AJSLP

Research Article

Stealing Cookies in the Twenty-First Century: Measures of Spoken Narrative in Healthy Versus Speakers With Aphasia

Shauna Berube,[a] Jodi Nonnemacher,[a] Cornelia Demsky,[b] Shenly Glenn,[c] Sadhvi Saxena,[b] Amy Wright,[b] Donna C. Tippett,[a,b,d] and Argye E. Hillis[a,b,e]

Purpose: Our goal was to evaluate an updated version of the "Cookie Theft" picture by obtaining norms based on picture descriptions by healthy controls for total content units (CUs), syllables per CU, and the ratio of left–right CUs. In addition, we aimed to compare these measures from healthy controls to picture descriptions obtained from individuals with poststroke aphasia and primary progressive aphasia (PPA) to assess whether these measures can capture impairments in content and efficiency of communication.
Method: Using an updated version of this picture, we analyzed descriptions from 50 healthy controls to develop norms for numbers of syllables, total CUs, syllables per CU, and left–right CU. We provide preliminary data from 44 individuals with aphasia (19 with poststroke aphasia and 25 with PPA).
Results: A total of 96 CUs were established based on the written transcriptions of spoken picture descriptions of the 50 control participants. There was a significant effect of group on total CUs, syllables, syllables per CU, and left–right CUs. The poststroke participants produced significantly fewer total CU and syllables than those with PPA. Each aphasic group produced significantly fewer total CUs, fewer syllables, more syllables per CU, and lower left–right CUs (indicating a right-sided bias) compared to controls.
Conclusions: Results show that the measures of numbers of syllables, total CUs, syllables per CU, and left–right CUs can distinguish language output of individuals with aphasia from controls and capture impairments in content and efficiency of communication. A limitation of this study is that we evaluated only 44 individuals with aphasia. In the future, we will evaluate other measures, such as CUs per minute, lexical variability, grammaticality, and ratio of nouns to verbs.
Supplemental Material: https://doi.org/10.23641/asha.7015223

Picture descriptions have been used to analyze cognitive–linguistic factors of spoken language across various patient populations. Descriptions have been used to capture deficits in language (Yorkston & Beukelman, 1980), interpretation (Myers, 1979), social communication (Marini, Martelli, Gagliardi, Fabbro, & Borgatti, 2010), spatial attention (Barbieri & De Renzi, 1989), and prosody (Nevler et al., 2017). These deficits have been identified in picture descriptions in distinct populations, such as normal aging (Cooper, 1990), dementia (Forbes-McKay & Venneri, 2005; Giles, Patterson, & Hodges, 1996), Williams syndrome (Marini et al., 2010; Rossi, Sampaio, Gonçalves, & Giacheti, 2011), primary progressive aphasia (PPA; Ash et al., 2013; Bird, Lambon Ralph, Patterson, & Hodges, 2000; Weintraub, Rubin, & Mesulam, 1990), traumatic brain injury (Hux, Wallace, Evans, & Snell, 2008), and stroke (Agis et al., 2016; Barbieri & De Renzi, 1989; Yorkston & Beukelman, 1980). Investigators have assessed a variety of measures, including grammaticality and speech rate (Ash & Grossman, 2015), mean length of utterance and noun–verb ratio (Kirmess & Lind, 2011), frequency and imageability of words produced (Bird et al., 2000), number of prepositional phrases and pauses (Cooper, 1990), or percentage of content units (CUs) that are "interpretive" (e.g., sister vs. girl; Myers, 1978). Many pictures have been used to

[a]Department of Physical Medicine & Rehabilitation, Johns Hopkins University School of Medicine, Baltimore, MD
[b]Department of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD
[c]Miro Corporation, San Francisco, CA
[d]Department of Otolaryngology–Head and Neck Surgery, Johns Hopkins University School of Medicine, Baltimore, MD
[e]Department of Cognitive Science, Johns Hopkins University, Baltimore, MD
Correspondence to Argye E. Hillis: argye@jhmi.edu

Editor-in-Chief: Margaret Blake
Editor: Christos Salis
Received August 21, 2017
Revision received December 7, 2017
Accepted April 8, 2018
https://doi.org/10.1044/2018_AJSLP-17-0131
Publisher Note: This article is part of the Special Issue: Select Papers From the 47th Clinical Aphasiology Conference.

Disclosure: *The authors have declared that no competing interests existed at the time of publication.*

analyze connected speech, although the traditional "Cookie Theft" picture from the Boston Diagnostic Aphasia Examination (BDAE; Goodglass, Kaplan, & Barresi, 2001) has been used as one stimulus for all these types of analyses and in each of the populations.

Description of the Cookie Theft picture from the BDAE is currently used to rate aphasia severity qualitatively in both the BDAE and the National Institutes of Health Stroke Scale (NIHSS; Brott et al., 1989; Lyden, Claesson, Havstad, Ashwood, & Lu, 2004). The latter scale is used to evaluate nearly every acute stroke patient in the United States and many other countries worldwide. In addition, quantitative analyses of picture descriptions have been shown to be sensitive to mild to severe aphasia (Yorkston & Beukelman, 1980) and right hemisphere dysfunction (Myers, 1978; Trupe & Hillis, 1985). Yorkston and Beukelman (1980) based their analyses on CUs (concepts mentioned by at least one healthy control in describing the picture), number of syllables, CUs per minute, and syllables per minute. These measures were utilized because CUs portray information conveyed whereas both syllables per minute and CU per minute provide a measure of the efficiency of communication. Syllables per CU is an additional measure of communication efficiency that has been shown to capture digressiveness and irrelevant CU in the spoken output of some individuals with right hemisphere stroke (Trupe & Hillis, 1985) and correlates with lesion volume (Agis et al., 2016). In addition to syllables per CU, total CUs and left–right CUs (the ratio of left-sided CU to right-sided CU) contribute valuable information about volume and location of acute infarct, independent of the concurrent NIHSS score (Agis et al., 2016).

Although the Cookie Theft picture is widely used to assess language in the stroke population, there are some intrinsic problems with the picture. It is outdated in appearance, with a woman wearing a dress and apron while washing the dishes. When asked to describe the picture, individuals frequently make comments regarding the stereotypical roles, as it depicts a woman washing dishes and "looking after" the children, rather than a man assisting with these tasks. Therefore, some of the CUs used to describe the picture are now different from CUs used to describe it when the norms were published. Furthermore, compared to some other frequently used pictures to elicit connected speech, there are relatively few objects and actions to describe in the picture, thus limiting the sample of verbal output.

The goal of this analysis was to evaluate an updated version of the Cookie Theft picture by obtaining norms based on picture descriptions by healthy controls for total CUs, total syllables, syllables per CU, and the ratio of left–right CUs. Total CU was chosen as a measure of information conveyed and syllables per CU as a measure of efficiency of communication. We did not use syllables per minute or CU per minute, as the duration of the speech sample often depended on nonlanguage variables, such as age (Cooper, 1990) and dysarthria (Niimi, 2001). Left–right CU was chosen as this has been shown to be a sensitive measure of contralesional hemispatial neglect in both left and right hemisphere strokes (Agis et al., 2016). A higher score (well above 1) indicates a left-sided bias (e.g., right neglect), whereas a low score indicates a right-sided bias (e.g., left neglect). In addition, we aimed to determine how well these measures distinguish language of individuals with poststroke aphasia and PPA from language of healthy controls to determine if these measures can capture impairments in content and efficiency of communication in aphasia.

Method

Procedure

This study was conducted in conjunction with Miro (http://miro.one), a company that creates apps for use in health care. A professional artist at Miro created an updated, colorful, and more "politically correct" version of the Cookie Theft picture and included additional events (dog eating cookies from the floor, cat chasing birds in the lawn, mother mowing over flowers while talking on her cell phone; see Figure 1). The update was based on informal input from six individuals with aphasia, six speech-language pathologists, and six stroke neurologists, who were simply asked for suggestions on how to make the picture more appropriate for the current time and how it could be more useful for assessing narrative speech. The picture was presented within an app on an iPad (Apple, iPad Pro), which recorded the description for later written transcription, allowing 90 s for description. The app was used merely for the convenience of having the picture and recording on the iPad. Of note, the picture can be shown independent of the app or iPad, and the description can be recorded independent of the app or iPad. Future studies will use automated analyses incorporating machine learning to assess picture descriptions, but such analyses were not conducted in this study. A trained transcriptionist, paid by Miro, transcribed the spoken descriptions. The participants were asked to describe everything that is happening in the picture (as though describing it for the blind), trying to use complete sentences. No additional cues were given. The samples were transcribed verbatim. Rules used by the transcriptionist are included in the Appendix.

Participants

We evaluated 50 healthy controls, 19 individuals with aphasia due to left hemisphere ischemic stroke, and 25 individuals with PPA. Among those with poststroke aphasia, nine individuals had nonfluent (Broca's, transcortical motor, or global aphasia), six had fluent aphasia (anomic, Wernicke's, or transcortical sensory), and four had unclassifiable aphasia using the BDAE classification. Among those with PPA, nine individuals had semantic variant PPA, 11 had logopenic variant PPA, four had nonfluent agrammatic PPA, and one individual was not classified into a variant of PPA using recent criteria (Gorno-Tempini et al., 2011). This individual was anomic and dysgraphic only. Table 1 provides demographics (sex, age, and education)

Figure 1. The updated version of the "Cookie Theft" picture. Copyright © Miro Inc. Reprinted with permission.

for the groups. The groups were not significantly different on these characteristics.

Measures of Content and Efficiency of Speech

For each sample, we measured total CUs, total syllables, syllables per CU, and left–right CUs. We selected these measures because a previous study using the traditional picture showed that these measures distinguished speech of stroke patients from healthy controls and correlate well with lesion volume in acute left and right hemisphere ischemic stroke (Agis et al., 2016).

CUs

Each verbatim written transcription was evaluated for CUs. A CU is defined as a concept or word/phrase referring to the same object, action, or state (e.g., chaos/mayhem) mentioned by at least three of the 50 healthy controls. If the same CU was mentioned twice in the same description, it was only counted once.

Left–Right CUs

Each CU was coded as left-sided (depicted on the left side of the picture; e.g., girl, boy, dog, cookies), right-sided (depicted on the right side of the picture; e.g., washing/doing/cleaning; dishes/plates/bowl; cat), or neither/both sides (e.g., inside/interior; chaos/mayhem). Ratio of left–right CUs was used to assess left or right bias (an indication of hemispatial neglect). If there were no right-sided CUs, we divided by 0.5, because it is not possible to divide by zero. A left–right or right–left bias was quantified on a continuum using the left–right CU ratio. A "cutoff" was not used, but 1 *SD* or 2 *SD*s greater or less than the mean for controls could be used as an indication of right and left neglect, respectively. An earlier study (using the traditional picture; Agis et al., 2016) showed that left-hemisphere stroke patients show, on average, significantly higher left–right CU ratio and right-hemisphere stroke patients show a significantly lower left–right CU ratio, compared to healthy controls. A score further from the mean ratio of healthy controls indicated more severe neglect (or spatial bias).

Table 1. Demographics of participants in each group.

Variable	Individuals with poststroke aphasia	Individuals with PPA	Healthy controls	Statistic	p^a
Sex (F), *n* (%)	9.0 (57.9)	6.0 (52.0)	36.0 (72.0)	$\chi^2(3) = 3.3$	.20 (*ns*)
Age (years), *M* (*SD*)	63.9 (8.1)	64.2 (9.6)	58.9 (18.2)	$F(2, 91) = 0.87$	.46 (*ns*)
Education (years), *M* (*SD*)	15.2 (2.3)	15.4 (1.9)	16.0 (0.7)	$F(2, 73) = 0.44$	.72 (*ns*)

Note. PPA = primary progressive aphasia; *F* = female; *ns* = not statistically significant.

[a]*p* Values were calculated using chi-square for sex and one-way analysis of variance for age and education.

Syllables

Transcriptions were further analyzed for number of syllables. Syllables were counted manually and started immediately after instruction was given. Total syllable tally included all utterances regardless of relevance or intelligibility, including fillers (e.g., "uh"), revisions, and repetitions. Remarks that were nonrelevant to the picture given at the end of description indicating that the subject was finished, such as "Is that enough?" or "I think that's it," were not counted.

Syllables per CU

The measure of syllables per CU (total syllables in the description divided by the total CUs) was used to measure efficiency of communication. If there were no correct CUs, we divided by 0.5, because it is not possible to divide by zero. This measure is sensitive to circumlocutions, digressions, repetitive content, and so on. Other possible measures of communication efficiency, such as syllables per minute, were not assessed in the current study, as speaking rate is often influenced by age (Cooper, 1990), dysarthria (Niimi, 2001), dialect, interruptions to reposition the iPad, and other variables unrelated to the study goals.

Statistical Analysis

We compared the three groups with respect to total CUs, syllables, syllables per CU, and ratio of left–right CUs initially using one-way analysis of variance and then using *t* tests to evaluate differences between each pair of groups. Interrater reliability was assessed using point-to-point percent agreement (agreed upon CUs minus disagreements, divided by total CU scored by either rater). Disagreements were CU scored by one rater but not the other.

Results

Normative Data

A total of 96 CUs were established based on the verbatim written transcriptions of the 50 healthy participants. The most frequently mentioned CUs were as follows: washing/doing/scrubbing/cleaning (dishes), dishes/plates/dinner plate/bowl, cutting (grass)/mowing (grass)/pushing a mower, etc. (each mentioned by 47/50). Several CUs were mentioned by at least 45/50 controls (see Table 2). Healthy controls produced a mean of 197 syllables (SD = 87.2). For CUs, they produced a mean of 33.5 CUs (SD = 11.4). Their mean score for syllables per CU was 5.8 (SD = 1.5). Mean ratio of right CU to left CU was 0.74 (SD = 0.49). On average, controls mentioned 10.3 left CUs (SD = 3.2), 15.3 right CUs (SD = 4.4), and 7.9 nonlateralized CUs (SD = 6).

Among the 96 CUs mentioned by healthy controls, 44 (45.8%) were usually expressed as nouns or noun phrases (e.g., cookie jar), 20 (20.8%) were usually expressed as verbs or verb phrases (e.g., climbing up, flying away), 27 (28.1%) were usually expressed as adjectives (e.g., little), three (3.1%) were usually expressed as prepositional phrases (e.g., off the floor), and two (2.1%) as noun–verb phrases (talking on the phone, making a mess).

There were no significant differences between men and women in the mean numbers of total CUs, syllable per CU, or left–right CUs (see Table 3). Using multivariable linear regression, neither age nor education (or age and education together) was significantly associated with total CUs, syllables per CU, or left–right CUs.

Interrater Reliability

The two raters (two authors who are certified speech-language pathologists, S. B. and J. N.) showed 92% point-to-point agreement in scoring CUs in the descriptions of 10 participants with aphasia. Interrater reliability in scoring CUs in the description of the 50 controls was 96.7% point-to-point percent agreement. It is likely that the reliability was slightly lower for participants with aphasia because they produced some circumlocutions that were arguably synonymous to the CUs of healthy controls.

Group Differences

There was a significant effect of group on total CUs, $F(2, 91) = 65.19$, $p < .001$, syllables, $F(2, 91) = 24.97$, $p < .001$, syllables per CU, $F(2, 91) = 6.04$, $p = .003$, and left–right CUs, $F(2,89) = 6.82$, $p < .001$. For two participants with poststroke aphasia, left–right CUs could not be calculated because there were no CUs. There were no significant differences between the poststroke aphasia group and the PPA group in syllables per CU or left–right CU. Compared to participants with PPA, those with poststroke aphasia produced significantly fewer total CUs (M = 7.2, SD = 5.1 vs. M = 13.3, SD = 8.8), $t(42) = -2.7$, $p = .01$, and fewer syllables (M = 59.8, SD = 39.9 vs. M = 122.1, SD = 71), $t(42) = -3.43$, $p = .001$. Each aphasic group produced significantly fewer CUs, more syllables per CU, fewer syllables, and lower left–right CUs compared to controls ($p < .001$) for each comparison using *t* tests (see Table 4).

A total of 18 controls and six individuals with aphasia described both the latest updated version and the traditional Cookie Theft picture. Controls described the two pictures on different days, and individuals with aphasia described them on the same day; they were presented in random order for both. There was a high correlation between the two pictures for CUs, $r(17) = .91$, $p < .001$, syllables, $r(17) = .65$, $p = .005$, and syllables per CU, $r(17) = .53$, $p = .03$, although the number of CUs was consistently and significantly higher for the updated version (M = 20.7, SD = 7.8) compared to the old version (M = 13.1, SD = 4.2), $t(17) = 6.4$, $p < .001$.

Individual Results

Most participants with poststroke aphasia (18/19) and PPA (20/25) produced total CUs that were more than 1 SD below healthy controls, and 25/44 participants with aphasia were more than 2 SDs below healthy controls. Individual

Table 2. Content units (CUs) mentioned by at least three healthy controls.

CU	No. of controls
Neither left nor right or both left and right CUs	
off the floor; from the floor; on the floor; on the kitchen floor; all over the floor	41
kitchen	26
top; shirt; blouse; jersey	20
little; small	19
red	16
skirt; dress	16
slippers; shoes; booties; pumps; boots	15
two; couple of	15
green	14
yellow; yellowish	14
family; family's	13
one	13
white	13
brown	12
gray; grayish	12
hair	11
pink; pinkish	11
wearing; dressed in	11
black	10
orange	10
blonde	9
smiling	8
three	7
long, longish	6
open	6
hand	5
happy; joyously	5
inside; interior	4
light; lighter	4
making quite a mess; slopping; a bit of a mess	4
mistake; by mistake	4
picture	4
afternoon	3
big	3
chaos; mayhem	3
tan; beige	3
turquoise	3
Left-sided CUs	
dog	45
eating; licking; picking up; sticking out his tongue to eat; picking up; to eat it	45
stool; step stool; chair; three-legged stool	45
cookies; treats	44
about to fall; ready to fall over; falling off; going to fall; tipping; unbalanced; losing his balance; toppling over; falling backward	44
getting into; getting; grabbing; stealing; breaking into; seeking	41
children; kids; child	34
boy	32
out of the cabinet; on a shelf; in the cupboard; from the top shelf; from the cabinet	23
standing there; standing in; standing on; on; standing next to	23
cookie jar; jar; container of cookies; jar of cookies	20
girl	19
reaching up; asking for	19
sister; sis	19
socks	13
striped; stripes	13
laughing; laughing her head off	12
climbing; tripping; climbed up	9
dropped; dropping; knock them down	7
shorts	6
son	6
younger; young	6
daughter	4
grasping to hang on; holding on to; holding	3
help; helping	3

(*table continues*)

Table 2. *(Continued).*

CU	No. of controls
Right-sided CUs	
cutting; mowing; mows; on/using lawnmower; yardwork; outside work; with the lawn mower; pushing a motorized mower; pushing a mower	47
dishes; plates; dinner plate; bowl	47
washing (dishes); doing (dishes); scrubbing; cleaning	47
overflowing; running out; running over; spilling; spilling on; spilled; pouring out of; flooding; flowing over; overrunning; dribbling over	41
cat	40
talking on cell phone; phone to ear; speaks on the phone; on the phone; on the telephone; hanging on that cell phone gabbing away; speaking on the cell phone; on the cell phone talking to somebody	38
dad; father	37
grass; lawn; yard; backyard; garden	37
birds	36
outside; out; in the background; behind	36
playing; chasing; having their way; preying on; running after; trying to catch; following; ready to spring; attacking	35
sink	35
mom; mother; mommy	33
flower garden; flower bed; garden of flowers; flowers; tulips; bed of flowers	28
houses; housing; buildings; apartment buildings; home; apartment houses; property	27
suds; bubbles; soap; sudsy; soapy	23
window; kitchen window	21
not paying a lot of attention; oblivious; didn't realize; distracted; doesn't know that it's going to go badly; fails to notice; not concentrating; completely clueless; not watching what she is doing	19
water	19
picket fence; fence; fenced in	18
blue; bluish; navy blue; tail blue	16
pants; jeans; trousers	14
woman; lady	12
man; guy	10
curtains	8
watching; looking out; looking through	7
nice day; nice outside; clear day; beautiful sunny day; beautiful day	6
spotted; polka dots; spots	6
wife	6
belt	4
flying around; flying away; flying up	4
husband	4
sponge	4
dishwasher	3

Note. CUs were mentioned by at least three of 50 healthy controls.

data are given in Supplemental Material S1. Two of 15 participants with poststroke aphasia and three of the 25 participants with PPA produced syllables per CU 1 *SD* below healthy controls. These individuals had telegraphic speech. In contrast, 11 of 19 participants with poststroke aphasia and 19 of 25 with PPA produced syllables per CU more than 1 *SD* greater than controls (23/44 participants with aphasia produced syllables per CU more than 2 *SD*s greater than controls), signifying that their speech was inefficient due to circumlocutions, repetitions, semantic errors, or meaningless phrases. Several individuals with aphasia showed a significant bias toward CUs on the left side of

Table 3. Mean scores by sex.

Subgroup	Total CU	Syllables/CU	Left–right CU
Women	34.1 (11.3)	5.8 (1.4)	0.75 (0.54)
Men	31.9 (12.1)	5.8 (1.6)	0.72 (0.34)
t Test	$t(49) = 0.6$, $p = .55$	$t(93) = -0.16$, $p = .56$	$t(49) = 0.19$, $p = .43$

Note. Standard deviations appear in parentheses. CU = content unit.

Table 4. Syllables, total content units (CUs), syllables per CU, and left–right content units for each group.

Group	Syllables	Total CUs	Syllables/CU	Left–right CU
Healthy controls, *M* (*SD*)	197 (87.2) Range: 43–355	33.5 (11.4) Range: 12–55	5.8 (1.5) Range: 2.9–10	0.74 (0.49) Range: 0.25–3.66
Individuals with poststroke aphasia, *M* (*SD*)	59.8 (39.9) Range: 10–135	7.2 (5.1) Range: 0–22	11.5 (9.8) Range: 3.3–43	2.8 (4.5) Range: 0–16
Individuals with primary progressive aphasia, *M* (*SD*)	122 (71) Range: 23–329	13.3 (8.8) Range: 0–30	15.7 (21.6) Range: 3.8–108	1.4 (0.9) Range: 0–4

the page (17/44 more than 1 *SD* above the mean and 13/44 more than 2 *SD*s above the mean for left–right CUs), indicating possible right hemispatial neglect. Only one poststroke participant and one PPA participant showed normal performance on all measures. Of these, the stroke survivor had fluent speech with fillers and repetitions, and the individual with unclassifiable PPA had somewhat halting speech with some sentence fragments, but both had normal content and efficiency. These results illustrate that the narrative speech measures we have selected do not capture all characteristics of aphasia. Examples of descriptions by the individuals with aphasia and healthy controls are provided in Supplemental Material S2.

Discussion

Analysis of descriptions of the updated version of the Cookie Theft picture can provide useful and reliable information about connected speech. Our preliminary data indicate that the measures of total CUs capture impairments in the quantity of information conveyed; total syllables capture the length of verbal output, syllables per CU capture impairments in efficiency of communication, and the ratio of right–left CUs captures right hemispatial neglect present in some individuals with aphasia. Compared to controls, individuals with aphasia conveyed less information in their picture descriptions, were often less efficient in verbal output, and sometimes showed evidence of right neglect.

We have shown that the measures using the new picture correlate with measures using the original picture. The original picture from the BDAE had many strengths, such as the variety of actions and the fact that it illustrates activities that can be interpreted and integrated. Our revised pictures address some of the weaknesses of the traditional picture while retaining its strengths. Therefore, this updated picture can be used as an alternative measure to elicit a speech sample, either individually or as part of the NIHSS. It is not intended to replace the original Cookie Theft picture as part of the BDAE.

A limitation of this study is that we evaluated only 44 individuals with aphasia and thus had too few to compare specific aphasia classifications or PPA variants. Furthermore, we did not compare the measures of total CUs,

Figure 2. Latest version of the "Cookie Theft" picture. Copyright © Miro Inc. Reprinted with permission.

syllables per CU, or right–left CUs to more formal and traditional measures such as the BDAE or Western Aphasia Battery (Kertesz, 1982), in order to more thoroughly assess validity because we did not have the same batteries in all participants.

In conjunction with Miro, we have developed a second updated Cookie Theft picture portraying a mixed-race family to assess if racial and ethnic diversity influences the content. In response to feedback from speech-language pathologists who reviewed the initial data, this image has more color on the left side of the drawing to have attention more evenly distributed (see Figure 2). Data are currently being collected using this picture. We have enrolled six healthy controls not significantly different in age, education, or sex from the 50 controls who described the initial revision in Figure 1. There are no significant differences (by *t* tests) in any of the norms for measures of narrative speech (CUs, syllables, syllables per CU, or left–right CUs; Supplemental Material S3). We thought that more color on the left side of the page would draw more attention to the left and change the left–right CUs, but this effect was not observed. The CUs remained the same, as there were no additional items mentioned by more than two people.

Future studies will also evaluate other measures, such as lexical variability, grammaticality, ratio of nouns to verbs, CUs per minute, and ratio of interpretive to total CUs in right- and left-hemisphere stroke survivors. An interpretive CU is something that makes sense only within the context of the picture (Myers, 1979). For example, labeling the "girl" as "his sister" would be interpretive. We are working with Miro to create automated analyses based on machine learning. Finally, we will determine if these measures provide information for predicting volume and location of stroke as accurately as measures from the traditional picture (Agis et al., 2016).

Acknowledgments

This work was supported by the National Institutes of Health (National Institute of Deafness and Communication Disorders) through R01 DC05375 (A. E. H., A. W.), P50 DC014664 (S. B., J. N., D. C. T., and A. E. H.), and R01 DC015466 (A. E. H., S. S.).

References

Agis, D., Goggins, M. B., Oishi, K., Oishi, K., Davis, C., Wright, A., . . . Hillis, A. E. (2016). Picturing the size and site of stroke with an expanded National Institutes of Health Stroke Scale. *Stroke, 47*(6), 1459–1465. https://doi.org/10.1161/STROKEAHA.115.012324

Ash, S., Evans, E., O'Shea, J., Powers, J., Boller, A., Weinberg, D., . . . Grossman, M. (2013). Differentiating primary progressive aphasias in a brief sample of connected speech. *Neurology, 81*(4), 329–336. https://doi.org/10.1212/WNL.0b013e31829c5d0e

Ash, S., & Grossman, M. (2015). Why study connected speech production? In R. Willems (Ed.), *Cognitive neuroscience of natural language use* (pp. 29–58). Cambridge, United Kingdom: Cambridge University Press. https://doi.org/10.1017/CBO9781107323667.003

Barbieri, C., & De Renzi, E. (1989). Patterns of neglect dissociation. *Behavioural Neurology, 2*(1), 13–24. https://doi.org/10.3233/BEN-1989-2102

Bird, H., Lambon Ralph, M. A., Patterson, K., & Hodges, J. R. (2000). The rise and fall of frequency and imageability: Noun and verb production in semantic dementia. *Brain and Language, 73*(1), 17–49. https://doi.org/10.1006/brln.2000.2293

Brott, T., Adams, H. P., Jr., Olinger, C. P., Marler, J. R., Barsan, W. G., Biller, J., . . . Hertzberg, V. (1989). Measurements of acute cerebral infarction: A clinical examination scale. *Stroke, 20*(7), 864–870. https://doi.org/10.1161/01.STR.20.7.864

Cooper, P. V. (1990). Discourse production and normal aging: Performance on oral picture description tasks. *Journal of Gerontology, 45*(5), P210–P214. https://doi.org/10.1093/geronj/45.5.P210

Forbes-McKay, K. E., & Venneri, A. (2005). Detecting subtle spontaneous language decline in early Alzheimer's disease with a picture description task. *Neurological Sciences, 26*(4), 243–254. https://doi.org/10.1007/s10072-005-0467-9

Giles, E., Patterson, K., & Hodges, J. R. (1996). Performance on the Boston cookie theft picture description task in patients with early dementia of the Alzheimer's type: Missing information. *Aphasiology, 10*(4), 395–408. https://doi.org/10.1080/02687039608248419

Goodglass, H., Kaplan, E., & Barresi, B. (2001). *Boston Diagnostic Aphasia Examination–Third Edition (BDAE-3)*. Philadelphia, PA: Lippincott Williams & Wilkins.

Gorno-Tempini, M. L., Hillis, A. E., Weintraub, S., Kertesz, A., Mendez, M., Cappa, S. E. E. A., . . . Grossman, M. (2011). Classification of primary progressive aphasia and its variants. *Neurology, 76*(11), 1006–1014. https://doi.org/10.1212/WNL.0b013e31821103e6

Hux, K., Wallace, S. E., Evans, K., & Snell, J. (2008). Performing cookie theft picture content analyses to delineate cognitive-communication impairments. *Journal of Medical Speech-Language Pathology, 16*(2), 83–103.

Kertesz, A. (1982). *The Western Aphasia Battery*. Psychological Corporation.

Kirmess, M., & Lind, M. (2011). Spoken language production as outcome measurement following constraint induced language therapy. *Aphasiology, 25*(10), 1207–1238. https://doi.org/10.1080/02687038.2011.589986

Lyden, P., Claesson, L., Havstad, S., Ashwood, T., & Lu, M. (2004). Factor analysis of the National Institutes of Health Stroke Scale in patients with large strokes. *Archives of Neurology, 61*(11), 1677–1680. https://doi.org/10.1001/archneur.61.11.1677

Marini, A., Martelli, S., Gagliardi, C., Fabbro, F., & Borgatti, R. (2010). Narrative language in Williams syndrome and its neuropsychological correlates. *Journal of Neurolinguistics, 23*(2), 97–111. https://doi.org/10.1016/j.jneuroling.2009.10.002

Myers, P. S. (1978). Analysis of right hemisphere communication deficits: Implications for speech pathology. In R. H. Brookshire (Ed.), *Clinical aphasiology: 1978* (pp. 49–57). Minneapolis, MN: BRK Publishers.

Myers, P. S. (1979). Profiles of communication deficits in patients with right cerebral hemisphere damage: Implications for diagnosis and treatment. In R. H. Brookshire (Ed.), *Clinical aphasiology: 1979* (pp. 38–46). Minneapolis, MN: BRK Publishers.

Nevler, N., Ash, S., Jester, C., Irwin, D. J., Liberman, M., & Grossman, M. (2017). Automatic measurement of prosody in

behavioral variant FTD. *Neurology, 89*(7), 650–656. https://doi.org/10.1212/WNL.0000000000004236

Niimi, M. N. S. (2001). Speaking rate and its components in dysarthric speakers. *Clinical Linguistics & Phonetics, 15*(4), 309–317. https://doi.org/10.1080/02699200010024456

Rossi, N. F., Sampaio, A., Gonçalves, Ó. F., & Giacheti, C. M. (2011). Analysis of speech fluency in Williams syndrome. *Research in Developmental Disabilities, 32*(6), 2957–2962. https://doi.org/10.1016/j.ridd.2011.05.006

Trupe, E., & Hillis, A. I. (1985). Paucity vs. verbosity: Another analysis of right hemisphere communication deficits. In R. H. Brookshire (Ed.), *Clinical aphasiology: 1985* (pp. 83–96). Minneapolis, MN: BRK Publishers.

Weintraub, S., Rubin, N. P., & Mesulam, M. (1990). Primary progressive aphasia: Longitudinal course, neuropsychological profile, and language features. *Archives of Neurology, 47*(12), 1329–1335. https://doi.org/10.1001/archneur.1990.00530120075013

Yorkston, K. M., & Beukelman, D. R. (1980). An analysis of connected speech samples of aphasic and normal speakers. *Journal of Speech and Hearing Research, 45*(1), 27–36. https://doi.org/10.1044/jshd.4501.27

Appendix

Transcription Rules

.wav audio files were transcribed, using annotations below:

1. Unclear speech
   Surround with double parentheses: I uh ((don't know)).
   If the speech is too unclear to make a guess, use double parentheses with only a space inside (( )).
   Example: I uh ((think that)) this works well. Actually (( )) tomorrow.
2. Voices other than the subject's voice
   Bracket off with curly braces { }.
3. Dysfluencies, restarts: – +
   I gue– +guess that's a cat, that's a do– +cat.
   (In this case, the subject interrupts him or herself and then starts again.)
4. Pauses in speech: …
   Ellipses surrounded by spaces.
5. Nonlinguistic spoken sounds: describe in angle brackets
   <cough> <laugh>
6. Filled pauses: spell out
   mm, uh, um, ah, er, oh
7. Nonvocalizations like cars, dogs: (background noise: ____)
   (Background noise: car)