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Typicality Mediates Performance during Category Verification in Both Ad-hoc and Well-defined Categories

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Abstract

Background—The typicality effect is present in neurologically intact populations for natural, ad-hoc, and well-defined categories. Although sparse, there is evidence of typicality effects in persons with chronic stroke aphasia for natural and ad-hoc categories. However, it is unknown exactly what influences the typicality effect in this population.

Aims—The present study explores the possible contributors to the typicality effect in persons with aphasia by analyzing and comparing data from both normal and language-disordered populations, from persons with aphasia with more semantic impairment versus those with less semantic impairment, and from two types of categories with very different boundary structure (ad-hoc vs. well-defined).

Methods and procedures—A total of 40 neurologically healthy adults (20 older, 20 younger) and 35 persons with aphasia (20 LSI (less-semantically impaired) patients, 15 MSI (more-semantically impaired) patients) participated in the study. Participants completed one of two tasks: either category verification for ad-hoc categories or category verification for well-defined categories.

Outcomes and Results—Neurologically healthy participants showed typicality effects for both ad-hoc and well-defined categories. MSI patients showed a typicality effect for well-defined categories, but not for ad-hoc categories, whereas LSI patients showed a typicality effect for ad-hoc categories, but not for well-defined categories.

Conclusions—These results suggest that the degree of semantic impairment mediates the typicality effect in persons with aphasia depending on the structure of the category.

1. Introduction

It is well known that members of a category are not equal and some items in a category are perceived as being more typical than other items in a category. This phenomenon is known as the *typicality effect* (Hampton, 1979; McCloskey & Glucksberg, 1978; Posner & Keele, 1968; Rosch, 1973, 1975) and is rooted in the notion that a typical member of a category is considered to be a good, representative example of that category (e.g. *apple* for the category *fruit*) and an atypical member is considered to be a poor representative example of that category (e.g. *fig* for the category *fruit*). Rosch (1975) found that for the categories fruit, science, sports, birds, vehicles, crime, disease, and *vegetables*, individuals consistently rated

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certain members as better examples than other members of the specific category. This same pattern of typicality has been observed in other studies with similar methodology (Garrard, Ralph, Hodges, & Patterson, 2001; Uyeda & Mandler, 1980).

The typicality effect can be observed during various cognitive tasks, such as category verification, category induction, category learning, and category naming. In category verification tasks, participants demonstrate faster reaction times when identifying typical items (e.g., *robin*) as members of a category (e.g., *bird*) than when identifying atypical items (e.g., *ostrich*) (Hampton, 1995; Kiran & Thompson, 2003a; Rosch, 1975; Storms, De Boeck, & Ruts, 2000). Also, when participants are asked to determine if two words belong to the same category, they will respond faster when the pair contains typical members than when the pair contains atypical members (Rosch & Mervis, 1975). In category induction tasks, if the individual item in question is a typical member (e.g., *robin*) rather than an atypical member (e.g., *ostrich*) of the category (e.g., *birds*), then a higher percentage of the items in the category will be assumed as having the same property as the individual item (Osherson, Smith, Wilkie, Lopez, & Shafir, 2008; Rein, Goldwater, & Markman, 2010; Rips, 1975). In category naming tasks, participants who are given typical members of a category will name the respective category with more accuracy than when they are given atypical members (Casey, 1992; Hampton, 1995). In category learning tasks, participants learn typical members of a category more rapidly than atypical members (Posner & Keele, 1968; Rosch, 1975).

Most of these studies have examined representation of examples within natural living and nonliving categories (e.g., *birds, clothing, vegetables, clothing, furniture*), which are graded in nature with fuzzy boundaries separating members from nonmembers (McCloskey & Glucksberg, 1978), meaning that if we think of categories as spheres of items, the spheres may overlap at items that belong to more than one category (e.g., *tomato* can be either a *fruit* or a *vegetable*). Additionally, these categories are said to have gradation, meaning that the best examples of the category cluster at the center and the distance away from the center increases with decreasing fit with the category (Rips, Shoben, & Smith, 1973; Rosch & Mervis, 1975). This observation can also be thought of as a central tendency for typical items (Barsalou, 1985). The nature of typicality among types of categories can differ based on the extent of gradation *across* boundaries in addition to the gradation found *within* categories. Boundary gradation can be thought of as existing along a continuum, where categories on one end of the continuum have very clear, strict boundaries and are called well-defined categories (e.g., *months, shapes*), while those on the other end of the continuum have very loose or minimal boundaries and are called ad-hoc categories (e.g., *things to take camping, things I love*).

Like natural categories, ad-hoc categories possess a graded structure in which typicality can be determined for members of a particular category (Barsalou, 1983, 1985). The difference is that ad-hoc categories are most often compiled to achieve goals, particularly goals of daily living, such as `*things to buy at a grocery store*', whereas natural categories have defining and/or characteristic features that constitute category membership (see Hampton, 1995 for a discussion of the relative contribution of defining and characteristic features). For this reason, ad-hoc categories are often called goal-derived categories and can conceivably have no boundaries, depending on the preciseness of the goal that is forming the category. For example, the category boundary for `*things to buy at a grocery store*' is defined by what is normally found in a grocery store. Conversely, one can imagine that the category boundary for `*things that might make someone happy*' is nonexistent, since it's a relatively vague and subjective goal. This is in contrast to natural categories, which will always have a boundary, however fuzzy it may be. Typicality in ad-hoc categories, therefore, is determined by how well the item-to-be-categorized fits with the goal. This is again different from typicality in natural categories, which is determined by similarity to a central tendency. The goal then becomes the ideal for the category and how precise the goal is determines the gradedness of the category boundary. Consequently, the gradedness of the category boundary contributes to the degree of gradedness within the category (Barsalou, 1983, 1985). Therefore, ad-hoc categories are similar to natural categories in that they are graded and so category members vary in typicality, but differ from natural categories in that typicality is determined by the goal rather than the central tendency (Barsalou, 1985).

In stark contrast to ad-hoc categories, categories such as *shapes* and *odd numbers* have clear category boundaries and consist of items that meet membership requirements to roughly the same degree. Categorization in these well-defined categories is thought to occur in a rule-based fashion (Hampton, 1998; Keil, Smith, Simons, & Levin, 1998). This would seem to argue against a typicality effect in well-defined categories. However, evidence for a typicality effect in well-defined categories comes from Armstrong, Gleitman, and Gleitman (1983), who demonstrated that well-defined categories such as *females* and *odd numbers* are graded in nature (e.g., *mother* is considered more typical of the category *female* than *cowgirl*). Notably, Larochelle, Richard, and Soulierres (2000) did not replicate the results of Armstrong et al. (1983) using enumerable well-defined categories (e.g., *months*) and found that typicality did not significantly contribute to reaction times above and beyond familiarity, instance dominance, or category dominance in the categories used in Armstrong et al. (1983) (e.g., *shapes*).

Depending on the amount of gradation within a category or across category boundaries, the method of assigning items to a category is likely to change. In a rule-based categorization strategy, a candidate item is checked against a set of defining features for a particular category to determine its membership in that category. In a similarity-based categorization strategy, a candidate item is compared to a prototype or known exemplars of the category to determine whether or not it is similar enough to belong to the same category (Smith & Medin, 1981). As mentioned previously, it could be postulated that well-defined, natural, and ad-hoc categories exist on a continuum of boundary gradedness. On one end of the continuum are categories whose boundaries are created solely by rules. If the item follows the rule, it is placed in the category, if not, it is placed outside the category (i.e., rule-based categorization strategy). These types of categories (e.g., *days of the week*) therefore have very strict boundaries and no gradedness and as a result, no typicality effect would be expected. On the other end of the continuum are categories with a clear prototype or goal and whose boundaries are created solely by distance from the prototype or goal. Category membership is judged by similarity to the prototype or goal (i.e., similarity-based categorization strategy). These types of categories (e.g., *items that make good gifts*) therefore have very loose boundaries and graded representation and as a result, there ought to be a clear typicality effect. For categories somewhere between these two extremes, some combination of rule- and similarity- based strategies should be utilized. Indeed, Smith, Patalano, and Jonides (1998) found that these procedures can act in a parallel fashion depending on the characteristics of the items in the category and that the neural regions involved in similarity-based categorization were also active during rule-based categorization. Although a rule may exist for categorization, if the item is similar to the prototype, a similarity-based process will be invoked in addition to the rule-based process. Alternatively, similarity- and rule- based processes may be different extremes of the same process (Pothos, 2005).

Rule- and similarity- based categorization procedures are the subject of a lively debate within the semantic processing literature. The terms are introduced here because they are helpful in describing the effect of typicality on semantic processing in persons with aphasia and the purpose of this study is to explore possible underlying mechanisms of the typicality effect, not the rule- versus similarity- based categorization distinction per se. For a more thorough discussion of categorization procedures, please refer to reviews by Goldstone and Kersten (2003), Pothos (2005), and Smith et al. (1998).

To summarize, the typicality effect has been shown to exist in natural animate and inanimate categories, ad-hoc categories, and (to a lesser extent) well-defined categories. This is in the face of different category structures and seemingly different categorization processes. The focus of these past studies has mainly been the existence of typicality effects, not the underlying mechanisms per se. Exploring the typicality effect in persons with chronic stroke aphasia with differing levels of semantic impairment may help uncover some of the underlying mechanisms of the typicality effect during semantic categorization. Thoughtful examination of dysfunction often leads to a more complete understanding of normal function and has implications for rehabilitation.

That being said, although the typicality effect is also apparent in persons with chronic stroke aphasia, there is relatively sparse information regarding category representation and differences in typicality effects due to category type in this population. The representation of category structure in these individuals may largely depend on the aphasic profile. In a category fluency task, Grossman (1981) found that patients with nonfluent aphasia were more sensitive to typical members of a category, whereas those with fluent aphasia tended to ignore category boundaries. Similarly, Grober, Perecman, Kellar, and Brown (1980) found that patients with anterior aphasia were better than those with posterior aphasia at classifying atypical items in a category. In a category verification task, Kiran and Thompson (2003a) found that patients with Broca's aphasia were faster and more accurate for atypical items versus typical items in animate categories, whereas patients with Wernicke's aphasia showed no sensitivity to typicality and had worse performance overall than those with Broca's aphasia. These studies, in general, suggest that individuals with fluent or posterior aphasia are insensitive to the graded structure and hierarchical organization within common categories. However, it may simply be that the nature of semantic impairment influences the representation of category boundary and structure independent of aphasia type. In a recent study, Kiran, Ntourou, and Eubank (2007) examined the effect of typicality in inanimate categories using an online category verification task in persons with aphasia who were divided into two groups depending upon whether or not they showed offline semantic impairments. Individuals in the semantically-impaired (SI) group demonstrated a greater number of errors on typical and atypical members than the non-semantically-impaired (NSI) group and normal controls. The results of this study suggest that general semantic deficits, not aphasia type or lesion location per se, may reflect impairment in the representation of semantic categories.

The representation of typicality in well-defined categories has not yet been examined in persons with chronic stroke aphasia. However, with regards to ad-hoc categories, Hough and Pierce (Hough & Pierce, 1989) found that both normal participants and persons with aphasia showed a typicality effect and had similar performance accuracy on a category verification task, but persons with aphasia required significantly more time to correctly identify category exemplars than normal participants. No differences between patients with fluent aphasia and those with nonfluent aphasia were found. During a subsequent study using both a category verification task and a category exemplar generation task, individuals with fluent and nonfluent aphasia and control participants exhibited a similar pattern in typicality range for ad-hoc categories. However, for natural categories, fluent and nonfluent persons with aphasia were more anchored to the central portion of a category's referential field (Hough, 1993).

From the scant research into the typicality effect that has been performed with persons with chronic stroke aphasia, it appears that natural animate and inanimate as well as ad-hoc categories have graded representations for persons with aphasia, regardless of the specific category tested or the type of aphasia. However, it is uncertain exactly what influences the behavioral patterns that have been observed in persons with aphasia. The present study systematically teases apart each of the possible contributors by (a) analyzing and comparing data from neurologically healthy adults and persons with post-stroke aphasia (dividing persons with aphasia into those with more semantic impairment versus those with less semantic impairment) in order to determine if the nature of aphasia in general or the nature of semantic impairment are more influential in category verification, (b) comparing two types of categories with very different boundary structure (ad-hoc vs. well-defined) in order to determine if the nature of category boundaries is influential in category verification, and (c) exploring the interaction of degree of semantic intactness and category structure to determine if there is some combination of semantic impairment and category structure that influences category verification.

Similar to Kiran et al. (2007), participants with aphasia in the present study were divided into two groups based on their performance on subtests of semantic processing rather than dividing them into diagnostic classification groups (e.g., anterior/posterior, fluent/nonfluent, or Broca's/Wernicke's). Reasons for this departure from the traditional approach are that (a) research has shown that persons with aphasia cannot be categorised into different language syndromes based solely on their site of lesion (e.g., Basso, Lecours, Moraschini, & Vanier, 1985), (b) neuroimaging studies suggest that semantic processing involves a network of activation that may include both the posterior and anterior regions (e.g., Thompson-Schill, 2003), (c) traditional aphasia classifications (e.g., Broca's, Wernicke's) are not relevant predictors of semantic processing as semantic processing deficits are ubiquitous across these classifications (e.g., Del Toro, 2000; Jefferies & Lambon Ralph, 2006), (d) the purpose of this study is to understand differences in online semantic processing due to category structure among groups with differing offline behavioral performance on related semantic processing tasks.

We hypothesized that (1) both normal control participants and persons with aphasia would exhibit longer reaction times for atypical examples than typical examples in both ad-hoc categories and well-defined categories during a category verification task and (2) persons with aphasia with more semantic impairment (MSI) and with less semantic impairment (LSI) would exhibit qualitatively different patterns depending on the type of category being tested (ad-hoc versus well-defined). Because the focus of this study was to examine the typicality effect resulting from category structure in populations varying in degree of semantic intactness, no specific predictions regarding rule- or similarity- based categorization procedures were made. No differences between the specific categories (e.g., *shapes* vs. *females* or *camping* vs. *garage sale*) for each type of category (e.g., *well-defined*, *ad-hoc*) were expected because psycholinguistic factors between categories were equated during stimulus creation.

2. Method

The two tasks for this study were carried out at different times and with different sets of participants. Therefore, the methods for each task will be described separately.

2.1. Task 1: Category verification for ad-hoc categories

2.1.1. Participants—Ten young normal control participants (*M* = 25.1, age range = 22 to 27 years), ten older normal control participants (*M* = 55.8, age range = 50 to 60 years), and 17 persons with aphasia (M = 65.1, age range = 39 to 84 years) participated in the experiment. The young and older normal control participants were recruited from the University of Texas at Austin and the Communication in Adults Research Group database. These participants were right handed, had normal or corrected to normal vision, normal hearing, and at least a high school education. Exclusionary criteria included neurological disorders such as stroke, transient ischemic attacks, Parkinson's disease, Alzheimer's disease, psychological illness, learning disability, seizures, and attention deficit disorders. Both older and younger neurologically healthy participants were recruited because recent research has shown that cognitive processes change with age (for a review, see Cabeza, 2001). As persons with aphasia tend to be older adults, control of this factor was warranted.

Participants with aphasia were recruited from the University of Texas Aphasia Research Laboratory. Several inclusion criteria were enforced: (a) diagnosis by a neurologist of a stroke in the left hemisphere (encompassing the gray and/or white matter in and/or around the perisylvian area confirmed by a CT or MRI scan), (b) at least 6 months post-stroke (c) no concomitant visual, hearing, or cognitive deficits as determined by a certified speech language pathologist, (d) at least a high school diploma, and (e) native speaker of English. All participants signed consent forms in accordance with the policies of the University of Texas at Austin Institutional Review Board.

Standardized language tests were administered to all patients prior to participation to ensure diagnosis of aphasia and quantify specific language deficits. Administration of the *Western Aphasia Battery* (WAB; Kertesz, 1982) provided the type of aphasia as well as the aphasia severity level via calculation of the Aphasia Quotient (AQ). Naming performance was assessed through the *Boston Naming Test* (Goodglass, Kaplan, & Weintraub, 1983) and the naming subtest of the WAB. Semantic processing was assessed using selected subtests from the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA; Kay, Lesser, & Coltheart, 1992): spoken word to picture matching (SWPM), written word to picture matching (WWPM), auditory synonym judgment (ASJ) and written synonym judgment (WSJ) (see Table 1).

2.1.2. Stimuli—Five potential ad-hoc categories were selected as preliminary options to be used in this task: things to take camping, things at a grocery store, things at a garage sale, things that fly, things that smell. These categories were chosen because they were used in previous ad-hoc category studies (Barsalou, 1983, 1985; 1993; Hough & Pierce, 1989). Forty young and older normal participants, none of whom participated in the experimental task but met the same inclusionary and exclusionary criteria as the previously described normal participants, were recruited to assist in the development of norms for stimuli employed in the study. Twenty of these participants provided as many exemplars as possible for each of the five potential ad-hoc categories. The remaining 20 participants rated the typicality of these items on a 7-point scale with 1 indicating a very good example and 7 indicating a very poor example of the category (Rosch, 1975). Participants also marked `U' next to the items with which they were unfamiliar (Malt & Smith, 1982). The average rating and standard deviation were calculated for each item across the 20 participants for all five categories. The average rating scores were then converted into *z*-scores for each item to account for individual variability.

For each category, the 15 items with the highest *z*-scores were chosen to be the typical examples and the 15 items with the lowest *z*-scores were chosen to be the atypical examples. Problematic stimuli (synonyms, unfamiliar items, outliers) were eliminated and the categories *things that fly* and *things that smell* were eliminated due to an insufficient number of items. Consequently, the categories *things to take camping, things at a garage sale*, and *things at a grocery store* were selected for the ad-hoc category verification task. In addition to the 15 typical and 15 atypical items that were chosen for each of these three remaining categories, 30 filler items (requiring a "no" response) were included to equate the number of yes and no responses during the category verification task. The fillers consisted of 15 nonmembers belonging to different natural categories including *weather phenomenon*, *animals*, and *professions* and 15 nonwords that were phonotactically legal and had orthographically existing onsets, which were selected from the ARC nonword database (Rastle, Harrington, & Coltheart, 2002).

In order to ensure that there were no differences in the written word frequency and familiarity between the typical members, atypical members, and the nonmembers for the three categories, main effects ANOVAs with three levels of typicality (typical member, atypical member, nonmember) and three levels of category (*camping*, *garage sale*, *grocery store*) were performed for both written word frequency and familiarity (Gilhooly & Logie, 1980; Kucera & Francis, 1967). Results revealed no significant main effects for typicality (F (2, 113) = 0.01, p = .98) or category (F (2, 113) = 2.32, p = .10) on written word frequency. Likewise, effects of typicality (F (2, 108) = 1.55, p = .21) and category (F (2, 108) = 3.22, p = .05) were not significant for familiarity.

In sum, each of the three ad-hoc categories (things to take camping, things at a garage sale, things at a grocery store) contained 15 typical members, 15 atypical members, 15 nonmembers, and 15 nonwords, resulting in a grand total of 180 items. Each of these items was paired with a superordinate label during stimulus presentation (see Table 2). Three blocks of 60 word pairs were constructed. Each block consisted of equal numbers of typical members, atypical members, nonmembers and nonwords from each of the experimental ad-hoc categories.

2.1.3. Procedure—Participants were seated in front of a computer with their nondominant hand placed on the keyboard. A laptop computer loaded with E-Prime software (Psychology Software Tools; Pittsburgh, PA) was used to present stimuli and record responses (reaction time and errors). Participants were presented with written instructions on the computer screen followed by verbal clarifications about the task. They were instructed that they would first see a superordinate category label followed by a word. Their task was to read each word pair and decide if the target word belonged to the preceding superordinate category label. Participants were instructed to respond as quickly and accurately as possible by pressing the `yes' response button on the keyboard if they judged the target to be a member of the category, and `no' if it did not belong to the category. The stimuli in each block were presented in a randomized fashion. The superordinate label was presented at the center of the screen for 500ms, followed by an interstimulus interval (ISI) of 200ms, and then the target, which was presented at the center of the screen and remained on screen until the participant made the category verification decision. The intertrial interval (ITI) was 2000ms.

2.2. Task 2: Category verification for well-defined categories

2.2.1. Participants—Ten young normal control participants (M = 23 years, age range = 18–35 years), ten older normal control participants (M = 50 years, age range = 40–65 years), and 18 persons with aphasia (M = 60.6 years, age range = 43–76 years) participated in Task 2. The recruitment procedures, inclusionary criteria, and exclusionary criteria for this task were identical to those in Task 1 with the exception that one patient (WD03) was left-handed. As in Task 1, all participants signed consent forms in accordance with the policies of the University of Texas at Austin Institutional Review Board and standardized language tests were administered to all patients prior to participation in the experiment (see Table 1).

2.2.2. Stimuli—As in Task 1, five potential well-defined categories were selected as preliminary options to be used in this study. Three of the five categories included *body* *parts, females* and *shapes* as they have been suggested as potential well-defined categories in previous studies (Armstrong et al., 1983; Larochelle et al., 2000). Two additional categories (e.g., *colors* and *males*) were determined to be well-defined based on an initial survey conducted on 20 normal adults. In each of the five categories (*body parts, females, males, shapes, colors*), 35 items were selected as potential category exemplars. Thirty young and older normal participants, none of whom participated in the experimental task, were recruited to rate the typicality of these items on a 7-point scale with 1 indicating a very good example and 7 indicating a very poor example of the category (Rosch, 1975). Participants also marked `U' next to items with which they were unfamiliar (Malt & Smith, 1982). The average rating and standard deviation were calculated for each item across the 30 participants for all five categories. The average rating scores were then converted into *z*-scores for each item to account for individual variability.

As in Task 1, the 15 items with the highest *z*-scores were chosen to be the typical examples and the 15 items with the lowest *z*-scores were chosen to be the atypical examples for each category. Problematic stimuli (synonyms, unfamiliar items, outliers) were eliminated and the categories *colors* and *males* were eliminated due to an insufficient number of items. Consequently, the categories *shapes, body parts*, and *females* were selected for the well-defined category verification task. As in Task 1, in addition to the 15 typical and 15 atypical items that were chosen for each of these three remaining categories, 30 fillers consisting of 15 nonmembers belonging to the categories *vegetables, birds, transportation, furniture*, and *fish* as well as 15 nonwords were included to equate the yes and no responses during the category verification task. In order to guarantee that there were no differences in written word frequency, familiarity, or number of letters between the atypical members, typical members, and nonmembers of the final three categories, univariate ANOVAs were performed. For the categories *body parts, females*, and *shapes*, no statistically significant difference was found for written word frequency ($p = .08$, $p = .35$, and $p = .23$, respectively), familiarity ($p = .15$, $p = .61$, and $p = .95$, respectively), or number of letters ($p = .06$, $p = 1.0$, and $p = .91$, respectively).

In sum, each of the three well-defined inanimate categories (*females, body parts, shapes*) contained 15 typical members, 15 atypical members, 15 nonmembers, and 15 nonwords, resulting in a grand total of 180 items. Each of these items was paired with a superordinate category label during stimulus presentation (see Table 2). Blocks were constructed in the same manner as in Task 1.

2.2.3. Procedure—The procedure for Task 2 was identical to that in Task 1, with the following exceptions: (1) instead of E-Prime, Superlab Pro (Cedrus Corporation; Phoenix, AZ) was used, (2) the superordinate category label was presented for 1000ms rather than 500ms, (3) the ITI was 1500ms rather than 2000ms. These differences in timing were judged to be acceptable since both of these tasks were meant to elicit controlled processing rather than automatic processing, the boundary between which is thought to be at 250ms (Neely, 1977).

2.3. Data Analysis

Data from both tasks were combined into one analysis. Accuracy and reaction time (RT) during the category verification tasks 1 and 2 were recorded for each item for each participant. For each participant, a semantic score was calculated from the average performance on the four PALPA subtests mentioned previously (SWPM, WWPM, ASJ, and WSJ). Although it could be argued that a test such as the Pyramids and Palm Trees Pictures subtest (PAPT; Howard & Patterson, 1992) is a more ideal test to measure pure semantic processing, since it does not require auditory or written word processing and the current experiment required written word processing to complete the task, the PALPA subtests were deemed to be more indicative of the type of semantic processing used in this task. The semantic score was used to divide participants into two groups: those with more semantic impairment (MSI) and those with less semantic impairment (LSI) group. The mean semantic score of all 35 participants was calculated (M = 89%, SD = 8%) and those with a semantic score above the mean were assigned to the LSI group and those with a semantic score below the mean were assigned to the MSI group. Consequently, the LSI group in the ad-hoc condition consisted of 9 participants (M = 95%, SD = 2%) and the MSI group consisted of 8 participants (M = 80%, SD = 6%). For the well-defined condition, the LSI group consisted of 11 participants (M = 96%, SD = 3%) and the MSI group consisted of 7 participants (M = 82%, SD = 7%) (see Table 1). Both item (collapsed across participants) and subject (collapsed across items) analyses were performed.

2.3.1. Item Analyses—For the item analyses, accuracy and RT were each analyzed as the dependent variable in a 2 × 4 × 4 factorial ANOVA with category type and typicality as the within-subject factors and group as the between-subject factor. The two levels of category type were ad-hoc and well-defined, the four levels of typicality were typical members, atypical members, nonmembers, and nonwords, and the four levels of group were healthy young adults, healthy older adults, LSI patients, and MSI patients.

2.3.2. Subject Analyses—The subject analyses for neurologically healthy adults and persons with aphasia were analyzed separately because the patient analysis necessarily included a covariate for aphasia severity. The accuracy and RT subject analyses for the neurologically healthy adults were performed using 2 × 4 × 2 factorial ANOVAs with the same parameters as above, except that the group variable contained only two levels: healthy young adults and healthy older adults. For patients, ANCOVAs were used because we expected aphasia severity to influence accuracy and reaction time and we wanted to control for this potential confound[1]. The group variable for the 2 × 4 × 2 ANCOVAs contained the two levels of LSI and MSI patients and the covariate was WAB AQ scores, which are a measure of aphasia severity. For the RT analyses, RTs in the patient data below 350ms were considered outliers, as this was the shortest RT in the neurologically intact adults. See Table 3 for the average accuracy and reaction time data for each patient group.

3. Results

3.1. Accuracy Analyses

3.1.1. Item Analysis—The 2 (category type) × 4 (typicality) × 4 (group) item factorial ANOVA revealed significant main effects for category type (F (1, 1413) = 89.64, $p < .001$), group (F (3, 1413) = 85.79, $p < .001$) and typicality (F (3, 1413) = 117.48, $p < .001$). Fisher's LSD tests revealed that all groups were significantly more accurate for items in well-defined categories than those in ad-hoc categories ($p < .001$); non-neurologically impaired young and older adults were not significantly different from each other ($p = .21$), but were both significantly more accurate than LSI patients ($p < .001$ for both tests), who were in turn significantly more accurate than MSI patients ($p < .001$); and responses to typical members were significantly more accurate than those to atypical members ($p < .001$). The item accuracy analysis also produced a significant three-way interaction between category type, group, and typicality (F (9, 1413) = 9.52, $p < .001$). Fisher's LSD tests for the three-way interaction revealed that typical members were significantly more accurately

[1]It should be noted that although there is precedent in the literature for using this type of analysis, it has been argued that ANCOVA theoretically cannot “control” for the covariate when using nonrandom assignment. However, there are gray areas in which ANCOVA is appropriate when groups differ on the covariate (Miller & Chapman, 2001).

confirmed as members of a category than atypical members by all groups for ad-hoc categories ($p < .001$ for all groups except MSI, which was $p < .01$); whereas for well-defined categories, MSI patients showed no significant difference in accuracy between typical and atypical members ($p = .99$) although LSI patients, healthy young adults, and healthy older adults showed a significant typicality effect ($p < .05$ for all comparisons) (see Figure 1).

3.1.2. Subject Analyses—The subject analysis of accuracy for neurologically healthy adults was performed using a 2 (category type) × 4 (typicality) × 2 (age group) factorial ANOVA and was significant for the main effects of category type ($F(1, 148) = 73.65$, $p < .001$) and typicality ($F(3, 148) = 52.65$, $p < .001$) and the two-way interactions of category type by typicality ($F(3, 148) = 13.70$, $p < .001$) and group by typicality ($F(3, 148) = 3.49$, $p < .05$). Fisher's LSD tests confirmed that items in the well-defined category condition were significantly more accurate than those in ad-hoc category condition ($p < .001$) and typical members were significantly more accurate than atypical members ($p < .001$). Interestingly, atypical members were significantly more accurate for the healthy older adults than the healthy younger adults ($p < .001$), which may indicate an age effect on category boundary. Additionally, although both types of categories elicited typicality effects, the difference was slightly more pronounced for ad-hoc categories ($p < .001$) than for well-defined categories ($p < .01$), suggesting a stronger typicality effect for ad-hoc categories. These results are consistent with the item analysis.

The subject analyses of accuracy for persons with aphasia was performed using a 2 (category type) × 4 (typicality) × 2 (semantic group) factorial ANCOVA, covarying WAB AQ. The main effects of group ($F(1, 123) = 9.07$, $p < .01$) and typicality ($F(3, 123) = 15.62$, $p < .001$) were significant, but the three-way interaction only approached significance ($F(3, 123) = 2.26$, $p = .09$). Fisher's LSD tests confirmed that LSI patients were significantly more accurate than MSI patients ($p < .01$), but the difference in accuracy between typical and atypical members did not reach significance ($p = .07$).

3.2. Reaction Time Analyses

3.2.1. Item Analysis—The 2 (category type) × 4 (typicality) × 4 (group) item factorial ANOVA revealed significant main effects for category type ($F(1, 1411) = 4.48$, $p < .05$), group ($F(3, 1411) = 345.56$, $p < .001$), and typicality ($F(3, 1411) = 24.56$, $p < .001$). Fisher's LSD tests confirmed that all groups were significantly faster for items in well-defined categories than those in ad-hoc categories ($p < .05$); non-neurologically impaired young adults were significantly faster than older adults, who were significantly faster than LSI patients, who were significantly faster than MSI patients ($p < .001$ for all tests); and responses to typical members were significantly faster than those to atypical members ($p < .001$) for all groups. The three-way interaction for the item RT analysis did not reach significance ($F(9, 1411) = 1.53$, $p = .13$); nevertheless, as seen below, some notable patterns emerge.

3.2.2. Subject Analyses—The subject analysis of RT for neurologically healthy adults using a 2 (category type) × 4 (typicality) × 2 (age group) factorial ANOVA was significant for the main effects of category type ($F(1, 148) = 5.24$, $p < .05$), group ($F(1, 148) = 37.67$, $p < .001$), and typicality ($F(3, 148) = 7.74$, $p < .001$), but the two-way interactions of category type by group ($F(1, 148) = 3.62$, $p = .06$) and category type by typicality ($F(3, 148) = 2.58$, $p = .06$) only approached significance. Fisher's LSD tests confirmed that items in the well-defined category condition were verified significantly more quickly than those in the ad-hoc category condition ($p < .05$); healthy young adults were significantly faster than healthy older adults ($p < .001$); and typical members were significantly more accurate than atypical members ($p < .01$). The subject analysis of RT for persons with aphasia was not significant.

Generally, these results validate the basic expectations about the data: (a) it is more difficult to categorize items into ad-hoc categories than well-defined categories, (b) non-neurologically impaired adults are better at this process than persons with aphasia, and (c) typical members of a category are more easily recognized than atypical members. Additionally, an interesting pattern emerges: the degree of semantic impairment appears to mediate the effect of typicality on accuracy and reaction time differently depending on whether the categories are well-defined or ad-hoc (see Figures 1 and 2). To further address this notion, planned comparisons were run for the RT item analysis with the patient data for only atypical and typical members of ad-hoc and well-defined categories. We found that the difference between atypical and typical members of ad-hoc categories was significant for LSI patients (t (90) = 2.78, $p < .01$), but not for MSI patients (t (90) = 1.52, $p = .13$); whereas the difference between atypical and typical members of well-defined categories was significant for MSI patients (t (88) = 2.71, $p < .01$), but not for LSI patients (t (90) = .48, $p = .63$).

3.3. Facilitation effect of typicality

To better understand these differential patterns, the advantage for typical examples over atypical examples in both types of categories (ad-hoc, well-defined) was calculated for each participant, then averaged for each group (young control, older control, LSI patient, MSI patient). This was accomplished using the formula [*(mean atypical RT - mean typical RT*) / *mean atypical RT*] which produced percent typicality facilitation effects for the RT data, with positive values indicating an advantage for typical items. Healthy older and younger adults exhibited typicality facilitation effects for both well-defined and ad-hoc categories, with no statistically significant differences between category types (t (18) = −1.34, $p = .19$ and t (19) = 1.20, $p = .24$, respectively) (see Figure 3A). LSI patients exhibited a greater typicality facilitation effect for ad-hoc categories than well-defined categories (t (18) = 3.16, $p < .01$). In contrast, the MSI patients exhibited a lower typicality facilitation effect for ad-hoc categories than well-defined categories (t (13) = −2.19, $p = .19$) (see Figure 3B). Additionally, we correlated RT with typicality z-score for the patient data (see Figure 3C). The typicality z-score was taken from the typicality ratings obtained during stimuli creation and used to sort typical members from atypical members of a category, with typical members being negative and atypical members being positive. LSI patients showed significant correlations of increasing reaction time with increasing atypicality in both ad-hoc ($r = .41$, $p < .001$) and well-defined ($r = .21$, $p < .05$) categories, whereas MSI patients did not show a significant correlation for ad-hoc categories ($r = .03$, $p = .81$), but well-defined categories approached significance ($r = .19$, $p = .07$). As expected, these correlations support the patterns seen with the facilitation effect calculations. This indicates that semantic impairment modulates the effect of typicality, depending on whether the categories are well-defined or ad-hoc. Specifically, semantic impairment lowers sensitivity to typicality, especially in ad-hoc categories (and may exaggerate sensitivity to typicality in well-defined categories as in Figure 3B), but sensitivity to typicality is preserved and appears similar to neurologically healthy adults in persons without semantic impairment.

4. Discussion

The aim of the present study was to explore the typicality effect in persons with aphasia and in normal control participants for ad-hoc and well-defined categories. These categories are very different from each other in terms of category boundaries and gradedness. To this end, we conducted two separate category verification tasks with four separate groups containing healthy older adults, healthy younger adults, persons with aphasia with more semantic impairment (MSI), and persons with aphasia with less semantic impairment (LSI). One category verification task utilized ad-hoc categories, which have very loose boundaries and are usually created to accomplish specific goals. The other category verification task utilized well-defined categories, which have very rigid boundaries and have an all-or-nothing type of membership. We hypothesized that regardless of the differences between these categories, both normal control participants and persons with aphasia would exhibit longer reaction times for atypical members than typical members in both ad-hoc categories and well-defined categories during a category verification task. We further hypothesized that the differences in gradedness within category and across category boundaries between these two categories would interact with the difference in semantic representation and organization between LSI persons with aphasia and MSI persons with aphasia such that these two groups of patients would exhibit qualitatively different patterns depending on the type of category being tested.

The results of this study confirm previous findings that both ad-hoc categories (Barsalou, 1983, 1985) and well-defined categories (Armstrong et al., 1983) are graded in nature. The difference between typical and atypical members of both ad-hoc and well-defined categories was significant for both young and older neurologically healthy adults in both item and subject analyses of both RT and accuracy data. Additionally, typicality facilitation effects were found for both ad-hoc and well-defined categories for both young and older adults.

For persons with aphasia, we found that regardless of semantic impairment (LSI vs. MSI) or category type (ad-hoc vs. well-defined), typical members of a category were faster and more accurately confirmed than atypical members of a category. The item analyses were significant, but due to small sample sizes and subject variability, not all subject analyses were significant. Upon closer inspection of this typicality effect across different category types and patients with differing levels of semantic impairment, interesting patterns begin to emerge.

Patients with more semantic impairment exhibited faster reaction times for typical members than for atypical members of well-defined categories but similar reaction times for typical and atypical members of ad-hoc categories as well as a higher typicality facilitation effect for well-defined categories than for ad-hoc categories. Conversely, patients with less semantic impairment exhibited faster reaction times for typical than for atypical members of ad-hoc categories but similar reaction times for typical and atypical members of well-defined categories as well as a higher typicality facilitation effect for ad-hoc categories than for well-defined categories. This pattern changes slightly for accuracy rates, for which both groups of patients show a typicality effect for ad-hoc categories, but only the LSI patients show a typicality effect for well-defined categories. Therefore, the degree of semantic impairment in persons with aphasia appears to mediate the effect of typicality on performance differently depending on the category type (ad-hoc or well-defined).

Furthermore, accuracy and reaction time appear to be mediated by typicality and semantic impairment differently. The reaction time data suggest that although persons with aphasia, in general, are more anchored to the center of the semantic field than their healthy adult counterparts (Hough, 1993), those with more intact semantic systems seem to recognize the goal of ad-hoc (goal-directed) categories and use this as their anchor better than those with less intact semantic systems. Conversely, persons with aphasia with less intact semantic systems seem to anchor themselves to the center of well-defined categories, exhibiting longer reaction times for atypical members than their more semantically intact counterparts. The accuracy data suggest that a slower response does not necessarily predict an inaccurate response. However, because RT data are a better indicator of initial word processing than accuracy data, the remainder of the discussion will focus on the conclusions that can be made regarding the results of the RT data.

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As mentioned previously, ad-hoc categories have loose boundaries and are centered with a goal which acts as the ideal for the category. Some items may be more pertinent to achieving this goal than others and will cluster around the ideal. In an intact semantic system, seemingly random items will have different degrees of relation to an arbitrary goal, creating a typicality effect, which is what was observed in the healthy younger and older adults. Even though similarity versus rule-based categorization were not specifically being tested, the evidence would suggest that in this scenario, only a similarity-based system can be used because (depending on how arbitrary the goal is) there are no predetermined rules for categorization (Barsalou, 1983, 1985).

Persons with aphasia with more intact semantic systems show the same typicality effect in ad-hoc categories as healthy younger and older adults, suggesting that they use the same categorization process, or at least, that they are able to anchor themselves to the items that are best related to the goal. Conversely, persons with aphasia with less intact semantic systems do not show a significant typicality effect in ad-hoc categories. This difference between these two groups of patients can be seen very clearly in the typicality facilitation effects and the correlations between typicality and RT for ad-hoc categories (see Figure 3C). The distinction between items that relate to the goal very well and those that do not relate to this goal as well may not be as clear to persons with aphasia with less intact semantic systems.

Imagine each category as a 3D parabola in semantic space with the prototype or ideal at the central peak and atypical items at the periphery. The slope and radius of the parabola represent gradedness, with a shallow slope and large radius indicating greater gradation (e.g., ad-hoc categories) and a steeper slope and small radius indicating less gradation (e.g., well-defined categories). Although there are many ways of visualizing the semantic system, similar threshold-type models have been used to describe reading deficits in patients with deep dyslexia (NICE, Newton & Barry, 1997). In a patient with semantic impairment, the periphery of categories would become disrupted, functionally steepening the slope and shrinking the radius such that no category member appears to be more related to the goal than any other and a similarity-based strategy accepts all members as being equally related to the goal. Therefore, when dealing with tasks related to ad-hoc categories, LSI patients still benefit from the gradedness of these categories while MSI patients do not. This means that a naming treatment that involved the manipulation of typicality in ad-hoc categories could conceivably be more beneficial for LSI patients than for MSI patients.

In contrast to ad-hoc categories, well-defined categories have very strict boundaries and have an all-or-nothing type of membership, implying that a rule-based strategy is in play. However, as mentioned previously, both strategies can be active to different degrees depending on the gradedness of the representations in the category. Although neither group of healthy adults exhibited a strong typicality effect for well-defined categories in the RT data, this effect was significant in the accuracy data and showed up in the typicality facilitation effect (see Figure 3A). Persons with aphasia with more semantic impairment showed significantly faster RTs for typical than atypical members of well-defined categories, but LSI patients did not show this same typicality effect. This was evident in both the item analyses and the calculation of the typicality facilitation effect (see Figure 3B). Again, although not specifically testing similarity versus rule-based categorization, this finding may indicate that patients with less-intact semantic systems have a decreased capacity to use a rule-based strategy for categorization. Similarly, semantically impaired patients with dementia of the Alzheimer's type have been found to have a decreased capacity to use a rule-based strategy for categorization (Grossman, Robinson, Bernhardt, & Koenig, 2001). Without access to a rule-based strategy, these patients rely solely on a similarity-based strategy, resulting in a typicality effect. Going back to the 3D parabola, well-defined categories would not be as affected by disruption at the periphery, as the radii are small and the slopes are already quite steep.

Therefore, MSI patients benefit from the gradedness of well-defined categories, but LSI patients do not. This observation suggests that a naming treatment that involves the manipulation of typicality in well-defined categories could be more beneficial for MSI patients than for LSI patients. In a treatment study utilizing typicality as a form of complexity in well-defined categories (Kiran & Johnson, 2008), some evidence that training atypical items is more beneficial than training typical items was observed. The participant in whom this effect was observed had semantic scores that would place him in the MSI group; however, these results are tentative since this was a single case study. Additional probing into the combined effects of category type and typicality in treatment for naming deficits in aphasia is warranted.

Another interesting way to look at this data is as an access issue rather than a representational issue. In a recent study, Noonan, Jeffries, Corbett, and Lambon Ralph (2010) showed that the behavioral differences observed between persons with semantic dementia and semantically-impaired persons with aphasia (Jefferies & Lambon Ralph, 2006) are due to a deficit in executive control in the persons with aphasia. Through the use of systematically varied cues that increased or decreased executive demands, Noonan and colleagues showed that semantically-impaired persons with aphasia perform well when the executive demands are decreased. Specifically, when items were closely-related or when there was a cue for more distantly-related items, performance was better. When misleading cues were used, performance was worse. The authors argue that taken together, these results point toward a deficit in cognitive control in semantically-impaired persons with aphasia rather than a deficit in semantic representations. The results of the current study fit nicely within this framework, with the decrease in the typicality effect for ad-hoc categories and the increase in the typicality effect for well-defined categories being a result of a decrease in the executive control required to either apply the appropriate categorization strategy or utilize the typicality information as a cue. It could be argued that the differences observed between the LSI and MSI groups of patients are simply due to aphasia type and/or severity. Although semantic impairment, aphasia type, and aphasia severity are related, the patient demographics in this study refute this argument. As can be seen in Table 1, both MSI and LSI groups contain a variety of aphasia types and levels of severity. Additionally, even though aphasia severity could be argued to affect the semantic score, several exceptions to this logic are evident. For example, some patients with an AQ below the group average had a semantic score that was above the group average and some patients with an AQ above the group average had a semantic score that was below the group average. This pattern should not be surprising, since semantic impairment is only one facet of an array of language functions that are normally measured to determine aphasia type and severity. The idea that aphasia type and severity do not perfectly predict semantic impairment is important for the discussion of category representation and the typicality effect in aphasia; it suggests that specific measures of semantic impairment, rather than overall aphasia type, should guide interpretations of damage to the semantic system and consequent therapy protocol.

5. Conclusion

In conclusion, we have confirmed that ad-hoc categories are graded in nature and are subject to the typicality effect and that although some well-defined categories may be graded in nature, there is still much needed research into the nuances of this type of category. We have confirmed the finding of the typicality effect in ad-hoc categories in persons with aphasia and extended the finding of the typicality effect in well-defined categories to persons with aphasia. The resilience of the graded nature of categories after damage to language networks can be utilized in the treatment of aphasia. As has been shown in previous work (Kiran, 2008; Kiran & Thompson, 2003b), typicality is a form of complexity that can be used to facilitate generalization in word-retrieval treatment. This study provides evidence for extending this type of treatment to categories other than common or natural categories.

Some limitations in this study should be noted. First, the results of this study may have been affected by the small numbers of participants in each group. Although a total of 35 persons with aphasia participated in this study, they were divided into four experimental groups, which may have decreased the power of the statistical analyses. Second, the results of the ANCOVA should be interpreted with caution since the groups were nonrandomly assigned. Future work may wish to explore aphasia severity as a variable in a regression rather than a covariate. Third, the division of aphasic participants into more semantically impaired and less semantically impaired groups based on a composite semantic score of existing diagnostic tests is not perfect, but was the most appropriate for this study given the available diagnostic tests and the experimental task. In the future, we propose measures tailored specifically to the experimental tasks being performed that test the type of semantic processing and access required for the tasks in order to tease apart the factors contributing to semantic deficits in aphasia, how they relate to the structure of the semantic system in persons with aphasia, and consequently how this information can help uncover the nature of semantic processing in neurologically healthy persons. Certainly, more research into the gradedness of categories, especially well-defined categories, is warranted.

In summary, the typicality effect appears to pervade categories all along a continuum of gradedness, from very loosely bound categories (ad-hoc) to very strictly bound categories (well-defined). This effect is robust enough to remain even after damage to the semantic system. However, the degree of semantic impairment appears to modulate the typicality effect in persons with aphasia depending on the structure of the category. Future research should include a larger cohort of patients with a wider range of semantic impairment to confirm these preliminary results.

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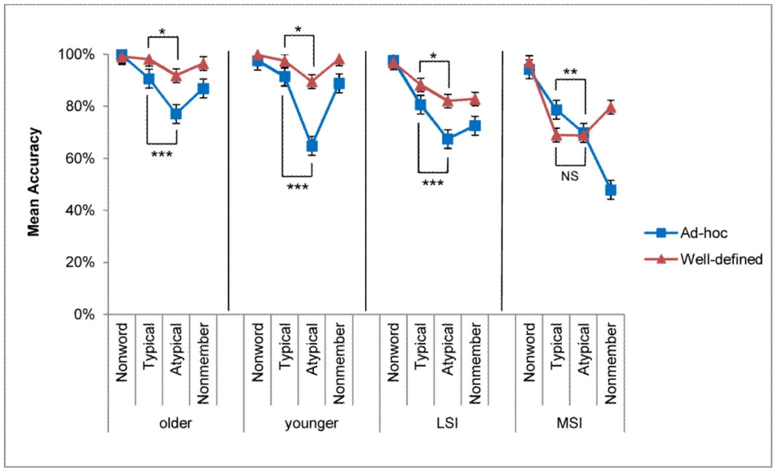

Figure 1.

Means and standard deviations for accuracy representing the significant three-way interaction from ANOVA between category type, group, and category.

The levels of category type are ad-hoc and well-defined. The levels of group are healthy older adult, healthy younger adult, MSI patient, and LSI patient. The levels of typicality are nonword, typical, atypical, and nonmember. Error bars represent standard error, ***$p < .001$, **$p < .01$, *$p < .05$, NS = not significant, MSI = more semantic impairment, LSI = less semantic impairment.

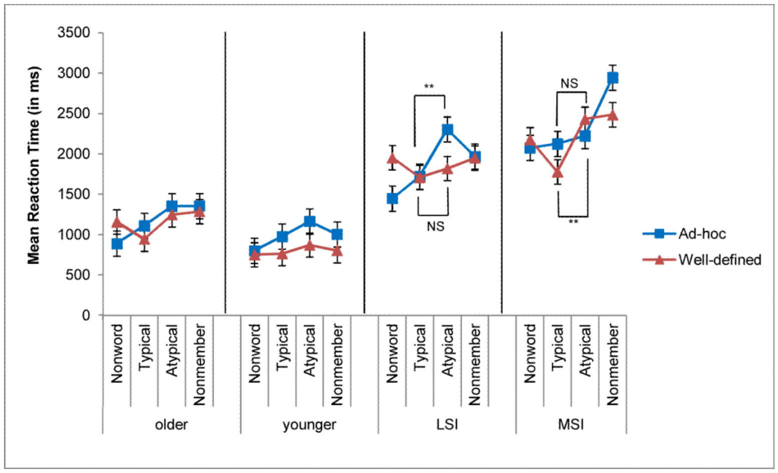

Figure 2.

Reaction time means and standard deviation for all groups for both category types and typicality condition.

The levels of category type are ad-hoc and well-defined. The levels of group are healthy older adult, healthy younger adult, MSI patient, and LSI patient. The levels of typicality are nonword, typical, atypical, and nonmember. Statistical data for patients was obtained from planned comparisons. Error bars represent standard error. MSI = more semantic impairment, LSI = less semantic impairment.

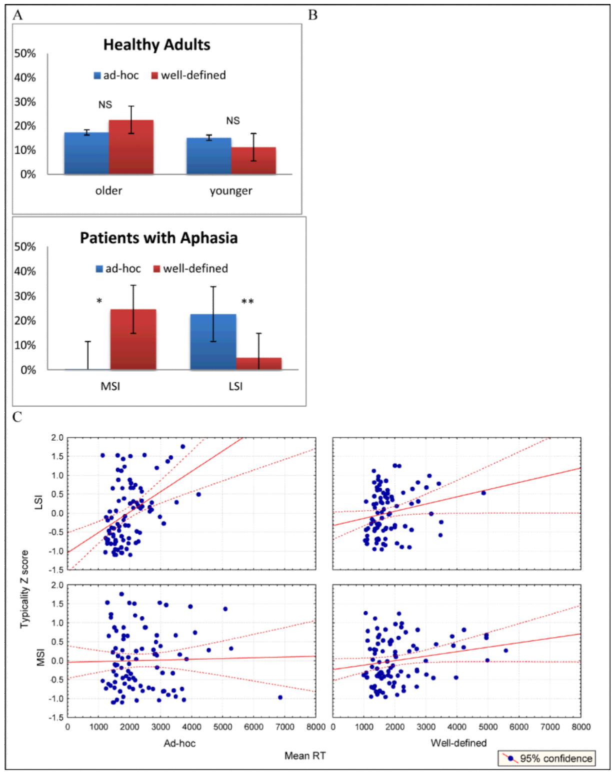

Figure 3.

Percent facilitation of typicality calculated from reaction time data for A) neurologically healthy groups and B) patient groups across category type and C) correlation between typicality and reaction time for patient groups.

Neurologically healthy groups consist of older and younger adults. Patient groups consist of MSI and LSI patients. Category types are ad-hoc and well-defined. See text for formula used to calculate typicality facilitation effect. For correlation, positive *Z* scores indicate atypical items and negative *Z* scores indicate typical items. Error bars represent standard error, $^{**}p < .01$, $^{*}p < .05$, NS = not significant, MSI = more semantic impairment, LSI = less semantic impairment.

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Table 1

Participant Information

	Participant	Group	Age	WAB AQ[a]	Aphasia Type[b]	PALPA-SWPM[c]	PALPA-WWPM[d]	PALPA-ASJ[e]	PALPA-WSJ[f]	Semantic Score
Ad-Hoc	AH01	LSI[g]	75	88.4	Anomic	100%	100%	93%	92%	96%
	AH02	LSI	74	84.3	Anomic	95%	100%	95%	87%	94%
	AH03	LSI	57	87.3	Anomic	98%	100%	82%	82%	90%
	AH06	LSI	73	84.6	Anomic	100%	100%	88%	93%	95%
	AH09	LSI	59	98.6	Anomic	100%	100%	97%	98%	99%
	AH10	LSI	77	79.0	Anomic	98%	100%	82%	100%	95%
	AH14	LSI	39	82.0	Anomic	100%	100%	85%	87%	93%
	AH17	LSI	76	86.7	Anomic	95%	100%	87%	92%	93%
	AH19	LSI	65	84.1	Anomic	100%	100%	90%	91%	95%
	AVERAGE		*66.11*	*86.11*		*98.33%*	*100.00%*	*88.71%*	*91.18%*	*94.56%*
	AH04	MSI[h]	56	88.6	Anomic	93%	93%	78%	85%	87%
	AH05	MSI	63	49.9	Broca's	93%	53%	80%	63%	72%
	AH07	MSI	57	74.7	Anomic	98%	88%	62%	90%	84%
	AH11	MSI	69	46.5	Wernicke's	85%	98%	58%	87%	82%
	AH12	MSI	46	46.8	Broca's	98%	98%	58%	32%	71%
	AH13	MSI	68	72.1	Conduction	95%	98%	60%	57%	77%
	AH15	MSI	70	97.8	Anomic	98%	95%	80%	80%	88%
	AH16	MSI	84	70.9	Conduction	90%	95%	65%	73%	81%
	AVERAGE		*64.07*	*77.23*		*96.05%*	*94.75%*	*77.50%*	*81.21%*	*87.38%*
Well-Defined	WD03	LSI	76	79.0	Conduction	100%	100%	88%	100%	97%
	WD04	LSI	63	82.9	TMA[i]	100%	100%	87%	88%	94%
	WD07	LSI	72	84.6	Anomic	100%	100%	88%	93%	95%
	WD08	LSI	52	92.1	Anomic	100%	100%	95%	98%	98%
	WD09	LSI	43	96.6	Anomic	100%	100%	98%	98%	99%
	WD10	LSI	62	60.0	Nonfluent	95%	100%	92%	90%	94%

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Participant	Group	Age	WAB AQ[a]	Aphasia Type[b]	PALPA-SWPM[c]	PALPA-WWPM[d]	PALPA-ASJ[e]	PALPA-WSJ[f]	Semantic Score
WD14	LSI	65	97.2	Anomic	98%	98%	93%	90%	95%
WD15	LSI	58	98.6	Anomic	100%	100%	97%	98%	99%
WD16	LSI	74	83.4	Anomic	98%	98%	93%	88%	94%
WD17	LSI	75	88.4	Anomic	100%	100%	93%	92%	96%
WD18	LSI	57	87.3	Anomic	98%	100%	82%	82%	90%
AVERAGE		*64.00*	*86.28*		*99.00%*	*99.50%*	*92.50%*	*93.67%*	*96.17%*
WD01	MSI	48	73.4	Nonfluent	98%	95%	77%	83%	88%
WD02	MSI	54	62.2	Fluent	68%	83%	65%	75%	73%
WD05	MSI	48	46.4	Nonfluent	85%	98%	67%	75%	81%
WD06	MSI	61	80.6	Nonfluent	98%	100%	78%	80%	89%
WD11	MSI	53	82.5	Anomic	98%	83%	83%	82%	86%
WD12	MSI	62	35.3	Global	85%	88%	37%	73%	71%
WD13	MSI	75	84.3	Anomic	95%	95%	67%	82%	85%
AVERAGE		*57.29*	*66.39*		*89.29%*	*91.43%*	*67.62%*	*78.57%*	*81.73%*

Note. Demographic information, aphasia severity, diagnosis, and selected PALPA (Psycholinguistic Assessments of Language Processing in Aphasia) subtest scores used to calculate the semantic score for the persons with aphasia who participated in the studies.

[a] WAB AQ = Western Aphasia Battery Aphasia Quotient,

[b] as determined from WAB scores,

[c] SWPM = spoken word to picture matching,

[d] WWPM = written word to picture matching,

[e] ASJ = auditory synonym judgment,

[f] WSJ = written synonym judgment,

[g] LSI = less semantic impairment,

[h] MSI = more semantic impairment,

[i] TMA = transcortical motor aphasia.

Table 2

Examples of word pairs for stimulus presentation

	Ad-hoc		Well-defined	
	Superordinate Label	**Target Item**	**Superordinate Label**	**Target Item**
Atypical Member	camping	boom box	shapes	prism
Typical Member	camping	tent	shapes	cube
Nonmember	camping	jet	shapes	guppy
Nonword	camping	alfs	shapes	teffs

Table 3

Reaction time and accuracy data for participants with aphasia

		Ad-hoc		Well-defined	
		Atypical Member	**Typical Member**	**Atypical Member**	**Typical Member**
Reaction Time	LSI[a]	2302.8 (841.7)	1719.5 (514.5)	1819.0 (372.1)	1709.5 (309.2)
	MSI[b]	2221.8 (1520.0)	2124.4 (1367.1)	2429.6 (786.2)	1777.5 (928.2)
Accuracy	LSI	67.5% (17.2%)	80.7% (11.3%)	82.1% (9.5%)	88.3% (13.1%)
	MSI	69.8% (27.6%)	78.7% (24.7%)	68.8% (16.3%)	69.0% (15.3%)

Note. Standard deviations in parentheses.

[a]LSI = less semantic impairment,

[b]MSI = more semantic impairment.