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Beyond Picture Naming: Norms and Patient Data for a Verb Generation Task**

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Abstract

Purpose—The current study aimed to: 1) acquire a set of verb generation to picture norms; and 2) probe its utility as an outcomes measure in aphasia treatment.

Method—Fifty healthy volunteers participated in Phase I, the verb generation normative sample. They generated verbs for 218 pictures of common objects (ISI=5s). In Phase II, four persons with aphasia (PWA) generated verbs for 60 objects (ISI=10s). Their stimuli consisted of objects which were: 1) recently trained (for object naming; n=20); 2) untrained (a control set; n=20); or 3) from a set of pictures named correctly at baseline (n=20). Verb generation was acquired twice: two months into, and following, a six-month home practice program.

Results—No objects elicited perfect verb agreement in the normed sample. Stimuli with the highest percent agreement were mostly artifacts and dominant verbs primary functional associates. Although not targeted in treatment or home practice, PWA mostly improved performance in verb generation post-practice.

Conclusions—A set of clinically and experimentally useful verb generation norms was acquired for a subset of the Snodgrass and Vanderwart (1980) picture set. More cognitively demanding than confrontation naming, this task may help to fill the sizeable gap between object picture naming and propositional speech.

Keywords

verb generation; aphasia; verb generation norms

BACKGROUND & SIGNIFICANCE

Confrontation naming is an efficient and widely used measure of word retrieval ability in persons with aphasia and correlations have been reported between naming and overall language ability (Goodglass & Wingfield, 1997). Despite its ubiquity, the task does not always reveal the severity of impairments in word retrieval. In some variations of aphasia (e.g., many cases of transcortical motor aphasia), an individual may perform quite well at naming common objects and picturable actions in spite of profoundly diminished ability to

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speak spontaneously (Goodglass, 1993). On the milder, more fluent end of the aphasia spectrum (e.g., mild-to-moderate anomic aphasia), many individuals may even perform within normal limits on some confrontation naming tasks, in spite of spontaneous production that is clearly aphasic. Still others may present with part-of-speech and/or modality specific deficits in which naming of objects vs. actions may be relatively spared or impaired (e.g., Hillis & Caramazza, 1991). For persons with aphasia who perform at or near ceiling naming objects, the typical confrontation naming tasks are inadequate as a tool for measuring treatment outcomes. Unfortunately, the administration, scoring and analysis of more appropriate tasks, i.e., discourse level tasks, is often prohibitively labor intensive, particularly as a tool with clinical applicability.

Like confrontation naming, verb generation is a semantic association task that can be administered by presenting pictures of common objects and requesting a single word response per picture. Much of the cognitive demand between the two tasks is shared, including early visual processing, the integration of perceptual, semantic, and phonological processes, lexical retrieval, and the planning, execution, and monitoring of speech production (e.g., Levelt, 1989). Over and above object naming, a skill that is normally acquired at a relatively early stage of linguistic development, production of an associated verb produces greater activation in regions associated with semantic processing (Herholz et al., 1997), suggesting that verb production requires more semantic analysis than object naming (Seger et al., 1999). This is not surprising, given that the search for a name or label often ends with one correct response (e.g., “cat”) as compared to the search for an associated verb which may conjure many choices related to biological function (“purr”, “meow”, “stalk”, etc.), domestic relationship (“pet”, “stroke”, “feed”, etc.), personal experience (“scratch”, “declaw”, etc.), etc. In the case of inanimate objects (e.g., “knife”), verb generation usually involves response selection from among functional associates (e.g., “cut”, “spread”, “sharpen”, “stab”, etc.).

The generation of verbs can thus be considered an `underdetermined' task (Snyder & Munakata, 2008) – possibly due to requiring selection from a large set of competing response alternatives (Thompson-Schill et al., 1997), or due to weak association strength between an object and the various appropriate verb responses (Martin & Cheng, 2006), or alternatively due to some combination of both retrieval and competition demand (Snyder, Banich, & Munakata, 2011). This feature makes the verb generation task more closely resemble spontaneous speech, where we must constantly select from alternative responses when attempting to put our thoughts into words. The latter suggests that verb generation may be a useful, complementary measurement of aphasia severity, and perhaps a more efficient tool for measuring aphasia treatment outcomes, i.e., compared to discourse analysis.

Verb generation has been utilized experimentally in behavioral and neuroimaging research to examine semantic knowledge and the mechanisms and neural substrates supporting retrieval of that knowledge. Most studies have involved healthy young control subjects (e.g., Thompson-Schill et al., 1997), although some have compared the performance of younger and older participants (Persson et al., 2004) and a few have examined aphasic performance (Weiller et al., 1995; Thompson-Schill et al., 1998; Martin & Cheng, 2006). In almost all

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cases, the experimental tasks were purely lexical, i.e., the stimuli were visually or auditorily presented words and participants were instructed to say the first verb that came to mind that was something the noun did or that one could do with the noun. Although several studies normed their noun/verb pairs, e.g., to create sets that were highly constrained ("scissors"-*cut)* vs. underdetermined ("cat"), the norms for the noun/verb pairs were mostly not reported. Nelson and colleagues (1998) have published norms for a word association task, but the responses were not limited to verbs. Importantly, even if norms were available, many persons with aphasia have impaired single word reading, which would confound their performance to a lexical verb generation task.

Despite the widespread use of the Snodgrass and Vanderwart (1980) black and white line drawings of common objects in experimental and clinical research, there are no norms for verb generation in response to these pictures. Two studies used the pictures to generate a normed sample of names in a non-English language and then using the words, investigated verb generation (Weiller et al., 1995) or word association (Fernandez, Diez, Alonzo, & Beato, 2004). Their norms, however, were collected in German and Spanish respectively; they were also generated from words, not pictures.

Adding norms for verb generation to the Snodgrass and Vanderwart (1980) standardized set of pictures would have obvious clinical utility and could provide a rich reference for clinicians and clinical researchers. The purpose of the current study was thus two-fold: 1) to acquire a set of verb generation norms for a subset of the Snodgrass and Vanderwart object pictures (n=218); and 2) to probe the tool's use as an outcomes measure in aphasia treatment.

METHODS

Phase One: Verb Generation Norms

Participants—Fifty volunteers (n = 32 female; mean age = 37.18; SD = 18.62; range = 19–77) were recruited from the University of Massachusetts Amherst and surrounding communities via flyer and word of mouth. The sample was predominantly white (92% white, 2% African American, 2% Asian, 2% American Indian, and 2% unreported). Many were students (n=20) in college; the majority had at least a Bachelor's degree. All participants scored within normal limits (mean = 29.34; SD = 0.77; range = 27–30) on the Mini Mental State Examination (MMSE; Folstein et al., 1975). None reported a history of neurologic incident.

Procedures

Stimuli: Verb generation stimuli were 218 black and white line drawings of common objects, extracted from the Snodgrass and Vanderwart (1980) standardized set of 260 pictures. Pictures from the full set were excluded in previous confrontation naming experiments on the basis of drawing simplicity (e.g., arrow, moon, heart, etc.), ambiguity (e.g., ashtray, cloud, hair, etc.) or tendency to elicit more than one word (French horn, football helmet, ironing board, etc.).

Prior to the norming study, a pilot study was conducted to determine the order of stimulus presentation to minimize order effects. Five "neurotypical" volunteers (n = 3 female; age range = 26–36) were presented with the 218 randomly-ordered object pictures electronically using the EPrime 2.0 software (Psychology Software Tools, Pittsburgh, PA) at the rate of one picture every three seconds. Participants were asked to supply the first verb that came to mind while viewing each object. Responses were recorded on-line. Those objects that elicited participant agreement of 80% or better were coded as high association stimuli. Stimuli were presented in pseudo-randomized blocks of 19–20 pictures. Each block contained 8–9 high association stimuli, pseudo-randomized within the blocks. Pseudo-randomization was also used to avoid semantic priming of adjacent pictures within blocks.

During the experimental sessions, control participants were consented and administered the MMSE (Folstein et al., 1975) before being presented with the 218 pseudo-randomized stimuli using EPrime 2.0 software at the rate of one picture every five seconds. Participants were asked to supply the first two verbs that came to mind while viewing each object. Responses were recorded on-line.

First responses only were analyzed for this study. Verb generation agreement was computed in two ways: 1) percentage agreement was calculated; and 2) using the information statistic *H* (Snodgrass & Vanderwart, 1980):

$$H=\sum_{i=1}^{k}\mathscr{P}_i log_2\left(1/\mathscr{P}_i\right)$$

where *k* is the number of different verbs generated for each picture using the first verb generated by each subject and p_i is the proportion of subjects generating each verb. Using this formula, an *H* value of 0.0 indicates perfect verb generation agreement; an *H* value of 1.00 indicates that participants generated exactly two verbs for an object with equal frequency. *H* values increase as agreement decreases. Failures to generate verbs (e.g., no response, `don't know', or generation of something other than a verb) were included in percentage agreement scores, but were eliminated when computing *H* values. Although both measures capture information about verb generation agreement, percent agreement only indicates how dominant a verb was, whereas the *H* value is also sensitive to the distribution of verbs generated over all of the unique verbs generated. Thus, the *H* value is more informative than percent agreement, in that it also incorporates information about how constrained or underdetermined it is to generate verbs for different concepts.

Phase Two: Probing Verb Generation as an Outcomes Measure in Aphasia

Persons with Aphasia (PWAs)—Four individuals (2 female; mean age = 64.5; SD = 5.2; range = 58–70) with chronic aphasia secondary to unilateral left hemisphere middle cerebral artery cerebral vascular accident (mean months post-onset = 36.25; SD = 32.4; range = 12–84) were enrolled in a treatment study. Treatment consisted of two phases: 1) a two-week intensive treatment program consisting of either Intensive Language Action Therapy (ILAT; Pulvermuller & Berthier, 2008) or a modified version of Promoting Aphasic Communicative Effectiveness (PACE; Davis & Wilcox, 1985; Carlomagno, 1994) chosen by ransom assignment; and 2) a six-month period of Home Practice using individually tailored interactive “books” on an iPad. The individualized books had interactive chapters for each of the participants' unique sets of half of the recently trained objects (n=20) and actions (n=20) and half of matched sets that had been probed daily during treatment, but were untrained (n=40). Thus each participant had unique sets of 40 chapters: objects that were trained-to-be-practiced (TR-PR; n=10), objects that were untrained-to-be-practiced (UNTR-PR, i.e., learned autonomously during the Home Practice phase; n=10), TR-PR actions (n=10) and UNTR-PR actions (n=10). Home practice included tasks such as naming to confrontation, cued naming, repeating from a video model, and picture/word matching. Each chapter had five pages of interactive tasks and participants could check their responses for accuracy. They were trained to keep track of days and hours of practice using a clock/timer app on the iPads. In addition, the six-month Home Practice phase included a weekly check-in with an SLP via video teleconferencing software (GoToMeeting©) and monthly confrontation naming probes that were acquired in the clinic. Details of the Home Practice phase are forthcoming (Kurland et al., *in revision*). See Table 1 for aphasia profiles on all four participants.

Procedures—Verb generation stimuli were subsets of the Snodgrass and Vanderwart (1980) black and white line drawings of common objects, and consisted of concepts that had recently been trained (TR) or not (UNTR) and were in the process of being “overlearned”, i.e., practiced (PR) or not (UNPR) during the Home Practice program. Thus each participant had a unique set of TR-PR, TR-UNPR, UNTR-PR, and UNTR-UNPR objects (n=10 each). In addition, verb generation sets included 20 objects that each participant had consistently correctly named during baseline testing (CORR), for a total of 60 unique objects for each person with aphasia.

Verb generation testing occurred twice: 1) approximately two months into the Home Practice (HP) program, and 2) at the completion of the six-month HP program. Although verb generation was not obtained prior to the commencement of the two-week treatment or of the six-month HP phase, it was expected that the additional four months of HP might have a `treatment effect' on participants' ability to generate verbs for their unique sets of objects. Participants were presented with the 60 pseudo-randomly ordered pictures using EPrime 2.0 software at the rate of one picture every ten seconds. Prior to the experimental task, PWAs were given instructions for verb generation that included questions like, “What does it do?” or “How can you use it?”. They were given examples of objects and several plausible verbs for each object, and then practiced on five objects that were not part of their TR, UNTR, or CORR sets of pictures. Once it was clear they understood the task, and importantly that they should not *name* the pictures, they were asked to supply the first verb or action word that came to mind while viewing their set of 60 pictures of common objects. Responses were video recorded.

RESULTS

Phase One: Norms

Verb generation norms for the subset of 218 Snodgrass and Vanderwart (1980) pictures are presented in the following Appendices. In all cases, counts for alternative morphological endings provided (e.g., eat, eats, eating) were combined and are presented in the root of the infinitive form (eat). Although participants were encouraged to respond with one word, they occasionally produced a prepositional phrase (e.g., sit on, plug in). In those cases, the two-word phrase was included in the count with the one-word responses (e.g., sit/sit on). Appendix A includes the most frequent verbs produced, and is sorted by the percentage of responders providing the most frequent verb.

Appendix B includes the *H* values and is sorted from lowest to highest, which in many cases corresponds roughly to the highest to lowest percent agreement in Appendix A. Appendix C includes responses to each object made by the majority (at least 86%) of responders and is listed along with percent agreement in alphabetical order of objects. The intention of selecting the top 86% or more of responders is to capture the verbs generated by a majority and also to exclude most of the verbs that were elicited by only one responder of fifty. These tended to be either generic (“use”) or outliers (e.g., “pick”, “pierce”, “poke”, or “hold” for the picture of a FORK). In some cases, however, omitting single responses from the list meant dropping perfectly predictable responses (e.g., “sharpen” for PENCIL).

Most of the participants were able to complete the task without difficulty. Out of the 10,900 targets (218 pictures times 50 participants), there were only 313 (less than 3%) “no responses”. Nearly half of the object pictures (103/218) elicited a response from all fifty participants. Forty pictures elicited no response from only one in 50 participants (not always the same participant). Two participants accounted for 20% of all the “no responses” and 11/50 participants provided 2/3 of all “no responses”. Ten participants generated verbs for all 218 of the object pictures.

No pictures elicited perfect agreement (mean = 50.63%; SD = 22.89; range = 10–96%) although fifteen pictures elicited 90% or better agreement (Appendix A). Forty-two pictures elicited verbs with over 75% agreement. More than half of the pictures elicited verbs with over 50% agreement.

No pictures had an *H* value of 0.00, which would indicate perfect verb generation agreement and is possible without 100% agreement, as when some participants failed to generate a verb. An *H* value of 1.0 would indicate that a picture elicited exactly two different verbs, i.e., in equal frequency. The closest instance was the picture of an EAR (*H* value = 0.99), which elicited just two verbs, “listen” (n=28) and “hear” (n=22). The *H* value thus reveals information about the distribution of responses, which the percentage agreement measure fails to capture. For example, both pictures of a GUITAR (*H* value = 0.765) and a CAR (*H* value = 1.310) elicited a verb with 76% agreement (“play” and “drive”, respectively). However, in the former case, most of the other respondents (20%) generated “strum” so that GUITAR generated two verbs (“play” and “strum”), while two respondents did not generate verbs. In generating verbs other than “drive” for the picture of a CAR, responses varied among remaining participants (“ride”, “buy”, “pollute”, “run”, “travel”, etc.), thus substantially lowering the *H* value for CAR (Appendix B).

An object category effect was found (Table 2). The dominant responses for vehicles (n=7), animals (n=34), birds (n=10), and insects (n=7) were most often verbs that represented locomotion. In the case of domesticated animals, the locomotion often included humans (e.g., "ride"). For others, the verb sometimes represented a distinguishing feature of the animal's locomotion (e.g., PENGUIN / "waddle", SNAKE / "slither"). But often, verbs of locomotion seemed to be generated by default, as in "walk" or "run" which were generated seven and nine times, respectively, in response to pictures of animals. Fifteen percent of dominant responses for animals and 30% for birds were verbs that represented communication (e.g., CAT / "meow", DOG / "bark", DUCK / "quack", etc.). The few exceptions to verbs of locomotion and communication for animals and birds included some domesticated animals with whom the salient relationship is farming (i.e., COW / "milk", CHICKEN / "lay") and the SKUNK for whom a majority of respondents (40%) clearly had an unpleasant mental model ("smell").

By a large majority (87%), most articles of clothing elicited "wear". Excluding concepts that were labeled clothing by Snodgrass and Vanderwart (1980) but that really fit into the category of "clothing accessory" (pocketbook) or that have a metonymous relationship to clothing (e.g., button), the dominant response to *all* of the exemplars was "wear". Similarly, 88% of musical instruments elicited "play" by a majority of respondents. Here again, a notable exception is BELL, which predominantly elicited "ring", but the picture does not suggest the type of bell that is customarily "played", i.e., one with a long handle. With a few exceptions, 91% of fruit and 73% of vegetables elicited "eat" more than any other verb.

Some closely related concepts yielded surprising variation in the number and nature of the verbs generated. For example, although BANANA and ORANGE are both peeled fruits, and FINGER and THUMB are both digits, only one concept per pair was strongly associated with one verb (BANANA / "peel" and FINGER / "point"), while the other concept yielded much wider response variability (Figure 1). This response pattern is captured in the *H* values: BANANA (0.75) vs. ORANGE (2.13) and FINGER (0.28) vs. THUMB (3.58).

In general, stimuli with the lowest *H* values that produced verbs with the highest percent agreement were mostly artifacts and the dominant verbs produced appeared to be primary functional associates. Table 3 shows the ten concepts with the highest percent agreement (90–96%) and lowest *H* values (0.17–0.54). With the exception of FINGER, the rest are artifacts whose object thematic role is direct or indirect object to the dominant verbs that were generated (e.g., CHAIR / "sit", KITE / "fly"). At the other end of the spectrum, stimuli with the highest *H* values that produced verbs with the lowest percent agreement were mostly animals and body parts (Table 4). As discussed earlier, the animals mostly elicited verbs of locomotion and communication. With the exception of WELL, the rest are in the living domain. Other than the two body parts, the object thematic role of the animals and birds tended to be as agents of the dominant verbs generated.

All dominant responses were action verbs, none were auxiliary, linking, or modal verbs. Occasionally, however, there were outlier single linking verb responses in which a participant was describing the object rather than generating a verb (e.g., CORN / "is delicious", LEMON / "is tart"). These were not counted as appropriate verb generation responses, i.e., they were counted as "other".

Phase Two: PWAs

Compared to the control participants, PWAs experienced greater difficulty with the verb generation task. On average, they provided “no response” or an “other” response (i.e., not a verb) to approximately half of their 60 pictures (mean = 27; SD = 14.99; range = 8–39) two months into the Home Practice (HP) program and to approximately one third of their pictures (mean = 22; SD = 14.75; range = 10–42) following the full six months (Post-HP).

In spite of the greater failure rate, three of four PWAs were able to generate appropriate verbs for the majority of pictures following a six-month home practice program to maintain and improve word retrieval of object and action names. Table 5 shows the number of verbs generated during the two testing sessions: two months into the HP program (Post-Tx) and Post-HP. Percentage of verbs generated for each training (TR) and practice (PR) condition are also shown. Neither the treatment nor the home practice program specifically targeted verb generation. Nonetheless, three of four participants appropriately generated verbs for the majority of their individual sets of sixty objects in the first session (Post-Tx: mean = 45.33; SD = 25.58; range = 21–72) and again four months later (Post-HP: mean = 49; SD = 15.72; range = 35–66). The fourth participant (MCR) generated 20 appropriate verbs in both sessions. The majority of verbs produced by all four participants were unique although there were plenty of opportunities to repeat verbs (Post-Tx: mean = 28.25; SD = 11.30; range = 18-39; and Post-HP: mean = 29.5; SD = 9.75; range = 16–39).

Verb generation by PWAs included dominant verbs generated by control participants (Post-Tx: mean = 10; SD = 5.60; range = 5–17). Following the HP program, three of four participants produced more of the dominant verbs generated by control participants (Post-HP: mean = 13.75; SD = 6.65; range = 7–22).

While naming verbs to confrontation of picturable actions was practiced during the HP phase, generating verbs to confrontation of objects was not targeted. Although not a targeted goal, home practice improved verb generation in three of four participants. This was particularly true for one participant (NWS), whose verb production more than doubled (Post-Tx: 21; Post-HP: 46) in the four additional months of object and action naming practice. The number of verbs she produced that matched dominant verbs generated by the norming sample nearly quadrupled in that same period of extended home practice (Post-Tx: 6; Post-HP: 22). Moreover, there were a number of instances in which the verbs produced by NWS that did not match the dominant verbs were actually more refined choices (e.g., OBJECT/*dominant verb*/**NWS verb**: PEACOCK/*walk*/**strut**; DONKEY/*walk*/**bray**; KEY/*open*/**unlock**).

It is also noteworthy that three of the four participants are hemiparetic and each had five related body parts in their sets of target objects (five of six possible limb-related targets: arm, hand, thumb, leg, foot, or toe). In many cases, the initial responses (Post-Tx) were naming the object, no response, or a circumlocutory response that seemed to reflect alienation from the body part (e.g., “hand, what are you gonna do with a hand?” or “arm, one for another, I'm not sure”). For two of these three participants (NWS and SSM), the improvement in verb generation over time was notable (Table 6).

DISCUSSION

The goal of the present study was twofold: 1) to acquire a set of verb generation norms for a subset (n=218) of the Snodgrass and Vanderwart (1980) black and white line drawings of common objects; and 2) to probe the tool's use as an outcomes measure in aphasia treatment. The study includes quantitative and qualitative examination of the ways in which responses of persons with aphasia differed from the normed sample as well as within participants over time. To the best of our knowledge, this work is the first to examine and provide a set of normed verb generation responses to a picture set which is commonly utilized in clinical and experimental research. In addition, it provides a first look at the usefulness of this tool in assessing outcomes following the final four of six months of a home practice program, and potentially as a tool for outcomes measurement in aphasia treatment.

Confrontation naming of objects, and of picturable actions, is often utilized to assess treatment outcomes in aphasia treatment programs. The task is efficient and convenient, in part because norms are available for name agreement and for a variety of psycholinguistic variables. Picture naming may be considered a gross measure of word retrieval that is, generally, correlated with expressive aphasia severity. For many persons with aphasia, however, relative ease with this task does not reflect their ever-present struggles with propositional speech. A verb generation task could help to fill the gap between confrontation naming and the more labor-intensive methods of discourse analysis. Until now, however, norms for verb generation to pictures have not been available.

The current study investigated associations between object and action concepts in 50 “neurotypical” adults and four persons with aphasia who were undergoing a concurrent home practice program to improve retrieval of nouns and verbs. Unlike the very high naming agreement originally found by Snodgrass and Vanderwart (1980), there was wide variability in verb generation responses to the subset of these same black and white line drawings. For example, in the Snodgrass and Vanderwart study, over 3/4 of the concepts had 80% or higher name agreement and 45 concepts had 100% agreement. In the current study, less than 15% of concepts elicited 80% or higher agreement, and not one concept elicited perfect agreement in verb generation.

It is not surprising that verb generation would elicit less agreement than naming, given that the latter task simply requests a label, while the former task requires retrieval and selection from an array of biological, functional, and other associates that can vary broadly depending on a person's world knowledge and personal experience. Unlike confrontation naming, retrieval and selection of a verb in response to an object forces a choice between competing responses that may vary along both syntagmatic and paradigmatic relations. An object may be the agent (“the pencil fell”), patient (“he sharpened the pencil”), or instrument (“she writes with a pencil”), and within each of these roles may elicit a variety of associative relations (“writes”, “draws”, “scribbles”, “erases”, “sketches”, etc.). In a nutshell, as Thompson-Schill and colleagues (1998) have suggested, verb generation is a more “difficult” task than naming because it requires selection of a response from among multiple competitors, including the pre-potent response to name the object (or to read it in the case of verb generation to nouns). In either case, the level of difficulty varies according to the association strength between an object (noun) and a verb.

In the norming phase of the current study, objects with the strongest verb associations, as demonstrated both by high percentage verb agreement and low *H* values, were mostly artifacts with a primary functional association to the verbs generated. Objects with the weaker verb associations, or what Snyder and colleagues (2008; 2011) have referred to as underdetermined responses, were mostly living objects and many of these would be assigned an agency role by the verbs generated. It is this latter group of objects that can be said to be more cognitively demanding, due to the need for some biasing mechanism to resolve the competition between plausible, and often weakly associated, verbs.

Indeed, there were 16 objects that were so cognitively demanding that they elicited no response in 10% or more of the neurotypical group (range=5–11). For these 16 objects, the *H* values were relatively high (mean=3.01; sd=0.75; range=1.23–3.98) while the % agreement was relatively low (mean=0.26; sd=0.15; range=0.12–0.54). This can be compared to the 16 objects with the lowest *H* values in which 13 had no failures, 2 had 1 failure, and 1 object had 2/50 failures to respond. The occurrence of so many "no responses" to objects with relatively high *H* values was likely influenced by the short response time allowed (5s). The *H* statistic has been shown to be more predictive of latencies in confrontation naming than variables such as print frequency or age of acquisition (Lachman, 1973; as cited in Snodgrass & Vanderwart, 1980). It is reasonable to assume that, given more time, all participants in the neurotypical group would have been able to generate verbs for all of the objects, including for example, "arm" which generated "no response" in 5/50 participants. It is interesting to note that "arm" was among the consistently correctly named pictures in three of the four PWAs and two of them generated appropriate verbs after six months of home practice ("bend" and "flex"). Thus knowing that some of the objects are more cognitively challenging stimuli for verb generation among neurotypical adults should not necessarily suggest that they are too difficult for persons with aphasia, or that they should be excluded from practice lists. The relatively high *H* values associated with these objects, however, does suggest that functional cues, such as "use" or "action" cues in Semantic Feature Analysis (Boyle & Coelho, 1995) for such objects might be less robust than those for objects with lower *H* values.

Since verb generation can be considered to be a more cognitively demanding task than confrontation naming, it is of course not surprising that persons with aphasia generally had greater difficulty with the verb generation task than did the neurotypical adults in the current study. This has been demonstrated previously with verb generation to nouns (Thompson-Schill et al., 1998; Martin & Cheng, 2006). Thompson-Schill and colleagues demonstrated that a lesion in left posterior inferior frontal cortex (L pIFG) is both necessary and sufficient to disrupt the generation of semantically appropriate verbs, particularly those with high demand for selection among competing responses. In a follow-up study that disambiguates retrieval and selection demands, Snyder and colleagues (2011) found that shared neural substrates in left middle ventrolateral prefrontal cortex (L mid-VLPFC, BA 45) and left anterior VLPFC (BA 47), support both retrieval and selection mechanisms, and that these mechanisms and their underlying neural substrates interact in meaningful ways.

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In the current study, structural imaging was available for only three of the four persons with aphasia and confirmed the presence of varying degrees of damage to L IFG. ACL's primarily posterior lesion extends minimally into L IFG (Pars opercularis), thus sparing BA 45 and 47. Both MCR and NWS have lesions that include Pars opercularis and Pars triangularis but spare Pars orbitalis (L ant-VLPFC, BA 47). Although SSM was not MRI compatible at 3T, medical records from the time of his ischemic stroke describe “highly restricted diffusion and marked T2 hyperintensity in the left insula, basal ganglia and adjacent white matter, and extending into the left corona radiata, and very slightly involving the anterior/superior left temporal lobe”. From this description, it appears that his lesion bordered but excluded portions of Broca's area and BA 47, at least acutely.

Performance by persons with aphasia varied widely from the norms and depended, to some degree, on object training and practice conditions. Overall, the task was more difficult for the PWAs as demonstrated by higher percentages of “no responses” or “other responses” despite having more time to generate verbs. What was surprising was that all four PWAs performed as well as they did, especially considering the varying degrees of damage to L IFG in three of four participants. Moreover, these same three participants improved their performance on the verb generation task, as noted by greater numbers of appropriate verbs generated and/or greater percentages of verbs matching the dominant verbs produced in the normative sample. This seems to confirm suggestions by Snyder and colleagues (2011), and others, that the processes of retrieval and selection, while somewhat dependent on L IFG, also recruit a larger network of regions that support the representation of semantic knowledge. Weiller and colleagues (1995) tested six individuals who had recovered from Wernicke's aphasia. Their patients were successful at verb generation and demonstrated increased activation in Broca's area and left prefrontal cortex in spite of complete destruction of Wernicke's area.

It would be interesting to examine the neurophysiology of how the PWAs in the current study were able to perform and improve upon the task, and whether such improvements were due to practice and refinement of a more domain general function related to selection and retrieval, as we hypothesize. Unfortunately, testing this hypothesis is beyond the scope of the current study. We also acknowledge that the current sample is too small to draw conclusions that might be afforded by a larger sample using lesion symptom mapping. We are continuing to collect verb generation data, along with structural imaging data, from a larger cohort of participants and will continue to pursue these important questions regarding mechanisms underlying successful retrieval and selection in chronic post-stroke aphasia.

With the exception of NWS (Post-Tx), in the other three cases, the majority of verbs generated both Post-Tx and Post-HP were to objects from their CORR set of objects, i.e., those that were consistently correctly named on 3/3 baseline confrontation naming tests. These tended to be the high frequency concepts (glass, fork, shoe, key, etc.). As such, they were neither trained nor practiced objects, yet in most cases participants produced the majority of verbs to CORR objects Post-Tx and then increased the number of verbs to CORR objects following four more months of home practice. Thus it appears that the home practice program, which targeted improved naming of objects and actions, but did not specifically target verb generation, nonetheless had a positive impact on verb generation that was not specific to either the objects or actions being trained or practiced in most cases. This appears to be a positive trend that might be explained by the beneficial effects of daily language stimulation and spreading activation within functionally reorganizing networks over the course of the extended home practice program. This is, of course, speculative and will need to be explored further. The current study is limited by the lack of a pre-treatment baseline, and the small number of PWAs who completed the home practice program and who were able to perform the verb generation task with some success.

Given the higher cognitive demand of verb generation compared to confrontation naming, the verb generation task is not likely to be an appropriate assessment tool for use with severely aphasic individuals. As the current study suggests, however, having norms for verb generation to pictures enables a broader swath of individuals with aphasia to be tested, given that neither single word reading ability nor a strong phonological input buffer for single words is required. Unlike previously reported verb generation experiments, in which a word is either visually or auditorily presented, the current normative study used pictorial stimuli. Given that visual object recognition is unimpaired in aphasia, and usually not a co-morbid factor, generation of verbs to pictures increases the odds that persons with aphasia will be able to perform the task. Still, there are noteworthy differences between generating verbs to pictures vs. words.

Aside from the obvious differences on the sensory input side of processing pictures vs. words, there are a number of other ways in which verb generation to pictures likely differs from verb generation to nouns. A good example in the current study was in responses to the picture of a TELEPHONE, which shows an old rotary style phone. One participant responded with “dial”, another with “turn”. Although some older participants might still conjure a rotary dial phone and generate “dial” to the word, it becomes less and less likely as situational models for telephone usage evolve. Similarly, a number of pictures in the Snodgrass and Vanderwart set represent still current concepts but use outmoded images, e.g., most of the clothing, kitchen appliances, and modes of transportation. Here and there, as with TELEPHONE / “dial”, the picture seemed to influence the mental model of the concept in generating verbs, e.g., HAT / “crease”, where the hat is a 1940s style Fedora, creased lengthwise down the crown. Current situational models for “hat” are as likely to be represented by baseball caps, or Peruvian beanies, neither of which would likely provoke the verb “crease”. For the most part, however, it appears that using these pictures did not influence the dominant responses. Even in the case of TELEPHONE, most participants (36%) generated “answer” which was also the dominant response in the verb generation phase of a recent word-word priming experiment (McRae et al., 2005).

Pictures can also constrain responses by representing a subordinate class of a concept. For example, in McRae et al. (2005), in which Patient-Verb pairs are preceded by instructions to “list the things that these objects commonly have done to them” BALL is expected to prime “thrown” based on thematic-based event generation norms they collected. The ball in the Snodgrass and Vanderwart picture set, however, appears to be a large beach ball and only 10% of participants generated “throw”. The dominant verb for BALL instead was “bounce” (56%). Of the nine Instrument-Verb pairs and seven Patient-Verb pairs in which the McRae et al. nouns overlapped with pictures used in the current study from the Snodgrass and

Vanderwart picture set, 12 (75%) of these generated the same dominant verb. It is likely that, as with BALL, the other three concepts that generated different verbs depending on the mode of stimulus presentation (KNIFE, PENCIL, and BOTTLE) owe the difference to the constraining influence of the pictures. That is, the picture of a KNIFE is a butter knife. In McRae et al., Instrument-Verb Pairs are preceded by instructions to "list the things that people commonly use each of the following to do". While you might use a butter knife to "cut" bread (as 84% of respondents suggested), you would be less likely to choose one for "slicing" anything, the predominant response to the word "knife" in McRae et al. Similarly, the PENCIL is a standard writing implement, as opposed to, for example, a colored pencil or an artist's pencil, and thus could be expected to generate "write" (82%) over "draw" (10%). The BOTTLE, which had an H value of 2.73 and mostly generated "fill" (32%), "drink" (28%), and "pour" (10%) is not in the shape of contemporary bottles that are now routinely "recycled". Here again is evidence of how dynamic language is and how a picture that implicitly or explicitly represents an older version of a common concept may constrain the choice of associations to that concept.

Importantly, as McRae et al. (2005) suggest, the task of generating verbs taps into more than just simple associations between nouns and verbs, but rather the ties that bind together objects and actions through real-world co-occurrence of events and of linguistic descriptions of those events. Indeed, these authors have suggested that generation of verbs from nouns can be understood as representing the "lower bound" of the information available when a person reads or hears a noun in naturalistic settings. Given their robust noun-verb priming results, they propose that their work on event-based expectancy generation may bridge the gap between theories of sentence and lexical-semantic processing. By extension, the verb generation to pictures task suggests that even pre-lexical representations of nouns activate classes of events and linguistic descriptions of those events to which they are tied in event memory. As such, it is hoped that the current study contributes towards bridging the gap between object naming and discourse as a tool for understanding language processing in aphasia.

It may also provide a means of measuring change in treatment outcomes, particularly in cases where confrontation naming is too "easy" of a task. One benefit of having a normed set of alternative verb responses is that it allows a clinician or clinical researcher to check whether a verb is a `reasonable' response, i.e., within normal limits. Since the task does not elicit perfect, or even high, agreement among neurotypical adults for the majority of the pictures, it helpful to know what the range of `normal' responses includes.

Moreover, there is potential clinical utility in a set of norms for verb generation to pictures in terms of treatment. Some very popular aphasia treatment programs use object pictures and cueing with functional associates, e.g., Semantic Feature Analysis (SFA; Boyle & Coelho, 1995). Recently, some verb-centered treatment programs have also been developed, e.g., Verb Network Strengthening Treatment (VNeST; Edmonds & Babb, 2011). Moreover, clinical speech language pathologists routinely use informal sets of pictures and cueing hierarchies to stimulate improved naming in aphasia. Because verbs are heavily used in semantic cueing (e.g., "It barks and wags its tail"), and the effectiveness of this strategy depends upon the quality of the semantic cues, having a set of verb generation norms might help in the development of future testing and treatment materials. For example, a commonly utilized set of black and white line drawings of picturable actions (Actions & Objects Naming Test, Masterson & Druks, 1998) includes a picture of a man peeling an orange. Although the pictures were reported to have achieved at least 93% naming agreement (in England), it has often elicited a "no response" or "don't know" response from aphasic and control participants in our clinical and experimental research. If these same participants are cued with a simple gesture of peeling a banana, most respondents will quickly say, "oh, peeling". Given the results of the verb generation task and the comparison between BANANA and ORANGE, it would suggest for example, that future pictographic representations of "peeling" include a banana, rather than an orange.

It is hoped that the verb generation normative data provided in the Appendices will be useful for streamlining therapy prompts and improving stimulus design in clinical and experimental applications. More research in this area, for example, expansion of the normative sample size and a more racially and ethnically diverse sample would improve the study. A larger sample of participants with aphasia who are able to perform the task might also contribute to a better understanding of as yet unresolved issues regarding the precise role of the L IFG in retrieving and selecting responses during such underdetermined tasks.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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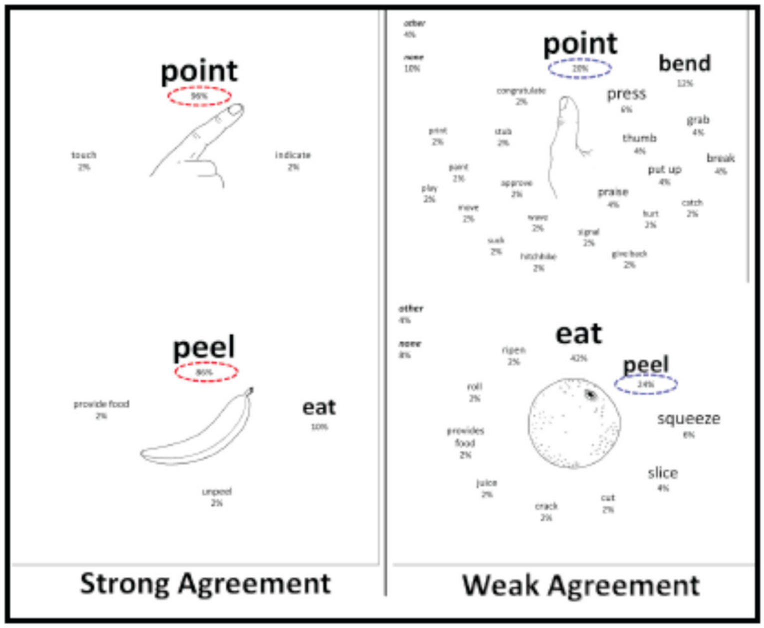

Figure 1.
Discrepancy in verbs generatrd for related object concepts

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Table 1

Aphasic Participant Demographics and BDAE[1] Selected Subtest Scores

Patient Data			Aud. Comp.				Repetition		Naming				
Patient/aphasia class'fn	**Age**	**TPO**	**AC[2]**	**WD**	**C**	**CIM**	**Single Word**	**Sent.**	**BNT**	**Resp. Naming**	**Animals**	**Tools**	**Actions**
			Maximum score:	*37*	*15*	*12*	*10*	*10*	*60*	*20*	*12*	*12*	*12*
ACL/mod-to-severe Wern'k	58	7 yrs.	18th	29.5	10	3	6	0	23	4	6	5	6
MCR/mod-to-severe anomia	70	12 mos.	82nd	36.5	15	9	10	7	37	12	10	4	6
NWS/mod anomia	67	24 mos.	72nd	36.5	13	10	8	7	47	15	11	8	9
SSM/mild anomia	63	25 mos.	83rd	36	15	10	10	9	48	20	10	9	10

[1] Boston Diagnostic Aphasia Exam 3rd ed. (Goodglass, Kaplan & Barresi, 2001)

[2] Auditory Comprehension (AC) computed from the mean of three percentiles – Word Discrimination (WD), Commands (C), and Complex Ideational Material (CIM)

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Table 2

Category effects of verb generation to pictures

CATEGORY	# TARGETS	DOMINANT RESPONSE	% DOMINANT RESPONSE	2ND DOMINANT RESPONSE	% 2ND DOMINANT RESPONSE	ODDBALLS
animal	34	(locomotion)	0.71	(communication)	0.15	eat (giraffe, lobster, squirrel); milk (cow); smell (skunk)
bird	10	(locomotion)	0.60	(communication)	0.30	lay (chicken)
insect	7	(locomotion)	1.00	-	-	-
clothing	23	wear	0.87	-	-	carry (pocketbook); sew (button); tie (bow)
fruit	11	eat	0.91	-	-	peel (banana)
musical instrument	8	play	0.88	-	-	ring (bell)
vegetable	11	eat	0.73	-	-	carve (pumpkin); crack (peanut); peel (onion)

Table 3

Verbs generated with ten highest *H* statistic agreement

#	Object	Dominant Verb	Dominant Verb Print Frequency (Kucera-Francis)	Dominant Verb Info Stat (H)	Dominant Verb % Agreement	Object Thematic Role*	LIVING vs ARTIFACT	PRIMARY FUNCTIONAL ASSOCIATE?
1	**chair**	SIT	67	0.169	0.96	IO	ARTIFACT	Y
2	**scissors**	CUT	192	0.169	0.96	IO	ARTIFACT	Y
3	**kite**	FLY	33	0.242	0.96	DO	ARTIFACT	Y
4	**finger**	POINT	395	0.282	0.96	MIXED	*LIVING*	*N*
5	**piano**	PLAY	200	0.310	0.94	DO	ARTIFACT	Y
6	**ruler**	MEASURE	91	0.336	0.92	IO	ARTIFACT	Y
7	**pipe**	SMOKE	41	0.383	0.94	DO	ARTIFACT	Y
8	**ladder**	CLIMB	12	0.423	0.94	DO	ARTIFACT	Y
9	**door**	OPEN	319	0.475	0.92	IO	ARTIFACT	Y
10	**toothbrush**	BRUSH	44	0.541	0.90	DO	ARTIFACT	Y
		MEAN	139.40	0.33	0.94			
		SD	132.47	0.12	0.02			

*IO=Indirect Object; DO=Direct Object; Mixed=can take role of Direct or Indirect Object

Table 4

Verbs generated with ten lowest *H* statistic agreement

#	Object	Dominant Verb	Dominant Verb Print Frequency	Dominant Verb Info Stat (H)	Dominant Verb % Agreement	Object Thematic Role*	LIVING vs ARTIFACT	PRIMARY FUNCTIONAL ASSOCIATE?
209	**raccoon**	WALK	100	3.607	0.14	*Agent*	*LIVING*	N
210	**goat**	WALK	100	3.666	0.22	*Agent*	*LIVING*	N
211	**chicken**	LAY	139	3.761	0.18	*Agent*	*LIVING*	N
212	**toe**	WALK	100	3.797	0.18	IO	*LIVING*	N
213	**squirrel**	EAT	61	3.896	0.12	*Agent*	*LIVING*	N
214	**peacock**	WALK	100	3.935	0.14	*Agent*	*LIVING*	N
215	**rooster**	CROW	2	3.982	0.12	*Agent*	*LIVING*	N
216	**monkey**	CLIMB	12	3.986	0.1	*Agent*	*LIVING*	N
217	**well**	TURN	233	4.052	0.12	IO	ARTIFACT	N
218	**hand**	TOUCH	87	4.211	0.14	IO	*LIVING*	N
		MEAN	93.40	3.89	0.15			
		SD	64.82	0.18	0.04			

*Agent=performer of the action; IO=Indirect Object

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Table 5

Verb Generation by Persons with Aphasia (PWA)

PWA	Treatment Phase*	# Approp Verbs Generated	# Unique Verbs	# "Weak" Verbs (go, get, like, etc.)	# Matching Dominant Verbs in Norms	% Matching Dominant Verbs in Norms	No Response or Other**	% Verbs from CORR Objects	% Verbs from TR-PR Objects	% Verbs from TR-UNPR Objects	% Verbs from UNTR-PR Objects	% Verbs from UNTR-UNPR Objects
ACL	Post-PACE	72	39	20	12	0.17	8	0.29	0.18	0.17	0.15	0.21
	Post-HP	66	33	10	16	0.24	10	0.35	0.12	0.15	0.2	0.18
MCR	Post-ILAT	20	18	4	5	0.25	39	0.65	0.2	0.05	0.1	0
	Post-HP	20	16	4	7	0.35	42	0.45	0.35	0	0.15	0.05
NWS	Post-PACE	21	19	0	6	0.29	39	0.19	0.1	0.19	0.43	0.1
	Post-HP	46	39	0	22	0.48	12	0.43	0.13	0.13	0.13	0.17
SSM	Post-ILAT	43	37	1	17	0.40	22	0.33	0.09	0.21	0.19	0.19
	Post-HP	35	30	1	10	0.29	25	0.51	0.06	0.17	0.17	0.09

* Treatment consisted of two weeks of intensive PACE (Davis & Wilcox, 1985) or two weeks of Intensive Language Action Therapy (ILAT; Pulvermuller & Berthier, 2008); the Home Practice (HP) program lasted six months; two measures of verb generation were acquired - the first, two months into the HP program following treatment and the second, after HP program ended

** For example, PWA attempts to name the object or describe it

Table 6

Aphasic Participant Verb Generation to Body Parts

TARGET	ARM	HAND	THUMB	LEG	FOOT	TOE
Dominant Verb	***bend***	***touch***	***point***	***bend***	***walk***	***walk***
MCR						
Post-2 mos. HP	*arm*	*(other) 1*	*thumb, no*	(other) 2	*ankle*	n/a
Post-HP	n/r	*(other) 3*	*thumb*	*leg and foot*	*toe*	n/a
NWS						
Post-2 mos. HP	knock	n/r	n/r	n/r	**	n/a
Post-HP	bend	grasp	bend	bend	walk	n/a
SSM						
Post-2 mos. HP	*(other)4*	*(other)5*	hitchhike	n/a	*(other)6*	cut, clip
Post-HP	flex	feel	*(other)7*	n/a	kick	feel

Notes: n/a = not applicable, i.e., target not in participant's picture sets; n/r = no response;

1 hand, what are you gonna do with a hand?

2 ankle, we have

3 I have a hand too

4 arm, one for another, I'm not sure

5 hand, not working

6 see doctor

7 print

** response was unintelligible; *italicized responses were not verbs and/or include “other” responses (see below)*