Introduction

In clinical practice, pictures are often used in multiple-choice arrays to assess linguistic comprehension of individuals with aphasia. From an array of images, the participant chooses the one that corresponds best to a verbal stimulus. Lack of linguistic comprehension is assumed when a participant fails by choosing an incorrect foil. However, an increasing body of research literature reports that participants might respond inappropriately because of the influence of stimulus-driven aspects, such as color, size or image frequency (e.g., Barbur, Forsyth, & Wooding, 1980; Heuer & Hallowell, 2005; Locher, et al. 1993; Wolfe, 2000). Those aspects are rarely considered in the design and evaluation of images used in multiple-choice components of aphasia batteries.

Heuer and Hallowell (2004) found that image sets from published aphasia batteries evoke disproportionate looking in adults without neurological disorders. Given that adults with neurological disorders are more likely than adults without such disorders to present with problems of attention (Helm-Estabrooks 2002; Murray, 2002) and vision (Fisk, Owsley & Mennemeier, 2002; Hallowell, Douglas, Wertz, & Kim, 2004) the potential impact of poor control in image design on assessment validity is an important consideration. It is impossible to predict influences of stimulus driven aspects and whether these influences may override the selection of images of particular individuals. The only way to ensure that these factors do not affect the visual attention of a given patient to any given item is to control for them in the image design. Eye movement measurements are an excellent tool to assess aspects of linguistic comprehension. Fixation duration, saccade length and frequency yield information about cognitive processes, such as language comprehension (Rayner, 1989). Physical stimulus properties and the semantic content conveyed by images influence eye movement patterns, as detected through eye movement monitoring (Rayner, 1989).

Heuer, Hallowell, Douglas, Kruse & Kim (2004) found that image sets that are controlled for physical stimulus properties and semantic conveyance evoke significantly less disproportionate looking than image sets not designed to control for those factors. The current study addresses means of comparing the degree of disproportionate looking with regard to physical stimulus features and semantic content conveyance in multiple-choice images drawn from published aphasia batteries, uncontrolled clipart images and images carefully designed to control for physical and semantic stimulus features.

Disproportionate looking is indicated when the number of fixations and the total duration of fixations are unequally distributed across the images presented in the display. The degree to which physical and semantic characteristics conveyed by images within multiple-choice displays is not controlled corresponds to the degree of disproportionate visual attention allocated to those images. Properties that might influence the viewer's visual attention include: a) physical stimulus properties (color, orientation, size, shading, luminance, complexity, symmetry, clarity), and b) semantic features (scene context, imageability of a semantic concept, perspective, image familiarity, concept frequency, social and cultural influences).

Methods

Eye movements of 19 individuals were monitored while they viewed each image set, using an ISCAN RK 426 pupil center/corneal reflection system (Hallowell, Wertz & Kruse, 2002). Three groups of image sets served as stimuli. The first group contained 20 image sets from multiple-choice reading and auditory comprehension tasks of published aphasia tests. These images were drawn from the Boston Diagnostic Aphasia Exam (BDAE) (Goodglass, 2001), the Western Aphasia Battery (WAB) (Kertesz, 1982), the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA) (Kay, Lesser & Coltheart, 1997), the Test of Communicative Abilities in Daily Living (CADL) (Holland,1980) and the Reading Comprehension Battery for Aphasia (RCBA-2) (LaPointe & Horner, 1998). The second group of images included 22 sets, each containing four carefully controlled images. These images were designed by a graphic artist who was familiar with the purpose of the study. The graphic artist created images to control for the following physical stimulus features, as described in detail by Heuer and Hallowell (2004): color, orientation, size, depth cues and shading, luminance, complexity, symmetry and asymmetry and clarity. The third group of image sets consisted of 22 sets, each containing four clip-art images. Each participant viewed 64 images sets presented in random order for three seconds. Each and was asked to simply look naturally at the images to be displayed.

Analysis

Disproportionate visual attention was detected as pop-out scores ranging from 0 to 1. 0 indicates equally distributed eye movements over all displayed images while a value close to 1 indicates a high degree of disproportionate looking.

$$\text{Pop-out score} = \frac{\text{Highest} - (1/\ \#\text{images})}{1 - (1/\ \#\text{images})}$$

where “Highest” means highest proportion of fixation duration within the display between 0 and 1. “# images” represents the number of images within the display.

Results

The degree of disproportionate looking at image sets was indexed using “pop-out” statistics. Pop-out scores for all three image groups are significantly different from 0, indicating disproportionate looking for all image types (controlled images $t(18) = 16.03$, $p < .01$; clipart images $t(18) = 14.422$, $p < .01$; published images $t(16) = 18.63$, $p < .01$). A comparison of the mean pop-out scores of the three groups revealed that the lowest degree of disproportionate looking exists in controlled image sets ($M = .53$, $SD = .15$), followed by image sets from published tests ($M = .56$, $SD = .12$) and clipart image sets ($M = .57$, $SD = .17$). Insufficient power and the small number of subjects ($N = 19$) precludes a valid statistical analysis. Further data are now being collected in our lab.

Conclusion

Pop-out scores indicate disproportionate looking at individual images within all 64 image sets. Mean pop-out scores for controlled images are smaller than those for images from published tests which are smaller than those for clipart images. These results confirm that disproportionate looking must be considered carefully in the design of new test image sets and taken into account when interpreting multiple-choice responses to existing test items. The relatively small difference of mean scores between controlled image sets and images from published tests speaks for the quality of the controlled design of the published images used. However, the difference between the mean pop-out score of the clipart images and the images from aphasia batteries is much smaller than the difference between controlled images and images from published tests. Still, given that it is impossible to predict the influence of visual attention on the linguistic comprehension process of a particular individual, even small differences between the pop-out score of controlled and uncontrolled images support the importance of a better controlled image design in multiple-choice test images for a valid assessment of language comprehension. Given the small number of aphasia tests represented in the sample, generalizations about the images in specific published aphasia tests cannot be made.

Clinical Implications

Visual attention can be influenced by stimulus driven aspects in multiple-choice image sets. Image sets that are not designed to control for physical stimulus features and semantic content conveyance may influence the validity of language comprehension testing. Use of clip-art images for aphasia assessment is not likely to allow for appropriate stimulus control. An invalid assessment of an individual's language comprehension abilities may lead to inappropriate socialization, rehabilitation, treatment planning, education and career opportunities.

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References

Barbur, J.L., Forsyth, P.M., Wooding, D.S. (1993). Eye movements and search performance. In Brogan, D., Gale, A. (Eds.), *Visual search* (pp.253-264).

Fisk, G. D., Owsley, C., & Mennemeier, M. (2002). Vision, attention, and self-reported driving behaviors in community-dwelling stroke survivors. *Archives of Physical Medicine and Rehabilitation, 83,* 469-477.

Goodglass, H. (2001). Boston diagnostic aphasia examination. (2nd Ed.) Baltimore, MD:

Hallowell, B., Wertz, R.T., & Kruse, H. (2002). Using eye movement responses to index auditory comprehension: An adaptation of the Revised Token Test. *Aphasiology, 16,* 587-594.

Hallowell, B., Douglas, N., Wertz, R.T., & Kim, S. (2004). Control and Description of Visual Function in Research on Aphasia and Related Disorders. *Aphasiology, 18* (5/6/7), 611-623.

Helm-Estabrooks, N. (2002). Cognition and aphasia: a discussion and a study. *Journal of Communication Disorders, 35,* 171-186

Heuer, S., Hallowell, B., Douglas, N., Kruse, H. & Kim, S. (2004, November) Pop-out effect in controlled and uncontrolled images in multiple-choice displays. Annual Convention of the American Speech-Language-Hearing Association. Philadelphia, PA.

Heuer, S., & Hallowell, B. (2004, June). Eye movement indices and subjective ratings of multiple-choice images in aphasia batteries. Clinical Aphasiology Conference. Park City, UT.

Holland, A.L. (1980). Communicative abilities in daily living. A test of functional communication for aphasic adults. Baltimore, MD: University Park press

Kay, J., Lessler, R. & Coltheart, M. (1997). Psycholinguistic assessments of language processing in aphasia. East Sussex, UK: Psychology Press

Kertesz, A. (1982). The Westerman Aphasia Battery. USA: The Psychological Corporation Harcourt Brace Jovanovich, Inc.

LaPointe, L.L. & Korner, J. (1998). Reading comprehension battery for aphasia. (2nd Ed.) Austin, TX: pro-ed

Locher, P.J., Cavegn, D., Groner, M., Mueller, P., d'Ydewalle & G., Groner, R. (1993). The effects of stimulus symmetry and task requirements on scanning patterns. In d'Ydewalle, G. Van Rensbergen, J. (Eds.) *Perception and Cognition*(pp.59-69). Amsterdam: Elsevier Science Publishers

Murray, L. L. (2002). Attention deficits in aphasia: presence, nature, assessment, and treatment. *Seminars in Speech and Language, 23,* 107-116.

Rayner, K., Sereno, S.C., Morris, R.K., Schmauder, A.R. & Clifton, C. (1989). Eye movements and on-line language comprehension processes. *Language and Cognition Processes, 4 (3/4),* pp. 21-49.

Wolfe, J.M. (2000). Visual attention. In K.K. De Valois (Ed.), *Seeing* (pp335-370). San Diego, CA: Ac