Title:

Emotion Recognition in Persons with Stroke: A Longitudinal Eye-Tracking Study

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Specific Aims

Stroke is the leading cause of long-term disability in the United States with over 800,000 persons suffering from stroke each year[1]. Persons with stroke are at risk of impairments in a variety of domains (e.g., physical, cognitive, and emotional). However, most studies overlook the impact of emotion recognition in stroke rehabilitation [2,3]. Impairment in emotion recognition after a stroke can negatively impact functional outcomes and quality of life [4,5]. Persons with stroke who have impaired emotional processing are less motivated[6], have difficulties in decision making[3], and trouble with social-interactions[7] (e.g., unable to empathize with others). Therefore, attention should be paid to how emotion recognition manifests in persons with stroke, so that appropriate interventions can be developed.

Previous research has suggested that persons with right-hemisphere (RH) stroke have deficits in recognizing facial emotions compared to individuals with left-hemisphere (LH) strokes and healthy controls[8]. However, persons with LH strokes may also be impaired in facial emotion recognition[3,9] as well as in recognition of emotional words[8]. The discrepancy in results could be attributed to methodological differences such as the use of different emotion recognition tasks and participant factors such as length of time post stroke onset. Most studies investigating emotion recognition have focused on chronic stroke (i.e., more than 6 months post-onset). Persons with chronic strokes may have undergone different recovery processes which may impact their emotion recognition differentially. Thus, a longitudinal study with sensitive measures of emotion recognition is needed in persons with both right and left hemisphere stroke.

Eye-tracking in neurologically healthy individuals and those with autism has been shown to be a robust tool in determining how individuals recognize emotional faces and emotional words[9-15]. For example, a recent eye-tracking study[16] found that successful emotion recognition of faces occurs when individuals focus on specific features of the face (e.g., eyes). Therefore, persons with stroke who have difficulty in recognizing facial emotions may have difficulty directing their visual attention to those parts of the face that are important for emotion recognition. Another eye-tracking study showed that neurologically healthy individuals direct their visual attention faster to emotional words as compared to neutral words, which aids their sentence comprehension[14]. Thus, eye-tracking has the potential to provide fine grained information regarding the pattern of emotional recognition deficit in persons with stroke. Yet, it has not been used with this population.

In this proposed study, we aim to recruit 36 participants (12 LH stroke, 12 RH stroke, and 12 healthy controls) and use eye-tracking to investigate emotional recognition of faces and words at 1 month, 3 months, and 9 months post-stroke.

<u>Aim 1:</u> Investigate emotional recognition of faces and words in person with a LH and RH stroke.
<u>Hypothesis 1A</u>. Based on the right-hemisphere hypothesis[17-19] (i.e., the right hemisphere processes emotions regardless of valance), we hypothesize that persons with RH stroke due to right hemisphere lesions will have deficits in emotion recognition for both words and faces compared to persons with a LH stroke and healthy controls.

<u>Aim 2:</u> Investigate whether emotional recognition trajectory will change over the course of 9 months.
<u>Hypothesis:</u> We hypothesize that emotion recognition will improve from baseline in both LH and RH stroke patients. However, persons with stroke will have emotional impairment compared to healthy controls.

Approach

We will recruit 24 persons with stroke (i.e., 12 with a RH stroke and 12 with a LH stroke). Participants will perform two eye tracking tasks, (a) facial emotion recognition and (2) emotion word recognition in sentences. The order of the tasks will be counterbalanced. Participants will also perform linguistic, cognitive, and mood assessments. The tasks will be administered 1-month post-stroke, 3 months post-stroke, and 9 months post-stroke. Twelve neurologically age and education matched healthy controls will also be recruited for our study and complete all the tasks once.

Participants

Patients will be recruited from the inpatient unit of Shirley Ryan AbilityLab and followed for a duration of 9 months. Inclusion Criteria: 1) Single right or left-hemisphere stroke as determined by MRI or CT scan, 2) 21-85 years of age, 3) premorbidly proficient in English, 4) education at least 6th grade, 5) visual acuity 20/40 correction. Exclusionary criteria: 1) Hemianopia, 2) cataracts, 3) Montreal Cognitive Assessment (MoCA) < 26[20] for healthy controls, and 5) Western Aphasia Battery-Revised Aphasia Quotient (AQ) < 25 to exclude individuals with severe language deficits.

Tasks

Cognitive Assessment: Montreal Cognitive Assessment (MoCA[20]) to assess general cognition.
Spatial Neglect: Behavioral Inattention Test[21] (BIT) will be used to assess neglect.
Aphasia Assessment: Presence of aphasia will be determined by the AQ of the Western Aphasia Battery-Revised[22].
Mood measures: *Center for Epidemiologic Depression Scale Revised (CESD-R[23])*- The CESD-R is a 20-item self-report measure of depression. *State Trait Anxiety*- The State-Trait Anxiety Inventory (STAI[24]) measures anxiety due to tasks or anxiety as a trait.

Eye-tracking Tasks

Eye-tracking will be collected using a 300 Hz infrared eye-tracker (Tobii-TX300, Sweden) mounted to a 23 inch monitor. Participants will be seated comfortably on a chair while performing emotion recognition tasks. Prior to both emotion recognition tasks (described below), participants will be shown practice trials to ensure they understand the task and can complete the tasks successfully.

Facial Emotion Recognition

Images of faces displaying seven different emotional expressions (i.e., angry, disgusted, happy, fearful, neutral, sad, or surprised) will be selected from the Karolinska Directed Emotional Faces picture set[25]. We will choose faces from 10 different actors with each actor displaying the seven emotions. Therefore, a total of 70 faces will be displayed in pseudo-randomized order. Each emotion will be displayed for 4 seconds. Participants will determine the emotion category of the face after each emotional face has been displayed by selecting the word denoting the appropriate emotion (e.g., **happy** for happy face).

Emotional Words

Twenty-five positive emotion words, 25 negative emotion words and 25 neutral words will be selected from the ANEW database[26]. ANEW database provides valance ratings with higher ratings reflecting positive valance. All the words will be matched on different lexical components (e.g., frequency). Sentences will be created that embed the target words in the middle of a single line sentence[14] (e.g., *The little boy was **excited** after he ate the ice cream*). A total of seventy-five words will be displayed in a pseudo-randomized order. Participants will press the spacebar when they have completed reading the sentence. After each sentence, participants will be asked a question regarding the sentence to ensure they comprehended the sentence.

Statistical Analysis

Multiple mixed repeated measures Bayesian ANOVAs will be completed with time and emotion as within-subject factors and group as a between subject factor. Dependent variables will be accuracy and gaze metrics. We will explore which parts of the face individuals fixated on when they judged emotions accurately. Bayesian analyses gives us advantages over inferential statistics by allowing us to set prior probabilities from prior eye-tracking studies of emotion in healthy individuals and extracting posterior probabilities which can be used to inform further analyses with different samples. Covariates such as age and gender will be included in our models.

Innovation

To our knowledge, this is the first study that investigates emotion recognition longitudinally and uses eye-tracking. The present study will provide us with evidence regarding change in emotion recognition as time post stroke increases. This will add to the body of literature that establishes physical and cognitive changes that occur from acute to chronic stages of stroke. Furthermore, eye-tracking will allow us to discern where persons with stroke fixate when they accurately identify different emotions. Results may provide us with preliminary evidence regarding compensatory mechanisms that can be taught to persons with stroke to aid them in emotion recognition (e.g., directing gaze to eyes). This study is consistent with the PIs line of work, yet it represents a new direction that will provide stronger evidence to support a more comprehensive R01 grant submission. This study adds a new population, those with RH stroke; it broadens the stimuli by adding a linguistic element, the emotional words embedded in sentences; and it targets individuals with acute stroke and then follows them longitudinally.

Post-Award deliverables

The post-award deliverables are as follows: 1) submit an R01 using pilot data from this foundational grant 2) submit a manuscript to the journal *Emotion*: 3) presentation of results at ACRM, ASHA and CAC.

Timeline

Months 1-2: IRB/ Train clinician, ***Months 2-18***: Recruitment, ***Months 10-12***: Interim data analyses and submit for oral presentation to CAC, ***Months 16***: Submit for oral presentation at ACRM and poster at ASHA, ***Months 18-22***: Final data analyses and submit R01. ***Month 22-24:*** Prepare and submit manuscript.

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