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Research Article

Identification and Expression of Themes Depicted in Visual Scene and Grid Displays by Adults With Traumatic Brain Injury

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Purpose: The study purpose was to compare the speed and accuracy with which people with traumatic brain injury (TBI) identified themes depicted in visual scene and grid displays. Additionally, we compared the verbal responses associated with the 2 display types to determine whether adults with TBI tended to produce more action or naming messages.
Method: Thirteen adults with and 13 without TBI viewed grid and visual scene displays matched for content and theme. They then provided verbal responses stating the theme or central idea of each image.
Results: Although no significant differences were noted between groups for theme identification accuracy, adults with TBI required significantly more time than adults without TBI to process both display types. Both participant groups more rapidly and accurately identified visual scenes than grid displays. Additionally, participants with and without TBI produced more action messages in response to visual scenes and naming messages in response to grid displays.
Conclusions: This investigation provides preliminary evidence that themes that depicted visual scenes maybe more rapidly and accurately identified than those depicted in grid displays. Additionally, visual scenes may more effectively represent action messages, and grids may more effectively represent naming messages for people with TBI.

Many adults with severe traumatic brain injury (TBI) face significant, immediate, and long-term challenges with functional communication as a result of persistent cognitive, linguistic, and motor impairments. In these instances, augmentative and alternative communication (AAC) supports may be implemented to supplement or replace ineffective expressive or receptive communication skills (Burke, Beukelman, & Hux, 2004; Doyle et al., 2000; Wallace & Kimbarow, 2016). Although essential, implementation of AAC supports is not always a straightforward process. For people with TBI, one of the primary challenges is to design supports that are sufficiently robust to meet a variety of communication needs, yet simple enough to require minimal new learning for successful implementation. As such, research describing the effects of design features on the interpretation of displays could shed light on ways to improve the usability of AAC supports for adults with TBI.

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Grid Displays

To ensure the effectiveness of an AAC system, clinicians must identify an appropriate message representation method and a suitable display style for each of their clients. Historically, this meant selecting from either line-drawn icons or photographs of decontextualized objects depicted on plain backgrounds. These icons and photos, sometimes referred to as decontextual images, are typically organized into grid displays consisting of rows and columns of individual cells, each representing a unique word or concept. To use grid-based systems effectively, individuals must identify and select a sequence of words or cells and combine them to communicate a complete message. Given the space limitations on many AAC device screens, this often requires navigating among several pages of content (Drager, Light, Speltz, Fallon, & Jeffries, 2003). The overall process of identifying and building messages as well as system navigation undoubtedly places strain on several facets of cognition including working memory, cognitive flexibility, attention, and reasoning (Light & Lindsay, 1991; Thistle & Wilkinson, 2013; Wallace, 2010). Wallace (2010) pointed out that the

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use of decontextual images, as well as the navigation required when using grid displays, results in a cognitive load that may burden or exceed the capabilities of an individual with TBI. As such, it is essential to identify ways to minimize the cognitive load associated with AAC use for these individuals. One method that may minimize the navigational requirements of an AAC system is to organize language concepts presented in a display into event schemas or themes. For example, all content related to the action of doing laundry (e.g., washing machine, laundry basket, washing) is displayed in a grid on one page of an AAC system display. In this manner, an individual could discuss the overall topic and its related subcomponents with minimal system navigation. Reduction of the navigational demands of a system could reduce the cognitive demands associated with AAC use; however, challenges may still exist with combining symbols to formulate messages and with identifying decontextual images.

Visual Scene Displays

In an effort to reduce the message formulation, representation, and navigational demands associated with AAC use, researchers have begun to investigate the effects of incorporating highly contextual images, often referred to as visual scenes, into AAC displays for people with aphasia (Beukelman, Hux, Dietz, McKelvey, & Weissling, 2015). Visual scenes depict people and objects within natural environments and are designed to represent situations, events, and experiences (Dietz, McKelvey, & Beukelman, 2006). The provided context along with the naturalistic orientation and placement of objects and people depicted in visual scenes are thought to allow for transparent representation of complex, holistic messages (Dietz et al., 2006). In addition, visual scenes naturally conform to a schematic organizational strategy. For example, like the hypothetical grid described above containing several elements associated with laundry, a visual scene may represent this same concept by depicting an individual in a laundry room pouring detergent. Because of these potential advantages over grids, visual scenes are gaining traction in individuals with aphasia as they have been shown to effectively support the comprehension and expression both of people with aphasia (Brock, Koul, Corwin, & Schlosser, 2017; Dietz et al., 2006; Griffith, Dietz, & Weissling, 2014) and their communication partners (Hux, Beuchter, Wallace, & Weissling, 2010).

Given the promising evidence emerging from the aphasia literature, it is not surprising that researchers have begun to examine the effects of incorporating visual scenes into AAC supports for people with TBI (Thiessen, Brown, Beukelman, Hux, & Myers, 2017; Wallace, Hux, & Beukelman, 2010). Although limited in quantity, studies examining visual scene use for people with TBI have revealed positive results. However, the effects of visual scene implementation among these individuals are not as clear as those documented in the aphasia literature. For example, Wallace et al. (2010) examined the effects of image context on AAC system navigation for a group of adults with TBI. Results indicated that participants more accurately navigated displays containing visual scenes than those containing decontextual photos. However, visual scenes required increased processing time resulting in slower navigation than decontextual photos. Further discrepancies in visual scene research in people with TBI include the relation between message type and image preference (Thiessen et al., 2017). Specifically, adults with TBI report a preference for visual scenes to represent action messages (e.g., Which of these would you choose if you wanted to tell me about making a hot drink?") and prefer decontextual photos to represent naming messages (e.g., "Which of these would you choose if you wanted to say 'teapot?'"). However, evaluation of visual support preferences for language expressed beyond the word or phrase level is currently unexplored. Visual scenes may provide further advantages compared to grids given that people with TBI exhibit visual attention patterns to engagement cues (i.e., human figure touching and looking at an object) depicted in visual scenes that are similar to their peers without neurological conditions (Thiessen, Brown, Beukelman, & Hux, 2017). However, they are not as adept at extracting the details or processing inferential information depicted in contextually rich images as individuals without neurological conditions (Brown, Hux, Knollman-Porter, & Wallace, 2016). Thus, evaluating discrepancies in comprehension when individuals with TBI view various forms of visuographic support is warranted.

Gist Comprehension

Although research reveals mixed benefits associated with the use of visual scenes for adults with TBI, one potential advantage is their ability to explicitly represent the "gist" of situations or events (Dietz et al., 2006). Gist reasoning involves rapid synthesis of large amounts of information to deduce a global meaning (Anand et al., 2011; Underwood, 2005). Researchers argue that the interaction of human figures, objects, and background context depicted in visual scenes allows for naturalistic gist reasoning of these images (Dietz et al., 2006; McKelvey, Dietz, Hux, Weissling, & Beukelman, 2007). Moreover, the discreet and individualized nature of the images found in grid displays may require people to exert more cognitive effort when attempting to deduce the overall theme of these displays (Dietz et al., 2006). Although gist reasoning requirements may be lower for visual scenes than grid displays, limited evidence exists to validate this claim for adults with TBI. Given that people with TBI often present with deficits in gist reasoning (e.g., Gamino, Chapman, & Cook, 2009), identifying features associated with AAC displays that reduced gist reasoning requirements may have a positive impact on the implementation of AAC support for these individuals.

Current Study

It is essential to learn more about the accuracy with which individuals with TBI acquire the gist of grids and visual scene displays. In addition, examination of the linguistic descriptors produced by individuals with TBI when viewing these two types of displays will help shed light on the potential benefits of each display type. Hence, the first purpose of this study was to examine the accuracy with which people with TBI identified the gist of themes depicted in visual scenes and grid displays. Given the challenges with gist processing commonly experienced by people with TBI and the isolated nature of items presented in grids, we hypothesized that our participants would more accurately identify themes depicted in visual scenes than grid displays. The second purpose of this study was to evaluate the theme response phrases elicited by presenting each of these two display types. Because people with and without TBI tend to prefer visual scenes for expressing action messages and decontextual photos to express naming messages (Thiessen et al., 2017), we hypothesized that our participants would produce more verb messages for visual scenes and more noun phrases for decontextual photos.

Method

Participants

Participants With TBI

The Institutional Review Board at the University of Houston approved this study. We recruited 13 adults (i.e., 10 male, three female) with TBI from a local inpatient brain injury rehabilitation facility. A member of the research team who was employed at the rehabilitation facility examined the charts of all incoming patients with a history of TBI at the facility to determine if each individual met the inclusion criteria to participate in the study. Specific inclusion criteria included the ability to speak intelligibly, attend to task with minimal cues for at least 15 min, sufficient vision to discriminate among pictured objects, and intact language functioning (i.e., no history of aphasia). All 13 participants who were recruited had sustained a single severe TBI resulting in a loss of consciousness for more than 1 day and/or post-traumatic amnesia lasting more than 1 week (Fortuny, Briggs, Newcombe, Ratcliff, & Thomas, 1980). These participants ranged in age from 22 to 69 years (M = 40.15, SD = 15.36) and were between 3 and 188 months (M = 27.31, SD = 48.67) postonset of TBI. All were fluent speakers of American English and had completed between 10 and 21 years (M = 14.23, SD = 2.54) of education. The participant who did not complete high school passed the high school equivalency test prior to injury. In an effort to control for previous learning and potential bias, none of our participants used AAC at the time of this investigation; however, two of these individuals presented with significant dysarthria and could have benefitted from augmentative support.

We administered the Aphasia Quotient portion of the Western Aphasia Battery–Revised (Kertesz, 2006) to ensure participants did not have concomitant aphasia, a diagnosis that could hinder accurate naming ability. All participants received Aphasia Quotient scores above 93.8 (range: 95.2–99.9, M = 97.74, SD = 1.54) indicating that they did not have aphasia. Participants also completed the Cognitive Linguistic Quick Test (CLQT; Helm-Estabrooks, 2001) to assess cognitive functioning at the time of study completion. Participants demonstrated a range of composite scores (M = 3.13, SD = 0.86) on the CLQT. Although some participants scored within the normal range, they still required skilled intervention for significant cognitive deficits and resided in a residential treatment facility. Two participants (i.e., Participants 4 and 10) were unable to complete the CLQT in its entirety as a result of concomitant physical disorders. See Table 1 for further information regarding participant demographics and testing.

Participants Without TBI

We also recruited 13 participants (i.e., 10 male and three female) without TBI to complete this investigation. We recruited these individuals through flyers on the university

Table 1. Participant demographics.

Demographics					Cognitive Linguistic Quick Test scores					
Part. no.	Gender	Age	Etiology	Mos. postinjury	Att.	Mem.	Exec. Func.	Lang.	Vis. Spatial	Total
1	M	25	MVA	7	4	4	4	4	4	4
2	M	48	Fall	19	3	4	2	4	3	3.2
3	M	44	MVA	17	3	3	1	3	3	2.6
4	M	35	MVA	188	N/A	2	N/A	2	N/A	N/A
5	M	42	Bicycle	12	3	2	1	2	3	2.2
6	M	60	Fall	3	4	4	4	4	4	4
7	F	23	MVA	23	4	4	4	4	4	4
8	M	25	MVA	10	4	3	4	4	4	3.8
9	F	29	MVA	10	4	2	4	4	4	3.6
10	M	57	MVA	12	N/A	3	N/A	3	N/A	N/A
11	M	43	MVA	13	2	1	1	2	1	1.4
12	M	22	MVA	25	2	3	2	3	3	2.6
13	F	69	Fall	16	3	3	3	3	3	3
Average		40.15	N/A	27.31	3.27	2.92	2.72	3.23	3.27	3.13

Note. MVA = motor vehicle accident; N/A = indicates that subtest could not be completed as a result of physical disability; Att. = Attention; Mem. = Memory; Exec. Func. = Executive Function; Lang. = Language; Vis. Spatial = Visual Spatial; part. = participant; no. = number; mos. = months.

campus and word of mouth by former participants. All of these individuals completed a neurological history questionnaire (Thiessen, Beukelman, Ullman, & Longenecker, 2014) to confirm that they had never experienced a neurological event (e.g., stroke, TBI) or been diagnosed with a neurological disease/disorder (e.g., multiple sclerosis). All participants were fluent speakers of American English who had completed between 12 and 22 years ($M = 14.77$, $SD = 2.62$) of education. They ranged in age from 23 to 64 years ($M = 41.69$, $SD = 13.65$). Two independent samples t tests confirmed no significant differences between participant groups relative to age, $t(24) = -0.270$, $p = 0.790$, or education, $t(24) = -0.512$, $p = 0.613$.

Equipment

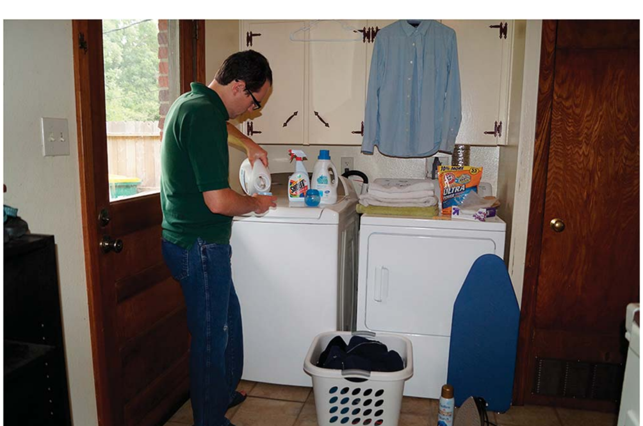
Study images were presented on the Tobii T60 17-in. monitor that was linked to a separate laptop computer loaded with Tobii Studio software. Tobii Studio software was specifically designed for eye-tracking experiments; however, for the purposes of this project, it allowed for individual image presentation on the monitor and provided us with accurate measurements of total viewing time for each stimulus image. The software also allowed for customizable screen advancement. Thus, when appropriate, the researcher had control over screen advancement by pressing a mouse, the participant could control advancement by pressing a response box, or viewing duration could be set in advance by a timing mechanism (e.g., fixation dot—see below).

Stimuli

Experimental Images

A total of 10 grids and 10 visual scenes served as experimental stimuli for this investigation (see Figures 1 and 2). Each grid was composed of 12 cells (16.5 x 22.85 cm) arranged in a 3 x 4 pattern. Each cell measured 5.08 x 5.72 cm and contained either a decontextual photograph of a human figure or an object depicted on a plain white background. We gathered decontextual photos from online and randomly arranged image content within each grid. The human figures in the grids were depicted in a camera-engaged (Thiessen et al., 2014), portrait-style manner—that is, from the waist up, facing forward toward the camera. All grids contained between one and three human figures ($M = 1.50$, $SD = 0.71$).

Figure 1. Example of a visual scene image representing laundry.



We also created 10 (16.5 x 22.85 cm) visual scene photographs with a Canon Rebel T1i camera. These photographs contained high levels of background context and depicted naturalistic environments. The number of human figures appearing in visual scenes was matched to the number appearing corresponding grids; however, all human figures were task-engaged—that is, looking at and touching a relevant object depicted in the photo context (Thiessen et al., 2014). Visual scenes depicted humans both in indoor and outdoor locations (e.g., home, back yard).

We formatted each grid and visual scene image to 700 x 466 pixels in Microsoft Paint. This was done to ensure that the digital images presented on the monitor were of equal size. All images were presented in the center of the monitor surrounded by a black border.

Theme validation. The experimental stimuli selected for this investigation were paired such that visual scene content corresponded with grid content. Each pair represented a unique theme (see Table 2 for theme list) that most individuals would either have direct experience or indirect knowledge of over the course of their lives. For example, the visual scene of a man doing laundry was paired with a grid composed of the same items associated with laundry (e.g., washing machine, detergent, laundry basket). All grids and visual scenes were organized using a schematic-based organizational strategy. Development of each theme involved a multistep process. First, members of the research team developed a list of plausible themes. Next, we created lists of relevant items associated with each possible theme. Given that the grids for this study contained 12 separate cells, each theme was required to have enough relevant associated items to fill the corresponding grid. To ensure that the associated items were in fact relevant and related to the corresponding theme, we created lists of these items and asked five adults without neurological conditions who did not participate in the research study to indicate whether each item listed related to the overarching theme. Items were included if at least 80% (i.e., four out of five) of raters agreed that they were related. Of the potential themes identified, 14 emerged meeting study criteria. We then developed our stimuli and randomly selected 10 of these themes to be included into the experimental stimulus set, the remaining four served as grid foil stimuli (see below). In addition to pairing stimuli based on theme, we also kept the number and gender of human figures consistent across visual scenes and grid pairs.

Experimental image validation. All experimental grids and visual scenes selected for use in this investigation were validated to ensure we had accurately represented chosen themes. Specifically, five adults without neurological conditions who were naïve to the study purpose and did not act as participants in the study rated each image on a 5-point Likert scale based on how well each image represented

Figure 2. Example of a grid display representing laundry. The text serves to represent the decontextual photographs used in the study.

its designated theme. The scale points ranged from *strongly disagree* (1) to *strongly agree* (5). Images were excluded if they were not rated at or above a 4 (i.e., *agree*) by all five raters. This process resulted in the removal of one visual scene from the set, which was later replaced by a different visual scene with the same theme that garnered higher ratings.

In addition, all elements depicted in our experimental displays were also validated to ensure that they were clear and unambiguous to viewers. To do this, 10 individuals without neurological conditions who did not participate in the study named each element as presented on a computer display. Of the 120 elements validated, 112 (i.e., 93.33%) were identified correctly by all 10 validators, and no objects were incorrectly identified by more than two validators.

Foil Images

In addition to the experimental stimuli created for this investigation, we also systematically dispersed eight foil images—four grids and four visual scenes—into the experimental image presentation order. Foil images were not matched for theme, and as such, they served to reduce the likelihood of a learning effect as image viewing progressed. The order of foils was maintained in both image presentation orders.

Table 2. List of display themes for grids and visual scenes.

Themes
- laundry
- sewing
- changing a diaper
- baking
- exercising
- office work
- grilling
- camping
- painting
- road trip

Vision Screening

All participants completed a vision screening prior to participating in the experimental task. The vision screening was designed to ensure that participants were able to visually attend to and perceive all regions of the stimulus presentation monitor. To complete the screening, each participant viewed 10 “X” symbols in various locations on the screen. To be deemed eligible, participants visually fixated on each “X” within 5 s of its appearance on the monitor. We made this determination through the use of eye-tracking software.

Experimental Procedures

The experimental session consisted of three separate events: (a) a training and practice period, (b) the experimental task, and (c) completion of a follow-up questionnaire and discussion. During the training period, we provided detailed instructions and demonstrated the experimental task with two example visual scenes and two example grids. Then, participants practiced the experimental procedures with three additional images (i.e., two scenes and one grid). During these practice attempts, we cued participants to verbally state the themes depicted in the images presented. Participants were allowed to ask questions for clarification only during the training and practice periods. Once they demonstrated successful practice activity completion by demonstrating appropriate seating position, pressing the response box, and attempting to state image themes, participants began the experimental task.

We used a quasi-randomization procedure to assign participants to one of two presentation orders prior to initiating the experimental task. The two presentation orders were counterbalanced such that, for each theme pair, half of the participants viewed the grid first and half of the participants viewed the visual scene first. Presentation of each stimulus item required a three-step process. First, a fixation dot page consisting of a black screen with a red dot appeared in the center of the monitor. The insertion of a fixation dot served to align participants' vision to the same location prior to viewing each experimental image (Brown, Thiessen, Beukelman, & Hux, 2015; Thiessen et al., 2014; Thiessen, Beukelman, Hux, & Longenecker, 2016). After 2 s, an experimental image—either a grid display or visual scene—replaced the fixation dot. Participants viewed each experimental image until they were ready to respond, and the total viewing time was recorded for later analysis through Tobii Studio software. At that time, they pressed a response box key, revealing a blank white screen. The appearance of the white screen indicated that participants should state what they believed to be the theme depicted in the previous stimulus item. The researcher video recorded this process to later transcribe verbatim and analyze oral responses. After the participant had viewed a stimulus set and provided a theme response, the researcher manually advanced the screen and a new fixation dot appeared. This process repeated until a participant viewed all 28 (i.e., 20 experimental and eight foil) images. Immediately after completing the eye-tracking portion of the experiment, participants completed an image rating task for each of the experimental images in which they rated to what extent they agreed that themes stated by the researcher were represented in corresponding images. Total time to complete the training and experimental tasks was approximately 45 min.

Dependent Variables

Data were analyzed across four dependent variables: (a) theme identification accuracy, (b) total viewing time, (c) elicited response type, and (d) theme likeness rating. Each dependent variable was selected because it provided unique information about the processing of grids and visual scenes.

Theme Identification Accuracy

We utilized a validation process to assess theme identification accuracy for experimental images. The first step in this process was to transcribe participants' recorded theme responses. Then, a group of 15 adults without neurological conditions (i.e., 10 female, five male) viewed each image and reviewed the corresponding transcribed responses. These raters then scored all responses on a 3-point scale with 0 points indicating that a stated theme does not match the image, 1 indicating that a stated theme somewhat matches the image, and 2 indicating that a stated theme completely matches the image. To be considered as an accurate response, 80% or more of raters (i.e., 12/15) scored stated themes as either 1 or 2 points. We considered those items not meeting these criteria as incorrect responses.

Total Viewing Time

In addition to analyzing theme accuracy, we also examined the amount of time participants needed to correctly interpret experimental images. Total viewing time referred to the elapsed time in milliseconds from when an image appeared on the monitor to the moment participants advanced the screen to state an image theme. Total viewing time was calculated only for accurately identified images to reduce the chance of prolonged views leading to inaccurate conclusions and skewed data. Behaviors associated with incorrect responses likely differed from correct responses and, thus, were not applicable to the proposed research questions. Viewing times for correct responses were averaged for each participant both for grids and visual scenes. Lengthier processing times were indicative of more difficulty with image interpretation and a need for greater cognitive effort.

Elicited Response Type

In addition to measuring accuracy and viewing time, we also examined the theme responses elicited from participants when viewing grids and scenes. Specifically, responses were divided into naming and action messages. Naming messages were defined as words or phrases that primarily listed items or named a particular event, activity, or task (e.g., "supplies for a cook out" to describe the theme grilling). Action messages were defined as messages that described the action depicted in a display (e.g., "grilling food" to describe the theme grilling). To calculate this variable, three trained research assistants coded transcribed responses into either naming or action messages. The research assistants were blinded to display type, image theme, participant type, and study purpose. In the event that the research assistants were not in agreement, a member of the research term examined the response and made a determination.

Theme Likeness Rating

In an effort to better understand perceptions and opinions of grids and visual scenes, participants completed a follow-up rating of each experimental image. Specifically, participants again viewed each image on the monitor individually and were asked to rate their agreement on a 5-point Likert scale ranging from *strongly disagree* (i.e., 1 point) to *strongly agree* (i.e., 5 points) with the theme stated by the researcher. The purpose of this rating was to determine whether differences were noted in adequacy of theme representation for grids and visual scenes for individuals within our participant sample. Higher scores indicated that participants felt an image was more representative of the researcher's intended theme than lower scores.

Data Analysis

Prior to completing parametric statistical analysis, we completed testing to determine whether parametric testing was appropriate for this investigation. To do this, we assessed the skewness and kurtosis of our data distributions using Shapiro-Wilk testing (Shapiro & Wilk, 1965; Razali & Wah, 2011) and examined the equality of variance between participant groups with a Levene's test. Results from the Shapiro-Wilk testing revealed that a majority of our data distributions violated the assumption ($p < .05$) of a normal distribution. In addition, results from the Levene's test indicated violations in the assumption of equality of variance for nearly all data. Given these results, we opted to complete nonparametric statistical testing on our data. We completed Mann–Whitney U testing to examine differences between participant groups. Wilcoxon signed-ranks testing was conducted to assess differences between grids and visual scenes. Effect sizes are also provided for significant effects.

Results

Theme Identification Accuracy

Mean and standard deviation scores for theme identification accuracy are presented in Figure 3. Computation of Mann–Whitney U tests revealed no significant differences in identification accuracy between participants with and without TBI for either grids, $U = 84.00$, $p = 0.978$, or visual scenes, $U = 75.50$, $p = 0.610$. When considering each group separately, comparison of theme identification accuracy through completion of a Wilcoxon signed-ranks test revealed that both participants with, $z = -1.992$, $p = .046$, $r = -.532$, and without TBI, $z = -2.333$, $p = .02$, $r = -.624$, achieved significantly greater accuracy when identifying visual scenes than grid displays.

Total Viewing Time

Mean and standard deviation values for total viewing time are presented in Figure 4. Computation of a Mann–Whitney U test comparing the total viewing time necessary to identify grids revealed that participants with TBI required significantly more time to identify grid displays than did participants without TBI, $U = 11.00$, $p < 0.001$, $r = 0.546$. Similarly, participants with TBI required significantly more time to identify visual scenes than did participants without TBI, $U = 18.00$, $p = 0.001$, $r = 0.447$. Comparison of total viewing time using a Wilcoxon signed-ranks test revealed that participants with TBI required significantly less viewing time to identify visual scenes than grid displays, $z = -2.132$, $p = 0.033$, $r = -0.570$. The same was noted for participants without TBI, as they required significantly less viewing time to identify visual scenes than grids, $z = -2.760$, $p = .006$, $r = -.738$.

Elicited Response Type

Mean and standard deviation results are presented in Figure 5. Results from a series of Wilcoxon signed-ranks tests indicate that both participant groups produced significantly more naming messages in response to grids than visual scenes (TBI: $z = -3.184$, $p = 0.001$, $r = -0.851$; without TBI: $z = -3.180$, $p = 0.001$, $r = -0.850$) and significantly more action messages in response to visual scenes than grids (TBI: $z = -3.184$, $p = 0.001$, $r = -0.851$; without TBI: $z = -3.180$, $p = 0.001$, $r = -0.850$).

Further comparison revealed that both groups produced significantly more action messages than naming messages in response to visual scenes (TBI: $z = -3.204$, $p = 0.001$, $r = -0.856$; without TBI: $z = -2.993$, $p = 0.003$, $r = -0.800$). Additionally, in response to grid displays, adults with TBI produced significantly more naming messages than action messages, $z = -2.703$, $p = 0.007$, $r = -0.722$; however, no significant differences were noted in the production of naming and action messages for adults without TBI in response to grids, $z = -1.307$, $p = .191$, $r = -0.349$.

Overall, no significant differences were noted between participant groups relating to response type for each stimuli condition. Specifically, results from a series of Mann–Whitney U tests revealed no significant differences between groups in the production of naming messages, $U = 78.00$, $p = 0.730$, or action messages, $U = 78.00$, $p = 0.730$, in response to visual scenes. Additionally, no significant differences were noted between participant groups in the production of naming messages, $U = 50.50$, $p = 0.078$, or action messages, $U = 50.50$, $p = 0.078$, in response to grids.

Theme Likeness Rating

Mean and standard deviation results for theme likeness ratings are presented in Figure 6. Results from

Figure 3. Mean results for theme identification accuracy. Error bars denote standard error. TBI = traumatic brain injury.

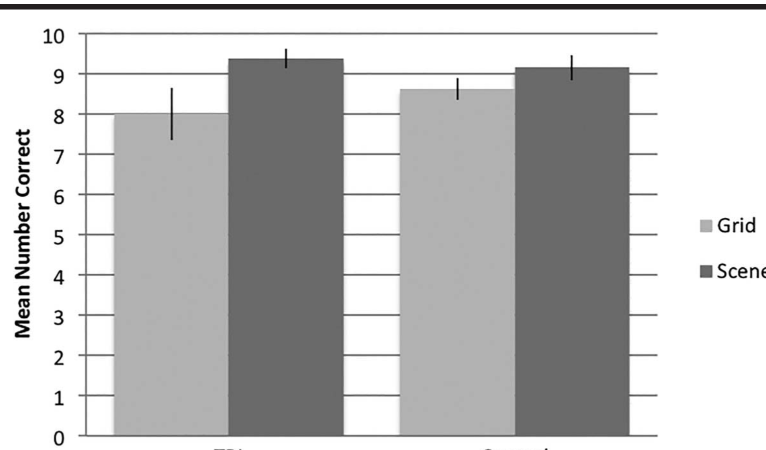
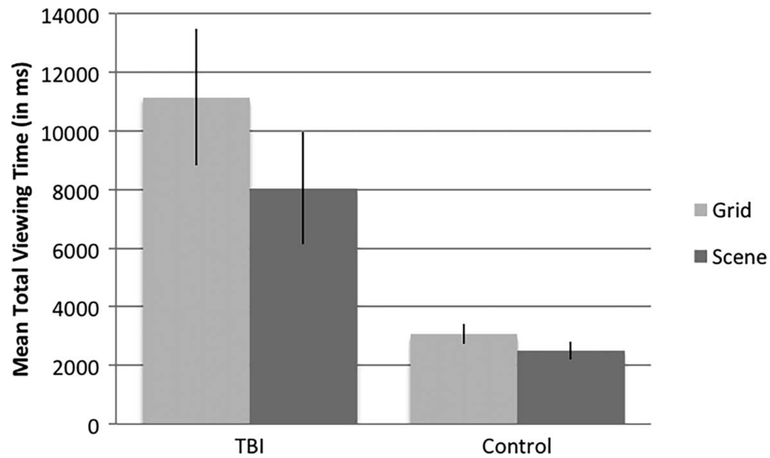


Figure 4. Mean results for total viewing time. Error bars denote standard error. TBI = traumatic brain injury.



a Mann–Whitney U test revealed that participants with TBI rated visual scene themes significantly lower than participants without TBI, $U = 42.50$, $p = 0.029$, $r = 0.184$; however, no significant differences were noted between participant groups for grids, $U = 54.50$, $p = 0.125$. Comparison between display types with a Wilcoxon signed-ranks test revealed that participants without TBI rated theme likeness significantly higher for visual scenes than grids, $z = -2.190$, $p = 0.029$, $r = -0.585$; however, no significant differences were noted between grids and visual scenes for participants with TBI, $z = -1.414$, $p = 0.157$.

Discussion

Many individuals with TBI rely on AAC for functional communication support. Given the prevalence and nature of the cognitive deficits experienced by these individuals, it is essential that clinicians design AAC displays that reduce the cognitive effort required to locate and identify appropriate messages. The purpose of the current study was to examine the speed and accuracy with which people with TBI interpret and identify visual scene and grid displays as well as to document the adequacy with which grids and visual scenes represent their intended themes. Results of this study revealed several findings that impact creation and selection of AAC supports for adults with TBI. First, visual scenes were both more accurately and rapidly identified than grid displays. Furthermore, analysis of the responses elicited when participants viewed grids and visual scenes indicated that visual scenes tend to elicit verb phrases at a significantly higher rate than grid displays and that grids tend to elicit noun phrases more frequently than visual scenes for people with TBI. Possible explanations, clinical implications, study limitations, and future research directions are discussed below.

Figure 5. Mean results for elicited response type. Error bars denote standard error. TBI = traumatic brain injury.

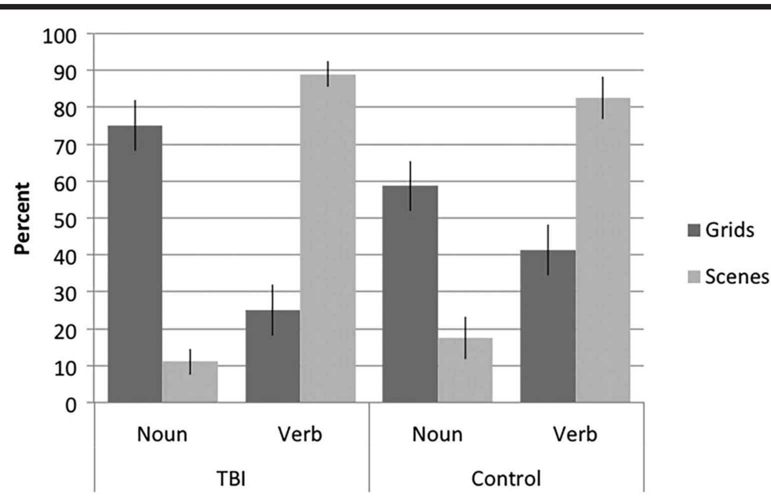
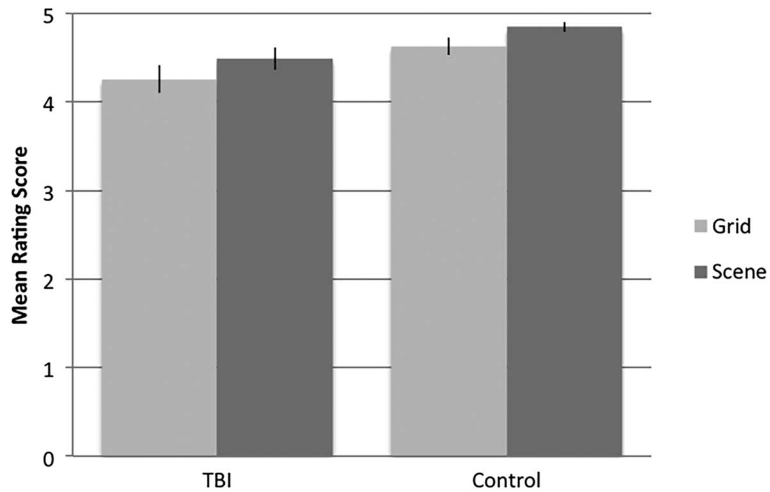


Figure 6. Mean results for theme likeness rating. Error bars denote standard error. TBI = traumatic brain injury.



Gist Reasoning and AAC Displays

Results from this investigation indicate that adults with TBI more rapidly and accurately identify themes depicted in photographic visual scenes than grids composed of decontextual photographs. Although limited empirical evidence exists to explain the way in which individuals with TBI interpret AAC displays, examination of the theme identification process reveals that theme comprehension and expression likely require (a) strategic attention to important details (e.g., particular visual components within a photograph) and (b) integration of newly acquired information with existing world knowledge—both of which are essential components of gist reasoning (Anand et al., 2011). Given that individuals with TBI often present with gist reasoning deficits (e.g., Cook, Chapman, Elliot, Evenson, & Vinton, 2014; Vas, Spence, & Chapman, 2015), the effect of design feature differences between these two display types on gist comprehension and expression must be considered when creating AAC supports. For instance, clinicians must consider that elements depicted in grid displays are presented as separate, discrete units. Thus, individuals must infer the relation among seemingly isolated elements. Conversely, elements presented in visual scenes are integrated into naturalistic contexts. Therefore, the relations among objects in visual scenes are likely to be evident as long as the individual has world knowledge of the event depicted.

In addition to reducing gist reasoning requirements, visual scenes could also prove beneficial by minimizing new learning, memory, and cognitive flexibility demands commonly associated with AAC use (Wallace, 2010). Specifically, using decontextual photos, which are typically found in grid displays, may require an individual to not only learn and remember the message associated with each image but to also engage in flexible thinking, as decontextual images could be interpreted in many ways. For instance, a decontextual image of a teapot could be used to request a cup of tea, to talk about having tea with a friend, or to share information about a favorite place to have tea. As such, the individual who is relying on decontextual photos will either have to remember the message associated with that image or engage in flexible thinking when an unintended message is selected. In her commentary on AAC and cognition, Wallace discusses the notion that visual scenes provide information beyond the single concept level that can assist viewers in quickly capturing the gist of the image and any associated messages and that this could potentially reduce AAC system navigation challenges.

Although the contextual nature of visual scenes likely supports gist reasoning and other cognitive processes for individuals with TBI, previous research indicate that these individuals may still fail to integrate information presented in contextual images beyond a basic level. When examining the ability to match images to messages conveying either explicit or inferential information, Brown et al. (2016) found that adults with TBI had significantly more difficulty with identifying inferential information presented in high-context images than their peers without neurological conditions; however, the two groups were comparable in identifying main action and detailed information from presented images. Results from the current investigation coupled with those reported by Brown et al. indicate that visual scenes are a promising avenue worth exploring for AAC display design. However, further work is necessary to fully understand the effects of various design features on display interpretation and use for adults with TBI.

Display Type and Response Elicited

In addition to examining the speed and accuracy of theme identification, we also chose to examine the relation between display type and message production. Specifically, we evaluated theme responses as either noun phrases or verb phrases. Results from the current investigation add to a small but growing body of literature indicating that visual scenes tend to support the comprehension and expression of action messages (Thiessen et al., 2017), whereas decontextual photographs—like those found in our grid displays—tend to support the comprehension and expression of naming messages (Brown et al., 2015; Thiessen et al., 2017).

The ability to represent words and messages through images is a key issue for AAC stakeholders. Specifically, the illustration of nouns tends to be relatively simple when compared to illustrating other more abstract parts of speech such as verbs (Beck & Fritz, 1998; Koul & Harding, 1998; Schlosser & Sigafoos, 2002; Simone, 1995). Designing displays that effectively and transparently depict messages is important for all individuals who rely on AAC, but it may be especially crucial for adults with TBI who present with cognitive deficits that could limit their ability to remember symbol–message relations (Wallace, 2010). Given the emerging evidence that visual scenes more transparently represent action messages than grids, clinicians should consider using these images when attempting to represent verbs for their clients with TBI.

Study Limitations and Future Directions

Results from this investigation must be considered in light of potential study limitations that could influence the findings and the nature of future research studies. Specific limitations worthy of note are described herein. The first potential limitation was the relative simplicity of the display themes selected for this investigation. Our themes represented commonly occurring events (e.g., doing laundry, camping) that most adults have either directly experienced or of which they have indirect knowledge. We selected common events as themes to ensure that participant accuracy scores were not reflective of a lack of exposure to themes but rather were indicative of an inability to recognize a familiar, depicted event. Although this decision allowed us to be confident that our participants had knowledge of the events depicted, the results may not be fully reflective of all events depicted in AAC systems. Hence, practitioners should exercise caution when interpreting these results, as the events depicted in this investigation may not be representative of those themes used in real-world conversations. Furthermore, the focus of this study was solely on identification of AAC display themes. Although crucial for independently communicating with AAC, identifying display themes is only one part of the use of AAC displays. Further research on the use of grids and visual scenes as communication supports for adults with TBI is a necessary step in the research process to fully understand the benefits of using varying display types to support communication beyond the word or phrase level.

The second potential limitation was that our participants did not rely on AAC for communication at the time of the study. We decided to recruit participants who did not rely on AAC for two reasons. First, given that this study involved a direct comparison between grids and scenes, including participants with extensive experience with either of the two display types could have resulted in selection bias (Brown et al., 2015) and invalidated the results. This is especially possible for people with TBI who often experience reduced flexibility of thought and could be highly influenced by previous experiences (Milders, Ietswaart, Crawford, & Currie, 2008; Tate, 1999). This decision was also made to ensure that our participants could verbally express themselves while identifying displays and when discussing their opinions of the selected stimuli. Although limiting our participants to individuals who do not rely on AAC allowed us to control for potential bias and to better understand the personal opinions of individuals with TBI, it is essential to conduct research with people who rely on AAC to ensure that the patterns documented in the current study are fully representative of the target population.

A third limitation of this study was the difference in the way in which people were depicted in grids and visual scenes. Specifically, the people appearing in the grid displays were depicted in a portrait position, facing forward toward the camera, whereas those appearing in scenes were depicted in a task-engaged manner, both looking at and touching items appearing with the scene (Thiessen et al., 2014). Because people in visual scenes were actually physically engaged in the scene context and completing a task or participating in an activity, it is likely that people appearing in scenes naturally depict action more clearly than those depicted in grids (Thiessen et al., 2017). As such, future research controlling for the positioning of people in grids and visual scenes is necessary to determine whether the messages associated with these two display types differ based on this factor.

The fourth limitation of this investigation was the fact that the images selected were not personalized for each participant. Rather, our displays were generic, depicting unfamiliar people in impersonal environments (i.e., scenes) or unfamiliar people with items that did not belong to participants (i.e., grids). We decided to use generic photos to ensure that our displays were equivalent across participants. This decision allowed for increased internal validity; however, in clinical practice, AAC supports may be personalized for each individual client. Although evidence of the effects of personalization is limited for people with TBI, research indicates that people with aphasia prefer personalized photos to generic images (McKelvey, Hux, Dietz, & Beukelman, 2010). Future research is necessary to determine if personalization is the best clinical practice for people with TBI, and if so, it is essential that research be conducted to determine whether the results noted in this study are representative of those for personalized AAC displays.

The final limitation worthy of note was that no formal measure of gist reasoning or comprehension was conducted with our participants. As such, it is difficult to determine the extent to which impaired gist reasoning influenced individual participant performance. Future researchers should consider examining more directly the relation between gist reasoning and AAC display theme to determine how this factor influences AAC theme identification.

Conclusions

This study provides insight on the accuracy and rate in which people with TBI identify two common AAC display types. Results indicate that visual scenes are more efficiently and accurately identified than grid displays composed of decontextual photos. Furthermore, evidence from this study suggest that word or phrase-level messages elicited by individuals with TBI differ depending on display type. Specifically, it appears that visual scenes elicit action messages at a higher rate and that grid displays elicit naming messages at a higher rate. These findings coupled with other existing research indicate that visual scenes may more effectively represent messages in AAC displays than decontextual photos for people with TBI. Future research is necessary to determine whether the benefits of using visual scenes extend beyond identification speed and accuracy to real-world communication tasks.

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References

Anand, R., Chapman, S. B., Rackley, A., Keebler, M., Zientz, J., & Hart, J. (2011). Gist reasoning training in cognitively normal seniors. *International Journal of Geriatric Psychiatry, 26,* 961–968.

Beck, A. R., & Fritz, H. (1998). Can people who have aphasia learn iconic codes? *Augmentative and Alternative Communication, 14,* 184–196.

Beukelman, D. R., Hux, K., Dietz, A., McKelvey, M., & Weissling, K. (2015). Using visual scene displays as communication support options for people with chronic, severe aphasia: A summary of AAC research and future research directions. *Augmentative and Alternative Communication, 31,* 234–245.

Brock, K., Koul, R., Corwin, M., & Schlosser, R. (2017). A comparison of visual scene and grid displays for people with chronic aphasia: A pilot study to improve communication using AAC. *Aphasiology, 31,* 1282–1306.

Brown, J., Hux, K., Knollman-Porter, K., & Wallace, S. E. (2016). Use of visual cues by adults with traumatic brain injuries to interpret explicit and inferential information. *Journal of Head Trauma Rehabilitation, 31,* 32–41.

Brown, J., Thiessen, A., Beukelman, D., & Hux, K. (2015). Noun representation in AAC grid displays: Visual attention patterns of people with traumatic brain injury. *Augmentative and Alternative Communication, 31,* 15–26.

Burke, R., Beukelman, D. R., & Hux, K. (2004). Accuracy, efficiency and preferences of survivors of traumatic brain injury when using three organization strategies to retrieve words. *Brain Injury, 18*(5), 497–507.

Cook, L. G., Chapman, S. B., Elliott, A. C., Evenson, N. N., & Vinton, K. (2014). Cognitive gains from gist reasoning training in adolescents with chronic-stage traumatic brain injury. *Frontiers in Neurology, 5,* 87.

Dietz, A., McKelvey, M., & Beukelman, D. R. (2006). Visual scene displays (VSD): New AAC interfaces for persons with aphasia. *Augmentative and Alternative Communication, 15,* 13–17.

Doyle, M., Kennedy, M., Jausalaitis, G., Phillips, B., Beukelman, D. R., Yorkston, K. M., & Reichle, J. (2000). AAC and traumatic brain injury. In D. R. Beukelman, K. M. Yorkston, & J. Reichle (Eds.), *Augmentative and alternative communication for adults with acquired neurological disorders* (pp. 271–304). Baltimore, MD: Brookes.

Drager, K. D., Light, J. C., Speltz, J. C., Fallon, K. A., & Jeffries, L. Z. (2003). The performance of typically developing 2½-year-olds on dynamic display AAC technologies with different system layouts and language organizations. *Journal of Speech, Language, and Hearing Research, 46,* 298–312.

Fortuny, L. A., Briggs, M., Newcombe, F., Ratcliff, G., & Thomas, C. (1980). Measuring the duration of post traumatic amnesia. *Journal of Neurology, Neurosurgery, & Psychiatry, 43,* 377–379.

Gamino, J. F., Chapman, S. B., & Cook, L. G. (2009). Strategic learning in youth with traumatic brain injury: Evidence for stall in higher-order cognition. *Topics in Language Disorders, 29,* 224–235.

Griffith, J., Dietz, A., & Weissling, K. (2014). Supporting narrative retells for people with aphasia using augmentative and alternative communication: Photographs or line drawings? Text or no text? *American Journal of Speech-Language Pathology, 23,* S213–S224.

Helm-Estabrooks, N. (2001). *Cognitive Linguistic Quick Test (CLQT)*. San Antonio, TX: The Psychological Corporation.

Hux, K., Buechter, M., Wallace, S., & Weissling, K. (2010). Using visual scene displays to create a shared communication space for a person with aphasia. *Aphasiology, 24,* 643–660.

Kertesz, A. (2006). *Western Aphasia Battery-Revised (WAB-R): Examiner's manual*. San Antonio, TX: The Psychological Corporation.

Koul, R., & Harding, R. (1998). Identification and production of graphic symbols by individuals with aphasia: Efficacy of a software application. *Augmentative and Alternative Communication, 14,* 11–24.

Light, J., & Lindsay, P. (1991). Cognitive science and augmentative and alternative communication. *Augmentative and Alternative Communication, 7,* 186–203.

McKelvey, M. L., Dietz, A., Hux, K., Weissling, K., & Beukelman, D. (2007). Performance of a person with chronic aphasia using personal and contextual pictures in a visual scene display prototype. *Journal of Medical Speech-Language Pathology, 15,* 305–317.

McKelvey, M. L., Hux, K., Dietz, A., & Beukelman, D. R. (2010). Impact of personal relevance and contextualization on word-picture matching by people with aphasia. *American Journal of Speech-Language Pathology, 19,* 22–33.

Milders, M., Ietswaart, M., Crawford, J. R., & Currie, D. (2008). Social behavior following traumatic brain injury and its association with emotion recognition, understanding of intentions, and cognitive flexibility. *Journal of the International Neuropsychological Society, 14,* 318–326.

Razali, N. M., & Wah, Y. B. (2011). Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors, and Anderson-Darling tests. *Journal of Statistical Modeling and Analytics, 2,* 21–33.

Schlosser, R. W., & Sigafoos, J. (2002). Selecting graphic symbols for an initial request lexicon: Integrative review. *Augmentative and Alternative Communication, 18,* 102–123.

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika, 52,* 591–611.

Simone, R. (1995). *Iconicity in language*. Amsterdam/Philadelphia: John Benjamins.

Tate, R. L. (1999). Executive dysfunction and characterological changes after traumatic brain injury: Two sides of the same coin? *Cortex, 35,* 39–55.

Thiessen, A., Beukelman, D., Hux, K., & Longenecker, M. (2016). A comparison of the visual attention patterns of people with aphasia and adults without neurological conditions for camera-engaged and task-engaged visual scenes. *Journal of Speech, Language, and Hearing Research, 59,* 290–301.

Thiessen, A., Beukelman, D., Ullman, C., & Longenecker, M. (2014). Measurement of the visual attention patterns of people with aphasia: A preliminary investigation of two types of human engagement in photographic images. *Augmentative and Alternative Communication, 30,* 120–129.

Thiessen, A., Brown, J., Beukelman, D., & Hux, K. (2017). The effect of human engagement depicted in contextual photographs on the visual attention patterns of adults with traumatic brain injury. *Journal of Communication Disorders, 69,* 58–71.

Thiessen, A., Brown, J., Beukelman, D., Hux, K., & Myers, A. (2017). Effect of message type on the visual attention of adults with traumatic brain injury. *American Journal of Speech-Language Pathology, 26,* 428–442.

Thistle, J. J., & Wilkinson, K. M. (2013). Working memory demands of aided augmentative and alternative communication for individuals with developmental disabilities. *Augmentative and Alternative Communication, 29,* 235–245.

Underwood, G. (2005). Eye fixations on pictures of natural scenes: Getting the gist and identifying the components. In G. Underwood (Ed.), *Cognitive processes in eye guidance* (pp. 163–187). Oxford, England: Oxford University Press.

Vas, A. K., Spence, J., & Chapman, S. B. (2015). Abstracting meaning from complex information (gist reasoning) in adult traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology, 37,* 152–161.

Wallace, S. E. (2010). AAC use by people with TBI: Affects of cognitive impairments. *SIG 12 Perspectives on Augmentative and Alternative Communication, 19,* 79–86.

Wallace, S. E., Hux, K., & Beukelman, D. R. (2010). Navigation of a dynamic screen AAC interface by survivors of severe traumatic brain injury. *Augmentative and Alternative Communication, 26,* 242–254.

Wallace, S. E., & Kimbarow, M. L. (2016). Traumatic brain injury. In M. L. Kimbarow (Ed.), *Cognitive communication disorders* (2nd ed., pp. 253–277). San Diego, CA: Plural.