EFFECTIVENESS OF MOVEMENT-BASED ACTION OBSERVATION THERAPY HOME EXERCISE PROGRAM IN TERMS OF IMPROVING UPPER EXTREMITY FUNCTION AMONG INDIVIDUALS WITH CHRONIC STROKE

Korrine Claire L. Alviar
University of Perpetual Help-Dr. Jose G. Tamayo Medical University
PHILIPPINES
alviar.kcl@gmail.com

Kenneth Bryan A. Facun
University of Perpetual Help-Dr. Jose G. Tamayo Medical University
PHILIPPINES
kennethfacun12@gmail.com

Norelle Geyll G. Jaranilla
University of Perpetual Help-Dr. Jose G. Tamayo Medical University
PHILIPPINES
norellegeyllj@gmail.com

Eds Joshua M. Pacomo
University of Perpetual Help-Dr. Jose G. Tamayo Medical University
PHILIPPINES
JoshuaPacomo123@yahoo.com

Lean Therese H. Samson
University of Perpetual Help-Dr. Jose G. Tamayo Medical University
PHILIPPINES
leansamson19@gmail.com

Gerardo M. Buhay, PTRP, MaEd
University of Perpetual Help-Dr. Jose G. Tamayo Medical University
PHILIPPINES
Buhay.gerardo@uphsl.edu.ph

ABSTRACT

Action observation therapy is one of the most recent interventions established that has a huge potential specially in terms of improving upper extremity function in stroke patients. Because the ease of application and feasibility, this intervention could be an effective intervention of stroke in the home setting. However, there is still a huge need to attest the applicability of the intervention in specific situations, including the phase of stroke. Aside from this, there are limited studies in terms of investigating the effectiveness of a movement-based action observation therapy home exercise program in improving upper extremity function of post-stroke individuals. The aim of the study is to determine the effectiveness of movement-based action observation therapy as a home exercise program in improving upper extremity function among chronic stroke individuals. A single-group pretest-posttest design has been used of which thirteen (13) participants with chronic stroke were purposively selected to receive a movement-based upper limb tasks coupled with action observation. The Fugl-Meyer Assessment of Upper Extremity is used to measure the upper extremity function of the participants before and after the exercise program of which lasted for 3 weeks in total. After data gathering, statistical data showed that there is a significant difference between the pretest and posttest scores of the participants ($-3.6742 > \pm 2.1788$). This indicates that there was a significant improvement in terms of the upper extremity function of the participants. The researchers concluded that movement-based action observation therapy home exercise program is an effective way of improving the upper extremity function of chronic stroke individuals.

Keywords: Movement-Based Action Observation Therapy, Upper Extremity Function, Chronic Stroke.

INTRODUCTION

Action observation therapy is one of the most recent interventions established that has a huge potential especially in terms of improving upper extremity function in stroke patients as multiple studies provided some promising results (Kim et al., 2014; Shih et al., 2017; Zhu et al., 2015; Hsieh et al., 2019). Because of its ease of application and its feasibility, a study suggests that the promising intervention could be an effective intervention of stroke in the home

setting (Zhang et al., 2019). However, because of the low quality of evidence about action observation therapy, a systematic review suggests that future studies about the intervention must emphasize the form of application to fully assess its effect like in terms of whether it is being applied through videos or live demonstrations, the perspectives being used, and treatment setting and dose (Borges et al, 2018). The review also mentioned that future studies must characterize their samples in more detail to attest the applicability of AOT in specific situations, according to the etiology and phase of stroke, degree of upper limb impairment and brain hemisphere affected. Lastly, it was observed in the literature that there is limited evidence regarding the effectiveness of a movement-based action observation therapy home exercise program in improving upper extremity function, especially in post-stroke individuals. Therefore, this study aimed to determine the effectiveness of movement-based action observation therapy as a home exercise program in improving upper extremity function among chronic stroke individuals.

LITERATURE REVIEW

Direct- Matching Hypothesis

In the work of Rizzollati, Fogassi & Gallese in 2001, one of the most popular theories that explain the function of action mirroring is the direct-matching hypothesis. According to the authors, the theory claims that "an action is understood when its observation causes the motor system of the observer to 'resonate'. In the study of Rizzollati and Sinigaglia in 2010, it is mentioned that action mirroring is a process of simulation that leads to understanding the goals of observed actions by automatically mapping those observed actions into the observer's own motor system. Csibra (2007) mentioned that the hypothesis is a stimulus-driven process, wherein a low-level representation of the observed movement kinematics could trigger a higher-level activation of the brain where goals and intentions are coded.

Rizzolati and Craighero (2004) mentioned that the direct matching hypothesis suggests a feed-forward flow of information whereby the visual information related to actions in occipito-temporal brain areas flows into the posterior parietal lobe and the premotor cortex (both contain mirror neurons) and leads to motor representation of the observed action for understanding of the action goals. This classic view of the direct matching hypothesis is fundamentally postdictive; it suggests that observers project backwards in time to recover associated goals or intentions that they experienced previously while executing the same actions (Wilson & Knoblich, 2005). However, a study conducted by Fogasi and colleagues in 2005 of which used a single cell recording reported that mirror neurons that show activation related to action sequences that are about to happen. These findings suggest that mirror neurons may support a more complex, predictive type mechanism for action understanding compared to the essentially postdictive process described by the classic direct matching hypothesis.

AOT in Improving UE function of Stroke Patients

There are many studies of which support the effectiveness of action observation therapy in stroke patients specially in terms of improving upper extremity function. This includes acute and subacute stroke (Fu et al., 2017; Kim & Bang, 2016; Zhu et al., 2015) as well as chronic stroke (Harmsen et al., 2015; Kuk et al., 2016; Lee et al., 2013). Dettmers et al. (2014) on the other hand investigated the effectiveness of AOT in acute, subacute, and chronic patients. Within those studies, Zhu et al. (2015) selected participants with severe UE impairment while Harmsen et al. (2015) and Kim & Bang (2016) considered participants with moderate impairment. Dettmers et al. on the other hand considered patients with mild, moderate, and

severe paresis. The remaining studies did not specify the initial upper limb impairment of their participants. In terms of the etiology of stroke, Fu et al. (2017) considered patients with ischemic stroke while Harmsen et al. (2015), Kim & Bang (2016), and Kuk et al. (2016) considered patients with both ischemic and hemorrhagic stroke. The remaining studies have failed to specify the stroke etiology of the participants. The different studies being included in the review have used different outcome measuring tools to measure the effectiveness of action observation therapy in improving upper extremity function among post-stroke individuals. This includes the Wolf Motor. Function Test, Motor Activity Log Scale, Fugl-Meyer Assessment, Nine-Hole Peg Test, and Box and Block test.

The different studies being included just showed the effectiveness of action observation therapy (AOT) specially in neurological cases like stroke. Because of its effectiveness, ease of application, convenience, and safety specially in dealing patients with stroke, AOT showed potential in terms of its application in the home care setting (Shih et al., 2017; De lima & Christofoletti, 2020). In a study, Dettmers et al. (2014) which investigated the effectiveness of unsupervised AOT in stroke patients, it is found out that home-based training suggests improvement of hand function, activities of daily living and quality of life. However, one of the limitations being mentioned by the researchers is the failure to select the participants by means of medical imaging (MRI and CT scan), and the failure to select the participants by means of the location of stroke (Ex. MCA stroke).

AOT As a Home Exercise Program

In terms of specifying the setting of application, Fu et al. (2017), Kim & Bang (2016), and Zhu et al. (2015) mentioned that the application of the intervention happened in a hospital setting or rehabilitation centers while Dettmers et al. (2014) was found to be the only study of which applied AOT within the participants' homes without direct supervision from the researchers. Other studies have failed to mention the treatment location. In the studies of Harmsen et al. (2015), Kuk et al. (2016), and Lee et al. (2013) reported that the participants did not undergo physiotherapy or occupational therapy in addition to the conduct proposed for the groups.

In all the studies being found (Fu et al., 2017; Kim & Bang, 2016; Zhu et al., 2015; Harmsen et al., 2015; Kuk et al., 2016; Lee et al., 2013; Dettmers et al., 2014) it is reported that all the participants were done action observation (AO) followed by physical activity specifically functional tasks. All the studies being mentioned deliver AOT by means of video sequences. Because of this, Borges et al. (2018) suggest that to raise the quality of the evidence about AOT in stroke patients, a huge importance must be focused on selecting participants based on a specific etiology and phase of stroke, degree of upper limb impairment and brain hemisphere affected. The authors also added that in having studies regarding AOT, it is important to describe the form of application to fully assess its effect in terms of whether it is being applied through videos or live demonstrations, the perspectives being used, treatment setting and dose.
METHODOLOGY

Research Design

This study was a single-group pretest-posttest design of which, a single treatment group of chronic stroke individuals received the movement-based action observation therapy home exercise program. It was conducted within the respective residences of each participant located in the selected provinces of Laguna, Philippines. All participants in the study have provided a written informed consent.

Participants, Inclusion, And Exclusion Criteria

13 chronic stroke individuals ages 40-75 years old who passed the inclusion/exclusion criterion provided during the screening process are purposively selected. The inclusion criteria include the following: 1) Diagnosed with unilateral ischemic or hemorrhagic stroke; 2) Stroke occurred >6 months previously; 3) Can follow simple instructions; 4) Brunnstrom Recovery Stages 2-5; 5) no visual impairment and field defect; 6) sitting balance and tolerance of fair to good; 7) regardless of gender; 8) patients who provided informed consent and were willing to participate in the study. On the other hand, the exclusion criteria are the following: 1) Severe aphasia; 2) severe neglect; 4) Cannot follow simple instructions 3) major medical problems or comorbidities influencing optimal usage of the upper extremity or cause severe pain; 4) Brunnstrom Recovery Stages 5.

Interventions

There were nine (9) different movements of the upper extremity selected for the video material in this study. These movements include: 1) finger tapping, 2) gripping and releasing, 3) thumb opposition, 4) wrist ulnar and radial deviation, 5) wrist extension and flexion, 6) forearm pronation and supination, 7) elbow extension and flexion, 8) moving the affected arm from the middle position to the lateral side, and 9) lifting the hand up and returning it to the table. These selected upper extremity movements being shown in the video were projected in a first-person perspective (see figure 4).

The video material lasted for about 45 mins as each of the motor acts being showed in the video lasted for approximately 5 mins to align with the concept of the execution of movement-based action observation therapy of which consists of observation phase (1 min) and execution phase (4 mins) together with a 30 second break in between the motor task. No audio cues were added in the video of which allows each participant to focus during exercise sessions. All the motor task that was shown in the video material was executed by a single actor to promote uniformity and consistency of the video content. The actor that depicted each of the motor task in the video was a member from the research team. The recorded video material was recorded using a high-quality camera to provide high quality images and stored in a CD or a flash drive. Aside from this, the video material was uploaded on the internet (YouTube) for other options.

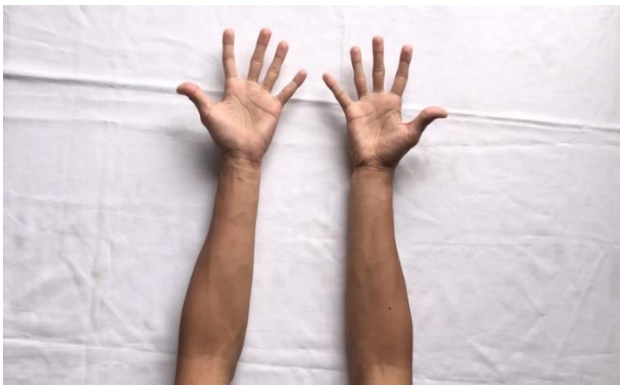

Figure 1. Sample of the Video Material in a First-Person Perspective.

Outcome Measure

In this study, the Fugl-Meyer Assessment of Upper Extremity (FMA-UE) was utilized. The guidelines in performing the said outcome measure were based in a guide released by Deakin, Hill, and Pomeroy in 2003 of which, consists of activities that includes movement observation, grasp testing and assessment of co-ordination. Reflex testing however was opted in the study because of the questions about its issues about dimensionality and internal validity, Woodbury et al (2007) concluded in their study that the assessment will be a unidimensional measure of volitional movement if the reflex items are removed. The whole procedure was done for approximately 10 minutes while the patient is in sitting position. The FMA-UE version utilized in the study consists of 30 items of which, the scoring is based on the direct observation of performance by a physical therapist. The score for each item is: 0-Unable to perform 1-Able to perform in part 2-Perform fully (Deakin, Hill & Pomeroy, 2003). Overall scores will range from 0- 60.

Statistical Analysis

To perform the statistical analysis needed, the FMA-UE averages of the treatment group during pretest and posttest was acquired. These averages were statistically treated using the paired sample t-test with a statistical significance of 0.05. Statistical analysis was performed using Microsoft Excel 2016.

RESULTS

The frequency of the FMA- UE scores of the selected chronic stroke individuals before implementing action observation therapy home exercise program has been presented in Table 1. Within the data being presented, it was found out that the highest pretest score was 53 and the lowest was 0 with a mean score was 21.69 and standard deviation (SD= ±17.79). On the other hand, the frequency of the FMA- UE scores of the selected chronic stroke individuals after implementing action observation therapy home exercise program was presented in Table 2. Here, it was found out that the highest posttest score was 57 and the lowest was 0 with a mean score 24.69 and standard deviation (SD= ±19.84). Lastly, the FMA-UE post-test scores of the respondents was found to be significantly higher than the pretest scores. Table 3 showed the comparison of the pre and posttest scores of the respondents' FMA-UE with the mean of 21.69 on pretest and 24.69 on posttest. It was also showed that the computed t - value was -3.6742 and critical t-value was ±2.1788. The analysis yielded a significant difference (-3.6742 > ±2.1788).

Table 1. The FMA-UE Pretest Scores of the Participants

Participant Number	FMA-UE Pre-test Scores
1	53
2	21
3	19
4	22
5	28
6	0
7	46
8	45
9	4
10	7
11	0
12	27
13	10
Mean	21.69
SD	±17.79

Table 2. The FMA-UE Posttest Scores of the Participants

Participant Number	FMA-UE Posttest Scores
1	57
2	23
3	22
4	26
5	37
6	0
7	49
8	51
9	4
10	7
11	0
12	34
13	11
Mean	24.69
SD	±19.84

Table 3. Comparison of the FMA-UE pretest and posttest scores of the respondents

Pretest	Posttest	Mean Difference	t-value	
			Computed	Critical
21.69	24.69	-3	-3.6742	±2.1788

DISCUSSION

In this study of which aimed to determine the effectiveness of a movement-based action observation therapy home exercise program in improving upper extremity function among chronic stroke individuals, it was hypothesized that there will be no significant difference between the FMA- UE scores of the selected chronic stroke individuals before and after implementing action observation therapy home exercise program. To answer this hypothesis, three (3) research questions needed to be answered. The first question focused on determining the baseline FMA-UE function of the participants. Here, it was found out that that the lowest score among the participants was 0 point and the highest score was 53 points with a mean of 21.69 and a standard deviation of ±17.79. The data being shown signifies that the baseline level of UE impairment among each participant greatly varies similar with other studies (Dettmers et al., 2014; Fu et al., 2017; Kim & Bang, 2016; Zhu et al., 2015; Harmsen et al., 2015; Kuk et al., 2016 & Lee et al., 2013). This great variation among the baseline levels of each participant was believed to be a confounding factor in terms of generalizing the outcome of the study to its intended population of chronic stroke individuals.

The second question on the other hand focused on determining the FMA-UE scores of the selected chronic stroke individuals after implementing action observation therapy home exercise program. After the three (3) week implementation period, it was found out that the lowest score among the participants was 0 point and the highest score was 57 with a mean of 21.60 and a standard deviation of ±19.84. The data being shown at this point signifies that the great variation of the posttest scores of the participants was due to the great variation of scores in the pretest. It was observed that 9 out of 13 participants have improvement in scores, with only 3 participants that has an improved score that reached the acceptable values of at least 10% of the total possible score of which was classified as the "true" value of improvement (Van der Lee et. al, 2001). The possible explanation for this significant improvement was because of the differences in terms of the baseline measurement of the participants in each section of the FMA-UE in comparison with other participants. It was observed that these patients had maximal scores in the first portion of the assessment of which signifies that these participants have been able to move away from the synergies as it was believed that the presence of synergies was a major factor in terms of eliciting the effects of the intervention.

This was different with a participant of which even though that the patient had a high baseline score (53 points), the improvement was not enough to be classified as clinical improvement. The possible explanation for this was because of the high baseline score of the patient depicting minimal UE impairment, the protocol itself might be inadequate to fully provide significant improvement. It was also observed that 4 out of 13 participants do not have differences on their pretest and posttest scores signifying no improvement in UE function. The possible explanation for this was because of possible relationship of the participants' baseline function and the duration of the exercise program of which was only 12 sessions in total. Because of the severity in terms of the participants' UE function, it was believed that the duration of 12 sessions might not be enough to elicit significant changes. Lastly, after statistical analysis, it was found that the FMA-UE post-test scores of the respondents was found to be significantly higher than the pretest scores. This indicates that there was a significant improvement in the upper extremity function of the respondents. And since the computed t-value was greater than the computed critical t-value (-3.67> ±2.18), the researchers have found that the intervention of movement-based action observation therapy home exercise program was effective in terms of improving the UE function of chronic stroke patients. Even though that the result of this study seems to be significant, there are still limitations being found. First, the FMA-UE baseline variability of

the participants as this was believed to be a confounding factor in determining the effectiveness of the intervention. It was therefore suggested to include the selection of participants based on a particular range of UE impairment (FMA-UE). The second limitation was about the timeframe of the study of which only 3 weeks in total (12 sessions). It was therefore suggested that future studies must conduct a study that will further assesses the long-term effects of movement-based action observation therapy home exercise program. Lastly, the sample size of the study was found to be not enough to fully characterize the results of the study into its intended population. It was therefore recommended that future studies must conduct similar studies with a larger sample size.

CONCLUSIONS

The statistical data have shown that there was a significant difference between the FMA-UE pretest and posttest measurement of the participants after participating the movement-based action observation therapy home exercise program. The posttest scores of the respondents were found to be significantly higher than the pretest scores that indicates that there was a significant improvement in terms of upper extremity function of the participants. Therefore, the researchers conclude that movement-based action observation therapy home exercise program is an effective way of improving the UE function of chronic stroke individuals. A precaution must be made when interpreting the results of this study as the effectiveness of the intervention was only interpreted statistically significant but not clinically significant.

ACKNOWLEDGEMENTS

The researchers would like to acknowledge and extend their heartfelt gratitude to the following persons who made the completion of the study possible. To the Almighty God, for giving us the strength as well as the opportunity to finish and have the confidence to continue our research. To University of Perpetual Help – Dr. Jose G. Tamayo Medical University, our second home, our training ground that hones us to be Christian professionals. To our Dean, John P. Lumagui, PTRP, MAEd, MSCPD, for the perpetual guidance and support, and for being a compassionate patriarch of our college. To our thesis adviser, Mr. Gerardo Buhay, PTRP, MAHSE, for understanding our goals and objectives in finishing our requirements in the study. To Mr. JC Mariano, PTRP, for sincerely guiding and supporting us during the whole duration of the research. To our research professor, Rufo S. Calixtro Jr. RMT, RPH, CPS, PhD, for teaching us the fundamentals, techniques, and know-hows of research writing. To Dr. Lazaro Avelino, for giving us your time, patience and for partaking your expertise in statistics that is indispensable to our research. To the respondents, for giving their time in completing the data needed for the study to be concluded. To our parents, for being our life coaches, for unending support, for inspiring us to achieve more and for supporting us financially, emotionally. Once again, from the bottom of our hearts, thank you.

REFERENCES

Bang, D.H., Shin, W.S., Kim, S.Y., & Choi, J.D. (2013). The effects of action observational training on walking ability in chronic stroke patients: a double-blind randomized controlled trial. *Clinical rehabilitation,* 27(12), 1118-25.

Borges, L. R., Fernandes, A. B., Melo, L. P., Guerra, R. O., & Campos, T. F. (2018). Action observation for upper limb rehabilitation after stroke. Cochrane Database of Systematic Reviews. https://doi.org/10.1002/14651858.cd011887.pub2

Deakin, A., Hill, H., & Pomeroy, V. M. (2003). Rough guide to the Fugl-Meyer assessment. *Physiotherapy*, *89*(12), 751–763.

De lima, A. C. de, & Christofoletti, G. (2020). Exercises with action observation contribute to upper limb recovery in chronic stroke patients: a controlled clinical trial. Motriz: Revista de Educação Física, 26(1). https://doi.org/10.1590/s1980-6574202000010148.

De Weerdt, W., & Harrison, M. (2009, April 8). Measuring recovery of arm-hand function in stroke patients: A comparison of the Brunnstrom-Fugl-Meyer test and the Action Research Arm test. Retrieved December 11, 2020, from https://utpjournals.press/doi/10.3138/ptc.37.2.065.

Fu, J., Zeng, M., Shen, F., Cui, Y., Zhu, M., Gu, X., & Sun, Y. (2017). Effects of action observation therapy on upper extremity function, daily activities and motion evoked potential in cerebral infarction patients. *Medicine,* 96(42), e8080.

Harmsen, W.J., Bussmann, J.B., Selles, R.W., Hurkmans, H.L., & Ribbers, G.M. (2015). A Mirror Therapy-Based Action Observation Protocol to Improve Motor Learning After Stroke. *Neurorehabilitation and neural repair,* 29(6), 509-16.

Hsieh, Y.-W., Lin, Y.-H., Zhu, J.-D., Wu, C.-Y., Lin, Y.-P., & Chen, C.-C. (2020). Treatment Effects of Upper Limb Action Observation Therapy and Mirror Therapy on Rehabilitation Outcomes after Subacute Stroke: A Pilot Study. Behavioural Neurology Retrieved December 11, 2020. From https://www.hindawi.com/journals/bn/2020/6250524/.

Kim, C.-H., & Bang, D.-H. (2016). Action observation training enhances upper extremity function in subacute stroke survivor with moderate impairment: a double-blind, randomized controlled pilot trial. Journal of the Korean Society of Physical Medicine, 11(1), 133–140. https://doi.org/10.13066/kspm.2016.11.1.133.

Kim, E., & Kim, K. (2015). Effects of purposeful action observation on kinematic patterns of upper extremity in individuals with hemiplegia. *Journal of physical therapy science*, 27(6), 1809-11.

Lee, D., Roh, H., Park, J., Lee, S., & Han, S. (2013). Drinking behavior training for stroke patients using action observation and practice of upper limb function. *Journal of physical therapy science,* 25(5), 611-4.

Lee, H. J., Kim, Y. M., & Lee, D. K. (2017). The effects of action observation training and mirror therapy on gait and balance in stroke patients. Journal of Physical Therapy Science, 29(3), 523–526. https://doi.org/10.1589/jpts.29.523.

Lima, A. C. de, & Christofoletti, G. (2020). Exercises with action observation contribute to upper limb recovery in chronic stroke patients: a controlled clinical trial. Motriz: Revista de Educação Física, 26(1). https://doi.org/10.1590/s1980-6574202000010148.

Park, C.S., & Kang, K.Y. (2013). The effects of additional action observational training for functional electrical stimulation treatment on weight bearing, stability and gait velocity of hemiplegic patients. *Journal of physical therapy science,* 25(9), 1173-5.

Park, E.C., & Hwangbo, G. (2015). The effects of action observation gait training on the static balance and walking ability of stroke patients. *Journal of physical therapy science,* 27(2), 341-4.

Park, S.D., Song, H.S., & Kim, J.Y. (2014). The effect of action observation training on knee joint function and gait ability in total knee replacement patients. *Journal of exercise rehabilitation,* 10(3), 168-71.

Rizzolatti, G., & Craighero, L. (2004). The mirror-neuron system. Retrieved December 11, 2020, from https://pubmed.ncbi.nlm.nih.gov/15217330/.

Rizzolatti, G., & Sinigaglia, C. (2010, April). The functional role of the parieto-frontal mirror circuit: Interpretations and misinterpretations. Retrieved December 11, 2020, from https://pubmed.ncbi.nlm.nih.gov/20216547/.

Shih, T., Wu, C., Lin, K., Cheng, C., Hsieh, Y., Chen, C., . . . Chen, C. (2017, October 4). Effects of action observation therapy and mirror therapy after stroke on rehabilitation outcomes and neural mechanisms by MEG: Study protocol for a randomized controlled trial. Retrieved November 23, 2020, from https://pubmed.ncbi.nlm.nih.gov/28978349/.

Van der Lee, J.H., Beckerman, H., Lankhorst, G.J., & Bouter, L.M. (2001). The responsiveness of the Action Research Arm test and the Fugl-Meyer Assessment scale in chronic stroke patients. *Journal of rehabilitation medicine*, 33(3), 110-3.

Woodbury, M.L., Velozo, C.A., Richards, L.G., Duncan, P.W., Studenski, S., & Lai, S.M. (2007). Dimensionality and construct validity of the Fugl-Meyer Assessment of the upper extremity. *Archives of physical medicine and rehabilitation*, 88(6), 715-23. Rizzolatti, G., Fogassi, L., & Gallese, V. (2001, September). Neurophysiological mechanisms underlying the understanding and imitation of action. Retrieved December 11, 2020, from https://pubmed.ncbi.nlm.nih.gov/11533734/.

Zhang, B., Kan, L., Dong, A., Zhang, J., Bai, Z., Xie, Y., ... & Peng, Y. (2019). The effects of action observation training on improving upper limb motor functions in people with stroke: A systematic review and meta-analysis. *PloS one*, 14(8), e0221166.