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Object and Action Picture Naming in Brain-damaged Persian Speakers with Aphasia

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Abstract

Background: Individuals with aphasia can be impaired in action and object naming and most typically are more impaired when naming actions than objects. However, it is not clear if effects of grammatical class are language-general as assumed by some theories of speech production.

Aims: We predicted greater impairments to action than object naming in persons with aphasia (PWA) in Persian. However, we expected any effect of grammatical class to be reduced when highly correlated variables are accounted for using generalized linear mixed-effects analysis.

Methods & Procedures: PWA (n = 57) were presented with pictured actions (n=80) and objects (n=100) rated by 100 Persian speakers in a preparatory study for psycholinguistic variables such as familiarity, age of acquisition (AoA), imageability, name agreement and visual complexity.

Outcomes & Results: 95% of PWA were more impaired on action naming than object naming. Rated AoA, name agreement, visual complexity and word length also significantly predicted naming accuracy for PWA and, there was an interaction between imageability and grammatical class such that imageability predicted object naming but not action naming.

Conclusions: The effect of grammatical class on picture naming for PWA in Persian might be accounted for by differences in psycholinguistic characteristics of actions and objects. Although we doubt an independent effect of grammatical class on naming in Persian, we acknowledge that psycholinguistic variables can have differential effects on action and object naming in aphasia. We offer an account of spoken word production in Persian that assumes a functionally common pathway for naming actions and objects with no obvious constraint given by grammatical class.

Key Words: Action naming, AoA, Imageability, Persian, Object naming

Introduction

Studies of acquired naming impairment have a long history in clinical neuropsychology (Goodglass, Kaplan, Weintraub, & Ackerman, 1976; Howard & Orchard-Lisle 1984; Kay & Ellis, 1987; Le Dorze & Nespoulous, 1989; Schwartz, Marin, & Saffran, 1979; Zingeser & Berndt, 1988). Studies focus on Indo-European languages including Italian, French, Spanish and to a less extent Dutch, German, Hungarian, Greek and Russian and results can be accommodated by extant models of speech production (e.g. Levelt, Roelofs, & Meyer, 1999; Kambanaros, 2008; Kambanaros & Grohmann, 2015). However, it is an open question if naming impairment in Persian, another Indo-European language with distinctive morpho-syntactic features, can also be accommodated by these models. The impact of damage to speech production in Persian aphasia is also not clear.

Cognitive models of speech production

Models of spoken word production assume spoken word production is a staged process starting from conceptual preparation and is completed by the execution of speech motor plans (Levelt et al., 1999). In the first stage of conceptual preparation, a speaker's intention leads to the construction of a discourse plan, which then activates early semantic concepts related to target words. For example, for the target cat, speakers will activate related concepts such as ANIMAL, HAIRY, DRINK MILK. In the next stage, selection of a target from the mental lexicon so called 'lemma selection' occurs (e.g. cat, dog, rat) in which the relevant morpho-syntactic properties are activated such as the affixation of grammatical gender, declension and tense (e.g. cat, cats). According to Levelt et al., (1999) the speaker has not accessed the phonological form (i.e. lexemes) of target words at this stage. Evidence for this assumption comes from aphasia patients who are not able to name a picture but who can detect grammatical features of a target word, thus confirming the existence of separate processes – morpho-syntactic processing and access to phonological form of a lexical concept (Badecker, Miozzo, & Zanuttini, 1995). Accordingly, one further assumption is that activation from preceding steps will be distributed into a separate step namely, 'word form or lexeme selection' during which phonemes and the stress pattern of targets are retrieved and syllabified (Levelt et al., 1999). Gestural motor planning and execution of word production using the articulatory motor system then follows. Other theorists argue against an amodal lemma processing stage responsible for semantic and syntactic processing (Caramazza, 1997) and assume instead a functional autonomy of the syntactic processing and lexico-semantic processing systems. It is also assumed the lemma stage is modality-specific and phonologically mediated in spoken production and orthographically mediated in written production. Evidence comes from dissociations during impaired word production for different grammatical classes i.e. verbs versus nouns or function words versus content words (for a review see Caramazza, 1997).

Studies of timed picture naming assume that psycholinguistic variables have an impact on picture naming latency at different stages, with each variable having an impact on at least one stage (Alario et al, 2004; though see Humphreys, Riddoch, & Quinlan, 1988, for a cascaded model of timed picture naming). Attributes such as image quality and complexity affect object identification and recognition (e.g. Humphreys et al., 1988; Snodgrass & Corwin, 1988). Another variable that is affecting visual recognition of the picture is image agreement i.e. judgments of similarity between a depicted image and its mental representation (Alario et al., 2004, Barry, Morrison, & Ellis, 1997; Ellis & Morisson, 1998). Rated familiarity and imageability are assumed to influence the stages of conceptual activation and rated age of acquisition (AoA) and word frequency are assumed to have an effect on lexical selection, whereas word length measured by the number of phonemes or syllables and phonetic features such as the initial phoneme characteristics have an impact on phonological output (Alario et al., 2004).Other than the aforementioned psycholinguistic variables, other variables such as morphology, argument structure, instrumentality and name relation (homophony) between an action and object name have important additional effects (see Barbieri, Basso, Frustaci, & Luzzatti, 2010; Jonkers & Bastiaanse, 2007; Kambanaros, 2009; Kambanaros & van Steenbrugge, 2006; Malyutina, Iskra, Sevan, & Dragoy, 2014; Park, Goral, Verkuilen, & Kempler, 2013;Parris & Weekes, 2001; 2006; Thompson, 2003).

Effects of grammatical class on speech production

Grammatical class has an effect on spoken word production in typical and brain impaired speakers (Kambanaros, 2008; Kambanaros & Grohmann, 2015; Kambanaros & Steenbrugge, 2006; Matzig, Druks, Masterson, & Vigliocco 2009). However, debate is ongoing about the effect of grammatical class on naming in aphasia (Luzzatti et al., 2002). Here we limit discussion to actions and objects as our study will not allow inferences beyond the semantic level of spoken word production e.g. morpho-syntactic features that constrain naming in aphasia, and refer the reader to Matzig et al. for a review of the voluminous literature. Some theorists claim that different morphological operations underlying nouns and verbs reflect an organizing property of lexical knowledge in the brain (Pulvermuller & Shtyrov, 2009; Shapiro, Moo, & Caramazza, 2006; Thompson, 2003; Thompson et al., 2007). Nouns (objects) and verbs (actions) also represent different morphological operations in Persian.

Others question whether effects of grammatical class reduce to a single level of linguistic representation (Black & Chiat, 2002; Kellenbach et al., 2002; Tyler, Russell, Fadili, & Moss, 2001) and argue that effects of correlated psycholinguistic properties of words such as rated age of acquisition (AoA), imageability and length can account for these effects (Matzig et al. 2009). In cases of PWA, the dissociated pattern of naming impairment disappears when effects of these variables are removed. However, in some cases superiority for action or object naming is preserved. Not all studies of PWA find evidence of grammaticality effects although when a case does show significant double dissociations in performance across task modalities e.g. nouns are named better than verbs in speech output but verbs are named better than nouns in writing, such observations have a significant impact on theoretical models of speech processing at the neural level (e.g. Hillis & Caramazza, 1995).

PWA in languages other than English show effects of grammatical class on spoken and written picture naming (Kambanaros & Weekes, 2012; Kong, Abutalebi, Lam, & Weekes, 2014). However, grammatical class effects are not always reliable when correlated variables are considered. Rodríguez-Ferreiro, Menéndez, Ribacoba, & Cuetos (2009) reported that grammatical class made no significant contribution to naming in Spanish speakers with aphasia if AoA and name agreement were partialled out of the regression model. Crepaldi, Che, Su and Luzzati (2012) using a mixed-effect analysis also reported a grammatical class effect for Chinese speakers with aphasia i.e. verbs were named more correctly than nouns but only for some items. A recent fMRI study found a modest effect of grammatical class in Persian speakers (Momenian, et al., 2016) i.e. activation in middle temporal gyri (bilaterally) and left fusiform gyrus for verb processing only. No study has investigated the reliability of grammatical class effects on action and object naming in Persian speakers with aphasia when predictors of action and object naming in typical and impaired Persian speakers are considered.

Linear mixed effect (LME) modeling is becoming standard in psycholinguistics (Bakhtiar & Weekes, 2015; Bakhtiar et al. 2016; Crepaldi et al., 2012; Van Assche, Duyck, Hartsuiker, & Diependaele, 2009). The modeling of item and participant factors as random effects increases generalizability by considering item-variability and subject-variability, allowing population level inferences to extend beyond limited numbers of participants and items in experiments including case series neuropsychological studies (Baayen, Davidson, & Bates, 2008; Bakhtiar et al. 2016).

Persian Language

Persian is an Indo-European language with an SOV word order. In Persian, verbs carry a rather complex morphology to express tense, aspect, mood, number and person. Verb generation is highly productive for simple and light verbs whereas noun generation is less. Light verbs are used with nouns, adjectives, adverbs, prepositions and prepositional phrases so that a compound verb or a light verb construction is synthesized (Mahootian, 2010). This process produces constructions with a completely new verbal meaning (e.g./be zæban aværdæn/, literally translated as “bring to the tongue”, and means “to say”). Unlike many languages which have simple verbs to be used instead of compounds, Persian does not have simple verbs that can replace light verb constructions (Family, 2014). Non-verbal elements always come first in the construction regardless of their category (see example 1). The verbal part of the construction is inflected to express information such as person and number, while pronominal clitics (PC) revealing the object of the verb can be conjoined to either verbal or non-verbal part of the construction (see examples 2 & 3). Light verb constructions are often quasi-compositional in Persian in that the meaning of individual constituents is different from the meaning of the whole. It is an open question whether these constructions are categorized as purely lexical or compositional in Persian and whether the element contributing to the whole construction is semantic or syntactic (Family, 2014).

1. /mæn dar-æm seda mi-kon-æm/ "I have-1S call -Duration-do-1S", "I am calling."

2. /mæn negah-kærd-am-esh/ "I watch-did-1S-3S. PC", "I watched it/him/her."

3./mæn negah-esh kærd-am/ "I watch-3S. PC-did-1S", "I watched it/him/her."

Very limited neuropsychological data is available on the production and comprehension of light verb constructions in Persian aphasia. The only study reporting data produced in aphasia comes from Nilipour and Raghibdoust (2001) who reported deficits with production of light verb constructions in 3 cases. One patient TB replaced non-verbal and verbal element with an empty word (the use of "thing" instead of the relevant element). Case AS replaced compound verbs with a verb similar in meaning ("broke" instead of "tore off") and substituted the verbal element with another verbal element. Due to scarcity of data on the production of light verb constructions in Persian, it is difficult to make predictions derived from a language production model, however.

Bakhtiar, et al. (2016) reported object naming for Persian speakers with aphasia. Mixed-effects logistic regression revealed AoA and frequency as well as imageability, image agreement and word length had significant effects on object naming, in addition to significant participant specific effects such as aphasia type (i.e. fluent better than non-fluent), age (younger the better), post-onset duration (i.e. longer the better) and education (higher the better). No study has compared the naming of actions and objects in Persian speakers with aphasia.

Study goals and hypotheses

Prior studies allow us to predict that objects would be named better than actions in PWA. This effect has been reported in many languages such as Chinese (Bates, Chen, Tzeng, Li, & Opie, 1991), Dutch (Jonkers, 1998), English (Kim & Thompson, 2000), Italian (Luzzatti et al., 2002) (see also Bastiaanse & Zonneveld, 2004).We expected action naming to be better than object naming for fluent PWA (Berndt, Haendiges, & Wosniak, 1997) and conversely nonfluent PWA to be better at naming objects than actions (Danielle, Giustolisi, Silveri, Colosimo, & Gainotti, 1994). Given that opposite effects for fluent and nonfluent PWA may cancel out any effects of grammatical class, we examined these effects separately for each group. We also expected, however, that grammatical class effects would be moderated when correlated variables are also considered using generalized linear mixed-effects analysis (LME) for each group. We isolated variables that are known to predict timed picture naming of objects in Persian including rated AoA, frequency, imageability, percentage name agreement, image agreement and number of phonemes (Bakhtiar et al., 2015). However, given unique properties of Persian verbs and lack of studies investigating action naming in PWA, we made no direct prediction about effects of psycholinguistic factors on action naming in Persian.

PART I: Normative Data Collection

Materials and Methods

Item Selection

In the process of adapting the Persian version of object and action naming battery (Nilipour, Pourshahbaz, & Momenian, 2015) several stages of screening were implemented in order to construct a set of normed objects and actions, which were culturally and linguistically familiar to our impaired and unimpaired Persian adult speakers. The first stage of the pilot study was to present all object pictures (162) and action pictures (100) from Druks and Masterson Battery (2000) to 10 healthy Persian speaking male and female adults and five linguists to eliminate culturally inappropriate pictures. The results were that 42 object pictures and 36 action pictures were judged as culturally unfamiliar for Persian speakers. In the second part of the preparatory phase, additional action pictures were taken from other resources viz. 31 pictures from the International Picture Naming project (Szekely et al., 2004). A set of 120 object and 95 action pictures were presented via computer screen to 50 healthy adult participants who were asked to name each item. In the final stage, further reduction of the set was performed based on criteria for name agreement of the stimuli. The cutoff points set for the selected objects and actions were 80% and 64% respectively based on name agreement. The final set comprised 100 objects and 80 actions.

The next stage of the preparatory study involved rating all items using the same method as Druks and Masterson (2000). The following criteria were used to select items for the ratings study: 1) a picture depicts a concept familiar to healthy Persian speaking adults in Iran as judged by experts; and 2) a picture has a Persian name used by typical adult Persian speakers in Iran. Items were initially selected by the first author. Each picture was presented on a computer screen to each healthy participant who was asked to (1) write down the name of each picture; (2) rate the imageability of each picture using a seven point rating scale indicating 1 for words arousing mental images with greatest difficulty and 7 indicating the words arousing mental images most readily; (3) rate the concept familiarity of each picture, defined as how often they were in contact with or thought about the object or action, using a 7-point rating scale in which 1 was defined as very unfamiliar and 7 as very familiar; (4) rate the visual complexity of each picture, defined as the number of lines in a picture (see also Snodgrass & Vanderwart, 1980) using a 7-point scale in which 1 indicated very simple and 7 indicated very complex; and (5) rate the estimated age of acquisition (AoA) of the name of each object and action using a 7 point scale (with 1 =0-2 years old;2=2-4 years old;3=4-6 years old; 4=6-8 years old; 5=8-10 years old; 6=10-12 and 7=13 years old or older). Word frequencies (per million) for objects and actions were extracted from a Persian corpus titled Peykare (Bijankhan, Sheykhzadegan, Bahrani, & Ghayoomi, 2011), which consists of 110 million words from written and spoken contemporary Persian texts. Summary statistics (mean values) of psycholinguistic variables for objects and actions are shown in Table1.

< Table 1 about here>

Survey Participants

As part of the preparatory stage, 50 unimpaired Persian speakers were invited to take part in the ratings survey (males: 32, females: 18; mean age = 29.58, SD = 11.87; mean education= 15.62, SD= 2.44).

Analysis of Survey Responses

To obtain correlations between variables, Spearman's rank correlation was used including grammatical class as a dichotomous variable (See Table 2). Correlations between grammatical class and psycholinguistic variables show that object stimuli have shorter names, higher frequency and familiarity values, higher name agreement and lower visual complexity compared to action stimuli. Furthermore, familiarity is significantly correlated with all variables (rated AoA, imageability, name agreement and visual complexity). Moreover, although there is a correlation between number of phonemes and number of syllables (r=0.93), the data in Table 1 show action names have more phonemes than object names. The difference in the number of phonemes and syllables in Persian stimuli can be understood from the following example:"mahi" (fish) →(syllable=2, phonemes=4) and "liz xordæn" (to slip)→ (syllable=3, phonemes=9). Diagnostic tests found high multicollinearity between variables, which justifies the use of LME as a regression model (Baayen, 2008). We removed familiarity, which correlates with nearly all variables and number of phonemes retaining number of syllables as our measure of word length. The means of all other variables were then centered in LME analysis. A follow up test showed collinearity between variables reduced after this preliminary treatment of data.

<Tables1 & 2 about here>

Part II: Predictors of Picture Naming in Persian

Materials and methods

Participants

Fifty seven native Persian speakers (Iranian nationals) took part in this phase of the study. None had participated in the preparatory study. All participants were diagnosed by an expert neurologist with aphasia with no evidence of dementia or depression following CVA and classified into two groups: fluent PWA (n=37) and nonfluent PWA (n=15) based on scores from the Aphasia Quotient and Fluency subtests taken from the Persian version of the WAB (Nilipour, Pourshahbaz, & Ghoreyshi, 2014) (see details in Table 3). Table 3 also describes the demographic information for the whole sample, which comprised 32 males and 25 females with average age of 56.07 (range: 18 to 78 years). Informed consent was confirmed before the study.

Procedure

One hundred object pictures and 80 action pictures were presented to each patient via a computer screen in two blocks in the same session. The patients had 10 seconds to name each picture; otherwise, the subsequent picture automatically appeared on screen. Before naming each block of pictures, participants were given a practice session. All pictures were presented based on their familiarity ratings starting from the most familiar to the least unfamiliar. We assigned 1 to correct responses and 0 for incorrect and null responses within time limits. Responses for light verb constructions (compound verbs) were marked correct only if a complete form of the verb (i.e. the non-verbal component together with its light verb component) was produced (see also Nilipour et al., 2015).

Results

Inspection of Table 3 shows objects were named better than actions for 95% of participants. This difference is significant by Wilcoxon signed rank test $V = 37$, $p < .0000$. However, as objects and actions have different psycholinguistic properties (see Table 1), an LME model was used to analyze performance using the lme4 package (https://cran.r-project.org/web/packages/lme4/) with R software (R Development Core Team, 2012). Mixed-effect models are preferable to the logistic regression models as they can consider the random effects imposed from item selection and participant sampling together with the effects of fixed variables defined here as predictors. Given the heterogeneity of PWA, mixed-effect models are more powerful as they accommodate variability across different participants (random intercept) and their sensitivity to different types of stimuli (random slope) (see Bakhtiar et al. 2016).

<Table 3 about here>

We tested different models to find the best fit for our data. We first entered all the fixed variables including grammatical class (binary) and centered psycholinguistic variables i.e. AoA, frequency, imageability, visual complexity, number of syllables and percent of name agreement (excluding familiarity and number of phonemes) as continuous variables and their interaction with grammatical class together with random intercepts of participants and items. Results found significant effects of AoA (increasing AoA reduces accuracy), visual complexity (higher visual complexity reduces accuracy), syllable number (increasing length reduces accuracy) and name agreement (lower name agreement reduces accuracy). There was no main effect of grammatical class (i.e. no significant difference between naming actions and objects) and no main effects of frequency and rated imageability. However, the interaction between grammatical class and imageability was significant showing that objects with higher imageability ratings were named more accurately than objects with lower imageability ratings but actions with higher imageability ratings were no different to actions with lower imageability ratings. There were no significant interactions between grammatical class and other variables. Figure 1 depicts significant effects of fixed variables and interactions between grammatical class and imageability on probability plots.

<Figure 1 about here>

Next, we removed non-significant variables and their interactions one by one and compared each model with the previous one using likelihood ratio test (LRT) to see if the new model explained additional variance significantly. Results showed no significant changes in model fit when word frequency and its interaction with grammatical class, was excluded $\chi^2(2)=0.17$, $p=0.92$ in the new model. Then, we excluded the other non-significant interactions based on the LRT. Results show that excluding the interaction between grammatical class and number of syllables, $\chi^2(1)=0.28$, $p=0.6$, and then excluding the interaction between grammatical class and percentage name agreement, $\chi^2(1)=0.12$, $p=0.73$, followed by excluding the interaction between grammatical class and visual complexity, $\chi^2(1)=0.71$, $p=0.4$ and finally exclusion of the interaction between grammatical class and AoA, $\chi^2(1)=3.4$, $p=0.07$, did not reduce model fit significantly. However, excluding the interaction between grammatical class and imageability did reduce the model fit significantly, $\chi^2(1)=8.0$, $p<0.01$. Therefore, we put forward a model including significant predictors i.e. number of syllables, percent name agreement, visual complexity and AoA and the interaction between grammatical class and imageability, which was highly significant ($p<0.01$).

Following the procedure recommended by Bakhtiar et al. (2016), we then tested whether inclusion of the random intercepts of participants and items was necessary to improve the model fit by comparing a model with random intercept of participants and items (model A) to a model with the random intercept of items only (model B) and a model with only random intercept of participants only (model C). LRT revealed a highly significant difference between models A and B, $\chi^2(1)=3373.00$, $p< 2.2 \times 10-16$, indicating that inclusion of random effect of participants was necessary to improve model fit. There was also a significant difference between models A and C, $\chi^2(1)=577.00$, $p< 2.2 \times 10-16$, justifying inclusion of the random effect of items as necessary to improve model fit. Then we tested if the by-participants random slopes for significant predictors significantly improved model fit. Results showed that adding by-participants random slopes for critical variables compared to a model with random intercept of participants and items improved model fit significantly i.e. number of syllables $\chi^2(2) = 21.60$, $p< 2.2 \times 10^{-5}$, percentage of name agreement $\chi^2(2) = 54.23$, $p< 1.68 \times 10^{-12}$, and visual complexity $\chi^2(2) = 26.5$, $p< 1.76 \times 10^{-6}$. However, adding by-participants random slopes for AoA did not improve model fit significantly $\chi^2(2) = 2.22$, $p= 0.33$ showing that the AoA effect per se is robust and consistent across different participants. Thus, we can assert with confidence that the later AoA of a name reliably reduces picture naming performance of all stimuli (actions and objects) for all participants. Also, AoA is the only variable that has a significant effect on naming that is not modified by differences in participant characteristics (e.g. fluent versus non-fluent). Finally, adding by-participant random slopes to other variables improved the model fit significantly. Therefore, in the final model we used random intercepts for participant and items and by-participant random slopes for number of syllables, percentage name agreement and visual complexity (see Table 4). Concordance (C)/Dxy is a measure of the goodness of fit for the final model with a Dxy value approaching 1 refers to perfect prediction of the model. We found a high correlation between the predicted model and observed responses and an acceptable fit C >0.8, Dxy=0.77 (Baayen, 2008).

<Table 4 about here>

To assess the confounding effect of fluency on performance, fluent PWA and non-fluent PWA were separated into two groups. Data from 5 patients without a diagnosis was removed. A separate mixed-effect analysis (using data for 52 patients) was used to test whether aphasia type had an effect on naming performance and whether there is any interaction between aphasia type and grammatical class. The results showed a trend for naming performance to be more impaired for nonfluent PWA than fluent PWA (b= -0.87, SE = 0.45, z= -1.931, p= 0.05) and a trend for an interaction between aphasia type and grammatical class i.e. nonfluent PWA named actions better than objects (b= -0.23, SE= 0.12, z=-1.87, p=0.06). Adding other demographic variables such as participant age and time post-diagnosis had no significant effects on naming accuracy. Therefore, we could exclude any significant effect of age related cognitive decline on naming performance.

In a post hoc analysis, we tested if verb type i.e. light verb versus simple verb construction and verb transitivity i.e. transitive verbs (n=37) versus intransitive verbs (n=43) predicted action naming performance using mixed-effect analysis. However, there was no significant difference between naming light verbs compared to simple verbs base on LRT $\chi^2(1)$=1.66, p=0.197. Moreover, there was no significant difference between naming the transitive versus intransitive verbs based on LRT $\chi^2(1)$=1.84, p=0.17. We further tested whether phonological neighborhood density would independently predict naming accuracy. However, given the limitation of the available corpora in terms of providing the phonological transcription of the words in Persian, calculation of phonological neighborhood density was only possible for object stimuli based on Flexicon corpus (www.dadegan.ir/catalog/flexicon). Therefore, we conducted a mixed-effect analysis to test the effect of phonological neighborhood density calculated as the mean of neighborhood token frequency for objects on object naming. There was no significant effect of phonological neighborhood density on the performance of object naming based on LRT $\chi^2(1)=0.96$, $p=0.33$.

Discussion

As predicted, object naming was better than action naming for most PWA in Persian with aphasia. We also expected that action naming might be better than object naming for fluent PWA (Berndt et al., 1997) and conversely nonfluent PWA to be better at naming objects than actions (Danielle et al., 1994). There was no evidence to support this expectation. The results showed a trend for an interaction between aphasia type and grammatical class in the opposite direction i.e. nonfluent PWA named actions better than objects. We found naming performance of nonfluent PWA to be very marginally more impaired than fluent PWA overall. Therefore, any differences in effects of grammatical class could be due to weaker naming in nonfluent PWA and does not support reliable dissociation between action and object naming in PWA in Persian. This outcome is in line with the conclusion of Momenian et al. (2016) for unimpaired Persian speakers. We, therefore, contend as they do that there is little evidence for an effect of grammatical class on the representation and processing of the mental lexicon in Persian at least when action and object naming is tested.

We expected any grammatical class effects to be moderated when correlated variables are considered using generalized linear mixed-effects analysis (LME). We found only rated AoA of a Persian word reliably predicted action and object naming in PWA (Bakhtiar et al., 2015). Although grammatical class or imageability alone did not predict naming performance in PWA, we found some evidence of a dissociation between grammatical class and imageability whereby objects with higher imageability were named better than objects with lower imageability ratings. This confirms the importance of imageability on object naming in Persian (Bakhtiar et al. 2016).

AoA was a robust predictor of naming as reported in Persian (Bakhtiar et al. 2016) and other languages such as Chinese (Law, Wong, Yeung, & Weekes, 2008), English (Kittredge, Dell, Verkuilen, & Schwartz, 2008) and Spanish (Cuetos, Aguado, Izura, & Ellis, 2002). However, other variables reported to impact on naming in aphasia were not at all significant when tested with the LME model. Crepaldi et al., (2012) used a mixed modeling approach and reported effects of frequency and imageability on picture naming for 20 Chinese speakers with aphasia and an interaction between grammatical class and morphological complexity. However, it is not clear if there was any interaction between imageability and grammatical class in their study. In fact, we found that rated imageability have some effect on object naming and not action naming contrasting with results from studies of PWA in English and Italian (e.g. Bird, Franklin, & Howard, 2000). We note that Bird et al., and others used a semi-factorial design. We, therefore, wonder if effects of imageability on action naming survive LME analysis. LME allows us to make the claim that rated imageability is a reliable predictor of object naming for Persian. The temporally more transient and less static nature of verbs compared to nouns may explain the null effect of imageability on action naming in Persian (Faroqi-shah & Waked, 2010).

Momenian et al. (2016) report few differences for verb and noun retrieval during covert sentence completion. Together with our findings, we find these surprising given the morpho-syntactic complexity of Persian grammar. We tested the grammatical complexity of verbs and found no effect of verb lightness and verb transitivity. Rodríguez-Ferreiro et al. (2009) reported that grammatical class had no significant effect on picture naming in Spanish speakers with aphasia, although significant effects of AoA and name agreement survived mixed modelling as we observed. Crepaldi, et al. (2012) reported a grammatical class effect for Chinese speakers with aphasia i.e. verbs were named better than nouns. We do not doubt dissociations between object and action naming may be found if demands are placed on morpho-syntactic processing. Nouns and verbs differ in their morphological operations as well as semantic and syntactic properties. Some theorists make the strong claim that morphological operations determine the organization of lexical knowledge in the brain (Pulvermuller & Shtyrov, 2009; Shapiro et al., 2006; Thompson, 2003; Thompson et al., 2007). Other authors, however, question whether the grammatical class effect can be reduced to a single level of linguistic representation, suggesting a combination of semantic, syntactic, morphological, and phonological constraints (Black & Chiat, 2002; Kellenbach, Wijers, Hovius, Mulder, & Mulder, 2002; Tyler et al., 2001). Our analysis revealed that PWA had comparable performance when naming simple versus light verb constructions. However, 70% of PWA reported in previous studies show a disadvantage in using light verbs compared to heavy verbs (i.e. semantically specific verbs) in narrative speech (for a review see Thorne & Faroqi-Shah, 2016). One conjecture for null differences here might be related to the scarcity of simple verbs (19) as actions versus the light verb constructions (61), which reflects the statistical properties of the Persian language. We acknowledge, however, that a different task e.g. story or sentence completion tasks and analysis of narrative language might be a better test of grammatical class effects. Specifically, naming the light verbs constructions and perhaps the transitive verbs in picture naming would be less demanding than naming them in natural contexts such as a narration of speech.

AoA and to a lesser extent name agreement seems to have a universal significance on timed picture naming across languages in impaired and unimpaired speakers (Alario et al., 2004; Bakhtiar et al. 2013; Bates et al., 2003; Juhasz, 2005). Our data support the view that rated AoA predicts naming performance for actions as well as objects in aphasia. We contend that AoA should be considered in models of spoken picture naming (for discussion see Juhasz, 2005).We also found that reported effect of word frequency on picture naming in aphasia did not survive LME (for a similar discussion on frequency effects see Bastiaanse, Wieling, & Wolthuis, 2015). One reason maybe that frequency measures are extracted from limited corpora. Word frequency measures are normally derived from written corpora (e.g. newspaper, magazine and etc.), which may not be an appropriate proxy for spoken word frequency (Cuetos, Rodríguez-Ferreiro, Sage, & Ellis, 2012).

In sum, we report fresh psycholinguistic norms for a set of action and object pictures that can be used for clinical and research purposes together with other sets of object pictures normalized in Persian (Bakhtiar et al., 2013; Ghasisin, Yadegari, Rahgozar, Nazari, & Rastegarianzade, 2015). Early acquired words compared to late acquired words are more resistant to acquired speech impairment. To the extent that actions and objects vary in their relative age of acquisition (as well as other psycholinguistic properties), we submit that studies of grammatical class effects in aphasia must exercise caution in the control of stimuli. We recommend mixed modeling and more specifically LME rather than semi-factorial designs. Effects of grammatical class on picture naming in Persian may be seen in more natural linguistic contexts with more morphological complexity. In fact, the infinitive form of a verb used to name a pictured action does not require the morphological features of aspect, person, tense and number in all languages and this reduces morphological load. Of note, Nilipour (2000) reported clear evidence that patients with aphasia replaced the infinitive for the inflected form of a verb in different spontaneous written contexts. Momenian et al. (2016) also reported minor dissociations between neural structures underpinning verbs and nouns in Persian when items were presented in a (silent) sentence reading context. Therefore, we predict that studies interrogating dissociation between object and action naming in Persian may be revealed in more natural syntactic contexts.

Conflict of interest

We have no conflict of interest to declare.

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Table1: Summary statistics of psycholinguistic variables for objects and actions

	Number	**Mean**	**SD**	**Min**	**Max**	**Skew**
Objects						
Phonemes	100	4.96	1.79	2.00	10.00	0.73
Syllables	100	1.92	0.84	1.00	4.00	0.56
LogFreq	100	2.09	0.90	0.00	4.42	-0.04
PNA	100	93.02	3.87	80.00	96.00	-1.62
Familiarity	100	6.31	0.36	5.33	6.83	-0.75
Age of acquisition	100	3.12	0.64	1.80	5.06	0.53
Imageability	100	5.63	0.45	4.36	6.50	-0.53

Actions						
Phonemes	80	9.80	2.52	6.00	17.00	0.61
Syllables	80	3.59	0.96	2.00	7.00	0.80
LogFreq	80	1.73	1.11	0.00	4.29	0.19
PNA	80	87.74	9.09	64.00	100.00	-0.92
Familiarity	80	5.77	0.51	4.41	6.56	-0.43
Age of acquisition	80	3.32	0.88	1.50	5.50	0.19
Imageability	80	5.52	0.62	4.40	6.88	0.17
Visual Complexity	80	2.44	0.69	1.38	5.55	1.30

Note: PNA= Percent of name agreement, LogFreq= Log (frequency+1)

Table 2.Correlation matrix (Spearman's rank) between predictor variables

	Phonemes	**Syllables**	**LogFreq**	**PNA**	**Fam**	**AoA**	**Ima**	**VC**
Syllables	0.93							
P	0.000							
LogFreq	-0.36	-0.31						
P	0.000	0.000						
PNA	-0.38	-0.32	0.18					
P	0.000	0.000	0.018					
Fam	-0.54	-0.47	0.41	0.67				
P	0.000	0.000	0.000	0.000				
AoA	0.22	0.18	-0.51	-0.25	-0.51			
P	0.003	0.016	0.000	0.001	0.000			
Ima	-0.15	-0.15	0.30	0.37	0.52	-0.58		
P	0.039	0.052	0.000	0.000	0.000	0.000		
VC	0.42	0.41	-0.20	-0.35	-0.63	0.30	-0.17	
P	0.000	0.000	0.007	0.000	0.000	0.000	0.026	
GC_OB	-0.77	-0.70	0.17	0.37	0.54	-0.12	0.12	-0.44
P	0.000	0.000	0.019	0.000	0.000	0.096	0.113	0.000

Note: PNA= Percent of name agreement, Fam= Familiarity, Ima = Imageability, VC= Visual complexity, GC= grammatical class, AoA= Age of acquisition, LogFreq= Log (1+frequency).

Table 3.Summary for demographic information and average naming accuracy of each patient.[2]

Subjects	Action naming	Object naming	Age	Gender	Education	PostOnset	Aphasia
1	0.40	0.42	48	M	16	20	NF
2	0.66	0.82	58	F	0	19	F
3	0.80	0.86	72	M	16	30	NF
4	0.81	0.87	58	M	-	14	NF
5	0.08	0.34	46	M	8	18	NF
6	0.26	0.12	56	M	12	110	NF
7	0.76	0.91	50	F	16	-	NF
8	0.79	0.99	34	F	14	45	NF
9	0.76	0.96	52	F	16	21	F
10	0.41	0.71	54	M	12	11	F
11	0.29	0.48	57	M	16	14	F
12	0.48	0.70	-	M	-	-	F
13	0.21	0.77	18	F	12	42	F
14	0.51	0.59	63	M	5	1	F
15	0.39	0.49	56	F	12	2	F
16	0.34	0.50	68	M	0	3	F
17	0.30	0.53	67	M	8	-	F
18	0.00	0.10	62	F	12	-	NF
19	0.00	0.20	70	M	0	1	-
20	0.00	0.06	56	F	5	6	-
21	0.25	0.36	54	F	5	6	-
22	0.55	0.86	58	F	8	4	F
23	0.29	0.60	-	M	3	48	F
24	0.59	0.68	29	M	12	3	F
25	0.79	0.82	22	F	16	86	F
26	0.24	0.23	22	M	12	28	NF
27	0.34	0.71	58	F	12	60	F
28	0.48	0.61	63	F	-	10	F
29	0.21	0.42	46	M	16	16	F
30	0.83	0.98	40	F	12	14	F
31	0.01	0.10	71	M	2	-	-
32	0.54	0.82	66	F	16	72	F
33	0.00	0.23	63	M	8	12	-
34	0.59	0.65	71	M	5	9	F
35	0.43	0.50	57	F	5	9	NF
36	0.70	0.80	72	F	6	16	F
37	0.66	0.82	53	F	12	3	F
38	0.70	0.91	70	F	5	1	F
39	0.54	0.57	52	F	0	7	NF
40	0.68	0.79	63	F	5	1	F

[2] The empty cells are missing values.

41	0.40	0.38	78	M	5	5	F
42	0.69	0.85	45	M	8	3	F
43	0.54	0.77	52	F	8	4	F
44	0.05	0.34	36	M	8	8	NF
45	0.31	0.50	68	M	0	3	NF
46	0.00	0.36	70	M	5	17	NF
47	0.48	0.51	77	M	5	1	F
48	0.84	0.92	47	M	8	1	F
49	0.34	0.35	63	M	0	4	F
50	0.66	0.92	69	M	0	2	F
51	0.23	0.32	75	M	0	1	F
52	0.75	0.92	49	F	5	6	F
53	1.00	0.99	48	M	22	1	F
54	0.24	0.40	68	M	12	10	F
55	0.88	0.97	51	F	14	9	F
56	0.71	0.84	62	F	5	2	NF
57	0.60	0.78	51	M	5	21	F

Table 4. Summary of mixed-effects models of naming accuracy in patients with aphasia in Persian

Fixed effects	Estimate	Std. error	Z value	P
(Intercept)	0.21615	0.2739	0.789	0.43
Syllables	-0.25507	0.07927	-3.218	0.0013
PNA	0.04135	0.01168	3.54	0.0004
AoA	-0.23111	0.11452	-2.018	0.0436
VC	-0.37614	0.14771	-2.546	0.0109
Imageability	0.08761	0.1855	0.472	0.6367
GC_OB	0.15644	0.19761	0.792	0.4286
Imageability*GC_OB	0.82283	0.28382	2.899	0.0037
Random effects	**Variance**	**Correlation**		
Items (Intercept)	0.682			
Subj (Intercept)	3.298			
Subj (*Syllables slope)*	0.026	0.49		
Subj (*PNA slope)*	0.001	0.35	-0.28	
Subj (*VC slope)*	0.077	-0.58	0.31	-0.2
Fit statistics	**Estimate**			
C (concordance)	0.88			
Dxy	0.77			
Log Likelihood	-4845			

Note: The fixed variables are centered. OB= Objects

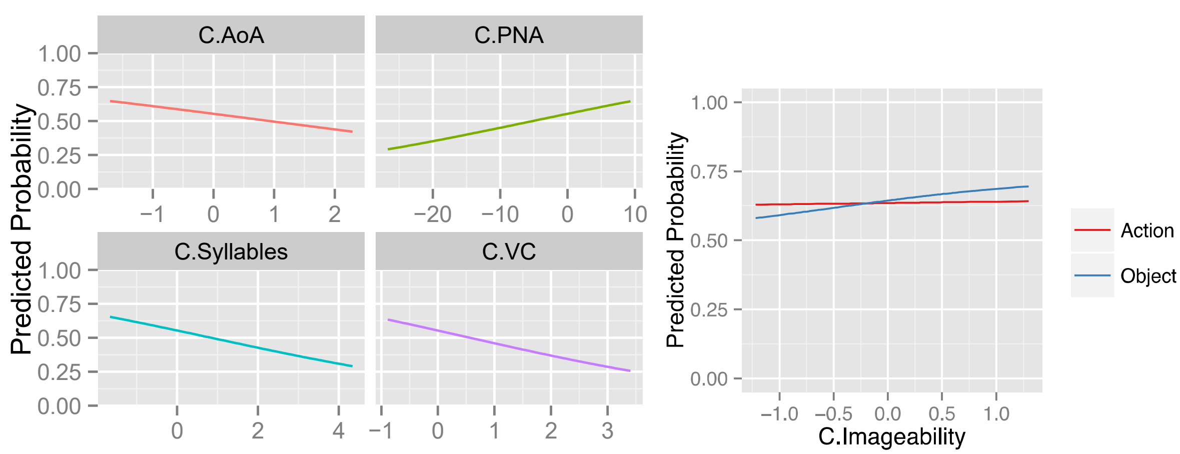

Figure1: Probability plots for the main effects and interaction effects of significant predictors on naming accuracy of patients with brain damage (Note: C.AoA= Centered Age of acquisition, C.PNA= Centered percentage of name agreement, C. Syllables= Centered number of syllables, C. VC= Centered visual complexity, C.Imageability= Centered Imageability).