

Research Article

Culture-Agnostic and Culture-Specific Analyses of Semantic Fluency in Korean and English Speakers With Alzheimer's Disease

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ABSTRACT

Purpose: This study investigated cross-linguistic and cultural influences on semantic fluency in monolingual Korean- and English-speaking individuals with Alzheimer's disease (AD) by contrasting culture-agnostic and culture-specific analytic frameworks. We focused on how culturally grounded schemas, such as the East Asian zodiac, shape clustering and switching patterns and on their associations with global cognition.

Method: We analyzed semantic fluency in 36 individuals with AD and 30 language-matched older adults using culture-agnostic and culture-specific frameworks. We examined total and first-response proportions of exemplars and compared clustering and switching patterns based on Troyer's taxonomy and a culture-specific scheme that included zodiac animals. All fluency measures were correlated with global cognition.

Results: In Korean-speaking individuals with AD, animal fluency was shaped by culture-specific schemas, with zodiac animals frequently produced early and in clusters. This pattern—marked by greater clustering—was unique to the Korean group and was not detected using culture-agnostic analyses, which showed no group differences. Only the Korean group showed positive correlations between fluency and Mini-Mental State Examination scores.

Conclusions: The present findings suggest that culturally grounded schemas may influence both word generation and the organization of clustering and switching in semantic fluency. In Korean-speaking individuals with AD, zodiac animals formed structured clusters and switches that uniquely correlated with global cognition, highlighting the need for culturally informed norms in cross-linguistic neuropsychological assessment.

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Semantic verbal fluency tasks are widely used measures of lexical retrieval that require individuals to generate words from a semantic category—most commonly animals—within a limited time (Henry & Crawford, 2004). As such,

these tasks are sensitive indicators of frontal lobe function and language-related retrieval processes across a range of neurogenic populations, including aphasia, traumatic brain injury, and Alzheimer's disease (AD; Henry & Crawford, 2004; Monsch et al., 1992; Rofes et al., 2017, 2019, 2020; Shao et al., 2014). Unlike confrontation naming tasks, such as the Boston Naming Test (Kaplan et al., 2001), which rely on predetermined pictorial stimuli and are therefore vulnerable to cultural familiarity with specific items (Ardila, 2020; Peña-Casanova et al., 2009), semantic verbal fluency tasks

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require participants to generate words without external stimulus presentation, relying instead on internally guided lexical retrieval. From a neurogenic communication disorder perspective, difficulties on verbal fluency tasks reflect both language impairment and executive function deficits (e.g., strategic search, cognitive control, mental flexibility) that support organized retrieval. In contrast, performance on confrontation naming tasks can be confounded by the culture-specific knowledge of pictorial stimuli (Kiran & Roberts, 2012; Sung et al., 2024, 2025).

Nevertheless, several studies have suggested that cultural factors should be considered when examining lexical retrieval processes in semantic fluency (Ardila, 2020; Villalobos et al., 2023). Performance in these tasks is shaped not only by cognitive resources but also by cultural and linguistic contexts, which influence lexical properties such as frequency and typicality (Sung et al., 2024). Words that are encountered more frequently in daily usage or judged as prototypical category members are more easily retrieved during fluency tasks (Almeida et al., 2007; Rosch et al., 1976). For example, Sung and Kim (2011) demonstrated that Korean speakers more frequently generated scallion as a typical vegetable, whereas English speakers more often produced celery and conversely regarded garlic as atypical. Together, these findings highlight that verbal fluency performance is determined by cognitive resources and reflects culturally mediated lexical experience (Sung et al., 2024).

Research on typicality in semantic fluency remains limited, with only a few studies examining cross-cultural differences in the extent to which exemplars are representative of their semantic categories (Castro et al., 2021; Park et al., 2014; Sung & Kim, 2011; Sung et al., 2014). In a recent large-scale category norms study, Castro et al. (2021) introduced two indices highlighting cultural and cognitive facets of typicality: (a) the total proportion of participants who produced a given item, reflecting how widely shared that exemplar is within a community, and (b) the first-response proportion, indexing how immediately accessible the exemplar is during retrieval. By capturing both the degree of community-wide consensus and the immediacy of lexical access, these indices enable a fine-grained interpretation of how exemplars represent the semantic knowledge of a given community. Their findings revealed substantial variation across age groups and cohorts, underscoring that “typical” exemplars are not static but dynamically shaped by cultural contexts across the lifespan.

Extending the investigation of cultural typicality, Sung et al. (2025) utilized a machine-learning technique—least absolute shrinkage and selection operator regression—to identify language-specific predictors of semantic fluency (e.g., animal category) performance among Korean- and English-speaking individuals with aphasia and healthy older

adults. Notably, all predictors that best characterized Korean participants with and without aphasia belonged to East Asian zodiac animals: 12 culturally salient animals (rat, ox, tiger, rabbit, dragon, snake, horse, goat, monkey, rooster, dog, pig) that structure the East Asian zodiac calendar and are deeply embedded in everyday communicative practices, such as calendrical references (e.g., age and birth-year labeling through zodiac animals). This finding underscores that culture-specific schema can dominate retrieval processes and shape the organization of semantic networks, even within a seemingly universal domain such as animals. In other words, zodiac animals function as a culture-bound semantic family nested within the broader animal category, illustrating how culturally shared knowledge can establish subcategory boundaries and bias retrieval patterns.

The structure of responses in semantic verbal fluency tasks is commonly characterized by semantic groupings, which are quantified using two principal measures—clustering and switching—that capture structural dynamics across words (Raskin et al., 1992; Troyer, 2000; Troyer et al., 1997). Clustering refers to the production of successive exemplars that belong to the same semantic subcategory, whereas switching denotes shifts between different subcategories (Troyer et al., 1997). A widely adopted framework is that of Troyer et al. (1997), which defined 22 animal subcategories based on habitat and taxonomic criteria (e.g., African animals, Australian animals, reptiles, amphibians). This framework is often regarded as culturally agnostic, as it relies on ecological and biological distinctions that may not align with everyday cultural experience. For example, when a participant produces “turtle, crocodile, and snake,” the system captures a coherent reptile cluster, reflecting taxonomic rather than culture-specific boundaries.

Within this traditional framework, clustering and switching behaviors have been shown to be sensitive to global cognitive status in neurodegenerative conditions. Prior studies have reported significant associations between global cognition and clustering- and switching-based indices, reflecting executive control and cognitive flexibility underlying efficient semantic retrieval (Henry & Crawford, 2004; Shao et al., 2014). For example, Lopes et al. (2009) reported strong positive correlations with clustering indices in Portuguese-speaking individuals with AD, while Cintoli et al. (2024) found that reduced cluster size and switching frequency predicted lower Mini-Mental State Examination (MMSE) scores in patients with amnesic mild cognitive impairment.

However, several studies in non-Western populations have raised concerns that habitat-based subcategories may fail to capture a culturally meaningful organization of animal concepts (Chung et al., 2014; Kim & Kim, 2012; Sa et al., 2011). Animals categorized as North American fauna, such

as raccoons or opossums, exemplify this limitation, as these species remain largely unfamiliar outside the United States, despite their systematic taxonomic classification. Through multidimensional scaling analyses, Sa et al. (2011) demonstrated that neurologically intact older Korean adults consistently organized animals into two primary dimensions—wild animals and domestic animals—irrespective of literacy or educational background, indicating that experiential familiarity rather than ecological or geographic taxonomy drives categorization patterns. These findings align with Yoo et al.'s (2025) proposal for clustering criteria adjusted for Korean semantic verbal fluency tasks, emphasizing the necessity of redefining subcategories to better reflect participants' experiential knowledge and cultural schemas.

Extending this perspective, Sung et al. (2025) introduced zodiac animals as a culturally salient subcategory for East Asian speakers, directly incorporating culture-specific knowledge into semantic fluency analyses. Comparing Korean- and English-speaking individuals with and without aphasia, they found that zodiac exemplars disproportionately structured the networks of Korean participants' vocabulary, with both Korean groups producing a higher proportion of zodiac animals compared with their English-speaking counterparts. Importantly, these cultural differences emerged even when the overall number of correct responses did not differ significantly between groups. Korean speakers, regardless of clinical status, consistently produced a higher proportion of zodiac animals, demonstrating that culturally embedded subcategories can dominate retrieval processes and qualitatively shape fluency performance. Their work provided novel evidence that cross-linguistic differences in semantic fluency cannot be understood without accounting for culturally grounded categories.

Previous studies, however, have documented the salience of zodiac animals among East Asian populations primarily through ratio-based measures of response frequency (e.g., Korean: Sung et al., 2025; Cantonese: Hui et al., 2023). While these findings underscore the cultural prominence of zodiac exemplars, they stop short of demonstrating how such responses influence the organizational patterns of semantic fluency. The present study extends this line of inquiry by employing clustering and switching analyses, thereby providing a more comprehensive account of how culturally embedded categories shape retrieval. In particular, extending the ratio-based analyses reported by Sung et al. (2025), we employ clustering and switching measures to examine the organizational structure of semantic fluency. We first evaluate word retrieval using the traditional clustering framework proposed by Troyer et al. (1997), which organizes responses based on taxonomic and habitat-based semantic relations. Because this framework does not incorporate culturally defined categories, it is treated here as "culturally agnostic." In contrast, the sequential production of zodiac animals (e.g., tiger, snake,

cow) represents a culturally salient feature, as these items are grouped through shared cultural knowledge rather than taxonomic or habitat-based relations. By explicitly contrasting culturally agnostic frameworks with culturally salient features, we test whether zodiac exemplars reorganize clustering and switching patterns in ways that extend beyond what traditional approaches can capture.

Accordingly, this study investigates cross-linguistic and cultural effects on semantic fluency by comparing Korean- and English-speaking individuals with AD. First, following Castro et al. (2021), we examine two indices—total proportion and first-response proportion—and hypothesize that Korean speakers will show higher proportions of zodiac exemplars than compared with English speakers. Second, we compare clustering and switching patterns derived from two analytic frameworks: Troyer's culture-agnostic taxonomy and a culture-specific scheme incorporating zodiac animals. We hypothesize that Korean speakers will form more culturally grounded clusters and exhibit more switches compared with English speakers, reflecting repeated transitions across zodiac-related subcategories. Finally, we examine whether fluency measures derived from each analytic framework show differential associations with global cognitive function. Given that culturally embedded category structures may shape clustering and switching behavior in Korean speakers, culture-specific indices (e.g., zodiac-based clustering and switching) may account for a greater proportion of variance in fluency performance compared with traditional indices in this group. Accordingly, associations between global cognitive status and fluency measures in Korean-AD participants may be more evident for culture-specific indices than for traditional clustering and switching metrics. By contrast, for English-speaking participants, for whom culture-specific categories such as the zodiac are less likely to be salient, fluency measures derived from the traditional framework are expected to provide a more appropriate characterization of the relationship between semantic fluency performance and global cognitive function.

Method

Participants

A total of 66 participants were included in this study: 36 individuals with AD and 30 neurologically intact older adults (OA). The AD group comprised 18 monolingual Korean speakers (Korean-AD) and 18 monolingual English speakers (English-AD). Data sources differed by language group: Korean participants were prospectively recruited for this study, whereas English-speaking participants' data were obtained from an existing database. Korean participants were clinically diagnosed with AD by neurologists according

to the criteria of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (McKhann et al., 1984). All Korean participants met the following inclusion criteria: classified as Stage 5 (moderate cognitive decline) on the Global Deterioration Scale and scored within the mild dementia range (11–23) on the Korean version of the MMSE (Kang, 2006). Exclusion criteria included uncorrected visual deficits; severe hearing impairments; and any history of neurological, psychiatric, or substance abuse disorders. All participants provided written informed consent prior to participation. This study was approved by the institutional review board of Ewha Womans University and was conducted in accordance with ethical research guidelines (Approval Nos. 2023-0213 and 2024-0056).

The 18 English-AD cases were obtained from the DementiaBank Pittsburgh Corpus (Becker et al., 1994), a component of the TalkBank repository (MacWhinney, 2007) supported by National Institutes of Health–National Institute on Deafness and Other Communication Disorders Grant R01-DC008524. Diagnoses in this data set were established in the early 1990s and relied primarily on MMSE (Folstein et al., 1975) scores and clinical judgment rather than on the standardized diagnostic criteria or biomarkers that are now widely applied (McKhann et al., 1984, 2011). Despite this limitation, the Pitt Corpus has been extensively employed in dementia research and has yielded replicable findings consistent with other AD cohorts (Forbes-McKay et al., 2005). Its open-access nature further makes it particularly valuable for cross-linguistic investigations such as the present study. The OA group, drawn from Sung et al. (2025), consisted of 15 English-speaking and 15 Korean-speaking individuals. Cross-linguistic comparisons showed that the Korean-OA and English-OA groups did not differ significantly in age ($p = .953$) or years of education ($p = .183$). Detailed demographic data for the OA group can be found in Table 1 on page 3 of Sung et al. (2025).

The AD groups were comparable in age ($p = .331$), sex ($p = .181$), and MMSE ($p = .647$) but differed in education ($p = .010$), which was higher in the English-AD group (see Table 1). Therefore, years of education was included as a covariate in all subsequent analyses.

Semantic Fluency Task

The semantic fluency task was administered individually to all participants in their native language, either Korean or English. Participants were instructed to verbally generate as many animal names as possible within a 60-s time frame, without repeating previously mentioned animals or including proper nouns such as personal or place names. No additional cues or prompts were provided if participants remained silent during the task.

Data Analyses

To examine response patterns in semantic fluency, we calculated two production-based indices: total proportion and first-response proportion, following Castro et al. (2021). Only correct responses were included; incorrect, nonanimal, repeated, and missing responses were excluded, and denominators were restricted to participants who produced at least one correct response. Total proportion was defined as the percentage of participants who produced a given item at least once, relative to the total number of participants in the group. For example, if six out of 18 Korean speakers produced “mouse” at least once, the total proportion for “mouse” was 33%. First-response proportion was defined as the proportion of participants who generated a given item as their initial response. For instance, if three out of 18 Korean speakers produced “dog” as their first response, the first-response proportion for “dog” was 16.7%.

For clustering and switching analyses, participants' responses were coded under two complementary frameworks. In the culture-agnostic analyses, clustering and switching were quantified using the Semantic Network and Fluency Utility (SNAFU; Zemla et al., 2020), which provides automated, reliability-enhanced scoring relative to traditional hand coding (Zemla & Austerweil, 2018, 2019). SNAFU implements a Troyer-based taxonomy (Troyer et al., 1997) to algorithmically identify semantic clusters and switches, thereby minimizing rater-dependent subjectivity and enhancing reproducibility. For each participant, three standard indices were derived: (a) total correct responses, defined as the number of valid animal names generated, excluding repetitions, nonanimal words, and ambiguous responses; (b) mean

Table 1. Demographic information for each language group.

Variable	Korean-AD ($n = 18$)	English-AD ($n = 18$)	t -test results
Age (years)	78.83 (7.94)	76.67 (4.91)	$t(34) = 0.984, p = .331$
Sex (female:male)	13:5	9:9	$t(34) = 1.364, p = .181$
Education (years)	5.75 (5.19)	9.38 (2.25)	$t(34) = 2.725, p = .010$
MMSE	17.44 (4.43)	18.11 (4.22)	$t(34) = -0.461, p = .647$

Note. Values are presented as mean (standard deviation). AD = Alzheimer's disease; MMSE = Mini-Mental State Examination.

cluster size, defined as the average number of consecutive words produced within the same semantic subcategory; and (c) switches, defined as the frequency of transitions from one semantic subcategory to another.

In the culture-specific analyses, following previous work (Sung et al., 2025), we treated the 12 East Asian zodiac animals (rat/mouse, ox/cow, tiger, rabbit, dragon, snake, horse, sheep, monkey, rooster/chicken, dog, pig) as a distinct semantic category. Three dependent variables were derived: (a) zodiac ratio, the proportion of zodiac animals relative to total correct responses; (b) zodiac switches, the frequency of transitions into or out of the zodiac category; and (c) mean zodiac cluster size, the average number of consecutive zodiac animals produced within a cluster.

For example, the responses “ox, horse, pig, dog, elephant, rabbit, rat, sheep” include a total of eight animal names. Among these, seven belong to the zodiac set (ox, horse, pig, dog, rabbit, rat, sheep), yielding a zodiac ratio of 0.875. Within this sequence, one zodiac switch occurred between two zodiac clusters (ox–dog and rabbit–sheep), resulting in a mean zodiac cluster size of 2.5 (each cluster size minus one; see Figure 1).

To assess interrater reliability for the culture-specific clustering and switching analyses, a randomly selected subset of approximately 20% of participants (three per language group) was independently coded by two trained raters following a predefined coding scheme. Prior to coding, raters were trained on the scoring criteria, and training samples were excluded from subsequent analyses. Results showed 100% agreement across all zodiac-based measures, indicating high interrater reliability.

Statistical Analyses

Prior to analysis, we examined the distribution of individual performance to identify potential outliers. No participants exceeded conventional thresholds (± 3 SDs from the group mean in total responses), and therefore, all participants were retained for analysis. Total proportion

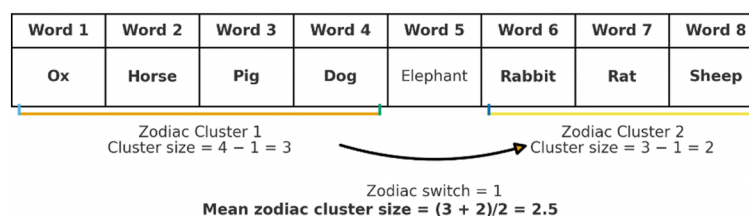
(the proportion of participants who produced an item at least once) and first-response proportion (the proportion who produced it as their initial response)—were then compared descriptively to illustrate cross-group differences in the distribution of salient exemplars.

For the clustering and switching analyses, generalized linear models (GLMs) were conducted to compare performance between the language groups (Korean vs. English) within each diagnostic group (OA and AD). Based on the distributional characteristics of the dependent variables, we employed specific model families: (a) negative binomial regression (with a log link) for count-based measures (total correct responses, switches, and zodiac switches) to account for potential overdispersion, (b) beta regression (with a logit link) for the proportional measure (zodiac ratio), and (c) Gaussian GLM (with an identity link) for continuous measures (mean cluster size and mean zodiac cluster size; see Supplemental Material S3).

For the OA group, the model included language as the main fixed effect. For the AD group, years of education was included as a covariate. To control for multiple comparisons across the variables, p values were adjusted using the false discovery rate (FDR) method. All statistical analyses were performed using R (Version 4.3.1) with the MASS (Modern Applied Statistics with S) and betareg packages. Full details of the model specifications and code are provided in Supplemental Materials S1 and S2.

Normality of dependent variables was assessed using the Shapiro–Wilk test alongside skewness and kurtosis. Several variables significantly deviated from normality: total correct responses ($p = .017$, skew = 1.09), mean cluster size ($p < .001$, skew = 1.76, kurtosis = 5.33), zodiac ratio ($p = .035$, skew = 0.72), zodiac switches ($p < .001$, skew = 1.35), and mean zodiac cluster size ($p = .003$, skew = 0.87). Although MMSE ($p = .090$) and NOS ($p = .085$) did not significantly violate normality, both exhibited bounded, noncontinuous distributions. Accordingly, Spearman rank correlations were used to assess their associations.

Figure 1. Example sequence of zodiac clusters based on culture-specific analyses in semantic verbal fluency responses. Cluster size was defined as the number of items within a semantic cluster minus one, following Troyer et al. (1997), such that a cluster requires at least two consecutive items.



Results

Response Proportions Between Language Groups

OA Group

For total proportion, in the Korean-OA group, the most frequently produced items were dog (86.7%), chicken (73.3%), and cow (73.3%). In the English-OA group, the most frequently produced items were cat (93.3%), dog (93.3%), and goat (53.3%). Among the 10 most frequently produced items, Korean-OA participants generated a greater number of zodiac exemplars, with six out of 10 items endorsed by at least 50% of participants. In contrast, English-OA participants produced only two out of 10 zodiac exemplars meeting this threshold. As illustrated in Figure 2, zodiac animals are shown in brown, emphasizing

the stronger cultural salience of zodiac-related items in the Korean-OA group compared with the English-OA group.

For first-response proportion, Korean-OA participants most frequently initiated their responses with tiger (53.3%), followed by crane (13.3%) and monkey (6.7%). Overall, 60.0% of first responses in the Korean-OA group consisted of zodiac animals (tiger, monkey), indicating a strong immediate accessibility of culturally salient exemplars. In the English-OA group, first responses were more distributed, with dog (33.3%), cat (20.0%), and cow (20.0%) being the most frequent. Among these, 53.3% of first responses were zodiac animals (dog, cow), while the remaining responses reflected globally prototypical or wildlife-related animals (see Table 2).

AD Group

For total proportion, in the Korean-speaking group, the most frequently mentioned responses, each endorsed by

Figure 2. Distribution of the 10 most frequently produced animal responses in semantic verbal fluency by language group in OA and AD. Percentages reflect the proportion of participants within each group who produced each item. OA = older adults; AD = Alzheimer's disease.

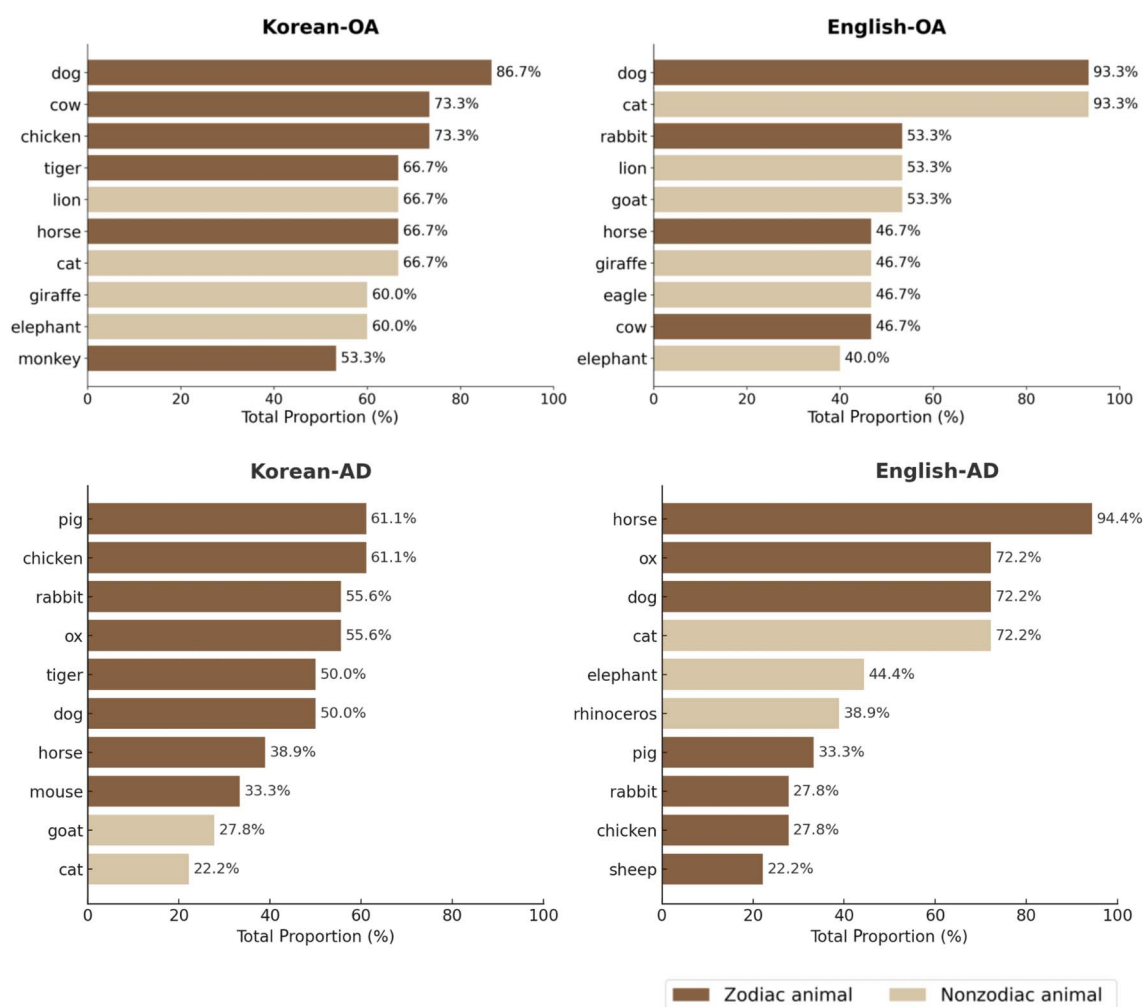


Table 2. First-response proportion in semantic verbal fluency responses by language group in older adults (OA) and Alzheimer's disease (AD).

Group	First-response proportion (% of participants)	% zodiac animals in first response
Korean-OA (<i>n</i> = 15)	Tiger: 53.3%, crane: 13.3%, monkey: 6.7%, stork: 6.7%, hye: 6.7%, sparrow: 6.7%	60.0% (tiger, monkey)
English-OA (<i>n</i> = 15)	Dog: 33.3%, cat: 20.0%, cow: 20.0%, giraffe: 6.7%, elephant: 6.7%, bear: 6.7%, chimp: 6.7%	53.3% (dog, cow)
Korean-AD (<i>n</i> = 18)	Dog: 16.7%, ox: 16.7%, tiger: 16.7%, pig: 11.1%, elephant: 11.1%, horse: 5.6%, monkey: 5.6%, mouse: 5.6%, rabbit: 5.6%, snake: 5.6%	88.9% (all except elephant)
English-AD (<i>n</i> = 18)	Dog: 33.3%, cat: 22.2%, ox: 22.2%, horse: 11.1%, elephant: 5.6%, rhinoceros: 5.6%	50.0% (dog, ox, horse)

at least 50% of participants, were chicken (61.1%), pig (61.1%), ox (55.6%), dog (50.0%), and tiger (50.0%; see Figure 2). In the English-speaking group, the most frequent responses meeting this threshold were horse (94.4%), cat (72.2%), dog (72.2%), and ox (72.2%). Among the 10 most frequently produced items, Korean participants generated a higher number of zodiac exemplars (eight items), endorsed by 77.8% of participants, indicating that zodiac animals accounted for a substantial portion of the shared response pool. In comparison, English participants produced fewer zodiac exemplars (six items: horse, dog, ox, pig, chicken, rabbit), endorsed by 66.7% of participants, with the remaining frequent responses consisting of globally prototypical animals such as cat, elephant, and rhinoceros.

For first-response proportion, Korean speakers most often initiated their responses with dog, tiger, or ox (each 16.7%), all of which are zodiac animals, with the exception of elephant (11.1%). In total, 88.9% of first responses were zodiac exemplars. By contrast, English speakers initiated their responses with six distinct animals—dog (33.3%), cat (22.2%), ox (22.2%), horse (11.1%), elephant (5.6%), and rhinoceros (5.6%)—of which 50% were zodiac animals (see Table 2).

Clustering and Switching Under Culture-Agnostic and Culture-Specific Analyses

Descriptive statistics for semantic verbal fluency performance in the OA and AD groups are presented in

Table 3. GLM results for culture-agnostic and culture-specific fluency measures comparing language groups within the OA and AD samples are summarized in Table 4.

OA Group

In culture-agnostic analyses, no significant language-group differences were observed in the total correct responses ($\beta = -0.149$, FDR-adjusted $p = .160$) or switches ($\beta = 0.208$, FDR-adjusted $p = .163$). However, a significant group difference emerged for mean cluster size, with the Korean-OA group showing smaller clusters compared with the English-OA group ($\beta = -0.643$, FDR-adjusted $p < .001$; see Table 3).

In culture-specific analyses, a robust language-group difference was observed for the zodiac ratio, with Korean-OA participants producing a significantly higher proportion of zodiac-related responses compared with English-OA participants ($\beta = 0.719$, FDR-adjusted $p = .002$; see Figure 3). No significant group differences were found for zodiac switches ($\beta = 0.244$, FDR-adjusted $p = .370$) or mean zodiac cluster size ($\beta = -0.163$, FDR-adjusted $p = .566$).

AD Group

In culture-agnostic analyses, no significant language-group differences were observed in total correct responses ($\beta = -0.016$, FDR-adjusted $p = .920$), switches ($\beta = -0.177$, FDR-adjusted $p = .495$), and mean cluster size ($\beta = 0.505$, FDR-adjusted $p = .066$). In contrast, culture-specific analyses showed significantly higher performance for the Korean-AD group

Table 3. Descriptive statistics for semantic verbal fluency task variables by language group in older adults (OA) and Alzheimer's disease (AD).

Variables	Korean-OA (<i>n</i> = 15)	English-OA (<i>n</i> = 15)	Korean-AD (<i>n</i> = 18)	English-AD (<i>n</i> = 18)
Culture-agnostic analyses				
Total correct responses	17.87 (5.77)	20.73 (4.04)	7.22 (3.38)	8.83 (4.94)
Switches	8.53 (3.27)	6.93 (2.55)	4.00 (2.68)	4.67 (3.27)
Mean cluster size	1.39 (0.18)	2.03 (0.40)	1.05 (0.50)	1.19 (0.95)
Culture-specific analyses				
Zodiac ratio	0.38 (0.15)	0.21 (0.08)	0.65 (0.20)	0.39 (0.13)
Zodiac switches	3.13 (1.36)	2.27 (1.10)	1.06 (0.87)	0.05 (0.24)
Mean zodiac cluster size	1.60 (0.99)	0.70 (0.65)	2.68 (1.60)	1.22 (0.94)

Note. Values are presented in mean (standard deviation).

Table 4. Generalized linear model results for culture-agnostic and culture-specific semantic verbal fluency measures by language group in older adults (OA) and Alzheimer's disease (AD).

Variable	Estimate (β)	SE	95% CI	z	Adj. p
1. OA group					
Total correct responses	−0.149	0.092	[−0.33, 0.03]	−1.61	.16
Switches	0.208	0.134	[−0.06, 0.47]	1.54	.163
Mean cluster size	−0.643	0.112	[−0.86, −0.42]	−5.74	< .001
Zodiac ratio	0.719	0.207	[0.31, 1.12]	3.48	.002
Zodiac switches	0.244	0.239	[−0.23, 0.71]	1.02	.37
Mean zodiac cluster size	−0.163	0.283	[−0.72, 0.39]	−0.58	.566
2. AD group					
Total correct responses	−0.016	0.16	[−0.33, 0.30]	−0.1	.92
Switches	−0.177	0.198	[−0.57, 0.21]	−0.9	.495
Mean cluster size	0.505	0.237	[0.04, 0.97]	2.13	.066
Zodiac ratio	1.052	0.297	[0.47, 1.63]	3.54	.002
Zodiac switches	0.612	0.355	[−0.08, 1.31]	1.72	.17
Mean zodiac cluster size	1.259	0.504	[0.27, 2.25]	2.5	.036

Note. Education was included as a covariate for the AD group. Adjusted p values (FDR) were corrected for multiple comparisons using the FDR procedure. Adj. = Adjusted; FDR = false discovery rate.

than for the English-AD group. Specifically, the Korean-AD participants showed a significantly higher zodiac ratio than did the English-AD group ($\beta = 1.052$, FDR-adjusted $p = .002$; see Figure 3). In addition, Korean-AD participants showed a significantly larger mean zodiac cluster size ($\beta = 1.259$, FDR-adjusted $p = .036$), even after controlling for education. No significant language-group differences were observed in zodiac switches ($\beta = 0.612$, FDR-adjusted $p = .17$).

Associations of Global Cognition With Fluency Measures in AD

Within the Korean-AD group, MMSE scores were significantly positively correlated only with the number of zodiac switches ($r = .670$, $p = .002$; see Figure 4). In contrast, no significant correlations were observed between MMSE scores and other fluency measures (all $ps > .05$). In the English-AD group, MMSE scores showed no significant associations with any fluency measures examined (all $ps > .05$). Complete scatter plots for all MMSE–fluency correlations are presented in Supplemental Materials S5 and S6, and Spearman correlations among semantic fluency measures and MMSE scores in AD groups are presented in Supplemental Material S4.

Discussion

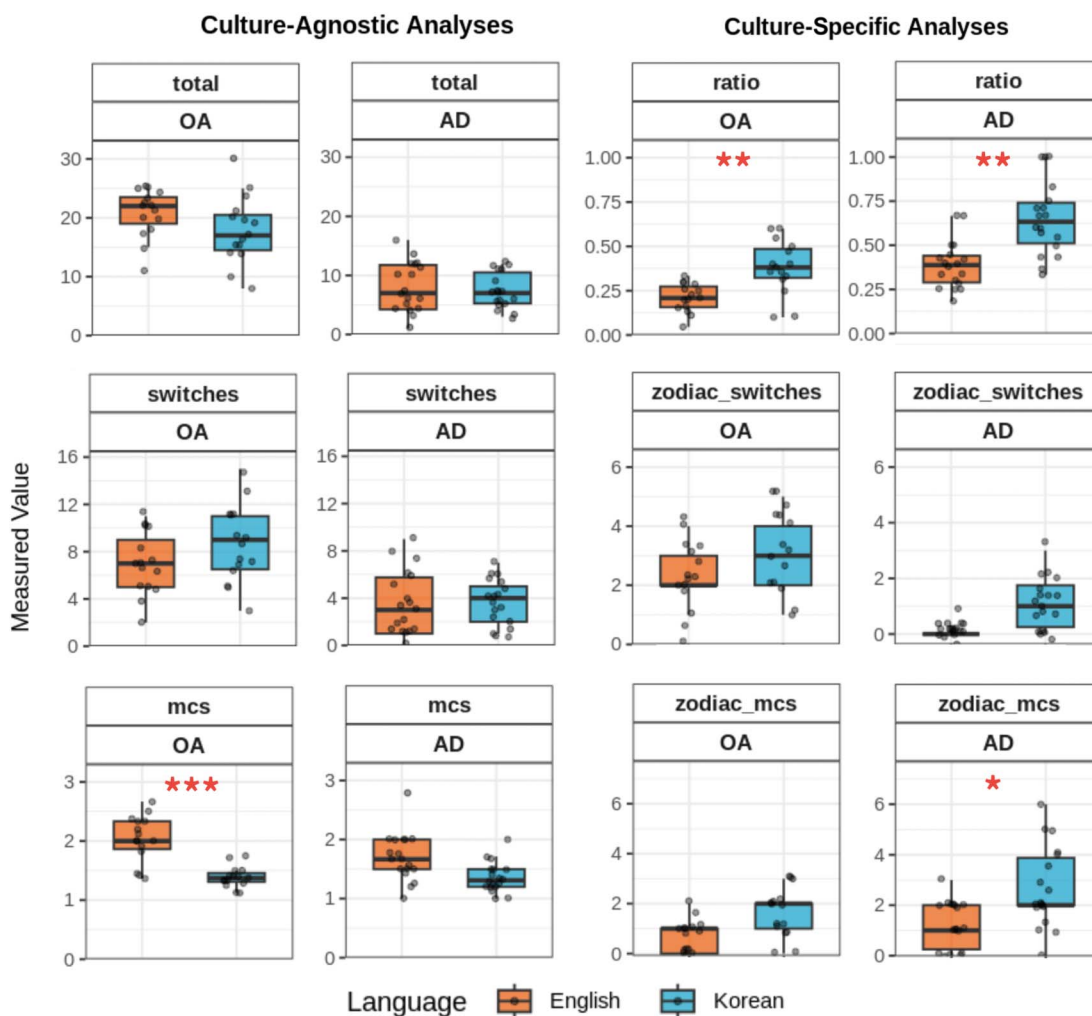
The present study investigated cross-linguistic and cultural influences on semantic fluency in Korean- and English-speaking individuals with and without AD by addressing three aims: (a) to compare the salience of animal exemplars between language groups, (b) to evaluate clustering and switching patterns under culture-agnostic versus culture-specific analytic

frameworks, and (c) to explore whether fluency indices derived from these frameworks relate differently to global cognitive function. Across analyses, Korean speakers showed a greater tendency to produce zodiac animals as salient exemplars, reflected in higher total and first-response proportions as well as increased clustering within a culture-specific framework. At the same time, under the culture-agnostic framework, the Korean-OA group exhibited significantly smaller mean cluster sizes than did the English-OA group. In addition, among Korean participants with AD, zodiac-based switching was modestly associated with MMSE scores, whereas no comparable associations were observed in the English-AD group. Together, these findings indicate that animal typicality is dynamically shaped by cultural context and that culturally embedded schemas not only structure semantic retrieval but may also relate to fluency performance and global cognitive functioning.

Cross-Linguistic Differences in Salient Animal Exemplars

As expected, in the analyses of total proportion, responses from Korean speakers tended to concentrate on zodiac animals across both the OA and AD groups. In the OA group, six of the 10 most frequently produced items by Korean speakers were zodiac exemplars, whereas only two such items met this threshold in the English-OA group. A similar pattern was observed in the AD group, such that all animals with a total proportion exceeding 30% in the Korean-AD group were zodiac exemplars, as compared with the English-AD group, in which only four of the seven zodiac animals produced exceeded the 30% threshold (see Figure 2). These findings indicate that culturally embedded animal typicality shapes semantic fluency performance in

Figure 3. Box plots comparing (A) culture-agnostic (total number of correct responses [total], number of switches [switches], mean cluster size [mcs]) and (B) cultural-specific analyses (zodiac ratio [ratio], zodiac switches [zodiac_switches], mean zodiac cluster size [zodiac_mcs]) in semantic verbal fluency responses between Korean- and English-speaking individuals with older adults (OA) and Alzheimer's disease (AD).



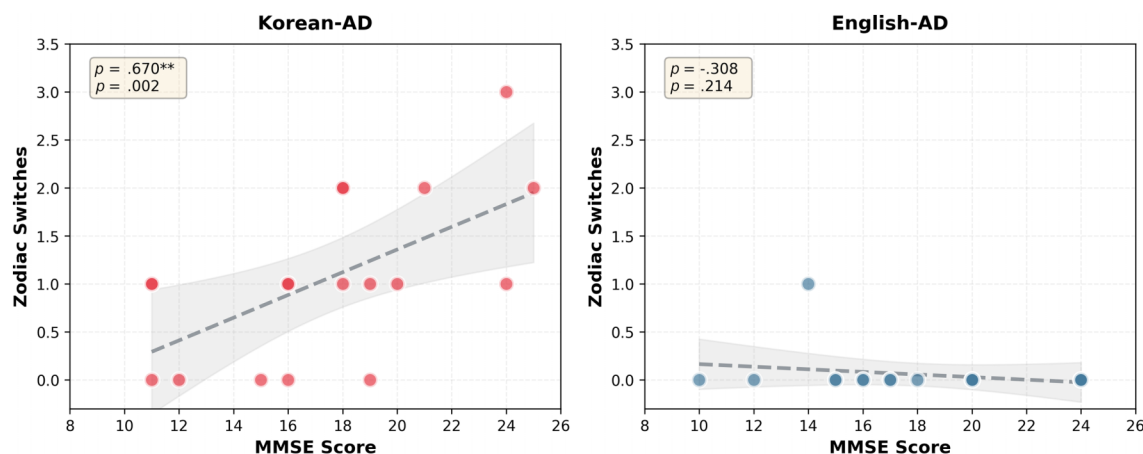
Korean speakers independently of disease status and that this cultural organization persists from normal aging into AD. Our findings parallel those of Sung et al. (2025), which reported that Korean participants—both healthy adults and individuals with aphasia—produced a narrower yet culturally coherent set of responses centered on zodiac animals, whereas English speakers drew on a more diverse semantic inventory. These converging results suggest that, in Korean contexts, culturally salient categories may play a more prominent role in structuring the semantic organization of animals, indicating that animal typicality is shaped, at least in part, by cultural context. This interpretation is further supported by Pekkala et al. (2009), which found that Finnish and English speakers, despite producing comparable total counts in an animal fluency task, diverged markedly in their subcategory preferences: Finnish speakers relied more heavily on farm and domestic animals (e.g., cow, horse, sheep, pig), whereas

English speakers more frequently retrieved zoo and wild animals (e.g., lion, elephant, giraffe).

First-Response Patterns and Cultural Salience at Retrieval Onset

A notable finding emerged from the analyses of first-response proportions—the percentage of participants who produced specific items as their initial response. Because first-produced items reflect the most strongly associated and readily accessible concepts, they index the exemplars most immediately activated within a given context (Castro et al., 2021). In the Korean-OA group, first responses were dominated by zodiac animals, most notably tiger (53.3%), with zodiac exemplars accounting for 60% of all initial responses. A more pronounced pattern was observed in the Korean-AD group, in which nearly all first responses consisted of zodiac animals, with elephant as

Figure 4. Scatter plots showing correlations between MMSE scores and zodiac switches in Korean-AD and English-AD groups. Dashed lines represent regression lines, and shaded areas indicate 95% confidence intervals. MMSE = Mini-Mental State Examination; AD = Alzheimer's disease.



the sole exception. This exception may reflect the cultural visibility of elephant in East Asian contexts, where it is frequently encountered through Buddhist symbolism and early educational materials, making it a highly familiar and readily accessible exemplar despite not belonging to the zodiac.

These patterns suggest that zodiac exemplars serve as highly accessible entry points to the animal category for Korean speakers across both healthy aging and AD. In contrast, first responses in the English-OA group were more distributed, with dog, cat, and cow being the most frequent initial items. Notably, approximately half of first responses in the English groups were also zodiac animals (e.g., dog, cow), which are also highly frequent exemplars in English. This overlap suggests that both culture and lexical frequency likely influence first response selection in both language groups, but their relative contributions may differ. The strong convergence on zodiac animals in Korean speakers—including less frequent exemplars such as tiger and rabbit—suggests that culturally salient categories may carry greater weight in shaping initial retrieval for Korean speakers, whereas first responses in English speakers may reflect a more frequency-dominant pattern. This contrast underscores the importance of considering culture when interpreting what constitutes a typical first response or a meaningful cluster in verbal fluency tasks. This contrast highlights how fluency tasks capture not only lexical-semantic processes but also the imprint of cultural and linguistic contexts, suggesting the need for culturally grounded norms in cross-linguistic neuropsychological assessment (Sung et al., 2025).

Culture-Agnostic Versus Culture-Specific Clustering and Switching Frameworks

Importantly, cross-linguistic differences in animal fluency became evident primarily when culture-specific criteria were applied. Under Troyer's taxonomy- and habitat-based

framework, Korean- and English-speaking participants showed largely comparable performance across groups. Specifically, no significant language-group differences were observed for total correct responses or switching in either the OA or AD groups, and mean cluster size differed only in the OA group, with Korean-OA participants forming smaller clusters compared with their English counterparts. Overall, these findings indicate that culture-agnostic metrics capture broadly similar retrieval patterns across languages, particularly in the AD group. This pattern aligns with previous cross-linguistic studies of semantic fluency that have focused on overall word production without examining clustering and switching patterns. For instance, Eng et al. (2019) reported no significant differences in animal fluency output between Mandarin- and English-speaking young adults. Acevedo et al. (2000) observed comparable performance between English and Spanish older adults on an animal fluency task, although differences emerged for other semantic categories such as vegetables—indicating that category type can lead to differential performance, depending on linguistic and cultural backgrounds.

In contrast, when culture-specific criteria were applied, clear language-group differences emerged. Beyond demonstrating that zodiac animals were frequently produced, the present findings show that these culturally salient exemplars also formed clusters during retrieval, particularly in the Korean-AD group, which exhibited larger zodiac cluster sizes than did the English-AD group. This result indicates that zodiac animals functioned not merely as frequent responses but as an internally coherent semantic grouping that shaped retrieval strategies within the animal category. Whereas prior studies documented zodiac salience among East Asian populations primarily in terms of response ratios (e.g., Korean: Sung et al., 2025; Cantonese: Hui et al., 2023), the present results extend this evidence to clustering-based

organization, indicating that culturally embedded schemas can influence not only what items are retrieved but also how semantic search is structured.

Associations Between Culture-Specific Fluency Measures and Global Cognition

Within the Korean-AD group, MMSE scores were significantly positively correlated only with the number of zodiac switches. This pattern is consistent with prior evidence suggesting that semantic fluency performance in AD is sensitive to executive control and cognitive flexibility, which support efficient switching between semantic categories (Henry & Crawford, 2004; Shao et al., 2014; Troyer et al., 1997). The observed association between MMSE and zodiac switching ($r = .670$) suggests that, in this group, culturally salient exemplars were not only accessed but also organized across multiple transitions, potentially reflecting the use of culture-specific organizational schemas during retrieval. These findings are consistent with prior reports indicating that culturally embedded categories may structure semantic search strategies in East Asian populations (Korean: Sung et al., 2025; Chinese: Hui et al., 2023).

In the English-AD group, no significant associations were observed between MMSE scores and fluency measures. Previous studies have reported links between global cognition and fluency indices in some populations: For example, Lopes et al. (2009) observed correlations with total responses and clustering measures in Portuguese-speaking individuals with dementia, and Cintoli et al. (2024) reported associations between clustering, switching, and the MMSE in amnesic mild cognitive impairment. The absence of significant MMSE–fluency correlations in the English-AD group may reflect several factors, including limited statistical power given the modest sample size ($N = 18$), reduced cognitive demand associated with zodiac categorization in a culturally less salient context, or the coarseness of the MMSE as a global cognitive measure. Importantly, this null finding should be interpreted as a failure to detect a relationship rather than evidence of no relationship.

What we further observed is that culture-specific influences on semantic fluency are not limited to aphasia (Sung et al., 2025) but were also evident in a neurodegenerative population with AD. The presence of similar patterns across two distinct clinical conditions—stroke-related language impairment and AD—suggests that cultural schemas may influence lexical retrieval across different etiologies. Importantly, while culture-agnostic scoring yielded relatively few cross-linguistic differences, culture-specific analyses (e.g., zodiac-based clustering and switching) revealed organizational patterns that were more pronounced in the Korean group. These findings indicate that semantic fluency performance is not solely determined by universal taxonomic structures, but it may also

shaped by culturally embedded schemas, even in the context of neurodegenerative decline. In the Korean group, positive associations between MMSE scores and switching indices further suggest that switching may remain an important cognitive resource in AD. Notably, these switches were often organized around zodiac-related clusters, raising the possibility that culturally familiar schemas can support retrieval strategies when lexical access is compromised. Together, these results extend prior observations in aphasia (Sung et al., 2025) and suggest that cultural influences on semantic organization may be observable across clinical populations.

The present findings suggest that patterns observed in semantic fluency tasks may benefit from interpretation that takes culturally shared retrieval strategies into account. In Korean speakers, the frequent production of zodiac animals likely reflects the use of culturally familiar semantic structures rather than atypical responding or reduced lexical capacity. Such responses may therefore provide insight into how semantic knowledge is organized and accessed within a cultural context, rather than indicating diminished task engagement or lexical diversity. In Korean-speaking individuals, clustering around zodiac animals may be indicative of relatively preserved semantic organization and strategic retrieval, even when overall fluency output is reduced. For example, a Korean-speaking individual with AD who produces a limited number of animal names but shows clear clustering within zodiac categories may retain access to culturally grounded semantic structures, potentially suggesting a less severe disruption of semantic organization than would be inferred from total output alone. In this context, supplementing standard fluency scoring with culture-specific analyses may help clinicians distinguish between semantic degradation and reliance on culturally familiar retrieval strategies, supporting a more nuanced interpretation of impairment severity.

Several considerations should be noted when interpreting the present findings. First, although the Korean-AD and English-AD groups were matched on age and global cognitive status (MMSE), some caution is warranted when interpreting direct comparisons between the two AD cohorts. The English-AD data were drawn from the DementiaBank corpus, a widely used legacy data set collected under earlier diagnostic standards, whereas the Korean-AD group was assessed using more recent clinical procedures. Such differences may partly reflect the use of legacy data sets alongside more recently assessed cohorts in cross-linguistic research. Although the inclusion of language-matched older adult control groups and comparable analytic pipelines strengthens the present design, interpretations of AD group differences should be made with appropriate caution regarding cross-cohort comparability. Second, cultural familiarity with zodiac animals was inferred at the group level based on language and cultural context, rather than assessed directly at

the individual level. In an English-speaking context—particularly within a multicultural society—some participants may have had varying degrees of exposure to East Asian cultural concepts, while others may have had none. This variability could have attenuated cross-group differences and adds uncertainty to individual-level interpretations. In addition, the overall sample size was modest, and the study did not include nonanimal control conditions (e.g., alternative semantic categories), which limits conclusions about the specificity of zodiac-related effects to the animal category. Taken together, these factors suggest that the present findings should be interpreted cautiously. Rather than providing definitive evidence of cultural effects, the results should be viewed as converging evidence that culturally shared semantic structures can shape fluency performance, even amid substantial cross-group variability. Future studies using larger, prospectively collected samples with harmonized diagnostic criteria, explicit assessment of cultural familiarity, and multiple semantic categories will be critical for establishing the robustness and generalizability of culture-related effects in semantic fluency.

Conclusions

The present study suggests that semantic fluency performance in AD is not determined solely by universal lexical–semantic structures, but it may also be influenced by culturally shared semantic schemas. Our findings highlight the importance of considering cultural context when interpreting semantic fluency performance in AD. Specifically, zodiac animals were frequently produced and clustered among Korean speakers, indicating that culturally salient categories can shape patterns of semantic retrieval. Moreover, the observed association between zodiac-based switching and global cognitive status in the Korean group suggests that culturally grounded retrieval strategies may be differentially engaged as cognitive impairment progresses. More broadly, these results illustrate how cross-linguistic approaches can inform the development of assessment frameworks that are sensitive to both linguistic structure and cultural context. Incorporating such perspectives may contribute to a more nuanced interpretation of semantic fluency performance and support the refinement of culturally informed evaluation paradigms in dementia research and clinical practice.

Author Contributions

Junyoung Shin: Conceptualization, Formal analysis, Writing – original draft. **Adolfo M. García:** Conceptualization, Writing – review & editing. **Michael Scimeca:** Formal analysis, Writing – review & editing. **Swathi Kiran:**

Writing – review & editing. **Jee Eun Sung:** Conceptualization, Writing – review & editing.

Data Availability Statement

The data sets generated and/or analyzed during the current study are available upon reasonable request to the corresponding author.

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