of generating these motor tendencies by affecting the motor planning of the movement towards the object. Glover et al. (2004) called this the semantic effect of movement. Interestingly, Glover et al (2004) found in their experiments that the semantic effect diminishes as the movement progresses. Therefore, they proposed the planning mechanism and the on-line control mechanisms of movements are probably governed by a separate set of inputs. Keeping this argument in mind, it might be possible that in older adults, the words relevant to generate a motor tendency for a later section of the movement possibly became ineffective because of slow input processing in older adults coupled within diminishing word effect for the later part of movement (Light, 1990; Glover, et al., 2004).

As suggested by others, interference of motor planning with the semantics of word may be explained by motor affordances posited by Gibson (Gibson, 1979; Gentilucci, 2003; Glover & Dixon, 2003). It might be possible that the action or verb words used in the present study generated motor tendencies that were similar to the motor plan generated for the action. For example, the word ‘reach’ or ‘grasp’ generated motor tendencies for reaching and grasping, respectively, that coincided with the planned reaching and grasping movement and thereby making them more efficient and faster. If this is true, then arguably, anything that is relevant to the action might generate the motor tendencies, for example sound, picture, smells etc. In this way, this concept is very much similar to the concept of ‘meaning’ in occupational therapy. Thus, any object in the visual scene that elicits ‘meaning’ towards an occupational performance, in actuality, elicits a motor tendency relevant to the use of that object.
As stated in the ‘introduction’ section, it is of interest that the language and motor planning centers are situated in close proximity in the brain, strongly lateralized to the left hemisphere (Kolb & Whishaw, 1995). Broca’s area, which is active during word reading (Price et al., 1994) and during action planning (Grafton et al., 1998) were theorized to be an offshoot of motor cortex (Rizzolati & Arbib, 1998). Thus there is an additional argument that motor areas and language areas are overlapping and a strong motor influence might be possible by activating motor tendencies via language (Damasio & Damasio, 1989). However, we did not find any differences in movement parameters between reading the word silently and reading the word loudly. It might be possible that Broca’s area is equally active in both reading and therefore, in terms of strength of generating the motor tendencies, the activation produced similar strength of motor tendencies in both cases. Therefore, considering these points, the present study reveals it is a possibility that the motor planning of an action is susceptible to changes or interferences from cognitive and perceptual variables like word reading and therapeutic use of this language interference in movement rehabilitation. Additionally, in older adults due to decline in sensory perceptual capability, the influence of word might be noticeable only in the initial part of the movement performance. Thus to influence the whole performance in older adults, additional sensory perceptual input might be considered.

**Implications for Occupational Therapy**

This study demonstrated that reading task-related words can positively affect the task performance. Occupational therapists could use this knowledge to enhance the treatment sessions of individuals by incorporating meaningful language. Thus, speech and language can be utilized to adapt for the normal decline in function that older adults naturally experience. Also, future studies can be done in older adults who need movement rehabilitation to
investigate the implications of using meaningful words during treatment. Furthermore, this knowledge that reading task-related words can affect performance of the task could prove useful in teaching patients new techniques in therapy, and it also could be effective in speech/occupational therapy co-treatment of a patient through using speech to enhance motor performance.

**Limitation**

As usual, the present study suffers from limitations of a study that was conducted in a laboratory environment rather than in a naturalistic environment. Thus a naturalistic environment would be more meaningful. In future studies, the sample size could be increased to investigate if a larger number of participants would create a significant difference between reading silently and reading aloud. A larger sample size will also increase the validity of the study. The other limitation of this study is that the experiments were conducted throughout different times of the day, based on the availability of the participants. Also, there is indirect evidence on motor planning. Since the study did not measure fMRI or PET studies, the inference on the motor planning was drawn from behavioral results. Furthermore, the generalizability of the results to all populations across all ethnicities and geographical locations cannot be made, since the subject pool is localized to a small, particular geographical area that is homogenously populated.

**Recommendations for future research**

The present study demonstrates that action word related to action could be used to prime the action. Occupational therapy is a ‘doing’ profession which is heavily based on the concept of meaning. The present research open the doors for various possibilities to establish treatment strategies for persons requiring movement priming as a result of old age or
Influence of Speech

disabilities. At the same time, it is important that the present is extended to explore various related questions that stem from this research. These are:

a) Whether a priming effect exists when the action word is embedded in sentence. For example, it is important to find out whether ‘reach for the cup’ or ‘reach for the book’ will have the same effect on the performance.

b) Whether a ‘psuedoword’ like ‘freach’ or ‘treach’ will have similar priming effect like ‘reach’.

c) Whether a priming effect of general action words like ‘view’ or ‘wake’ is possible on motor performance.

d) Whether the priming effect of word on action is possible with persons suffering from degenerative diseases like Parkinson disease.

Therefore, present research opens a number of other possibilities which need to confirmed by further research to establish a rehabilitative strategy involving language and action.

Conclusion

The results of the present study suggest that words relevant to an upcoming motor performance if present in the visual scene of the performer can interfere with the performance. For example, when the person silently or loudly read the visually presented word ‘reach’, the reaching movement became faster and the reaching velocity became higher. However, when the person reads ‘return’, the reading did not interfere with the return performance which was the end performance of a long movement sequence. Thus, it might be concluded that since the subject population was older adults, the semantic interference only affects the initial movement sequence and the semantic interference decline as the movement proceeds due to diminished
sensory perceptual processing capabilities in the older adults. Thus, it would be interesting to see whether the semantic interference effect is present throughout the movement in a population of young adults. Therapeutically, this result holds significance in that occupational therapists can use performance relevant, semantically congruent words to increase the meaning of occupational performance to the client.
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References


Table 1
Means, Standard Deviation, and ANOVA Results for REACH Components Separated by SPEECH factors

<table>
<thead>
<tr>
<th></th>
<th>REACH TIME (sec)</th>
<th>PV (Y) (m/s)</th>
<th>PV (Z) (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL (a)</td>
<td>0.911 (0.309)</td>
<td>1.058 (.249)</td>
<td>0.622(0.180)</td>
</tr>
<tr>
<td>RS_REACH (b)</td>
<td>0.771 (0.108)*</td>
<td>1.223 (0.243)*</td>
<td>0.610 (0.176)</td>
</tr>
<tr>
<td>RA_REACH (c)</td>
<td>0.758 (0.129)*</td>
<td>1.289 (0.290)*</td>
<td>0.630 (0.208)</td>
</tr>
<tr>
<td>RS_LIFT (d)</td>
<td>0.841 (0.103)</td>
<td>1.059 (0.168)</td>
<td>0.627 (0.142)</td>
</tr>
<tr>
<td>RA_LIFT (e)</td>
<td>0.884 (0.261)</td>
<td>1.070 (0.197)</td>
<td>0.660 (0.219)</td>
</tr>
<tr>
<td>RS_PLACE (f)</td>
<td>0.852 (0.256)</td>
<td>1.023 (0.199)</td>
<td>0.618 (0.175)</td>
</tr>
<tr>
<td>RA_PLACE (g)</td>
<td>0.834 (0.097)</td>
<td>1.045 (0.211)</td>
<td>0.653 (0.223)</td>
</tr>
<tr>
<td>RS_RETURN (h)</td>
<td>0.789 (0.108)*</td>
<td>1.048 (0.169)</td>
<td>0.647 (0.191)</td>
</tr>
<tr>
<td>RA_RETURN (i)</td>
<td>0.807 (0.123)</td>
<td>1.038 (0.184)</td>
<td>0.640 (0.205)</td>
</tr>
<tr>
<td>RS_GRASP (j)</td>
<td>0.835 (0.123)</td>
<td>1.065 (0.159)</td>
<td>0.623 (0.191)</td>
</tr>
<tr>
<td>RA_GRASP (k)</td>
<td>0.807 (0.139)</td>
<td>1.019 (0.215)</td>
<td>0.615 (0.208)</td>
</tr>
<tr>
<td>(F(r))</td>
<td>2.464 (0.084)</td>
<td>14.00 (0.341)</td>
<td>1.033 (0.037)</td>
</tr>
<tr>
<td>(P)</td>
<td>.008*</td>
<td>.0001*</td>
<td>.416</td>
</tr>
</tbody>
</table>

Note: \(df=(10, 270)\). (\* denotes significance). In pairwise comparisons means within columns are significantly different from CONTROL at least \(p \leq .05\). Standard Deviations appear in parenthesis beside means. Control = no speech condition, RS_ = read silently condition, RA_ = read aloud condition. \(r\) = effect size. Lift/Place Time = time taken to complete lift/place component, PV (X) = Peak place velocity in a lateral direction; PV (Z) = Peak lift velocity in upward direction.
<table>
<thead>
<tr>
<th>SPEECH factors</th>
<th>LIFT TIME (sec)</th>
<th>PV (X) (m/s)</th>
<th>PV (Z) (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL (a)</td>
<td>1.015 (0.190)</td>
<td>-1.111 (1.53)</td>
<td>1.078 (0.142)</td>
</tr>
<tr>
<td>RS_REACH (b)</td>
<td>1.045 (0.223)</td>
<td>-1.086 (0.171)</td>
<td>1.061 (0.142)</td>
</tr>
<tr>
<td>RA_REACH (c)</td>
<td>1.032 (0.188)</td>
<td>-1.093 (0.159)</td>
<td>1.093 (0.131)</td>
</tr>
<tr>
<td>RS_LIFT (d)</td>
<td>1.017 (0.139)</td>
<td>-1.091 (0.146)</td>
<td>1.069 (0.115)</td>
</tr>
<tr>
<td>RA_LIFT (e)</td>
<td>1.002 (0.207)</td>
<td>-1.104 (0.143)</td>
<td>1.094 (0.152)</td>
</tr>
<tr>
<td>RS_PLACE (f)</td>
<td>1.050 (0.204)</td>
<td>-1.084 (0.146)</td>
<td>1.080 (0.148)</td>
</tr>
<tr>
<td>RA_PLACE (g)</td>
<td>1.050 (0.199)</td>
<td>-1.103 (0.161)</td>
<td>1.094 (0.146)</td>
</tr>
<tr>
<td>RS_RETURN (h)</td>
<td>1.021 (0.169)</td>
<td>-1.092 (0.147)</td>
<td>1.067 (0.141)</td>
</tr>
<tr>
<td>RA_RETURN (i)</td>
<td>1.053 (0.172)</td>
<td>-1.078 (0.153)</td>
<td>1.086 (0.135)</td>
</tr>
<tr>
<td>RS_GRASP (j)</td>
<td>1.046 (0.191)</td>
<td>-1.072 (0.150)</td>
<td>1.054 (0.120)</td>
</tr>
<tr>
<td>RA_GRASP (k)</td>
<td>1.032 (0.189)</td>
<td>-1.114 (0.150)</td>
<td>1.099 (0.156)</td>
</tr>
</tbody>
</table>

| F (r)           | 0.813 (0.029)  | 0.888 (0.032)| 1.543 (0.054)|
| F (r)           | 0.616          | 0.545        | 0.124        |

Note: df = (10, 270). (*) denotes significance. In pairwise comparisons means within columns are significantly different from CONTROL at least p ≤ .05. Standard Deviations appear in parenthesis beside means. Control = no speech condition, RS_ = read silently condition, RA_ = read aloud condition. r = effect size. Lift/Place Time = time taken to complete lift/place component, PV (X) = Peak place velocity in a lateral direction; PV (Z) = Peak lift velocity in upward direction.
Table 3
Means, Standard Deviation, and ANOVA Results for RETURN Components Separated by SPEECH factors

<table>
<thead>
<tr>
<th></th>
<th>TIME (sec)</th>
<th>PV (X) (m/s)</th>
<th>PV (Y) (m/s)</th>
<th>PV (Z) (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL</td>
<td>1.048 (0.190)</td>
<td>1.257 (0.169)</td>
<td>-1.255 (0.219)</td>
<td>-1/038 (0.250)</td>
</tr>
<tr>
<td>RS_REACH</td>
<td>1.123 (0.191)</td>
<td>1.242 (0.149)</td>
<td>-1.254 (0.208)</td>
<td>-1.032 (0.220)</td>
</tr>
<tr>
<td>RA_REACH</td>
<td>1.120 (0.225)</td>
<td>1.287 (0.179)</td>
<td>-1.243 (0.217)</td>
<td>-1.055 (0.236)</td>
</tr>
<tr>
<td>RS_LIFT</td>
<td>1.113 (0.214)</td>
<td>1.240 (0.159)</td>
<td>-1.197 (0.193)</td>
<td>-1.037 (0.230)</td>
</tr>
<tr>
<td>RA_LIFT</td>
<td>1.077 (0.195)</td>
<td>1.219 (0.248)</td>
<td>-1.216 (0.270)</td>
<td>-0.993 (0.283)</td>
</tr>
<tr>
<td>RS_PLACE</td>
<td>1.089 (0.185)</td>
<td>1.214 (0.188)</td>
<td>-1.189 (0.165)</td>
<td>-0.992 (0.223)</td>
</tr>
<tr>
<td>RA_PLACE</td>
<td>1.099 (0.190)</td>
<td>1.240 (0.186)</td>
<td>-1.203 (0.209)</td>
<td>-1.013 (0.233)</td>
</tr>
<tr>
<td>RS_RETURN</td>
<td>1.092 (0.176)</td>
<td>1.285 (0.177)</td>
<td>-1.241 (0.188)</td>
<td>-1.035 (0.258)</td>
</tr>
<tr>
<td>RA_RETURN</td>
<td>1.100 (0.152)</td>
<td>1.245 (0.234)</td>
<td>-1.213 (0.236)</td>
<td>-1.047 (0.273)</td>
</tr>
<tr>
<td>RS_GRASP</td>
<td>1.119 (0.224)</td>
<td>1.236 (0.241)</td>
<td>-1.231 (0.223)</td>
<td>-0.978 (0.286)</td>
</tr>
<tr>
<td>RA_GRASP</td>
<td>1.096 (0.211)</td>
<td>1.266 (0.242)</td>
<td>-1.259 (0.230)</td>
<td>-1.047 (0.249)</td>
</tr>
</tbody>
</table>

\(F(6, 270)\) 1.005 (0.036) 0.862 (0.031) 0.952 (0.035) 0.861 (0.031)

\(P\) 0.439 0.569 0.486 0.570

Note: df=(10, 270). (*) denotes significance. In pairwise comparisons means within columns are significantly different from CONTROL at least p < .05. Standard Deviations appear in parenthesis beside means. Control = no speech condition, RS_ = read silently condition, RA_ = read aloud condition. r = effect size. Lift/Place Time = time taken to complete lift/place component, PV (X) = Peak place velocity in a lateral direction; PV (Z) = Peak lift velocity in upward direction.
Table 4
Means, Standard Deviation, and ANOVA Results for GRASP Components Separated by SPEECH factors

<table>
<thead>
<tr>
<th></th>
<th>MAX GRASP APERTURE (m/s)</th>
<th>PV (X) (m/s)</th>
<th>MAX GRASP TIME (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONTROL (a)</td>
<td>0.183 (0.054)</td>
<td>0.885 (0.266)</td>
<td>0.513 (0.119)</td>
</tr>
<tr>
<td>RS_REACH (b)</td>
<td>0.189 (0.038)</td>
<td>0.947 (0.271)*</td>
<td>0.435 (0.118)*</td>
</tr>
<tr>
<td>RA_REACH (c)</td>
<td>0.191 (0.034)</td>
<td>0.932 (0.319)</td>
<td>0.478 (0.139)</td>
</tr>
<tr>
<td>RS_LIFT (d)</td>
<td>0.198 (0.032)</td>
<td>0.956 (0.242)</td>
<td>0.462 (0.151)*</td>
</tr>
<tr>
<td>RA_LIFT (e)</td>
<td>0.201 (0.032)</td>
<td>0.996 (0.302)*</td>
<td>0.478 (0.125)</td>
</tr>
<tr>
<td>RS_PLACE (f)</td>
<td>0.192 (0.038)</td>
<td>0.988 (0.277)*</td>
<td>0.443 (0.120)*</td>
</tr>
<tr>
<td>RA_PLACE (g)</td>
<td>0.192 (0.033)</td>
<td>0.952 (0.274)*</td>
<td>0.451 (0.109)*</td>
</tr>
<tr>
<td>RS_RETURN (h)</td>
<td>0.194 (0.039)</td>
<td>1.020 (0.331)*</td>
<td>0.435 (0.115)*</td>
</tr>
<tr>
<td>RA_RETURN (i)</td>
<td>0.191 (0.043)</td>
<td>0.992 (0.338)*</td>
<td>0.448 (0.123)*</td>
</tr>
<tr>
<td>RS_GRASP (j)</td>
<td>0.200 (0.034)</td>
<td>1.024 (0.271)*</td>
<td>0.472 (0.102)*</td>
</tr>
<tr>
<td>RA_GRASP (k)</td>
<td>0.186 (0.044)</td>
<td>0.944 (0.295)</td>
<td>0.440 (0.115)*</td>
</tr>
<tr>
<td>F (r)</td>
<td>1.562 (0.055)</td>
<td>2.722 (0.092)</td>
<td>3.111 (0.103)</td>
</tr>
<tr>
<td>P</td>
<td>.118</td>
<td><strong>0.003</strong></td>
<td><strong>0.001</strong></td>
</tr>
</tbody>
</table>

Note: df=(10, 270). (* denotes significance). In pairwise comparisons means within columns are significantly different from CONTROL at least p \leq .05. Standard Deviations appear in parenthesis beside means. Control = no speech condition, RS_ = read silently condition, RA_ = read aloud condition. r = effect size. Lift/Place Time = time taken to complete lift/place component, PV (X) = Peak place velocity in a lateral direction; PV (Z) = Peak lift velocity in upward direction.
*Figure 1.* Picture of the experimental set-up, depicting the bottle, DS, laptop with a sample task-related word displayed on the screen, and shelf.
Figure 2. Side view depicting the lift/place component of the performance. The microphone headset, bottle, DS, laptop, shelf, motion sensors are in view.