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 when in fact participants might have been influenced by stimulus driven aspects, such as color or size of an object (e.g., Barbur, Forsyth, & Wooding, 1980; Heuer & Hallowell, 2004; Locher, et al. 1993; Wolfe, 2000). Given that most patients with neurogenic language disorders demonstrate generalized deficits in attention (Helm-Estabrooks, 2002; Murray, 2002), and that many also present with specific visual attention deficits (Denes, Semenza, Stoppa, & Lis, 1982; Edmans & Lincoln, 1987; Harrington & Drake, 1990; Liesegang & McPhee, 1992; Myers, 1998; Tompkins, 1995; Wilson & Wyper, 1992; Ylvisaker, 1992), the influence of such characteristics is especially important to consider. Attentional impairments may affect not only the accuracy and efficiency of an individuals' language comprehension skills (Murray, 2002), but also the accuracy and efficiency of the selection of an appropriate multiple-choice response.

Eye movement measures have been shown to yield important information about cognitive and linguistic processes (Hallowell, Wertz & Kruse, 2002; Rayner, 1989). Physical stimulus properties and the semantic content conveyed by images have been shown to influence eye movement patterns (Rayner, 1989). Heuer, Hallowell, Douglas, Kruse and Kim (2004) found that image sets designed to control for physical stimulus properties and semantic conveyance evoke less disproportionate looking than image sets not designed to control for those factors. They reported differences in the degree of disproportionate looking when no verbal stimulus is presented with multiple-choice image sets having varied degrees of stimulus control. Results of Heuer, Hallowell, Douglas, Kruse and Kim (2004) and Heuer and Hallowell (2004) indicate that there are differences in visual attention due to differences in control of image characteristics. However, results to date have not yielded information regarding which specific image characteristics account for significant effects on disproportionate looking, and the relative influence of specific characteristics on differential allocation of visual attention.

The first goal of this study is to explore the influence on visual attention of specific characteristics of images within multiple-choice image sets that are controlled in terms of physical stimulus features. The image characteristics studied were derived from a previous study by Heuer and Hallowell (2004): size, color, orientation, and luminance. The second goal was to explore viewers' visual attention under the influence of a verbal stimulus. It is common clinical practice to present a word, phrase, or sentence together with a multiple-choice image set when assessing language comprehension skills. If there is an interaction between the verbal stimulus and the image characteristics of the corresponding multiple-choice display, it is generally assumed that the verbal stimulus overrides the possible stimulus-driven influences. However, given the known likelihood of individuals with neurological impairments to have deficits in attention, the comparison of verbal and nonverbal conditions, using the same image set, may yield important information about the influence of a verbal stimulus on participants' performance.

Methods

Participants were 40 adults, age 18 to 24, who were native speakers of English and reported no history of brain injury or learning disability. For each of the image characteristics, 10 image sets, each containing three simple shapes, were created. Within each set, two images were controlled for physical image characteristics (majority images) while one image was manipulated with regard to one characteristic (minority image).

Twenty control image sets were created, each containing three identical simple shapes. They were presented in random order during the nonverbal condition only.

For the nonverbal condition 60 multiple-choice image sets were for four seconds each on a computer screen. Participants were instructed to look "naturally" at the displays. Eye movements were reported with an ISCAN RK 426 pupil center/corneal reflection system at 60 Hz (Hallowell, Wertz & Kruse, 2002).

During the verbal condition participants viewed the same image sets (minus control image sets and sets with manipulated orientation). Participants were instructed to look at the image that corresponded best to the spoken word. For half of the sets corresponding to each image characteristic the verbal stimulus corresponded to the minority image. For the remaining image sets the verbal stimulus corresponded to the majority images. The verbal stimuli were single words: green, red, small, large, bright, and dark.

Analysis

A fixation was defined as a stable eye position of at least 100 milliseconds (Manor & Gordon, 2003). The degree of visual attention was expressed as the proportion of fixation duration on a particular image. In the nonverbal condition disproportionate visual attention was indexed via 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. The equation will be provided in this paper.

Results

In the nonverbal condition, the mean fixation duration allocated to the minority images (M = .39, SD = .10) was significantly greater than the mean fixation duration distributed to the majority images (M =.31, SD = .05), t (39) = 4.02, p < .001 (two tailed).

The mean pop-out score of the control image sets (M = .42, SD = .04) is not significantly different from that of the image sets containing minority and majority images (M = .42, SD = .08), t (58) = .06, p = .95 (two tailed) in the nonverbal condition. When comparing the mean pop-out score of the control images to zero, the mean pop-out score (M = .42, SD = .04) was significantly different from an ideal pop-out score of zero t (19) = 45.09, p < .001(two tailed).

Greater visual attention was allocated to the target in the verbal condition than to the corresponding image in the nonverbal condition. A significant main effect of both, condition F (1,58) = 41.02, p > .001 and image type F (1, 58) = 350.32, p > .001 was observed. The interaction between condition and image type was also significant F (1,58) = 223.37, p > .001.

Proportional fixation durations on minority images were greater when matching the verbal stimulus than when majority images matched the verbal stimulus. F (1, 28) = 593.31, p <.001.

Conclusion and clinical implications

In summary, each of the specific image characteristics had a significant influence on visual attention. Stimulus-driven processes appear to interfere with the influence of the verbal stimulus, even with participants with no language impairment, as indexed by the mean proportional fixation durations of minority and majority images within the verbal condition. There were no statistically significant differences in the influence of the four image characteristics.

Overall, results support the need for control of stimulus-driven aspects in multiple-choice displays, especially in the presence of a verbal stimulus. In clinical and research applications with individuals with neurogenic language disorders, it is not appropriate to assume that, for any given patient in a given multiple-choice testing situation, the influence of a verbal stimulus overrides the influence of visual stimulus characteristics.

It is important to further explore the interaction of verbal stimuli and image characteristics. Specifically, the complexity of verbal stimuli and their interaction with stimulus driven aspects should be studied.

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).

Denes, G, Semenza, C, Stoppa, E, & Lis, A. (1982). Unilateral spatial neglect and recovery from hemiplegia: A follow-up study. *Brain*, 105 (3), 543-52.

Edmans, J. A., & Lincoln, N. B. (1987). The frequency of perceptual deficits after stroke. *Clinical Rehabilitation, 1*, 273-281.

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.

Harrington, D.O., & Drake, M.V. (1990). *The Visual Fields* (pp. 5 - 64). St. Louis, MO: The C.V. Mosby Company.

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.

Liesegang, T.J., & McPhee, T.J. (1992). Neuro-ophthalmology. In Bartley, G. B. and Liesegang, T.J., (Eds.), *Essentials of Ophthalmology* (pp. 4-182). Philadelphia, PA: J. B. Lippincott Company.

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 G. d'Ydewalle, & J. Van Rensbergen (Eds.), *Perception and Cognition*(pp.59-69). Amsterdam: Elsevier Science.

Manor, B. & Gordon, E. (2003). Defining the temporal threshold for ocular fixation in free-viewing visuocognitive tasks. *Journal of Neuroscience Methods, 128*, 85-93.

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

Myers, P. S., (1998). *Right hemisphere damage: Disorders of cognition and communication*. San Diego, CA: Singular.

O'Donnell, B.F. (2002). Forms of attention and attentional disorders. *Seminars in Speech and Language, 23(2),* 99-106.

Photo Research Operating Manual (1990). Kollmorgen Corporation, Burbank:CA

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),* p. 21-49.

Reiff Cherney, L. (2002). Unilateral neglect: a disorder of attention. *Seminars in Speech and Language, 23 (2),* 117-128.

Tompkins, C. (1995). *Right hemisphere communication disorders: Theory and management*. San Diego. CA: Singular Publishing.

Wilson, J., & Wyper, D. (1992). Neuroimaging and neuropsychological functioning following closed head injury: CT, MRI and SPECT. *Journal of Head Trauma Rehabilitation, 7,* 29-30.

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

Ylvisaker, M. (1992). Communication outcome following traumatic brain injury. *Seminars in Speech and Language, 13,* 239-251.