ABSTRACT

Title of thesis: VERB PRODUCTION IN APHASIA: TESTING THE DIVISION
OF LABOR BETWEEN SYNTAX AND SEMANTICS

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Verb production is commonly impaired in aphasia, but it has been shown that not
all verbs are impaired equally. Some individuals with aphasia have been shown to prefer
semantically general "light" verbs, while others prefer semantically specific "heavy"
verbs. The "division of labor" theory, that access to syntactic and semantic processes in
language production influences the weight of verbs selected, was explored in this study
by examining the verbs used in the narrative language of 166 neurologically healthy
individuals and 164 individuals with aphasia. The proportions of light verbs used were
compared to narrative language measures of syntactic and semantic ability as well as test
scores. It was found that certain semantic and syntactic measures showed a significant
relationship to the proportion of light verbs used for individuals with aphasia, supporting
the "division of labor" model. For healthy individuals, one measure of syntactic
complexity significantly predicted light verb use.

Verb Production in Aphasia: Testing the Division of Labor Between Syntax and
Semantics

by

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One classic method of learning about the representations and processes underlying language production examines the effects of focal brain damage on language. Aphasia is a language impairment in comprehension or production stemming from focal brain injury (Lesser, 1987). Individuals with aphasia can present with a variety of combinations of deficits in any of the major domains of language, although there is usually a predominant linguistic impairment. For example, agrammatic aphasia is primarily characterized by the disruption of morphosyntax, resulting in errors of verbal inflection, errors of sentence structures, reduced syntactic complexity, and reduced use of function words (e.g., auxiliary verbs, copula verbs, articles, and prepositions) (Goodglass, Kaplan, & Barresi, 2001). Anomic aphasia, on the other hand, is characterized by primarily lexical-semantic difficulties, with problems of lexical access resulting in errors of word-finding (Goodglass et al., 2001).

Verb deficits are among the most common lexical deficits in aphasic individuals. In a review of 280 patients from 38 picture naming studies, Matzig, Druks, Masterson, & Vigliocco (2009) found that 75% of participants showed relative deficits in naming verbs whereas only 11% demonstrated a deficit in naming nouns more so than verbs. Verb deficits have long been thought to be associated in particular with agrammatism (e.g., Fillenbaum, Jones, & Wepman, 1961; Myerson & Goodglass, 1972; Saffran, Berndt, & Schwartz, 1989; Goodglass, 1997). The association of verb deficits with agrammatism has been attributed to the greater syntactic demands of verb production, the source of which is the syntactic information that must be encoded in verb representation and processed during verb retrieval (Bastiaanse & Jonkers, 1998; Druks & Carroll, 2005).

However, verb-specific deficits have been found in other aphasias, including fluent subtypes, and not all agrammatic individuals show verb deficits (Matzig et al., 2009).

Some authors have argued that the existence of verb-specific deficits results from the inherent greater difficulty of verb processing and production (Goodglass & Geschwind, 1976; Saffran, Schwartz, & Marin, 1980; Saffran, 1982). This explanation is supported by the fact that verbs are acquired later by English-speaking children, both in production and comprehension, which has been attributed to both the linguistic complexity of verbs as well as the difficulty of perceiving and conceptually understanding verb relations (Gentner, 1982). However, this explanation alone cannot account for the observed existence of noun naming or comprehension deficits in the absence of verb deficits (Berndt, Mitchum, Haendiges, & Sandson, 1997; McCarthy & Warrington, 1985; Zingeser & Berndt, 1990). This differential impairment, referred to as a double dissociation between nouns and verbs, has traditionally been interpreted as an inherent difference between the lexical or neuroanatomical organization of the two grammatical classes of words (Caramazza & Hillis, 1991; Damasio & Tranel, 1993).

Nonetheless, multiple theories of verb-specific deficits have been proposed that explain apparent verb deficits as something other than a specific grammatical class deficit. Several studies suggest that the noun/verb double dissociation is the result of the impairment of features on which nouns and verbs tend to differ, rather than a strict lexical impairment affecting a single grammatical class or the impairment of different linguistic processes (Vinson & Vigliocco, 2002; Vigliocco, Vinson, Lewis, & Garrett, 2004; Bird, Howard & Franklin, 2000). For example, the semantic features of both verbs and nouns may differ based on whether the word represents an object or an action, and therefore an

apparent verb deficit may result from the fact that verbs tend to contain action features whereas nouns tend to depend on object features (Vinson & Vigliocco, 2002; Vigliocco et al., 2004). Similarly, the reduced imageability of verbs and the increased processing demands of verbs have been shown to contribute to apparent verb-specific impairments (Bird, Howard, & Franklin, 2003; Matzig et al., 2009). Such explanations do not require nouns and verbs to be represented separately in the lexicon or located separately neuroanatomically, which is supported by the heterogeneity of lesion sites resulting in verb deficits (Matzig et al., 2009).

The exploration of the possible sources of the differential impairment of nouns and verbs has allowed researchers to better understand factors influencing the organization of verbs and nouns in the lexicon and the process of lexical retrieval. While verb-specific impairment is still not fully understood, it has been determined that a variety of factors beyond lexical organization play a role in the retrieval of verbs and nouns, including their semantic features, their frequency, and their imageability.

While a great deal of study has been devoted to understanding the differences between verbs and nouns in aphasic lexical access, the different patterns in retrieval and comprehension within the particular grammatical class of verbs have been less well-explored. One currently known factor affecting the retrieval of verbs specifically is syntactic complexity (i.e., the number of the arguments that the verb takes), which has been shown to influence the success of verb production in agrammatic aphasic individuals. More syntactically-complex verbs have been shown to be more difficult across a variety of tasks for agrammatic aphasic individuals, including picture naming, categorization, and narrative speech production, with difficulty increasing with each

additional argument (Thompson et al., 1999; Kim & Thompson, 2000; Kim & Thompson, 2004). Moreover, verbs that take more arguments have been shown to be more difficult even for neurologically healthy individuals to process (Shapiro, Gordon, Hack, & Killackey, 1993; Shapiro & Levine, 1990).

Similar to syntactic complexity, a few studies have examined the effects of the semantic complexity on the retrieval of verbs by English-speaking individuals with aphasia, comparing the use of verbs with different semantic "weights" (Berndt, Haendiges, Mitchum, & Sandson, 1997; Breedin, Saffran, & Schwartz, 1998; Kim & Thompson, 2004; Barde, Schwartz, & Boronat, 2006). Some individuals with aphasia have been shown to use more semantically general "light" verbs (e.g., *have, make, do, go*) in narrative language production, whereas others have demonstrated a preference for semantically specific "heavy" verbs.

In these studies of light and heavy verb usage in aphasia, the definition of light verbs has tended towards a specific subset of semantically underspecified or "general" verbs identified by Pinker (1989). These verbs include *be, bring, come, get, give, go, make,* and *take,* with the exclusion of some verbs and the addition of other verbs such as *put, have, move,* and *do* across different studies (Berndt, Haendiges, et al., 1997; Breedin et al., 1998; Kim & Thompson, 2004; Barde, et al., 2006). These verbs are considered to have fewer semantic features than other verbs, resulting in meaning that can vary widely depending on context (Pinker, 1989). Heavy verbs have been traditionally defined as the more specific, semantically-complex verbs (e.g., *run* and *bake* as heavy counterparts to *go* and *make*), usually including all verbs that are not considered light.[1]

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[1] Breedin et al. (1998) experimentally examined pairs of "general" versus "specific" verbs in addition to the classic light verbs versus their heavy counterparts, reporting results for these verb

Experimentally, verb weight has primarily been examined through the use of a sentence completion or story completion verb naming task (Breedin et al., 1998; Kim & Thompson, 2004; Barde et al., 2006) and the analysis of verb production in narrative language (Berndt, Haendiges, et al., 1997; Kim & Thompson, 2004). In the story completion paradigm (Breedin et al., 1998; Barde et al., 2006), participants listened to a three-sentence story containing a light or heavy verb (e.g., *The car company had to fire Bob. Bob* got/found *a new job. His wife was glad.* from Breedin et al., 1998) and then were asked what the character in the story did, having been initially instructed to use the verb that they heard in the story. Kim and Thompson (2004) adjusted the task slightly, using picture stimuli to elicit a particular verb after the participant was exposed to the heavy or light verb with a different picture stimulus. Responses were then analyzed for which types of verbs they produced correctly. In the analysis of narrative language (Berndt, Haendiges, et al., 1997; Kim & Thompson, 2004), participants retold the story of *Cinderella* after a brief period of refamiliarization with the story using a wordless book. The verbs in the resulting narrative were then coded as light or heavy and the proportions of light and heavy verbs in the sample were calculated.

With regards to the classification of participants for performance analysis, these studies again show some similarities and some differences due to different approaches to the possible source of light or heavy verb deficits. Each study reported diagnoses of participants as agrammatic or non-agrammatic using the Quantitative Production Analysis (QPA) method detailed in Saffran et al. (1989). Earlier exploratory studies reported but largely ignored the agrammatic labels in their analysis of light versus heavy

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distinctions separately. It should be noted that Barde et al. (2006) reported results for "lighter" verbs versus "heavier" verbs together, with the "lighter" subset including the classic light verbs as well as verbs judged to be "general" by Breedin and colleagues.

verb production, focusing instead on the QPA measures' indication of overall verb impairment (Berndt, Haendiges, et al., 1997; Breedin et al., 1998). Later studies, however, explicitly compared agrammatic and non-agrammatic individuals in their productions of light and heavy verbs, with the assumption that agrammatic individuals might be impaired in producing light verbs due to the increased syntactic demands of light verbs compared to the primarily semantic demands of heavy verbs (Kim & Thompson, 2004; Barde et al. 2006). It should be noted that Kim and Thompson's (2004) non-agrammatic participants were not individuals with aphasia, but rather individuals with probable Alzheimer's disease.

A summary of the results of these four studies of verb weight can be found in Table 1. Out of forty individuals with aphasia tested with the sentence or story completion paradigm, twenty-eight (70%) showed a numerical advantage for heavy verb naming, while the remaining twelve (30%) demonstrated comparable performance for naming heavy and light verbs. None showed a light verb advantage in the sentence or story completion paradigm. In narrative language analysis, fifteen out of nineteen (79%) participants with aphasia showed an advantage for heavy verbs, while the remaining four (21%) showed an advantage for light verbs. Use of light and heavy verbs in narrative language was not associated with agrammatism, with both agrammatic and non-agrammatic individuals showing heavy verb advantages and light verb advantages. Finally, in the two studies that tested neurologically healthy control participants, one group of control participants showed numerically more heavy verbs in narrative language production, suggesting that heavy verbs are used more frequently in typical narrative

language, but another group showed comparable performance on naming light and heavy

verbs in the story completion paradigm.

Table 1

Results and group sizes of four studies of verb weight in aphasic and non-aphasic individuals

Study	Task	Agrammatic Aphasic Participants		Non-agrammatic Aphasic Participants		Controls	
		n	Finding	*n*	Finding	*n*	Finding
Berndt, Haendiges, et al. (1997)	Narrative language analysis	3	All used higher proportion of light verbs in narrative speech (no statistical significance reported)	7	6/7 used higher proportion of heavy verbs in narrative speech (no statistical significance reported)	0	None
Breedin et al. (1998)	Story completion	3	Numerical advantage shown for heavy verbs for all participants (statistical significance only reached for 1/3 participants due to small number of items tested)	5	Smaller numerical advantage for heavy verbs for 4/5 participants (statistical significance reached for 1/5 participants)	0	None
Kim & Thompson (2004)	Sentence completion and narrative language analysis	9	Non-significant numerical advantage for heavy verbs in sentence completion for all participants; greater proportion of heavy verbs than light verbs in narrative speech (statistically significant)	0	None	10	Greater proportion of heavy verbs to light verbs in narrative speech for all participants (statistically significant)
Barde et al. (2006)	Story completion	12	Statistically significant group decrement in light verb production	11	Comparable group performance on light and heavy verbs	12	Comparable performance on light and heavy verbs

In summary, the most common finding has been that aphasic individuals show a

heavy verb advantage both in story completion tasks and narrative language analysis. An

advantage for light verbs has only been documented in the narrative language of a subset of individuals with aphasia. Additionally, an advantage for heavy and light verbs does not appear to be associated with agrammatism in a straightforward way, as individuals in both aphasic groups have demonstrated both patterns.

Gordon and Dell (2003) contend that the findings of these studies represent a double dissociation, with light verb production being affected by syntactic impairment and heavy verb production by semantic impairment. Indeed, both possible patterns of verb use are observed: some individuals show a light verb advantage over heavy verbs, while some show a heavy verb advantage over light verbs. However, these results are by no means straightforward. The pattern of double dissociation has only been found in the analysis of narrative language, as an advantage for naming light verbs over heavy has not been found using the story completion task. In addition, while these studies have postulated that agrammatism plays a role in the advantage of or preference for heavy verbs over light verbs, few studies have found significant differences in the abilities of agrammatic and non-agrammatic aphasic individuals to name heavy verbs or use heavy verbs in narrative speech.

A number of limitations in previous studies of verb weight in aphasia may explain these unclear findings. The first and foremost issue is the inconsistent definition of which verbs are counted as light. While a certain subset of verbs from Pinker's (1989) list is represented in all of the cited studies (*be, come, get, give, go, make,* and *take)*, the addition of some verbs and omission of others occurs in each study without explanation. Barde et al. (2006) do not even make the distinction between the classic set of light verbs and heavier ones in their analysis, instead reporting on a larger set of "lighter" verbs

versus "heavier" ones. Little theoretical context is given in the definition of light verbs, and as a result studies differ on what exactly counts as light and what counts as heavy.

In addition to inconsistent definitions, the cited studies differ in their task design, with some using narrative analysis and others using a sentence or story completion paradigm to elicit single verbs. As Barde et al. (2006) point out, in the single verb elicitation paradigm used in three of the four cited studies, the instructions given to participants during the task might affect their accuracy in retrieval of the correct light or heavy verbs, while Breedin et al. (1998) proposed that the story completion task may include a memory component that could confound the results. Moreover, the language production demands of the story completion paradigm, which elicits single word responses, are different than those required during narrative language production, which limits the conclusions that can be drawn when comparing results from the different task designs.

Another problem affecting the data reported in the previously cited studies is the difference in approach to determining what factors influence the advantage of one verb weight over another, and why individuals with aphasia might differ in the types of verbs they tend to select. Only two of the cited studies included neurologically healthy control participants for comparison to aphasic individuals (Kim & Thompson, 2004; Barde et al., 2006), leaving the patterns of verb usage by healthy individuals unclear. It should be noted that Kim and Thompson's (2004) control group showed a significant preference for heavy verbs in narrative speech, in spite of the fact that light verbs are expected to be highly frequent in adult language production (Clark, 1978). Therefore, it is unknown

whether aphasic individuals showing a significant heavy verb advantage are deviating from the normal pattern or are demonstrating consistency with normal verb production.

Moreover, while general attempts have been made to describe relevant participant information that might affect verb selection in individuals with aphasia (i.e., the grouping of participants as agrammatic and non-agrammatic), the inclusion of aphasic participants who are only described as "non-agrammatic" obscures the possible effects of their particular impairments in areas other than morphosyntax (in particular, their semantic impairment) on their patterns of verb selection. Kim and Thompson's (2004) comparison of aphasic individuals to individuals with probable Alzheimer's disease overcomes this problem, but these two groups necessarily differed on the etiology of their language impairment, and possibly differed on cognitive abilities that could affect task performance (i.e., memory).

Finally, as shown in Table 1, very few of the findings in the cited studies achieved statistical significance, with some studies not even reporting statistical analysis. While the numerical advantages found for light verbs or heavy verbs in these studies might show an interesting pattern, due to small group sizes and inconsistent statistical analysis it is unclear whether these patterns could have arisen due to chance.

In summary, considering the compilation of data from previous studies of light and heavy verb use in individuals with aphasia, a number of questions remain to be answered regarding the differential impairment of light and heavy verbs. While some have claimed a double dissociation exists, due to inconsistent methodology, indistinct groupings of participants, lack of control data, and poor reporting or findings of statistical significance in previous studies, it is unknown whether both heavy and light verb

preferences are seen in aphasia, nor is it known exactly what contributes to the use of one verb weight over another in neurologically healthy individuals or individuals with aphasia.

Although the available data supporting the double dissociation between light and heavy verb usage in narrative speech is somewhat unclear, attempts have been made to explain a mechanism for dissociation between the two verb types in models of language production. Gordon and Dell (2003) have proposed a connectionist model of sentence production in which the retrieval of heavy verbs and light verbs differs due to a "division of labor" between syntactic and semantic input during lexical access. The Gordon and Dell model depends on the process of sentence production as a "slot-filling" mechanism, where slots specified for syntactic category form the syntactic frame of a sentence (Garrett, 1975; Bock & Levelt, 1994). These slots are filled by the activation of "conceptual-semantic units" (Gordon & Dell, 2003), which spreads to the activation of possible items in the lexical network to fill the slots (Levelt, Roelofs, & Meyer, 1999; Dell, Schwartz, Martin, Saffrin, & Gagnon, 1997). At this stage, a syntactic network is also activated, what Gordon and Dell call "syntactic-sequential states," that contributes information about which words are syntactically appropriate at that particular point in the utterance (Gordon & Dell, 2003). Therefore, at the point of word selection, both conceptual-semantic information and syntactic-sequential information contribute to the activation and selection of the word.

Using these principles, Gordon and Dell simulated a computational connectionist model of sentence production that used a learning process to create a "division of labor" between semantic and syntactic input in word production. In this model, Gordon and Dell

explain the selective impairment of light verbs as the result of lesioning of the syntactic system. Light verbs, due to their semantic simplicity, relied more heavily on syntactic input in the model rather than semantic input. This is consistent with findings that light verbs occur in a wider range of syntactic structures and with a wider variety of complements (Hollebrandse & van Hout, 1998). Heavy verbs, on the other hand, occur in a smaller range of possible contexts, relying more heavily on their own semantic representation to convey meaning. Therefore, lesioning of the syntactic system in the Gordon and Dell model results in the selective impairment of light verbs and a reliance on heavy verbs in speech production. This syntactic lesioning is analogous to the syntactic impairment found in agrammatic aphasia, which has been found to be associated with preference for heavy verbs (Barde et al., 2006).

This model is also able to predict the second portion of the semantic weight double dissociation, that the selective impairment of the production of heavy verbs is possible. Such a pattern would result from impairment to the semantic system with the syntactic system remaining intact. This impairment of semantics with the relative sparing of syntax is analogous to the impairment seen in certain individuals with aphasia, who show difficulties in accessing and using lexical-semantic representations during word production, resulting in problems of word-finding and semantic errors (Papathanasiou, Coppens, & Potagas, 2013; Mirman & Britt, 2014). Impairment specifically to the semantic system with the sparing of syntactic ability also occurs in Alzheimer's disease (Kim & Thompson, 2004).

Kim and Thompson (2004) tested the predictions of Gordon and Dell's model by comparing the verb naming abilities and narrative speech of a population known to be

impaired primarily in syntactic production (agrammatic aphasic individuals) to one known to be impaired primarily in semantic production (individuals with probable Alzheimer's disease, or PrAD). Consistent with the Gordon and Dell model, syntactically-impaired agrammatic participants showed a significant preference for heavy, semantically-complex verbs over light ones in narrative speech and sentence completion tasks. In addition, unlike the aphasic and control groups, the semantically-impaired PrAD group showed no significant preference for heavy verbs over light verbs, and they additionally showed a significantly lower proportion of heavy verbs in narrative speech than the aphasic group. However, neurologically healthy control participants showed the same pattern of heavy verb preference as aphasic individuals in narrative speech; while the aphasic group showed a relatively higher proportion of heavy verbs than the control group, the difference was not statistically significant. Therefore, data from real participants has only partially confirmed Gordon and Dell's simulated findings.

While the division of labor between syntactic and semantic processes could explain the possible differential impairment of heavy and light verbs, Gordon and Dell's model has not been sufficiently tested. In addition, alternative explanations for the existing data are possible. Notably, the heavy verb preponderance seen in most individuals with aphasia was also found in healthy adults. Therefore, it is possible that individuals with aphasia who are less impaired overall exhibit this typical pattern, whereas an increased proportion of light verbs is seen in the more severely impaired.

Heavy verbs might be more difficult for more severely impaired individuals to retrieve than light verbs for several reasons. Their enriched semantic representations may simply present an increased processing demand. In addition, light verbs are acquired

earlier and are more frequent than heavy verbs, which may enhance ease of access to light verbs for some aphasic individuals. However, the impact of frequency on lexical retrieval in aphasia is not straightforward. While some people with aphasia demonstrate the standard facilitative effects of frequency seen in neurologically healthy individuals (i.e., increased speed and ease of access to more frequent words), others show no frequency effect, or show increased speed and accuracy for less frequent words, and the mechanisms underlying these different frequency effects are unclear (see Mirman & Britt, 2014, for a review of frequency effect findings).

One factor that has been hypothesized as a cause of the general lack of strong frequency effects seen in individuals with aphasia is the "semantic diversity" of a word (Hoffman, Rogers, & Ralph, 2011). In this case, semantic diversity refers to the variability of a word's meaning across different contexts, which tends to increase with word frequency. Aphasic individuals with semantic access deficits have been shown to have more difficulty retrieving these highly variable words, possibly due to reduced cognitive control processes during lexical selection or the reduced ability to select among competing lexical items, which accounts for the lack of facilitative frequency effects found in these individuals (Marshall, Pring, Chiat, & Robson, 2001; Hoffman, Rogers, & Ralph, 2011; Mirman & Britt, 2014). In this account for word retrieval deficits, individuals with semantic access deficits should demonstrate increased difficulty retrieving light verbs, as these verbs are highly semantically diverse (i.e., highly variable in meaning depending on context). Thus, it is possible that the heavy-light differences are not an effect of syntax-semantics as Gordon and Dell propose, but a result of other factors such as lexical frequency, lexical diversity, or aphasia severity.

To summarize, while verb deficits are a common lexical retrieval failure in aphasia (Matzig et al., 2009), they are not well understood. Moreover, while one interesting aspect of verb impairment is a difference in the semantic complexity of verbs that are used, only four major studies have examined this issue in depth. Further exploration of how aphasic and neurologically healthy individuals produce heavy and light verbs will shed light on how the semantic and syntactic systems contribute to both the process of normal lexical access and the process of lexical access in individuals with aphasic deficits. A promising possible mechanism for distinction between verbs of different semantic complexities in lexical access has been proposed by Gordon and Dell's (2003) "division of labor" model, but real-world evidence supporting this model is currently incomplete, and alternative explanations for the existing data exist.

The purpose of this study is to test the Gordon and Dell (2003) model as well as reasonable alternative sources of light/heavy verb distinctions by addressing the following questions. First, it is important to ask, what is the pattern of heavy and light verb use in the narrative language of neurologically healthy English-speaking adults? While the production of light and heavy verbs has been studied in children and in people with aphasia, no current consensus exists on the proportions of light and heavy verbs expected to be found in the narrative speech of normal adult English speakers. Kim and Thompson (2004) found a significant preference for heavy verbs in the narrative language in a small sample of neurologically healthy individuals, indicating that while light verbs are frequent in English, they might comprise less than half of the verbs used in normal English-speakers' narrative language. Therefore the proportion of light verbs used in the narrative speech of neurologically healthy individuals is expected to fall below

50% of total verbs produced. In terms of distribution, it is expected that normal individuals will show some variability in the proportion of light verbs used, but this variability will fall along a normal distribution.

Second, it should be ascertained whether aphasic individuals show a different pattern in their usage of light verbs compared to neurologically healthy individuals. According to Gordon and Dell's model, aphasic individuals are expected to show different patterns of light and heavy verb production based on the relative impairment of syntactic and semantic systems in language processing. Therefore, considering that aphasic individuals experience degrees of syntactic and semantic impairment not experienced by neurologically healthy individuals, it is expected that they will show greater variability (i.e. greater variance, with a broader distribution) in the proportion of light verbs used compared to neurologically healthy individuals.

Finally, to test the central predictions of Gordon and Dell (2003), the following question should be addressed: in aphasic or neurologically healthy individuals, do measures of syntactic ability or semantic ability predict the proportion of light verbs used in narrative speech? If Gordon and Dell's (2003) model is supported, when examining narrative speech alone, it is expected that individuals with aphasia who show a lower proportion of light verbs in narrative language will also show lower scores on syntactic measures because light verb retrieval is assumed to rely on the integrity of the syntactic system. Individuals who show a higher proportion of light verbs in narrative speech will demonstrate increased scores on syntactic measures. Neurologically healthy individuals are not expected to show a significant association between measures of syntactic and semantic complexity in their narrative language and the proportion of light verbs used

due to intact semantic and syntactic systems, which are equally able to "divide the labor" during lexical retrieval.

If the Gordon and Dell model is not supported, measures of syntax and semantics will show no relationship to the proportion of light verbs used, or the relationship will follow a different pattern. If the reduced processing load due to low semantic complexity, the higher frequency, or the increased lexical diversity of light verbs are the source of observed differences between aphasic individuals in producing heavy and light verbs, one of two patterns will emerge. Aphasia severity could be a stronger factor in predicting the proportion of light verbs used than the degree of syntactic or semantic impairment, with less impaired individuals preferring light verbs due to their higher frequency or reduced semantic complexity. On the other hand, if the increased lexical diversity of light verbs presents problems for individuals with semantic access deficits due to competitive selection, increased semantic ability will associate positively with the use of light verbs.

In order address these questions adequately, a consistent methodology should be defined. To avoid the confounds associated with elicitation of verbs in isolation, which may favor heavy verbs, analysis of verbs in narrative language is preferred. To assess the association between semantic impairment, syntactic impairment, and light verb usage, it is necessary to measure semantic and syntactic abilities in narrative language as well, to remain consistent with the context in which heavy and light verbs are produced. Therefore, to test the model, measures that quantify syntactic and semantic impairment in narrative language production should be identified and compared with a measure of verb weight.

Many measures of semantic and syntactic ability in narrative language have been proposed in the literature, in studies of both language development and aphasia (Templin, 1957; Lee, 1974; Malvern & Richards, 1997; Turner & Greene, 1977; MacWhinney, Fromm, Holland, Forbes, & Wright, 2010; see Armstrong, 2000, for a review of narrative analysis in aphasia). In order to quantify syntactic ability, it is necessary to capture a variety of possible impairments. The presence of grammatical errors is an important indicator of syntactic impairment and a key indicator of agrammatism (Saffran et al., 1989; Gordon, 2006). In addition, individuals with a core syntactic deficit have been shown to not only make grammatical errors, but also produce utterances with reduced syntactic complexity (Goodglass, 1997). Finally, individuals with syntactic deficits tend to show reduced use of function words, such as auxiliary verbs, articles, and prepositions (Goodglass, Kaplan, & Barresi, 2001). With regards to semantic impairment, individuals with semantic access deficits tend to use fewer different types of words (Fergadiotis & Wright, 2011), and may omit words that are important to convey critical information, such as in retelling a story (Ernest-Baron, Brookshire, & Nicholas, 1987), due to reduced capacity to access semantic representations. These individuals may also demonstrate decreased semantic density, using more words than necessary to convey the same amount of information (Bryant et al., 2013).

After reviewing a variety of possible measures, it was determined that the use of three different measures for both semantic and syntactic narrative analysis would capture the variety of possible deficits. With regards to syntactic analysis, in order to quantify the presence of grammatical errors in a narrative sample, the proportion of grammatical utterances was selected as a reliable measure due to its common use in analyses of

narrative syntax, such as Quantitative Production Analysis (Saffran et al., 1989; Gordon, 2006). A second measure, the number of verbs per utterance, captures syntactic complexity, with single utterances tending to increase in syntactic complexity with higher numbers of verbs (e.g., multi-verb utterances tend to contain multiple clauses, embedded clauses, etc.). Finally, as a more comprehensive measure of syntactic ability, Developmental Sentence Scoring (DSS: Lee, 1974) was selected. While this measure has been traditionally used to quantify children's syntactic development, it can be used to provide an overall view of any individual's morphosyntactic abilities, taking into account the use of eight syntactic constructions: indefinite pronouns or modifiers, personal pronouns, main verbs, embedded verbs, negatives, conjunctions, interrogative inversions, and the *wh-* question form (Lee, 1974). In addition to taking complexity and grammatical accuracy into account, DSS captures the final potential indicator of syntactic impairment: the use of function words.

With regards to semantic ability, a measure of lexical diversity was selected to quantify the overall variety in the words used by the speaker. While Type-Token Ratio (TTR: Templin, 1957), calculated as the number of different words in a sample divided by the total number of words, is a classic measure of lexical diversity, this measure is affected by sample length: the longer the sample, the more likely words are to be repeated, decreasing lexical diversity (Fergadiotis, Wright, & West, 2013). The D measure (Malvern & Richards, 1997), which can be automatically estimated in the CLAN computer program with the VOCD command (MacWhinney, 2000), is calculated by taking TTR values from random selections in a sample and using them to create a TTR curve whose *D* coefficient represents lexical diversity (see Malvern, Richards, Chipere, &

Duran, 2004, for more detailed discussion of D's calculation), and thus avoids the

influence of text length on the measure (Malvern & Richards, 1997; McCarthy & Jarvis,

2010; McKee, Malvern, & Richards, 2000). D was therefore selected as a reliable

measure of semantic ability due to the reduced influence of sample length on the

measure.

The second selected measure of semantic ability was the lexical completeness of

the story. For stories that are commonly re-told as a means of assessing narrative

language, such as the *Cinderella* story used in several previous studies of light verb usage

(e.g., Berndt, Haendiges, et al., 1997; Kim & Thompson, 2004), a "core lexicon" has

been devised of key words that make the story semantically complete (MacWhinney et

al., 2010). In narratives produced by individuals who experience difficulties in lexical-

semantic access, it is expected that use of these "core" words would be reduced.

A final measure of semantic ability was chosen in order to represent the semantic

density of a sample in addition to the lexical diversity. Idea density (ID) is a semantic

measure first defined by Turner and Greene (1977) and later refined in the analysis of the

Nun Study (Kemper, Greiner, Marquis, Prenovost, & Mitzner, 2001; Kemper, Thompson

& Marquis 2001; Snowdon, Greiner, & Markesbery, 2000). Idea density is calculated as

the number of ideas (represented as propositions) expressed per ten words in a sample,

and can be calculated automatically with the Computerized Propositional Idea Density

Rater (CPIDR) software (Brown, Snodgrass, Kemper, Herman, & Covington, 2008),

which is available in an adapted version through the speech analysis software CLAN

(MacWhinney, 2000). This automated calculation of ID simplifies the measure somewhat

by counting propositions as non-modal verbs, adjectives, adverbs, prepositions, and

subordinating conjunctions. This raises questions about the automated calculation of the measure as a pure representation of semantic ability, as the verb-specific deficits that commonly co-occur with syntactic impairment or the reduced use of function words could result in reduced ID scores (Brown et al., 2008). However, it was determined that individuals with verb-specific deficits or reduced use of prepositions would still show some variation in the number of propositions used through use of adjectives and adverbs, and therefore ID could still provide important information about semantic access abilities.

To summarize, six measures of syntax and semantics have been selected as potentially reliable continuous indicators of syntactic and semantic ability for this study. The proportion of grammatical utterances, the number of verbs per utterance, and the DSS measure syntactic ability, whereas D, the core lexicon proportion, and ID are measures of semantic ability. The analysis of narrative language with these measures provides a consistent, quantitative way to examine the syntactic and semantic contributions to verb production in line with the Gordon and Dell model. The quantification of light and heavy verb usage for comparison to semantic and syntactic measures is somewhat simpler, with the proportion of light verbs out of the total number of verbs in the sample conveying a representative picture of the preference for one verb weight or another. Therefore, the final issue in quantifying light and heavy verb usage in narrative language lies in consistently defining which verbs are light.

While the different properties of light and heavy verbs have long been studied in literature of language acquisition and aphasia, most studies have differed in their definitions. The term "light verb" has generally referred to semantically weak or unspecified verbs, not to be confused with the specific syntactic "light verb construction"

described in the linguistic literature (see Plante, 2014 for more detailed discussion). The language acquisition literature restricted the light verb definition to include verbs that are frequently grammaticalized cross-linguistically (i.e., verbs that were once lexical but became closed-class morphemes, such as auxiliary verbs) (Ninio, 1999) and verbs that are general in meaning and frequently occurring (Clark, 1978). Maouene, Laakso, and Smith (2010) attempt to clarify these general definitions and define a continuum of verb weight that can be quantified with the number of possible noun objects with which a verb can occur, which they measured through object-association tasks. In their definition, lighter verbs can take more possible objects due to their reduced semantic specificity, whereas heavier verbs are more constrained in the objects that they can take. These studies differ from the treatment of light verbs in aphasic individuals, where the definition of light verbs has tended towards the specific subset identified by Pinker (1989).

Considering the lack of previous consensus on this topic, for the purposes of this study, light verbs shall be defined based on several factors. Verbs previously defined as light by consensus in the literature of both language acquisition and aphasia (in two or more studies) will continue to be defined as light, with two exceptions. The exhaustive list of these verbs is as follows: *come, do, get, give, go, have, make, put, and take*. These verbs are frequent in English corpora (Wilson, 1988; Davies, 2008), take diverse noun complements (Maouene et al., 2010), and also share the feature of frequently grammaticalizing cross-linguistically based on the analysis of Ninio (1999), all of which strengthen the evidence in favor of their status as light verbs. In spite of their inclusion in multiple studies of light verb usage (Breedin et al., 1998; Barde et al., 2006), *bring* and

move have been excluded in this analysis due to their relative lower frequency in English

corpora (Wilson, 1988; Davies, 2008). Finally, auxiliary verbs and the verb *to be* (copula)

are not considered to be light verbs or heavy verbs due to their grammatical nature.

Methods

This study was a retrospective analysis of data available on AphasiaBank

(MacWhinney, Fromm, Forbes, & Holland, 2011), an online database of transcriptions of

discourse produced by people with aphasia secondary to a cerebrovascular accident as

well as neurologically healthy individuals. Both aphasic and non-aphasic participant data

on AphasiaBank was gathered according to a pre-specified protocol, with a number of

narrative transcripts available from each participant in addition to standardized test scores

and detailed demographic data. These transcripts of narrative language were analyzed in

the CLAN computer program (MacWhinney, 2000) to calculate syntactic and semantic

measures as well as tabulate the proportions of light verbs in the samples.

Participants

Narrative samples from 164 monolingual people with aphasia (86 male, 78

female) were selected from the AphasiaBank database for analysis. According to the

AphasiaBank protocol, no participants with dementia or other conditions associated with

cognitive decline were included. All included participants were more than one year post-

cerebrovascular accident. In addition to these criteria, participants were selected based on

narrative transcript length, with transcripts of fewer than 100 words being excluded from

analysis in order to achieve accurate and reliable measurement of discourse measures.

A control group of narrative samples from 166 monolingual English-speakers without aphasia (76 male, 90 female) was also selected from the AphasiaBank database in order to calculate the expected proportion of light verbs in the narrative language of neurologically healthy individuals for comparison to aphasic individuals. According to AphasiaBank protocol, control participants had no history of a neurological condition, a cognitively deteriorating condition, or depression. Control participant transcripts were also selected based on length, with any transcripts of less than 100 words being excluded.

Experimental and control groups were matched for demographic factors. Two-sample t-tests revealed no significant difference between the groups on age ($t(328)=1.42$, $p>0.5$) or years of education ($t(328)=1.07$, $p>0.5$). Fisher's exact test revealed no significant difference in gender distribution between the two groups ($p>0.5$).

Data Source

The AphasiaBank Protocol. Both aphasic and non-aphasic participant data on AphasiaBank were gathered according to a pre-specified protocol, with a number of narrative transcripts available from each participant in addition to standardized test scores and detailed demographic data. Scores on the *Western Aphasia Battery – Revised* (WAB-R: Kertesz & Raven, 2007), the *Short Form Boston Naming Test – 2nd Edition* (BNT: Goodglass et al., 2001), the *Verb Naming Test* from the *Northwestern Assessment of Verbs and Sentences – Revised* (Cho-Reyes & Thompson, 2012), and the non-standardized *AphasiaBank Repetition Test* (MacWhinney et al., 2011) were available from each participant. Narrative language samples included free speech samples (elicited as the participant's retelling of his or her stroke story and an important life event), picture

description, and a story narrative (elicited as a retelling of the *Cinderella* story)

(MacWhinney et al., 2011).

  Narrative Elicitation. This study used a sample of discourse from each

participant elicited by the retelling of the *Cinderella* story. This particular discourse

elicitation task was chosen as it has been demonstrated that during story retell procedures,

individuals tend to produce language with significantly higher lexical diversity than

during picture description tasks (Fergadiotis & Wright, 2011). This suggests that story

retell tasks produce language samples that are more representative of the individual's best

semantic abilities than samples elicited by picture description. In addition, the *Cinderella*

story was selected in order to be consistent with past studies of verb weight in narrative

discourse (Berndt, Haendiges, et al., 1997; Breedin et al., 1998; Kim & Thompson, 2004;

Barde et al., 2006).

  Elicitation procedures for each AphasiaBank participant followed standard scripts

to reduce variability in instructions or prompts across data sources (MacWhinney et al.,

2011). When retelling the *Cinderella* story, participants were asked if they were familiar

with the story and then were given a wordless picture book depicting the story's events.

Once they had familiarized themselves with the images, the book was removed and they

were asked to tell as much of the *Cinderella* story as they could. Short or incomplete

responses were prompted with "What happened next?" or "Go on".

  Transcription and Coding. Narrative samples in the AphasiaBank database were

previously transcribed word-for-word in the CHAT format for analysis by the CLAN

computer program (MacWhinney, 2000) by the researchers who originally collected the

sample. Individual words in the transcription were tagged with morphosyntactic roles

(e.g., auxiliary verb, subject pronoun) and were also coded for aphasic errors (e.g., semantic paraphasias, neologisms, disfluencies, morphological agreement errors, etc.). In addition, utterances were coded with utterance-level errors, including grammatical errors, jargon errors, perseverations, and circumlocutions.

Automated Analysis

In order to calculate the proportion of light verbs in the samples, light and heavy verbs over the course of the entire *Cinderella* story sample were counted using the FREQ program in CLAN (MacWhinney, 2000) for both aphasic and control samples. Verbs classified as light were a closed set limited to: *come, do, get, give, go, have, make, put, and take*. All non-copula, non-auxiliary, non-modal forms of light verbs were included in the total light verb count, including different verb form variations for tense and aspect. Auxiliary verbs and the copula *be* were excluded from the total verb count, and all non-light, non-copula, non-modal, and non-auxiliary verbs were considered as heavy. The total number of light verbs was then divided by the total number of non-copula, non-modal, and non-auxiliary verbs in the sample.

To obtain the majority of the morphosyntactic and semantic measures in narrative language production, the EVAL program in CLAN (MacWhinney, 2000) was run on the *Cinderella* story samples for both groups. EVAL analyzed the sample for a variety of measures, including the number of utterances in the sample, the number of utterances with grammatical errors, the idea density (ID), the D (estimated by the VOCD program), and the average number of verbs per utterance. The number of utterances with grammatical errors was subtracted from the total number of utterances and then divided by the total number of utterances in order to obtain the proportion of grammatical

utterances. In addition, the KidEVAL program was run to calculate the Developmental

Sentence Score (DSS).[2]

To obtain the proportion of words from the *Cinderella* core lexicon present in the

sample, the ten most frequent non-light verbs and ten most frequent nouns were selected

from MacWhinney et al. (2010)'s core lexicon (see Appendix A). Both nouns and verbs

were chosen in order to prevent possible impacts of noun- or verb-specific lexical

impairments on proportional scores. While several light verbs (*go, have, get, come, do,*

and *make*) were part of the core lexicon identified by MacWhinney et al. (2010) due to

their high frequency, these were excluded from this study's lexicon as they were not

considered integral to the semantically complete retelling of the *Cinderella* story. The

total number of word types from this core lexical set present in each sample was counted

for each participant using the FREQ program, and then divided by the total number of

possible core lexicon words to provide the proportion of the core lexicon present in each

sample.

Results

Preliminary analysis

While past studies of verb weight have used the proportion of light or heavy verbs

in the sample to represent the preference for light or heavy verbs in narrative speech, this

approach gives equal importance to proportions calculated for individuals producing very

few verbs and those producing a large number of verbs in their sample. This problem is

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[2] Grammatical errors in the AphasiaBank transcripts were originally represented by the
[+ gram] code, whereas DSS counted grammatical errors with the [*] code. In order to
accurately calculate DSS, transcript codes were altered to reflect grammatical errors with
the [*] code.

unavoidable, as individuals with more severe language impairments are likely to produce few verbs and few words overall, but these individuals still provide valuable information about the differing effects of syntactic and semantic impairment on verb weight.

The most severely aphasic individuals have been excluded from this study due to the minimum sample word length. Amongst the remaining participants, in order to ensure that those producing fewer words were not disproportionately affecting tests of the relationship between the proportion of light verbs and semantic or syntactic measures, two Spearman correlation analyses were performed comparing the total number of verbs in the sample and the proportion of light verbs in the sample for aphasic and control participants. Neither group showed a significant correlation between the two variables (for the aphasic group, $r_s = 0.10$, n = 164, $p > 0.5$, and for the control group, $r = -0.05$, n = 166, $p > 0.5$). This indicates that individuals producing small numbers of verbs do not tend to produce significantly more or fewer light verbs than individuals producing large numbers of verbs.

Light verb proportions

Descriptive statistics (mean and standard deviation) for light verb usage in the Cinderella story retell passages were calculated for the neurologically healthy control group in order to determine the normal pattern of light verb production. The mean proportion of light verbs used by controls was 0.383 with a standard deviation of 0.093, supporting the hypothesis that less than 50% of verbs used in the narrative speech of neurologically healthy individuals are light. The distribution of light verb proportions appeared normal, as demonstrated in Figure 1, and normality was confirmed with the Shapiro-Wilks test ($W = 0.991$, $p > 0.5$).

The mean light verb proportion use by aphasic individuals was 0.389 with a standard deviation of 0.171. As predicted, the mean light verb proportions for the two groups were similar, but the aphasic group showed a slightly higher standard deviation, indicating greater tendency for aphasic individuals to vary from the mean light verb proportion. Distribution of light verb proportions used by individuals with aphasia was also normal ($W = 0.985$, $p > 0.5$), though as predicted, the control group showed a narrower distribution than the aphasic group, as demonstrated in Figure 1.
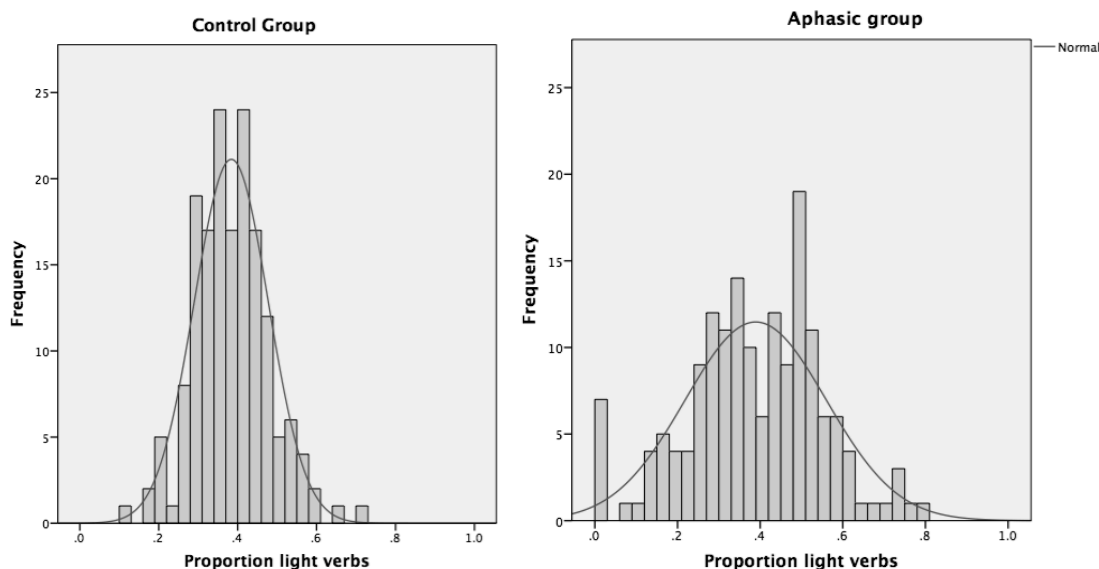
Figure 1. Histograms of the proportion of light verbs produced by aphasic and control groups

Due to the fact that the distributions of the proportion of light verbs used in the two groups appeared somewhat different in spite of their similar means, Levene's test was used to compare the variance between the two groups. Levene's test indicated significantly unequal variances ($F = 47.158$, $p < 0.01$), which confirmed that the aphasic group demonstrated significantly more dispersion from the mean than the neurologically healthy group. With the variances confirmed as unequal, the groups were compared with

an independent samples Mann-Whitney U test, which revealed no significant difference in means between the two groups ($U(298) = 13,129$, $Z = -0.557$, $p > 0.05$).

Examination of the distribution of light verb proportions among the aphasic individuals revealed a few participants were situated at the extremes, producing either no light verbs at all, or only light verbs. Analysis of transcripts at these extremes of light verb usage revealed qualitative differences (see Appendix 2 for examples from transcripts from two such individuals). One of the individuals producing only heavy verbs, coded as "Scale02a" in the AphasiaBank database, showed obvious difficulty with syntax, producing very few syntactically complete utterances. This was confirmed by this participant's mean number of verbs per utterance in the sample, which was 0.12, indicating extremely reduced syntactic complexity compared to the aphasic group as a whole (overall mean number of verbs per utterance = 1.13, $SD = 0.47$). In addition to this participants' exclusive use of heavy verbs, this individual produced a number of other semantically specific words, such as "stern", "chariot", "castle", and "polka". This qualitative observation was supported by scores on semantic measures, with VOCD, core lexicon, and ID scores at or above the mean for the aphasic group as a whole (VOCD = 31.98, mean VOCD = 33.07, $SD = 12.62$; core lexicon proportion = 25%, mean core lexicon proportion = 26%, $SD = 14\%$; ID = 0.55, mean ID = 0.47, $SD = 0.05$).

These observations were in stark contrast to the language produced by the individual producing exclusively light verbs, coded as "Star03a" in the database. This individual produced relatively more syntactically complete utterances, with an average number of verbs per utterance of 0.86. In addition to the use of semantically vague light verbs, a number of other semantically general terms were apparent in this individual's

language, with frequent occurrence of terms such as "stuff", "thing", and "different".

Scores on semantic measures tended to fall below the group means for this individual and

fell well below those of participant Scale02a, supporting the qualitative observation of

semantically vaguer language (VOCD = 17.15, core lexicon proportion = 10%, ID =

0.45).

Predictors of light verb use

  Basic measures – controls. A multiple regression analysis was used to identify

predictors of light verb usage in the neurologically healthy control group. Five

independent variables were entered into the regression: the number of verbs per

utterance, DSS, VOCD, the proportion of the core lexicon present, and ID for their

narrative samples. Fewer measures were available for the controls compared to the

aphasic individuals due to the unavailability of linguistic test score data for

neurologically healthy individuals.

  Intercorrelation between the narrative measures as well as the proportion of light

verbs used are reported in Table 2. The measures show some degree of correlation using

a Bonferroni adjusted alpha level of 0.03 for multiple comparisons (0.05/15), most

significantly between DSS, verbs per utterance, and ID. These intercorrelations suggest

that semantic complexity and syntactic complexity are related in the speech of

neurologically healthy individuals to some degree. Notably, ID showed little correlation

with other measures of semantics in the neurologically healthy group.

Table 2

Intercorrelations between measures and light verb proportions for the control group

	Syntactic measures		Semantic measures		
	Verbs/utt.	DSS	VOCD	Core lex.	ID
Verbs/utterance	1.000	0.735*	0.142	-0.049	0.176
DSS		1.000	0.141	0.100	0.285 *
VOCD			1.000	0.223 *	0.151
Core lexicon				1.000	-0.065
ID					1.000
Proportion light verbs	-0.231 *	-0.109	-0.154	-0.048	0.021

* $= p < 0.003$

Results of the multiple regression analysis for the control group are presented in Table 3. The five predictor variables were able to predict light verb usage significantly ($F(5, 160) = 2.908, p < 0.05, R^2 = 0.083, R^2_{Adjusted} = 0.05$). However, the number of verbs per utterance was the only measure that emerged as a significant independent contributor to the prediction of light verb proportion. Interestingly, the number of verbs per utterance was negatively associated with light verb proportion, indicating that, for neurologically healthy individuals, as the number of verbs per utterance (i.e., syntactic complexity) increased, the number of light verbs used decreased. This suggests a relationship between overall increased syntactic complexity and the increased semantic complexity of verbs in neurologically healthy individuals' narrative language.

Table 3

Results of a multiple linear regression analysis for the control group with light verb proportion as the dependent variable

	B	SE	Beta Coefficient	t
Verbs/utterance	-0.083	0.029	-0.327	-2.855 *
DSS	0.005	0.004	0.138	1.170
VOCD	-0.001	0.001	-0.125	-1.562
Core Lexicon	-0.038	0.066	-0.046	-0.577
Idea Density	0.231	0.333	0.056	0.691

* $= p < 0.01$

Basic measures – aphasia. For the aphasic group, ten predictor variables were entered in a multiple regression analysis with the proportion of light verbs as the

dependent variable. The narrative semantic predictor variables were ID scores, VOCD scores, and the proportion of the core lexicon present in the samples, while the narrative syntactic predictor variables were DSS, the proportion of grammatical utterances, and the number of verbs per utterance calculated from the samples. In addition, scores on the BNT, the VNT, and the AphasiaBank Repetition Test (part II.B, the total number of words correct) were included. While the WAB-R Aphasia Quotient (AQ) was included in the regression initially to test whether severity might influence light verb proportion, it demonstrated a high degree of multicollinearity (variance inflation factor > 5) and was removed from the analysis, which improved the predictive ability of the remaining variables. While the AQ correlated with many of the independent variables, a Pearson's correlation between WAB-R AQ and the proportion of light verbs used indicated no significant relationship between the two ($r = 0.013$, $p > 0.05$), suggesting that the severity of aphasia did not influence the proportion of light verbs used.

Intercorrelations between the remaining variables in the multiple regression analysis are reported in Table 4 using a Bonferroni adjusted alpha level of 0.001 (0.05/35). It was expected that many of the independent variables would show relationships to one another due to the effects of aphasia severity (i.e., individuals with more severe aphasia are more likely to be impaired in both semantic and syntactic ability). Notably, both the number of verbs per utterance and DSS showed a significant moderate correlation with the proportion of light verbs used, showing a positive association as predicted. VNT scores demonstrated a small but significant negative correlation with light verb proportion.

Table 4

Intercorrelations between measures and light verb proportions for the aphasic group

	Syntactic measures			Semantic measures			Test scores		
	Verbs/ utt.	DSS	Prop. gramm.	VOCD	Core lex.	ID	BNT	Rep. Test	VNT
Verbs/ utterance	1.000	0.766 *	0.460 *	0.508 *	0.202	0.344 *	0.196	0.374 *	0.302 *
DSS		1.000	.352 *	0.417 *	0.182	0.498 *	0.129	0.263 *	0.248 *
Proportion gramm.			1.000	0.294 *	0.393 *	-0.051	0.470 *	0.555 *	0.552
VOCD				1.000	0.128	0.319 *	0.129	0.126	0.217
Core lexicon					1.000	-0.108	0.604 *	0.494 *	0.532 *
ID						1.000	-0.129	0.085	0.004
BNT							1.000	0.556 *	0.661 *
Repetition test								1.000	0.581 *
VNT									1.000
Light verb proportion	0.332 *	0.322 *	0.06	0.106	-0.007	0.071	-0.115	0.079	-0.127

* = $p < 0.001$

Results of the multiple regression analysis are reported in Table 5. Together, the nine predictor variables significantly predicted the variance in light verb proportion for the individuals with aphasia, ($F(9, 154) = 4.47$, $p < 0.01$, $R^2 = 0.207$, $R^2_{Adjusted}=0.161$). Three of the measures, DSS, ID, and VNT scores, emerged as significant contributors to the prediction of light verb proportion, while the remaining measures did not contribute significantly. Of note, DSS was positively associated with light verb proportion, meaning that a higher DSS score (i.e., higher syntactic ability) was related to increased use of light verbs, consistent with the predictions of the Gordon and Dell model. ID was negatively associated with light verb proportion, indicating a higher ID score (i.e., greater semantic ability) was related to decreased use of light verbs as predicted. The VNT score was also negatively associated with light verb proportion, indicating that as verb naming skills increased, the proportion of light verbs used in narrative language decreased.

Table 5

Results of a multiple linear regression analysis for the aphasic group with light verb
proportion as the dependent variable

|	B	SE	Beta Coefficient	t
Verbs/utterance	0.062	0.046	0.172	1.368
DSS	0.016	0.006	0.327	2.642 **
Proportion grammatical	-0.038	0.080	-0.048	-0.472
VOCD	4.557×10^{-5}	0.001	0.003	0.038
Core Lexicon	0.036	0.114	0.030	0.312
ID	-0.580	0.289	-0.184	-2.006 *
BNT	-0.005	0.004	-0.137	-1.269
Repetition	0.001	0.001	0.187	1.814
VNT	-0.008	0.003	-0.268	-2.496 *

** $= p < 0.01$
* $= p < 0.05$

Difference score. For individuals with aphasia, in accordance with the Gordon

and Dell model, it was suspected that a measure of relative syntactic or semantic

impairment might provide more insight into the proportion of light verbs used than

independent absolute measures of syntax or semantics due to the fact that semantic and

syntactic impairments can co-occur. Representation of relative syntactic versus semantic

impairment was accomplished by using a difference score that was calculated for each

aphasic individual by converting their ID and DSS scores into z-scores, and then

subtracting the normalized syntactic DSS score from the normalized semantic ID scores.

For these difference scores, a positive score indicated relative syntactic impairment, a

negative score indicated relative semantic impairment, and a score of zero indicated equal

semantic and syntactic impairment. While it was possible to calculate nine difference

scores as indicators of relative semantic versus syntactic impairment from the six

measures of syntactic and semantic ability used in the initial analysis, two of these six

measures emerged as the most significant influences on light verb usage: DSS as a

measure of syntax, and ID as a measure of semantics. Therefore, the ID/DSS difference

score was selected as the best indicator of relative semantic versus syntactic impairment.

A Spearman correlation analysis between the ID/DSS difference score and the proportion of light verbs used showed a significant small negative association between the two variables ($r_s = -0.165$, $p < 0.05$). This indicates that, as the ID/DSS difference score increased to indicate a relatively higher syntactic impairment than semantic, the proportion of light verbs used decreased as predicted. As the ID/DSS difference score decreased, representing greater semantic impairment than syntactic, the proportion of light verbs used increased. This relationship was small in magnitude, but significant. The linear relationship between these two variables is demonstrated in the scatterplot in Figure 2.
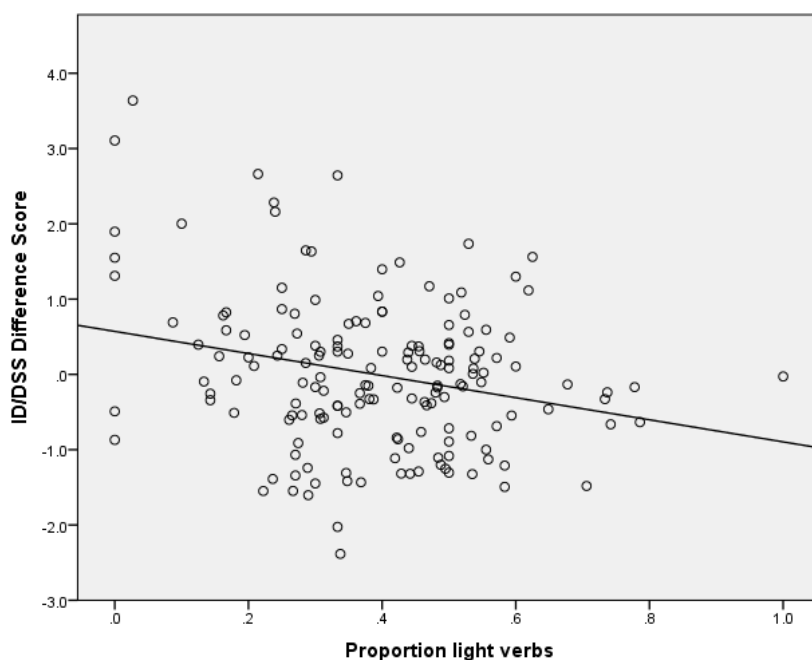
Figure 2. Scatterplot showing the negative relationship between ID/DSS difference score and the proportion of light verbs used

Aphasia profile. In order to test whether individuals classified with different types of aphasia demonstrated significantly different usage of light verbs as a result of different patterns of syntactic and semantic impairment, individuals were grouped by

WAB-R classification. Individuals classified as having transcortical sensory or transcortical motor aphasia were excluded from the analysis due to low group sizes (n=1 and n=3, respectively). The 5 possible WAB-R aphasia classifications were Broca's (n=23), Wernicke's (n=15), conduction (n=30), anomic (n=72), and "nonaphasic" (i.e., aphasia severity low enough to preclude classification on the WAB-R, n=20). The ANOVA did not reveal a significant difference between groups in the proportion of light verbs used ($F(4, 155) = 1.14$, $p > 0.5$).

Discussion

The main goal of this study was to test Gordon and Dell's (2003) "division of labor" hypothesis by examining the use of light verbs by neurologically healthy individuals as well as individuals with aphasia. This was achieved by identifying the typical pattern of verb production, identifying the aphasic pattern of verb production, and comparing the use of light verbs with measures of syntactic and semantic ability for both groups. The main findings were that aphasic and neurologically healthy individuals produced similar average proportions of light verbs, but aphasic individuals showed more variance. In addition, for individuals with aphasia, the proportion of light verbs showed no relationship to aphasia severity, and narrative language measures of syntactic and semantic ability were significantly associated with the proportion of light verbs used. These findings will be discussed in detail in the following sections.

Aphasic versus neurologically healthy verb production

The narrative language of 164 individuals with aphasia and 166 neurologically healthy individuals was analyzed for the proportion of light verbs that were used. About

38% of verbs produced by both neurologically healthy and aphasic individuals were light verbs. However, the aphasic group showed greater variance in light verb production. This was predicted due to the fact that the possibility of syntactic or semantic deficits in aphasia was expected to influence the individuals' use of light verbs.

These results are consistent with the previous finding that a numerical advantage for heavy verbs is typical in the narrative language of neurologically healthy individuals (Kim & Thompson, 2004). Moreover, the findings of this study confirm that, on average, individuals with aphasia also produce more heavy verbs than light verbs in narrative speech. This shows that aphasic individuals using higher proportions of heavy verbs than light verbs are showing the typical pattern, rather than a deviant one.

Predicting light verb proportions in neurologically healthy individuals

For the neurologically healthy control group, only one measure of narrative linguistic ability showed a significant ability to predict the proportion of light verbs used, the number of verbs per utterance. Increased syntactic complexity as represented by verbs per utterance was associated with a decreased proportion of light verbs in narrative speech.

Gordon and Dell (2003) did not predict that neurologically individuals would demonstrate significant differences in accuracy of retrieving light and heavy verbs due to their intact semantic and syntactic subsystems. The key to explaining this finding, then, is that neurologically healthy individuals were not expected to show reduced accuracy in retrieving one type of verb over the other; all verbs were expected to be retrieved successfully. In this case, with no breakdown of verb retrieval depending on semantic complexity to alter the type of verb that is successfully selected, it appears that

individuals using more syntactically complex language also prefer using more semantically complex verbs. This is consistent with the finding that several of the measures of syntactic and semantic complexity taken from the language of neurologically healthy individuals correlated positively with one another; increased semantic complexity was associated with increased syntactic complexity overall.

Predicting light verb proportions in aphasia

   The influence of severity. Overall, the severity of aphasia was not found to influence the proportion of light verbs used. This was apparent in considering the lack of relationship between the proportion of light verbs used and the total number of verbs used, as individuals using very few verbs (i.e., the individuals with more severe linguistic impairments) did not use a higher or lower proportion of light verbs than less impaired individuals. In addition, the WAB-R Aphasia Quotient, a measure of severity which takes multiple linguistic abilities into account (Kertesz & Raven, 2007), was not found to correlate significantly with the proportion of light verbs used. By ruling out severity as a possible confounding influence on the proportion of light verbs used, this study additionally confirms that light verbs are not simply used more by certain individuals with aphasia because they are highly frequent or semantically simpler than heavy verbs, and therefore more easily accessed by individuals with more severe impairments.

   Narrative semantic and syntactic measures. While six measures overall were used to represent individuals' narrative syntactic and semantic ability, not all of these measures emerged as strong predictors of the proportion of light verbs used. However, one measure of syntax (DSS) and one measure of semantics (ID) were able to predict the proportion of light verbs significantly. As predicted, DSS showed a positive relationship

to the proportion of light verbs used, indicating increased syntactic performance as measured by DSS was associated with an increased use of light verbs. ID showed a negative relationship to light verb proportion, with increased semantic performance as measured by ID associating with a lower proportion of light verbs used.

At face value, these results are consistent with previous claims that agrammatism (i.e., core syntactic impairment) is related to decreased accuracy in producing light verbs (Gordon and Dell, 2003; Barde et al., 2006). If DSS truly represents syntactic ability and ID accurately portrays semantic ability, these findings provide further support the Gordon and Dell model overall: lesioning of the semantic system (i.e., impairment in semantic access) is associated with increased use of light verbs in narrative language, and lesioning of the syntactic system (i.e., impairment in syntactic access) is associated with decreased use of light verbs. Additionally, these findings indicate that impairment in semantic access does not result in decreased use of light verbs due to the factor of competitive selection or the increased lexical-semantic cognitive control necessary during their retrieval.

Nonetheless, it remains to be explained why other measures of syntactic and semantic ability did not show a significant relationship to the proportion of light verbs used, while ID and DSS did. One possible explanation is that ID and DSS are more representative of semantic and syntactic abilities, respectively, than the other measures individually. Considering all of the measures used, ID and DSS stand out as the most general. This is most apparent for DSS, which takes into account the factors of syntactic impairment represented by the proportion of grammatical utterances (grammatical accuracy) and the number of verbs per utterance (syntactic complexity), and additionally

accounts for difficulty using function words seen in agrammatic aphasia. As a more global measure, it is possible that DSS was able to capture syntactic impairment more accurately, which in turn allowed it to show a stronger relationship to the proportion of light verbs used. This is consistent with findings that DSS is a valid measure of general syntactic ability and development in children, whose DSS scores increase as they age (Koenigsknecht, 1974; Kemper, Rice, & Chen, 1995; Reed, Griffith, & Rasmussen, 1998).

However, the developmental nature of the DSS measure presents some possible problems for the quantification of syntactic ability in aphasia. While DSS does represent global syntactic ability by quantifying production of a variety of syntactic structures, it gives greater weight in scoring to later-acquired forms in syntactic development (Lee, 1974). For example, more points are given for reflexive pronouns, such as *myself* or *yourself*, than for first person pronouns, such as *I* or *you*. In some cases these later-acquired structures correspond to more complex structures that have been shown to present greater difficulty in production or comprehension for individuals with aphasia, such as passive verb forms (Saffran et al., 1980; Grodzinsky, 1986; Goodglass, Christiansen, & Gallagher, 1993), but it remains unclear whether giving greater weight to all later-acquired structures is valid in the measurement of aphasic syntactic ability.

Another syntactic measure, also used in studies of language acquisition, was considered as a potentially more valid indicator of general syntactic ability in aphasia: the Index of Productive Syntax, or IPSyn (Scarborough, 1990). IPSyn measures the presence or absence of 56 syntactic structures across a language sample without weighting scores based on the typical age of acquisition for the different structures. However, the total

IPSyn score is traditionally based on 100-utterance samples, an unfeasible length for the aphasic *Cinderalla* narratives used in this study, which on average consisted of 37 utterances but ranged from 10 to 87. It was suspected that IPSyn measurement amongst samples of such varying length could be more reflective of factors other than syntactic ability, such as overall aphasia severity, than DSS. This was confirmed by correlational analysis, which showed that IPSyn scores demonstrated a stronger relationship to the overall length of the sample ($r_s = 0.525$, $p < 0.01$) than DSS scores ($r_s = 0.376$, $p < 0.01$). Therefore, for the purposes of this study, it was determined that DSS was the best global indicator of syntactic ability, though its developmental weighting was not ideal.

With regards to the differences in significance found between the semantic measures, ID logically seems to be a more general measure than VOCD or the proportion of the core lexicon present, but it does not obviously encapsulate the same possible semantic impairment factors represented by the other two measures. This is consistent with the finding that, in neurologically healthy individuals, ID did not correlate strongly with the other semantic measures, whereas VOCD and the proportion of the core lexicon showed a significant relationship to one another. However, ID does appear to represent a more global skill than those individual measures: using words efficiently to convey information. An individual experiencing difficulty retrieving diverse words or retrieving relevant words is expected to show reduced economy of expression, which is represented by the ID measure. In addition, ID has been shown to correlate with other established measures of semantic abilities, including word retrieval measures and verbal fluency tasks (Cheung & Kemper, 1992; Kemper & Sumner, 2001).

While it is plausible that ID and DSS simply represent semantic and syntactic ability better than the other measures used, it was possible that ID in particular did not purely measure semantic ability. Due to the fact that ID counted ideas or propositions as verbs, prepositions, adjectives, adverbs, and coordinating conjunctions, it has been suggested that this measure might be sensitive to syntactic as well as semantic impairment (Brown et al., 2008), calling into question the conclusions that can be drawn about Gordon and Dell's model with this measure. While ID did show significant correlation with measures of syntax in the aphasic group, this relationship could plausibly have occurred due to the influence of aphasia severity – semantic and syntactic deficits are not exclusive of one another, and an individual severely impaired in one area is more likely to be severely impaired in another. Even disregarding the relationship between ID and measures of syntax, while ID did significantly correlate with one measure of lexical-semantic access that was used (VOCD) for individuals with aphasia, it did not show a strong relationship to the other (the proportion of the core lexicon used). DSS, on the other hand, showed a strong relationship to both other syntactic measures for the aphasic group. All of this evidence suggests that ID might be measuring something other than semantic ability.

With ID called into question, however, few possible explanations presented themselves for the significant relationship found between the measure and the proportion of light verbs used. This relationship was in the opposite direction than that found for DSS, an established measure of syntax, and the difference scores representing relative semantic/syntactic impairment calculated with ID and DSS showed a significant relationship to the light verb proportions in the expected direction. This suggests that ID

is not measuring syntactic ability in a significant way; otherwise, the relationship between ID and the proportion of light verbs used would mirror that of DSS. Therefore it was considered reasonable to assume that ID was representative of semantic ability to some significant degree. However, it is possible that a more independent measure of global semantic ability might have shown a stronger relationship to the proportion of light verbs used.

Difference score. With ID and DSS identified as measures of semantic and syntactic ability as well as significant predictors of the proportion of light verbs used, a difference scores was used to create a measure to indicate aphasic individuals' relative semantic versus syntactic impairment, rather than their absolute ability in either area. The significant negative association found between the ID/DSS difference score and the proportion of light verbs used further supports the Gordon and Dell model. The presence of more semantic impairment than syntactic impairment was associated with an increased use of light verbs, predicted by the Gordon and Dell model as a function of increased dependence on syntactic processes to retrieve the verb. The presence of syntactic impairment that was greater than semantic impairment was, in turn, associated with decreased use of light verbs, which is consistent with increased dependence on the semantic system during verb production.

It should be noted that the magnitude of the relationship found between ID/DSS difference score and the proportion of light verbs used was relatively small ($r_s = -0.165$), indicating that changes in difference score were not associated with large changes in light verb proportion. This is consistent with the fact that verb retrieval has been shown to depend on a multitude of factors other than verb weight, such as imageability (Bird et al.,

2003), semantic features (Vinson & Vigliocco, 2002; Vigliocco et al., 2004), and frequency (Hoffman, Rogers, & Ralph, 2011), which to a certain extent can vary amongst light and heavy verbs. Therefore, the presence of relative semantic or syntactic impairment was not expected to explain all or even most of the variation seen in the proportion of light verbs used, and the significant but small relationship found between difference score and light verb proportion was interpreted as evidence supporting the Gordon and Dell model.

A note on differences between aphasic and healthy individuals. Overall, the significant predictors of light verb use in narrative language differed greatly between aphasic and neurologically healthy individuals. Most notably, relationships between syntactic measures and light verb use showed opposite directions in the two groups: for individuals with aphasia, increased syntactic scores were associated with increased light verb use, and in healthy individuals, the opposite pattern emerged. However, these findings do not necessarily suggest that the mechanisms underlying verb retrieval for these two groups are inherently different. While the present findings indicate that individuals with aphasia are able to rely on syntactic processes to retrieve light verbs more accurately in a semantically lesioned system, healthy individuals do not need to rely on syntactic or semantic networks during verb retrieval. Healthy individuals have intact access to both systems, and it can be concluded that they do still process both semantic and syntactic information during verb retrieval, just as individuals with aphasia do. In the unimpaired system seen in healthy individuals, however, light verb use was free to vary with overall linguistic complexity, rather than as a function of specific semantic or syntactic abilities.

Test scores. In addition to findings regarding narrative syntactic and semantic ability, a number of test scores were included in the multiple regression analysis for individuals with aphasia to identify predictors of the proportion of light verbs used. It was not expected that test scores would show a strong relationship to light verb proportions due to the different nature of linguistic testing and narrative language production. In narrative language, production of verbs, nouns, or syntactic structures relies on the contribution of both syntactic and semantic processes, whereas linguistic tests tend to focus on the use of one process (e.g., single word retrieval) to identify specific breakdowns. This has been demonstrated by the fact that some aphasic individuals show better word retrieval in narrative language than in confrontation naming tasks, or vice versa, depending on the nature of their impairments (Williams & Canter, 1982; Williams & Canter, 1987; Hadar, Jones, & Mate-Kole, 1987; Breen & Warrington, 1994; Zingeser & Berndt, 1988; Pashek & Tompkins, 2002; Mayer & Murray, 2003).

As expected, in spite of their general assessment of lexical-semantic and syntactic abilities, the BNT and the AphasiaBank Repetition Test scores did not show a significant ability to predict the proportion of light verbs used. However, the VNT was a significant predictor of light verb proportion, and it showed a negative relationship to the proportion of light verbs used. This indicates that increased performance on a test requiring the individual to name single verbs was associated with a decreased proportion of light verbs in narrative speech, and corresponding increased proportion of heavy verbs.

Further examination of the VNT explains the source of this association. The VNT consists of naming twenty-two actions from pictures; these actions consist almost entirely of heavy verbs (e.g., *wash, pour, throw*, etc.), with one light verb (*give*) in the set (Cho-

Reyes & Thompson, 2012). For individuals who are impaired in syntactic access but relatively preserved in semantic access (i.e., those who tend to produce a higher proportion of heavy verbs in narrative speech than average), it is expected that a naming task would present relatively little difficulty, due to the fact that the task relies purely on lexical-semantic access. On the other hand, individuals impaired in semantic access (i.e., those producing a greater proportion of light verbs in narrative speech) would demonstrate difficulty with the task, due to the fact that they were unable to rely on syntactic processes to produce the verbs, as they did in narrative speech. Therefore, increased scores on the VNT were associated with a decreased proportion of light verbs in narrative speech, and the division of labor between syntactic and semantic processes in word production was supported. In addition, these findings were consistent with previous findings that individuals with Broca's aphasia, who are more likely to demonstrate syntactic deficits, showed poorer word retrieval performance in narrative language than in confrontation naming tasks, whereas individuals with more fluent aphasias showed the opposite pattern (Williams & Canter, 1982; Williams & Canter, 1987).

Conclusions

Overall, the findings of this study support the predictions of the Gordon and Dell (2003) "division of labor" hypothesis. Amongst individuals with aphasia, those with increased syntactic ability and decreased semantic ability have been shown to use a higher proportion of light verbs, suggesting that these individuals rely more on syntactic processes during the process of verb selection. The opposite pattern has also been demonstrated, with aphasic individuals who show increased semantic ability and decreased syntactic ability producing lower proportions of light verbs, indicating reliance

on semantic processes during verb retrieval. Accounts for the differing usage of light verbs by individuals with aphasia based on word frequency or aphasia severity have not been supported.

While this study was able to examine the use of light and heavy verbs in individuals with aphasia without many of the limitations seen in earlier examinations of the topic (e.g., lack of description of data from neurologically healthy individuals, reduced reporting of statistical significance, small group sizes, etc.), one major limitation presented itself. Although ID was identified as a potentially reliable general measure of semantic ability in narrative language, it is currently unclear whether the automated calculation of ID might make it vulnerable to the influence of syntactic as well as semantic complexity. Many factors suggested that ID was, in fact, a valid measure of semantic ability; however, the validity of ID needs to be further examined by rigorous comparison to other established measures of lexical-semantic access.

In addition, further analyses beyond the scope of this study could provide a more reliable method of examining the relationships between syntactic ability, semantic ability, and the proportion of light verbs used. One such analysis would compare light verb proportions used by a group of individuals with a known core syntactic deficit (i.e., individuals with agrammatic aphasia) to one with a known core semantic deficit (i.e., aphasic individuals performing poorly in confrontation naming and word comprehension without syntactic deficits in narrative language). Use of continuous syntactic and semantic variables was desirable for the purposes of this study because of the heterogeneity of deficits in the aphasic profiles used in previous studies, which obscured the patterns behind light verb use (e.g., Berndt, Haendiges, et al., 1997; Breedin et al.,

1998; Kim & Thompson, 2004; Barde et al., 2006). However, examination of the light verb proportions used by groups already known to be at the two ends of the continuum of syntactic and semantic impairment could validate the use of these continuous measures, and thus could strengthen the support for the Gordon and Dell model found in this study.

Another potentially useful analysis would examine verb weight as a continuous, rather than dichotomous, variable. While investigation of the light/heavy distinction with a small closed set of light verbs has provided preliminary insight into semantic and syntactic access issues in verb retrieval, amongst heavy verbs, it is clear that some are lighter than others (for example, *wash* is a heavy verb, but it is less semantically specific than *scrub*). It is unknown whether retrieval of these less specific heavy verbs demonstrates a similar relationship to syntactic and semantic ability as that demonstrated in this study for the closed set of light verbs. Earlier studies of verb weight have described findings for more general verbs versus more specific ones in addition to the classic light/heavy distinction, but have not operationalized a method for determining non-dichotomous semantic specificity reliably (Breedin et al., 1998; Barde et al., 2006). Maouene et al. (2009) have attempted to address this concept, quantifying verb weight continuously as a function of the diversity of complements following the verb. Other important factors, however, could be factored into quantification of the "lightness" of a verb, such as its frequency and the extent of its grammaticalization. By creating a system for quantifying verb weight continuously, future studies could examine the relationship between syntactic ability, semantic ability, and verb weight in narrative language more precisely.

With these caveats in mind, the results of this study can be cautiously interpreted in support of Gordon and Dell's division of labor hypothesis. As such, this study contributes to the understanding of factors underlying verb-specific deficits in aphasia, a problem that has proved complex and remains poorly understood. It is clear that a multitude of factors are involved in the lexical retrieval of verbs: word frequency, imageability, lexical diversity, syntactic complexity, and now semantic complexity have all been shown to play a role across studies of verb retrieval, and further study of these factors is necessary to fully comprehend the representations and processes underlying the production of verbs.

Appendix A

Cinderella Core Lexicon Adapted from MacWhinney et al. (2010).

Nouns (n=10)	Verbs (n=10)
Cinderella	say
ball	try
prince	marry
slipper	know
mother	work
dress	fit
daughter	find
fairy	see
godmother	dance
sister	leave

Appendix B

Selections from Transcripts of Aphasic Discourse

Transcripts have been altered to remove codes representing multiple word repetitions, rephrasings, pauses, interruptions gestures, phonological fragments, phonological errors, and semantic errors to improve readability. Utterances consisting primarily of fillers or function words were replaced with the "…" mark. All main words, function words, and fillers within utterances were preserved.

Participant Scale02a, producing only heavy verbs

Um, middle-aged woman and, um, mid- uh, early twenties um, uh, no, um, ten years old. … And um, older gentleman. And uh, a paint, a painting sunlight, beautiful sunlight. … Uh, next, um, um, next um, a bad um, um, older woman and um, mid-twenties dark, dark, stern fighting and lovely uh, girl. … Um, um, older women and um, mid twenties um, uh, cursing and stuff. … Next um, um, fairy, uh, father [: fairy godmother] uh… … Um, cot [: god]… A woman, uh, father [: fairy godmother]. Next um, horses and um, uh, a chariot um, uh, horses and ride to the uh, castle. And um, uh, gaily um, um, waltzing the, what called, polka and um, uh, music .

Participant Star03a, producing only light verbs

Uh, the story was um, (a)bout Cinderella . And she uh, was uh, having a different stuff uh, with the maid of the house. And the the lady in the house uh, with uh, her two uh, thing were were angry at Cinderella. And so uh, then they had a uh, uh, difference with Cinderella. And Cinderella had uh, some differences with them. And uh, uh, so, and

uh, Cinderella had a big uh, um, big deal with uh, the prince. And Cinderella was doing okay. But then she was, she had their deal xxx out . And she had, the uh, prince, uh had them. All of them had the table, table and, and so forth.

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