PILOT EDUCATIONAL STUDY: INTRODUCING ERROR AUGMENTATION AS A STROKE REHABILITATION INTERVENTION TO OCCUPATIONAL THERAPY

A thesis submitted to the faculty at Stanbridge University in partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy.

by

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Certification of Approval

I certify that I have read *Pilot Educational Study: Introducing Error Augmentation as a Stroke Rehabilitation Intervention to Occupational Therapy* by Andrew Coleman, Remington Markwell, and Regina Yi, and in my opinion, this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Occupational Therapy at Stanbridge University.

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Abstract

Purpose: The objective of our research study was to introduce error augmentation as a stroke rehabilitation intervention to occupational therapy. We also wanted to provide occupational therapy practitioners with a detailed overview of evidence-based research on error augmentation and demonstrations of how this concept can be applied in a stroke rehabilitation setting.

Design: We created a pilot educational video that demonstrated four error augmentation techniques occupational therapy practitioners could implement in stroke rehabilitation. These intervention methods addressed common self-care and functional mobility activities for patients recovering from a stroke. We recruited occupational therapy practitioners who currently practice in the United States and work with post-stroke patients. Participants were recruited through a recruitment flier, which was posted to Facebook and the AOTA's community research forum. In addition, participants were asked to view the pilot educational video and then provide feedback of the video by completing a survey.

Results: Six licensed and registered occupational therapists participated in our study, all of which reported that they were unfamiliar with the concept of error augmentation prior to participating in this research study. Also, all six participants stated they would like to learn more about error augmentation as a stroke rehabilitation intervention. All participants reported that they are likely or very likely to implement error augmentation methods into their current practice after participating in this research study.

Conclusion: We found that our educational video demonstrating error augmentation techniques introduced the concept to occupational therapy and provided practitioners

with an evidence-based resource regarding the concept. We propose that further research utilize larger sample sizes and randomized control trials. Based on the survey of participant input and current literature, error augmentation may be a beneficial intervention that has the potential to be used in multiple occupational therapy settings.

Keywords: stroke, error augmentation, neuroplasticity, occupational therapy, activities of daily living (ADL), upper extremity, rehabilitation

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Pilot Educational Study: Introducing Error Augmentation as a Stroke Rehabilitation Intervention to Occupational Therapy

According to the Centers for Disease Control and Prevention (2021), a stroke occurs when there is an interruption or reduction of blood supply to the brain caused by a ruptured or blocked blood vessel. The disruption of blood flow leads to an inadequate supply of vital nutrients and blood to brain tissue causing the death of brain cells. This may cause brain damage, serious long-term disability, or even death. Rehabilitation is crucial following a stroke so that an individual can attempt to return as close to their prior level of function as possible. Post-stroke rehabilitation may help individuals overcome disabilities that result from a stroke. In addition, error augmentation is a relatively new concept in occupational therapy stroke rehabilitation that has shown promise in addressing common post-stroke deficits (Israely & Carmeli, 2016).

Error augmentation utilizes false sensory feedback to improve or adapt motor learning and rehabilitation to a specific environment (Abdollahi et al., 2014). It is an intervention that isolates and enhances motor errors. The amplification of errors provides feedback that promotes the correction of movement patterns and allows for changes in motor control. This type of error-driven learning is thought to be crucial to neuroplasticity and the reacquisition of skill in human movement. The importance of error augmentation is rooted in the ability of the human nervous system to relearn and shape movements for optimal motor performance. Thus, this intervention has shown promise in the rehabilitation process of individuals post-stroke as it helps to increase functional recovery and independence.

Effects of a Stroke on Activities of Daily Living

The effects of a stroke can significantly inhibit individuals post-stroke from participating in and completing activities of daily living (ADL) that are necessary tasks of everyday life. Occupational therapy plays an essential role in stroke rehabilitation through its client-centered and holistic approach. Through an occupational therapy lens, stroke has a significant impact on several broad occupational therapy domains such as one's occupations, performance skills, contexts, performance patterns, and client factors (American Occupational Therapy Association [AOTA] & American Occupational Therapy Foundation, 2011). Our study addressed how occupational therapy practitioners play a key role in ADLs. Stroke survivors may experience weakness in the upper extremities that may be needed to complete ADLs. For example, everyday activities may involve reaching for an object, eating with a fork, or drinking out of a cup. Our educational video demonstrated error augmentation techniques through motor tasks. Error augmentation provides feedback to the individual that an error has occurred in their movement pattern. This feedback cues the individual, which encourages them to make corrections to their movement. Abdollahi et al. (2014) states that repetitive and targeted practice of these techniques enhances brain plasticity and allows it to make modifications to its neural connections. This allows individuals structured opportunities to relearn and solidify motor skills that are required for their participation in ADLs.

AOTA Research Agenda

The AOTA Research agenda highlights the major research goals and priorities for occupational therapy research. Three categories related to our thesis include research training, intervention, and translational research (AOTA & American Occupational

Therapy Foundation, 2011). Our main priority was research training as we hoped to expand practitioners' knowledge and skills. Furthermore, the category of intervention was addressed as our study focused on the use of error augmentation techniques that promote one's occupational performance. Lastly, translational research was applicable because we launched a pilot educational video to demonstrate a new concept that may be adopted into practitioners' current practice. Our study aimed to educate occupational therapy practitioners on the theory of error augmentation and provide occupational therapy practitioners with techniques that address ADLs. The goal of this study was to provide resources for practitioners to readily access and implement in stroke rehabilitation.

Literature Review

Social Significance

According to the National Institute of Neurological Disorders and Stroke (2021), approximately 800,000 people each year suffer a stroke in the United States and approximately two-thirds of these individuals survive and would benefit from rehabilitation. Post-stroke rehabilitation may help patients regain lost functioning in mobility and restore independence in ADLs. Since a stroke results from an interruption or reduction of blood supply to the brain, rehabilitation may be beneficial to relearn skills that were potentially lost following a stroke (Centers for Disease Control and Prevention, 2021). In our literature review, we analyzed the effectiveness of error augmentation as a stroke rehabilitation intervention and discussed the role of neuroplasticity and motivation in the rehabilitation process.

Effectiveness of Error Augmentation

The first theme we found was the effectiveness of error augmentation as an intervention compared to traditional methods in stroke rehabilitation. While Abdollahi et al. (2014) focused on the effectiveness of error augmentation in reshaping arm movements in individuals following a stroke, a study conducted by Marchal-Crespo et al. (2014) examined the benefits of error augmentation in stroke rehabilitation based on the appropriate selection of participants. Both research articles contributed knowledge about the use of error augmentation and examined the benefits of this specific rehabilitation method compared to traditional techniques. Both articles also used a similar sample size of less than 30 participants and utilized robot-directed error amplification. However, Michal-Crespo et al. conducted research using 23 healthy subjects, while Abdollahi et al. conducted research using 27 individuals who were six months post single cortical stroke.

According to Abdhollahi et al. (2014), error augmentation enhances the motor performance of the upper extremity and boosts learning in stroke survivors. This study also supported error augmentation as a more effective option when reshaping movements in stroke individuals when compared to regular repetitive practice therapy. Liu et al. (2018) conducted a systematic review that compared the effectiveness of error augmentation intervention methods to conventional repetitive motor recovery. Researchers found that error augmentation was more effective at improving the quality and control of movement. Marchal-Crespo et al. (2014) also supported these findings but added that error augmentation is most effective when it optimally challenges the individual. Furthermore, research has found motor learning is boosted when the augmentation of errors optimally challenges the individual.

Role of Neuroplasticity

The second common theme we found was that researchers addressed methods that focus on error-driven learning. These methods utilized neuroplasticity to facilitate motor learning and skill acquisition in stroke rehabilitation. Neuroplasticity is defined as the ability of the nervous system to change its activity in response to stimuli through the reorganization of its function, structure, or connections after an injury (Puderbaugh & Emmady, 2022). Error augmentation is a technique that amplifies movement errors so that the brain can recognize these stimuli. Abdollahi et al. (2014) showed how this method promotes learning by making errors more noticeable to the impaired nervous system of post-stroke patients. Israely and Carmeli (2016) used evidence-based literature to justify the use of error augmentation for upper extremity stroke rehabilitation over traditional methods. This study concluded that using error augmentation allows the damaged nervous system to adapt and learn. Both articles discussed the significance of using repetitive practice to recalibrate the nervous system to promote motor learning. However, more research is necessary to further support the role of error augmentation in rewiring brain circuits to aid in motor learning and skill acquisition.

Impact of Therapist and Patient Engagement

A third common theme seen among researchers is the relationship between patient and therapist levels of engagement and the impact this association has on the rehabilitation process. According to Bright et al. (2017), patient and practitioner engagement can influence the patient's overall rehabilitation experience and therapeutic outcomes. Practitioners who prioritize their patient’s engagement in the rehabilitation process strive to provide services that focus on the patient’s needs and values. The

disengagement of a practitioner can negatively influence their clinical reasoning and decision-making when working with their patient (Bright et al., 2017). The patient's and practitioner's perceptions of each other's engagement may significantly impact each party's active participation in the rehabilitation process. This study highlights the importance of practitioner engagement and its influence on clinical reasoning and patient care.

According to Maclean et al. (2000), there are different attitudes and beliefs between post-stroke patients who identify as having either low or high levels of motivation. The main influence in these differences was the patient's environment during their rehabilitation process, so professionals and caregivers should consider the effects of their own behavior on the patient's engagement in the therapy process. Literature shows that positive and motivating behavior from therapists can increase motivation levels seen in patients, resulting in more favorable therapeutic outcomes (Maclean et al., 2000).

Remaining Gaps in Evidence

The effectiveness of error augmentation in stroke rehabilitation has yet to be determined because of limited research on the subject. According to Israely and Carmeli (2016), there have only been eight quantitative studies published on error augmentation in stroke rehabilitation. These studies generated limited results due to small sample sizes. According to Abdollahi et al. (2014), quantitative studies suggest that error augmentation methods may be beneficial to patients recovering from a stroke. However, this study used technology to facilitate movement errors, and more research is needed on therapist-guided interventions and their implications on motor function. Future research is needed

on the efficacy of error augmentation in stroke rehabilitation and its relevance to the field of occupational therapy.

Qualitative studies related to our topic focused on motivational levels for rehabilitation in stroke patients. Similar to quantitative studies, there is a limited number of studies that show the efficacy of their research. Maclean et al. (2000) showed how professionals have stated that patients' motivation plays an essential role in their outcomes. Maclean et al. also highlighted that other studies have found that patients who have higher levels of motivation for rehabilitation receive more attention from therapists. Current research literature states that there is no clear clinical understanding of what determines patient motivation (Maclean et al., 2000). However, the literature presents unsupported evidence of motivation as a personality trait, without an actual analysis of motivation. As a result, future studies should attempt to provide a clear and evidence-based definition of how patients perceive motivation and identify its role in rehabilitation outcomes.

Clinical Significance of Research Evidence

There is limited evidence that provides evidence on the efficacy of technology-facilitated interventions regarding error augmentation methods. Overall, the literature supports therapist-guided error-augmented interventions to improve upper extremity function in post-stroke patients (Abdollahi et al., 2018). There is currently limited research on the use of error-augmentation techniques in occupational therapy practice settings (Israely & Carmeli, 2016). However, error-augmentation has been shown to be beneficial in occupational therapy treatment because it provides amplified feedback that promotes motor learning and skill acquisition necessary for ADLs. The evidence showed

that error augmentation promotes neuroplasticity in post-stroke patients by reorganizing and adapting damaged neuronal connections. (Abdollahi et al., 2014).

Statement of Purpose

Practitioners should consider not only the effect their patient's engagement has on the rehabilitation experience, but also the impact their own engagement has on the rehabilitation experience and therapeutic outcomes. Highly engaged practitioners and patients may have higher levels of motivation in the rehabilitation process. As a result, positive engagement from both the patient and therapist may lead to more favorable therapeutic outcomes. Our goal was to provide a resource for practitioners who currently work directly with patients in stroke rehabilitation settings. When creating this project, we hoped to increase practitioners' knowledge and motivation to learn about a novel technique that they could incorporate throughout the rehabilitation process.

This pilot educational study aims to introduce occupational therapy practitioners to error augmentation techniques that they may implement in stroke rehabilitation settings. Due to a lack of current research and training on error augmentation, our study aims to educate occupational therapy practitioners on the theory of error augmentation and the research evidence that supports its effectiveness. It is important for occupational therapy practitioners to have knowledge about error augmentation and have access to resources on how to apply the theory into practice.

This study consists of a video created by the current research team to introduce the concept of error augmentation. We demonstrate four error augmentation techniques addressing functional independence in occupations that post-stroke patients may experience challenges with. This pilot educational study will not only potentially benefit

occupational therapy practitioners working in stroke rehabilitation, but also individuals who receive occupational therapy services following a stroke. We believe that the educational video will increase occupational therapy practitioners' knowledge of error augmentation and lead to the implementation of this method into occupational therapy practice. Lastly, we expect that our pilot educational study will encourage further research on the topic.

Theoretical Framework

Biomechanical Approach

Motor impairments, such as muscle weakness, perceptual difficulties, and coordination issues, are commonly seen in post-stroke patients (Li, 2017). Motor impairments significantly impact activities involving both the upper and lower extremities and require various levels of motor control (Marchal-Crespo et al., 2019). For example, the functional mobility of the arms and fingers in both gross and fine motor movements play a crucial role in maintaining individuals' independence in activities of daily living (Marchal-Crespo et al., 2019). Therapists commonly utilize the biomechanical approach to address motor impairment following a stroke. This theoretical framework is considered a remediation approach that is focused on client factors and impairments that limit occupational performance. The biomechanical framework assumes that the impairment will be responsive to remediation (McMillan, 2011). Engagement in occupation and therapeutic exercise can lead to rehabilitation and improved occupational performance.

The key to the biomechanical approach is linking the client factor or impairment to deficits in one's occupational performance. The approach addresses an individual's

quality of movement specific to occupational performance. The objective of the biomechanical frame of reference is to prevent further decline and maintain the existing range of motion, while simultaneously restoring movement for participation in occupation (McMillan, 2011). This approach may be beneficial for clients with movement limitations, inadequate muscle strength, loss of endurance, and biomedical conditions. The biomechanical approach places emphasis on the effect these deficits have on occupational performance.

Motor Control and Learning

According to Carey et al. (2019), neuroplasticity is the ability of the nervous system to respond to stimuli through the reorganization of its structure and connections. These changes in neural plasticity may occur following a stroke. The brain and body are significantly impacted by a stroke and this event may result in impairments to one's motor function, sensation, and cognition. Thus, neural plastic changes within the brain must be taken into consideration following a stroke due to their role in one's motor learning and task acquisition. Neurorehabilitation specifically focuses on promoting learning experiences to help individuals who have been impacted by a stroke to improve and achieve optimal outcomes for individuals in motor learning and control.

According to Levin and Demers (2021), motor learning is a process, condition, and rate in which a person learns motor skills. This process is clinically significant to our research as it helps occupational therapy practitioners understand the complex process producing accurate and smooth movements. Practitioners can integrate motor control and learning into their daily practice to identify dysfunction in one's motor performance, and design treatment programs that target the adaptation or reacquisition of motor skills and

patterns. It is important that practitioners understand the relationship between the motor skill task, type of feedback, and environment in the interventions they provide. From a motor learning approach, rehabilitation interventions for stroke survivors may be given at a high intensity. Challenging tasks may engage neuroplastic processes and allow post-stroke patients to perform motor tasks in various environments and situations (Levin & Demers, 2021).

Error augmentation promotes learning by enhancing errors so that it is more noticeable to the impaired nervous system (Abdollahi et al., 2014). The implementation of error amplifying techniques may promote recovery of any neuronal changes that may be present following a stroke. The use of error-based learning provides structured opportunities for individuals to make errors, become aware of these errors, and allow them to self-correct them through feedback (Ownsworth et al., 2017). Neural plastic changes may be accommodated through these opportunities so that they may anticipate these errors in their everyday tasks and situations.

Methodology

Our study implemented a mixed-methods design utilizing quantitative and qualitative data. Using a mixed methods design was beneficial because it allowed us to benefit from the detailed insights of qualitative data, while also giving us the ability to validate previous literature on error augmentation using quantitative data. Participants completed a survey through Google Forms that consisted of Likert scale ratings and open-ended questions. This mixed methods format allowed participants to share their thoughts regarding the educational video. Furthermore, this design applied both approaches to counteract any limitations that may arise from each individual method.

Utilizing a mixed methods design also provided stronger evidence and confidence in our findings. This was essential to our research because our pilot educational video introduced therapist directed error augmented interventions to occupational therapy practitioners in stroke rehabilitation settings. Our methodology allowed us to obtain measurable data and have more insight into our participants' understanding of the demonstrated techniques through their survey responses.

Participants

The target population for our study was occupational therapy practitioners, which consisted of occupational therapists and occupational therapy assistants, working in post-stroke rehabilitation. We recruited participants through convenience sampling from Facebook and the AOTA's community research forums. We hoped that the use of convenience sampling would initiate a snowball effect in which the participants themselves would share the flier with other occupational therapy practitioners whom they personally know so that they may participate in the study. This method of sampling was also utilized to reduce bias.

The following inclusion criteria were used to select participants for this study: occupational therapy practitioners (occupational therapists and occupational therapy assistants) who currently practice in stroke rehabilitation settings in the United States. Another inclusion criteria we set for the purposes of our study was that participants needed to be English-speaking, as our pilot educational study included a video and survey that were both conducted in English. We hope to expand this criterion in further research. The following individuals were excluded from this study: those who are not occupational therapists or occupational therapy assistants, occupational therapy practitioners who do

not work in stroke rehabilitation, occupational therapy students, practitioners who do not speak English as their primary language, and practitioners practicing outside of the United States. We posted a flier to online platforms that contained information on participants needed for this study and how potential participants could access the pilot educational video and subsequent survey.

Procedure

The first step of our thesis project was to conduct a literature review to analyze the current research on the theory of error augmentation. Our literature search revealed that there was a limited number of resources available on this topic. Due to the limited resources available on error augmentation, we chose to focus our project on introducing error augmentation to occupational therapy practitioners practicing in stroke rehabilitation. We created an educational video to introduce practitioners to the theory of error augmentation and to provide them with evidence supporting its use. The video was filmed in a therapy lab on the Stanbridge University campus with permission from the Office of Instruction. We personally demonstrated four error augmentation techniques utilizing common rehabilitation clinic items to demonstrate the techniques which included: eating utensils, ankle weights, and resistance bands. Our first technique addressed bilateral coordination through a reaching activity. Next, we demonstrated bringing a utensil to the mouth addressing hand to mouth coordination necessary for self-feeding. Our third demonstration focused on poor static standing balance caused by a posterior lean. Lastly, we addressed poor dynamic sitting balance resulting from pusher syndrome.

Once the video was created, we posted the flier on Facebook and AOTA's community research forums. The flier contained information about our study and was used as a method of participant recruitment. This flier also contained a link that provided access to our educational video, which was uploaded to YouTube. Prior to viewing the video, participants were provided with the informed consent document and the study's participant inclusion criteria. The end of the video was embedded with a link to a survey on Google Forms. The link was also included in the description section located below the video. The survey was only accessible to participants once they had viewed the video in its entirety, which was 12 minutes and 22 seconds in duration. This was to ensure that participants viewed the educational video in its entirety prior to completing the survey portion of the study. Additionally, we wanted to make sure that participants provided answers related to the educational video and its content. Following the viewing of the educational video, participants were required to acknowledge receipt of the informed consent document at the beginning of the survey on Google Forms. Participants then answered a few self-screening questions allowing the authors to ensure proper data was obtained for the purposes of this study.

The survey contained five questions that utilized Likert scale ratings to determine the participants' satisfaction of the educational course video and the likelihood of implementing the demonstrated techniques into their practice. The Likert scale was ranked by participants on a scale of one to five, with one representing strongly disagreeing and five representing strongly agreeing. Additionally, we included open-ended questions to allow the participants to share their thoughts and attitudes regarding the educational video. We created these open-ended questions to have a better

understanding of the perceptions and attitudes of the participants in regard to error augmentation. Our goal was to gauge how participants felt about error augmentation as a potential intervention technique in stroke rehabilitation and its implications in occupational therapy. Also, we wanted to measure participants' understanding of error augmentation before and after participating in the study. Lastly, our aim was to understand how interested occupational therapy practitioners are in learning about error augmentation and how the concept can be applied in stroke rehabilitation.

Course Design

Our pilot educational video demonstrated four error-augmentation techniques that could be implemented by occupational therapy practitioners in stroke rehabilitation settings. The educational video introduced the topic of error augmentation and provided a brief literature review of current research on this technique. It emphasized the potential benefits of using this technique in the field of occupational therapy. For each demonstration, we provided a brief introduction and support research, equipment required, demonstration done by the current research team, and its occupational relevance. For each technique, we demonstrated how the “patient” performs each motor instruction prior to the application of an error-augmented technique. The viewer saw the “patient” experience difficulties in carrying out their movement. Then, the “therapist” repeated the motor instruction and applied the technique to the “patient” while they executed their movement. Lastly, the demonstration concluded with the “patient” completing the movement pattern independently to indicate a change in their movement through self-correction. Our goal was to ensure that the viewers saw how the patient was able to become aware of their movement errors and can self-correct.

Data Analysis

We utilized Google Forms and Microsoft Excel spreadsheets to analyze the survey responses of our six participants. In order to analyze the qualitative data, we used a coding system. The coding system was developed by analyzing the participants' responses, and then identifying common phrases within the responses. We then combined the data with their respective themes. Once the data had been coded, we analyzed the themes to determine the perceptions and attitudes of the study participants. A Likert scale was used to analyze the quantitative data and helped us determine if the study participants found the demonstrated methods informative and if they would implement these techniques into their current practice. Then, we created bar-charts from the Likert-scale rating responses to provide a visual representation of the data from the survey.

Ethical Considerations

We did not collect any personally identifying information from the occupational therapy practitioners who chose to participate in this pilot educational research study. This was done to maintain participant anonymity and confidentiality. For informed consent, participants who self-screened based on the inclusion criteria could choose to continue with the study by reviewing the informed consent form. Once participants had confirmed that they had gone through the inclusion criteria and met the requirements to participate as well as confirmed that they were provided informed consent, they accessed the link to the educational video to continue with the study. Since our study was done electronically, data provided by the participants was only viewed by the authors and advisor during the duration of the study. Data will be stored electronically on data collection databases for three years following study completion per the Code of Federal

Regulations (Protection of Human Subjects, 2022, para. 115). Data, consent records, and Institutional Review Board documentation will be stored electronically and will be password-protected. The authors and advisor are the only individuals with access to the study data to maintain participants' confidentiality.

Our educational course does not directly address vulnerable populations. However, it is important to highlight that the participants may apply the knowledge they have gained from this course and implement these techniques with vulnerable populations in their practice in stroke rehabilitation. Thus, our educational video highlights the need for practitioners to take precautions into consideration prior to implementing a technique or to have another practitioner present to ensure the safety of both the patient and the practitioner. We aimed to limit response bias by providing the survey link after practitioners completed the educational course video. Before starting the survey, participants answered a few screening questions regarding the inclusion criteria and to confirm their understanding of their involvement in our research study.

Results

The results of the survey are displayed in Appendix F. The survey was available for a total of 29 days from September 9, 2022, to October 7, 2022. We anticipated ten participants to be recruited for the survey, however, it resulted in a total of seven participants. Six participants stated they currently practice occupational therapy in the United States and work with post-stroke rehabilitation patients. Of these six participants, all stated that they are both registered and licensed occupational therapists. Three participants have been practicing licensed occupational therapy practitioners for six to ten years and three have been licensed for ten or more years. All six participants reported

they were not familiar with the concept of error augmentation prior to participating in this study.

Participants answered five Likert scale questions rated on a scale of one to five, with one being strongly disagree, two being disagree, three being neutral, four being agree, and five being strongly agree. Four participants rated their satisfaction of the pilot educational video on error augmentation as a five out of five, and two rated their satisfaction as a four out of five. Five participants rated the likelihood of them implementing error augmentation methods into their current practice five out of five and one reported a likelihood of four out of five. Three participants rated five out of five that error augmentation could potentially be more beneficial than traditional intervention methods in stroke rehabilitation, two rated four out of five, and one rated three out of five.

When asked to rate their interest in learning more about error augmentation as a stroke rehabilitation intervention, all six participants rated their interest as a five out of five. Four participants reported the likelihood of them recommending this video to their colleagues as a five out of five, one reported a likelihood of four out of five, and one reported a likelihood of three out of five. Participants also answered three open ended questions regarding their perceptions and feelings toward the pilot educational video. See Appendix G for full statements.

Discussion

The survey results indicate that the pilot educational video effectively introduced error augmentation as a stroke rehabilitation intervention to occupational therapists who had no previous knowledge of the concept. Additionally, analysis of the survey results

indicates that the pilot educational video successfully provided occupational therapy practitioners with error augmentation techniques they can implement in their current practice setting. In terms of the information we obtained from the participants (see Appendix F), all seven participants were licensed and registered occupational therapists currently practicing in the United States. Six of the seven participants were occupational therapists working in post-stroke rehabilitation. Due to our inclusion criteria, we did not include the individual who reported that they do not work directly with post-stroke patients in our data analysis. Although our study was available for both occupational therapists and occupational therapy assistants, we were unsuccessful in recruiting occupational therapy assistant participants for the study. This may suggest that future studies focus primarily on occupational therapists practicing in stroke rehabilitation since there was little interest from occupational therapy assistants. Three participants reported that they have been practicing as licensed practitioners for ten or more years, while the other three participants responded that they have had six to ten years of experience. All participants reported that they were not familiar with the concept of error augmentation prior to their participation in this study which supports the need for further research and more accessible resources for practitioners on the concept.

The responses to the Likert scale rating questions showed that all six participants were satisfied with the pilot educational video and felt that they could implement it in their current practice. This supports our hypothesis that occupational therapy practitioners may benefit from having access to resources about error augmentation. We also found that the majority of the participants believed that error augmentation could be more beneficial than traditional intervention methods in stroke rehabilitation. This shows that

providing practitioners with opportunities to learn about more novel approaches to interventions may encourage implementation of different techniques and concepts within rehabilitation settings. This helps foster learning and motivation that may further benefit the practitioner and patient in the therapeutic process.

For the open-ended questions, when asked about which technique participants were most likely to use in their setting, most stated that they would utilize the bilateral integration technique demonstrated in the video in their current practice. These participants stated that the addition of a resistance band during a functional reaching task would increase awareness of the affected side and improve functional movement. Increased awareness of the affected side may help improve the ability to carry out everyday tasks that require the functional use of both upper extremities. Participants were also asked to expand on what changes they would have made to the educational video. Some participants stated that they would have incorporated actual clients in the demonstrations to closely replicate actual treatment sessions. Demonstrations of error augmentation methods with clients currently in stroke rehabilitation for the educational video may have shown the use of different variables, such as the TheraBand and resistance bands more effectively when targeting specific motor deficits.

Based on responses of what participants learned from the educational video (see Appendix G), participants stated that they were more familiar with error augmentation and the evidence that supports the use of this concept in rehabilitation settings. We propose the need for future research in error augmentation as well as its implications in occupational therapy and our pilot educational video is an accessible resource that occupational therapists can engage with and utilize in their current practice settings.

Since this educational video is uploaded onto YouTube, occupational therapists as well as other healthcare professionals have opportunities to view and share it with others. The educational video will remain on YouTube following the completion of the study, with no plan of removing it from the platform. Occupational therapy practitioners can feel more confident in a newer approach that may have positive implications in interventions for post-stroke patients. The educational video also demonstrates techniques specific to functional movement and postural training that are crucial in self-care tasks.

Limitations

This study had a few potential limitations to consider. The survey had a small sample size of six individuals. The survey was posted on Facebook and the AOTA community research forum, which had many survey requests posted by occupational therapy practitioners and students. With multiple surveys being posted daily, our study may not have been easy to locate. Due to this, our study did not reach the number of participants that we had hoped for. In addition, individuals needed to have access to a Google account and have knowledge of how to use the link to access the video. Participants were also required to self-screen themselves based on the inclusion criteria provided in the recruitment flier. This showed to be an ineffective screening method since one individual completed the survey who did not meet the inclusion criteria. When participating in the study, it was predicted that it would take approximately 25 minutes total to complete. This time requirement may have excluded some individuals from participating in or withdrawing from the study. Furthermore, the survey was only made available to English-speaking occupational therapy practitioners who practice in the United States which limits the number of individuals who could participate in the study.

Due to the small sample size of our study, the results cannot be generalized to the larger field of occupational therapy.

Clinical Implications

Occupational therapy is a profession that promotes the independence and well-being of individuals of all ages through the use of meaningful activities. Implementation of this evidence-based pilot educational video into an occupational therapy practice may assist occupational therapy practitioners in providing services for patients recovering from stroke by addressing upper extremity dysfunction to promote more independence in meaningful tasks. Since the pilot educational video addresses components that affect an individual's occupational performance, occupational therapy practitioners can implement the concept of error augmentation to help their patients return as close to their prior level of functioning as possible. Additionally, this pilot educational video bridges the gap in previous research by providing actual demonstrations and examples of how error augmentation can be implemented in a stroke rehabilitation setting.

Our educational video provides occupational therapy practitioners with a single resource that consolidates research evidence on error augmentation and provides demonstrations of how to implement the concept into their current practice. This video will help to reduce the barriers identified in the literature review regarding the lack of resources and examples of how error augmentation is implemented into practice. As stated in the video, the four techniques we demonstrated are based on the theory of error augmentation and were adapted from previous research studies on the concept. Upon viewing the educational video, a disclaimer should be added to advise occupational

therapy practitioners to utilize their clinical reasoning skills when implementing error augmentation into a patient intervention to ensure patient safety.

Conclusion

The purpose of this study was to introduce error augmentation as a potential stroke rehabilitation intervention to occupational therapy. This study aimed to provide occupational therapy practitioners with a pilot educational video that provides a detailed overview of evidence-based research on error augmentation and examples of how this concept can be applied in interventions in stroke rehabilitation. All studies collected from the literature review support therapist-guided error-augmented interventions as an effective way to improve upper extremity function in post-stroke patients. We propose that further research utilize larger sample sizes and randomized control trials. We also suggest that future studies examine the use of error augmentation techniques for various diagnoses since most of the current literature is specific to stroke rehabilitation. Literature supports the use of error augmentation as an intervention in motor learning, but further investigation is needed to support its efficacy in addressing motor performance and occupational engagement. Based on the survey of participant input and current literature, we believe that error augmentation may have positive implications as a useful intervention method in the field of occupational therapy.

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Appendix A

Consent Form

Before continuing with participation in this study, please read this page to understand the purpose of this study, as well as associated risks, ethical considerations, and confidentiality agreements.

MSOT students from Stanbridge University are conducting this research study to introduce error augmentation as an intervention to occupational therapy practitioners who work with clients in stroke rehabilitation. Participation in this research study is voluntary and is anticipated to require 15 minutes to complete viewing of this educational video and 10 minutes to complete this survey (25 minutes total). As such there are no anticipated risks involved to participate in this survey, however at any time if you feel you don't want to answer any question or would like to voluntarily withdraw from the survey, you can do so.

If you have been harmed in any way by this research or have any specific questions regarding this research, please contact the research team. Principle Investigator: Dr. Alice Cheung OTD, OTR/L, CSRS, CPAM Contact: acheung@stanbridge.edu

If you have questions or concerns regarding your rights as a research participant, you may contact the Institutional Review Board (IRB). If you feel you have any questions, complaints, or concerns you cannot discuss with the research team, please contact the IRB coordinator for Stanbridge University at: irb@stanbridge.edu

By submitting this survey, participants consent for their anonymous responses to be used for data collection and analysis by the research team. Data collected from answered questions will not be tied to or associated with any identifiable individual subjects.

By choosing to continue, participants understand that their participation in the study is completely voluntary, and they can withdraw from the study at any time without penalty. Participants understand that all collected data will not contain identifying information. All data will securely be kept through Stanbridge University. Only the research team will have access to submitted surveys. Submitted data will be destroyed three years after completion of the research study. Participants understand that the results of this survey may be discussed at future OT conferences keeping all the ethical considerations for the purpose of benefiting the occupational therapy profession.

Appendix B

Recruitment Flier

PARTICIPANTS NEEDED

FOR A STUDENT RESEARCH STUDY INVESTIGATING ERROR AUGMENTATION IN STROKE REHABILITATION

Student researchers from MSOT Stanbridge University looking for licensed OT and OTAs to participate in pilot educational course addressing innovative technique for stroke rehabilitation

Held online via link. Access to short survey to follow (12 min to view video; 10 min for survey)

Enrollment opens on 9/09/22 and will close 10/07/22

PARTICIPANT REQUIREMENTS:

- **Practicing OT or OTA**
- **Currently working with post-stroke patients**
- **Speak English as first language**

To learn more or sign up, please email research team at **earesearchstudy@gmail.com** or contact Dr. Alice Cheung at **acheung@stanbridge.edu**

Appendix C

Video Script

- **Introduction - All**
  - **Regina** - Hi, we are occupational therapy students from Stanbridge University. Our names are Andrew Coleman, Remington Markell, and Regina Yi.
  - **Remy** - As part of our master thesis project, under the guidance of our thesis advisor, Dr. Alice Cheung we have created a pilot educational video for occupational therapists.
  - **Andrew**- The purpose of this video is to introduce error augmentation as a stroke rehabilitation intervention to occupational therapy.

- **Video Overview - Regina**
  - Our course will consist of a brief introduction to error augmentation, an overview of current literature we have found on this topic, and lastly we will provide 4 demonstrations of error augmentation techniques that address functional independence in occupations that individuals post-stroke may experience challenges with

- **Introduction of EA - Remy & Regina**
  - **Remy** - So what is error augmentation? Error augmentation is a fairly new concept to occupational therapy that aims to improve and adapt motor learning. It is a technique that amplifies errors in someone's movement pattern with the goal that these errors will provide cues that give someone opportunities to make corrections and adjustments to their movements. Since feedback mechanisms are often damaged with neurological injury, making errors more obvious to the senses provides the individual with better feedback. Error augmentation essentially proposes that an individual may learn more effectively when the error being addressed is increased.
  - **Regina** - This concept has shown promise as an intervention approach because it isolates and enhances movement errors which promotes changes in movement control. This kind of feedback may seem counterintuitive, and it differs greatly from common rehabilitation methods since rarely does a therapist try to amplify a patient's errors. However, according to Abdollahi and researchers in 2013 error-driven learning processes are believed to be central to the reacquisition of skill in human movement. There is growing evidence to support the use of error augmentation in stroke rehabilitation as individuals who have had a stroke may often have impairments in both motor skills and control.

- **Literature Review - Andrew**
  - Now I will be going over a brief overview on the literature we found on error augmentation. In a study completed by Liu and researchers in 2018, error augmentation was found to be a more effective option when

reshaping movements in post stroke individuals when compared to conventional repetitive motor recovery. Error augmentation has specifically been shown to enhance motor performance of the upper extremity and boost learning in stroke survivors through a process referred to as neuroplasticity. Neuroplasticity is the brain's ability to change and adapt. When a stroke occurs, neural connections or pathways that retrieve and store information can be impacted, and the severity may vary by individual. Because of this, it is important to take advantage of neuroplasticity during every stage of the stroke recovery process. Utilizing the concept of neuroplasticity allows an individual who has suffered a stroke to relearn motor skills and regain motor control. Through the use of task-specific activities, we can alter patterns in the affected area of our brain by performing movement tasks for the purpose of motor learning. Israely and researchers in 2017 used evidence-based literature to justify the use of error augmentation for upper extremity stroke rehabilitation over traditional methods. Our literature review supports the use of error augmentation as a stroke rehabilitation intervention allowing the damaged nervous system to learn and adapt movement patterns.

- **Reason for study and OT relevance - Regina**
    - So why are we researching this topic and how is it relevant to occupational therapy? According to Israely and Carmeli as of 2016 there have only been eight quantitative studies published on error augmentation in stroke rehabilitation. Even though there is limited research on the topic of error augmentation, the results of these studies have shown error augmentation to produce more beneficial therapeutic outcomes. Amplifying errors can retrain the brain and lead to more successful outcomes in motor learning and recovery. Occupational therapy practitioners can implement error augmentation techniques to guide patients in practicing movements and skills needed for their activities of daily living. Now we will be demonstrating 4 error augmentation techniques utilizing common rehabilitation items found in a clinic. It is important to note that these methods we will be demonstrating have not been validated by research, they are based on the theory of error augmentation and have been adapted from other research studies.

EA Demonstrations

- Bilateral reaching - **Andrew**
    - **Introduction**: We will now be demonstrating a bilateral reaching activity using a theraband to amplify a reaching error. In a study completed by Abdollahi and researchers in 2018, robotics were used to create errors during bilateral reaching activities of post-stroke rehabilitation patients. This study found greater improvement in the group in which error augmentation methods were used compared to groups that did not. We will be replicating

this technique using a theraband to create an error during a bilateral reaching activity. This activity relates to occupational therapy because bilateral arm training is essential in addressing upper extremity paresis after one suffers a stroke. It is important to train and assess unilateral and bilateral upper extremity functioning as bilateral reaching is important for self-care activities such as dressing, feeding, grooming, bathing, and personal hygiene.

- **Demonstration**: To start, the therapist will have the patient sitting at a table and will place two cups in front of them. The therapist will instruct the patient to reach for the cups with both hands. As you can see, the patient is having difficulty with their line of reach toward the cup on the right side. To address this issue, the therapist will now attach a TheraBand to the patient's right affected wrist. Next the therapist will once again instruct the patient to grab both cups. As the patient begins to miss the target, the therapist will pull the patient further away from the non-affected hand in order to increase the error. This will cue the patient to self-correct and attempt to resist the amplified error in a more controlled manner so that they can bring themself closer to the target. The therapist will remove the TheraBand from the patient's wrist and instruct them to grab both cups again. As you can see, the patient's right arm is moving closer towards the target than was previously observed.

- Feeding - **Remy**
  - **Introduction:** Now we will be demonstrating a feeding activity addressing poor hand to mouth coordination. The equipment needed for this intervention includes a utensil and an ankle weight. An individual post-stroke may experience challenges with feeding due to difficulty with hand to mouth coordination and weakness of the upper extremity. Using this method, we will be using an ankle weight to create an error. The goal of this is to make the act of bringing the hand to the mouth more difficult so that the patient has an easier time performing the action once the weight is removed. This technique is an occupation-centered intervention that aims to enhance the patient's ability to engage in eating and feeding activities of daily living.

  - **Demonstration**- First, the therapist will have the patient sitting at a table. Next, the therapist will instruct the patient to grab the utensil using their affected side which in this case is the right. They will then instruct the patient to bring the utensil to their mouth. As you can see, the patient is having difficulty completing this task due to weakness and the patient can be seen compensating by hiking their right shoulder up to get the utensil closer to their mouth. The therapist will then apply an ankle weight to the

patient's affected wrist. Now the therapist will instruct the patient to once again grab the utensil and bring it to their mouth. The additional weight to the wrist will make this task even more difficult for the patient to complete. However, once the weight is removed the patient will have an easier time bringing the utensil to their mouth. The therapist will now remove the weight. Once the weight is removed the therapist will instruct the patient to bring the utensil to their mouth once again. As you can see, the patient still shows difficulty reaching towards their mouth, but there is slightly less compensation of the right shoulder, and you can see that the patient has brought the utensil significantly higher and closer to their mouth than before.

- Posterior Lean - **Remy**
  - **Introduction:** We will now be demonstrating an error augmentation technique for a posterior lean which is commonly seen in post stroke individuals. We will be using a 2 handled resistance band and a gait belt to help stabilize the patient to prevent possible falls.
    Two therapists will be present for this technique to ensure the safety of the patient. One therapist will be holding the bands that are attached to the patient while the other is standing in front of the patient to ensure safety. The therapist holding the resistance band will apply force posteriorly in the direction of their lean to create an even greater error forcing the patient to exaggerate a lean in the opposite direction. This technique can be used as an occupational therapy intervention as supported by Verheyden and researchers in 2014 that found that impaired postural control and proprioception may be underlying factors of poor trunk control. This technique works on strengthening the patient's trunk muscles and maintaining proper alignment of the spine for dynamic standing balance and trunk control needed for activities of daily living.

  - **Demonstration** - First, the therapist will put the resistance band around the patient's waist. Next, they will apply resistance posteriorly cueing the patient to lean anteriorly to maintain their balance. As you can see, once the resistance band is removed, the patient will be in a more upright standing posture.

- Pushers Syndrome - **Andrew**
  - **Introduction** - Lastly, we will now demonstrate a technique that addresses pushers' syndrome. For this technique, we will be using a gait belt to maintain the patient's safety and an ankle weight to amplify the lean to the affected side, which in this case is the right side. Addressing Pusher syndrome is important in stroke recovery as patients may have difficulty participating in everyday activities. Also, this deficit may impact their ability to

        - **Demonstration -** First, we will have the patient sitting at the edge of the mat. Then, the therapist will apply the ankle weight to the wrist of the patient's affected side. With the affected side to the edge of the mat, the therapist will allow the weight to create an even greater lean so that the patient can perceive the lean which they were not aware of prior to the weight being applied. While the patient is in this position, it is important for the therapist to stand on the patient's affected side to maintain their safety. As you can see, once the ankle weight is removed, the patient will overcorrect to account for the weight that was previously there, bringing them closer to actual midline.

- **Conclusion - All**
    - **Regina -** Our educational video aims to introduce error augmentation to occupational therapy and to provide practitioners with more strategies and resources for a novel, innovative intervention approach that is supported by research literature.
    - **Remy**- As previously mentioned, error augmentation is a topic that has been largely unexplored in the field of occupational therapy. We hope that our study presents the need for more research opportunities for this intervention technique in occupational therapy and stroke rehabilitation settings.
    - **Andrew -** We want to thank you for taking the time to participate in our research project and ask that you please follow the link below to complete a quick 10-minute survey regarding the educational video.

Appendix D

Video Link

Introducing Error Augmentation as a Stroke Rehabilitation Intervention to Occupational Therapy

https://www.youtube.com/watch?v=Wmi6_OlqviE

Appendix E

Survey Questions

1. By taking this survey, I acknowledge that I have been provided with an informed consent document and agree to have my answers published in a thesis research study.

   □ I agree

   □ I DO NOT agree

2. Are you currently practicing occupational therapy in the United States?

   □ Yes

   □ No

3. Do you currently work with post-stroke rehabilitation patients or clients?

   □ Yes

   □ No

4. What type of occupational therapy practitioner are you? (please include your credentials)
   _____

5. How long have you been practicing as a licensed occupational therapy practitioner?

   □ 0-2 years

   □ 3-5 years

   □ 6-10 years

   □ 10 or more years

6. Were you familiar with the concept of error augmentation prior to participating in this study?

 Yes

 No

7. I am satisfied with this pilot educational course on error augmentation.

   Strongly Disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly Agree 5

8. I will implement error augmentation methods into my current practice.

   Strongly Disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly Agree 5

9. I believe error augmentation could potentially be more beneficial than traditional intervention methods in stroke rehabilitation.

   Strongly Disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly Agree 5

10. I would like to learn more about error augmentation as a stroke rehabilitation intervention.

    Strongly Disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly Agree 5

11. I would recommend this pilot educational video to my colleagues.

    Strongly Disagree 1 Disagree 2 Neutral 3 Agree 4 Strongly Agree 5

12. What is one technique demonstrated in the pilot video that you would implement in your current setting?
    _____

13. What would you change about the video?
    _____

14. What are some things you learned from this pilot educational study?
    _____

Appendix F

Survey Results

Figure F1

Percentage of Length of Time Participants Have Been Practicing OTP's

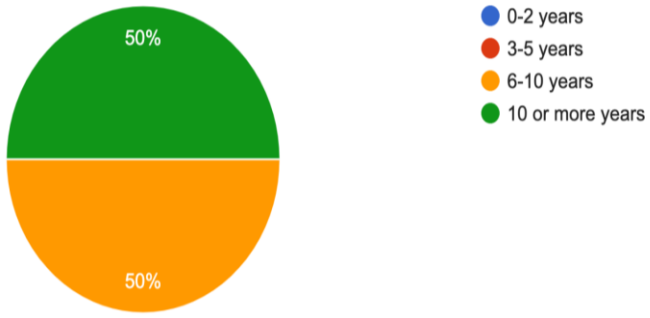


Figure F2

Percentage of Participants Unfamiliar with EA Prior to Participating in This Study

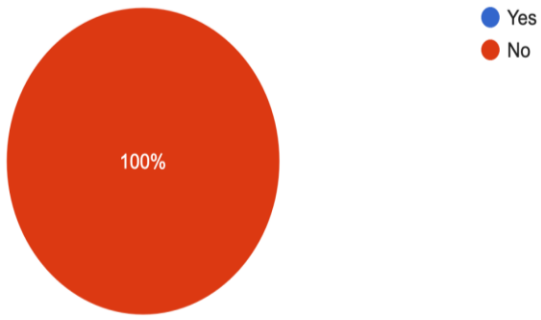


Figure F3

Number & Percentage of Participants Satisfaction with the Educational Video

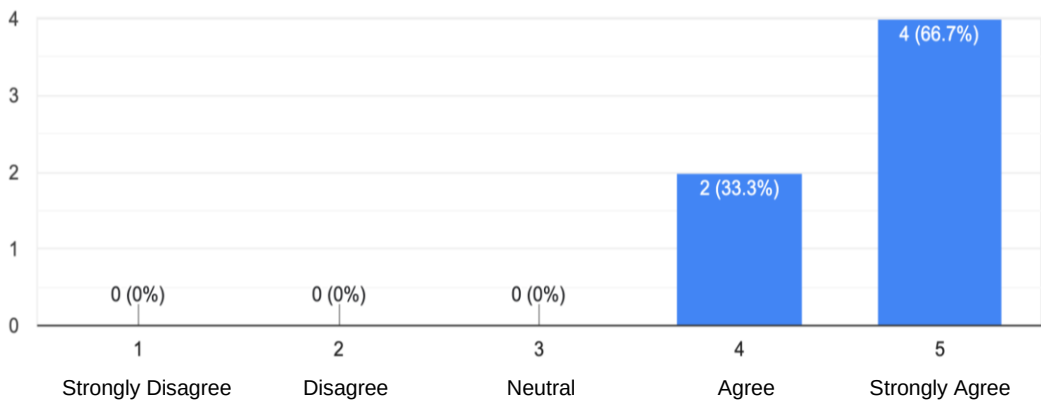


Figure F4

Number & Percentage of Participants That Will Implement EA Into Current Practice

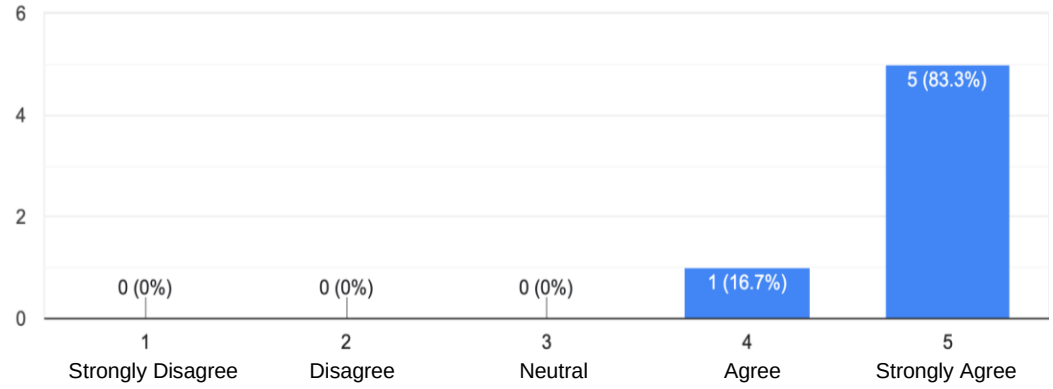


Figure F5

Number & Percentage of Participants That Believe EA Could Potentially Be More Beneficial Than Traditional Intervention Methods

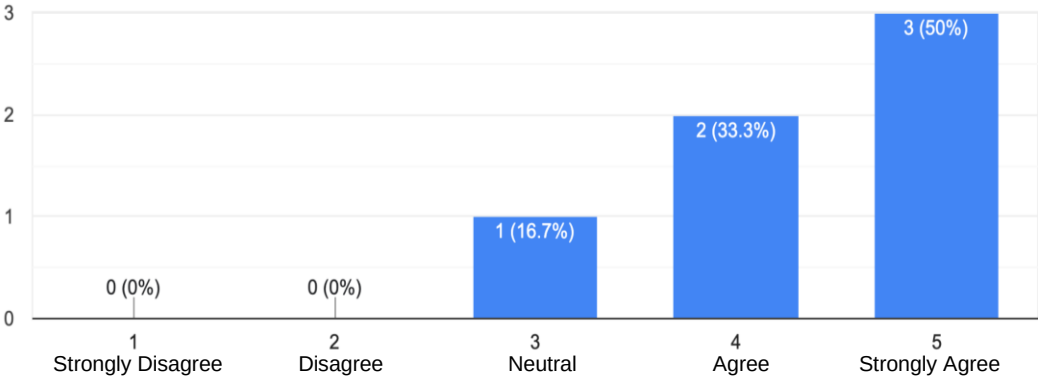


Figure F6

Number & Percentage of Participants Who Want to Learn More About EA

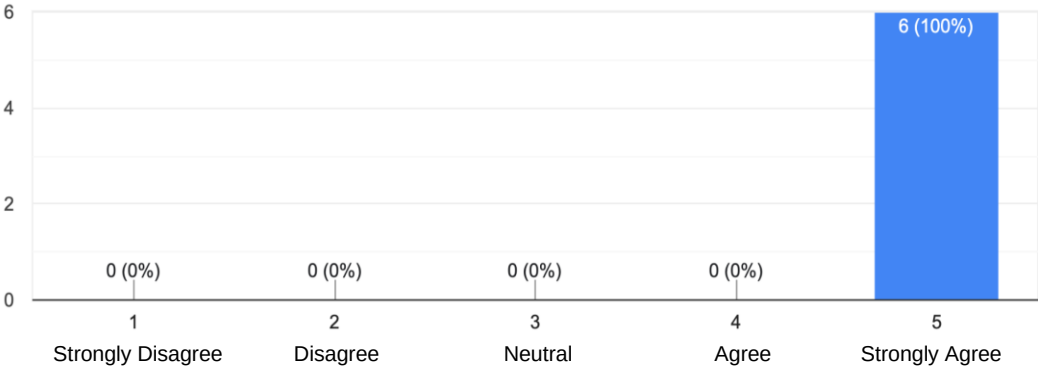
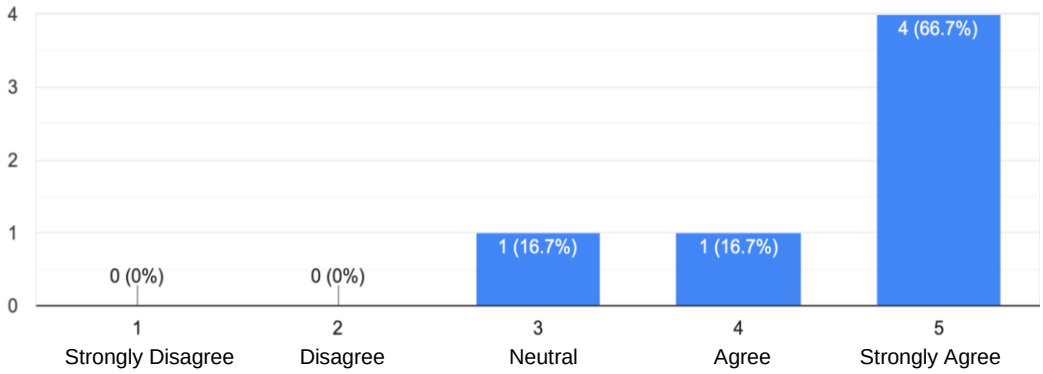


Figure F7

Number & Percentage of Participants Who Would Recommend This Video to Colleagues



Appendix G

Participant Statements

Table G1

Statements From Participants Regarding What Type of Occupational Therapy Practitioner They Are Including Their Credentials

Participant 1	"EdD, MS-OTR/L, SCFES, SCLV"
Participant 2	"OTR/L"
Participant 3	"Outpatient Neuro OTD, OTR/L"
Participant 4	"OTRL, HTC, PAMs"
Participant 5	"MA-OTR/L, OTDS"
Participant 6	"OTR/L inpatient hospital, outpatient clinic, and mental health"

Table G2

Statements From Participants Regarding What Technique Demonstrated in the Pilot Educational Video That They Would Implement in Their Current Setting

Participant 1	"Theraband on arm during reach"
Participant 2	"Bilateral integration using the theraband"
Participant 3	"Using the theraband to increase the error"
Participant 4	"Adding a resistive variable to increase awareness of affected side"
Participant 5	"Lean and feeding approach"
Participant 6	"Utilizing resistance bands during functional reaching and postural training to facilitate improved functional movement with decreased compensatory movements"

Table G3

Statements From Participants Regarding What They Would Change About the Educational Video

Participant 1	"Examples with actual clients, and additional treatment examples"
Participant 2	"None"
Participant 3	"Maybe have the students be more animated"
Participant 4	"Nothing, it was thorough and informative"
Participant 5	"It was pretty good"
Participant 6	"The individual demonstrating pusher-syndrome would be pushing much harder to the affected side, to the point where they are almost falling over. Set up should be done prior to the patient being sat up at the edge of a seat."

Table G4

Statements From Participants Regarding what they learned from the pilot educational video

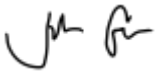
Participant 1	"Evidence behind error augmentation (evidence-based practice)"
Participant 2	"Different techniques to implement while working with patients post stroke"
Participant 3	"I learned what error augmentation is"
Participant 4	"Theraband and ankle weight techniques to improve functional outcomes for patients with hemiparesis"
Participant 5	"What Error Augmentation is"
Participant 6	"What error augmentation is, and that it promotes changes in movement control. Also learned some helpful techniques that can be utilized both in inpatient and outpatient settings."

Appendix H

Institutional Review Board Approval

Dear Dr. Alice Cheung and Students,

The Stanbridge University Institutional Review Board has completed the review of your application entitled "Pilot Educational Study: Introducing Error Augmentation as a Stroke Rehabilitation Intervention to Occupational Therapy." Your application (MSOT011-501) is approved and categorized as Exempt.

IRB Application Number	MSOT011-501
Date	08/22/2022
Level of Review	**Exempt**
Application Approved	X
Conditional Approval	
Disapproved	
Comments	The requested Minor changes have been reviewed and confirmed as completed by the IRB. (08/22/2022)
Signature of IRB Chair	

Please note that any anticipated changes to this approved protocol requires submission of an IRB Modification application with IRB approval confirmed prior to their implementation.

Sincerely,
Julie Grace, M.S., M.A.
IRB Chair