Review Article

Category Specificity, Alzheimer Disease and Normative Studies: A Review and Several Recent Instruments for Spanish Speakers

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Abstract

The study of category specific dissociations has enabled to postulate semantic knowledge has an internal structure that could depend on different neural substrates. Several studies have found that category/domain effects (i.e., a relative impairment of one semantic category/domain respect to the other) are present in patients with Alzheimer Disease. However, there is still some controversy about which semantic domain (living or nonliving things) is mainly affected or not by this selective damage. Some of these inconsistencies could be due to different methodological issues. Throughout this work some of them -such as the lack of control on nuisance variables or the consequences derived from ceiling effects- will be described. Our goal is to highlight the importance of conducting an adequate methodological control, in order to develop suitable assessment tools. Furthermore, we present different normative studies in Spanish that suitability face several methodological problems. It is our intention these works can be useful instruments for those interested in the study of the semantic processing and category specific deficits in Spanish language.

Keywords: Alzheimer's disease; Category effects; Living-Nonliving things; Normative studies

Introduction

Alzheimer´s disease (AD) is a progressive and degenerative disorder which affects memory, language, motor control, as well as executive functions [1]. At the neuroanatomical level, AD is characterized by the presence of tau neurofibrillary tangles and amyloid plaques in the central nervous system [2,3]. The strongest risk factor for AD is aging; it is estimated that by 2050, about 106 million people around the world could be affected by this disease [4].

One extensively studied issue in AD pathology is the disruption of long term memory systems. The seminal work by Tulving [5] established two types of (explicit) long term memory: episodic and semantic. Semantic memory (SM) is considered as "*an organized body of knowledge involving words, concepts, their meanings, their associations, and the rules for manipulating these symbols and concepts*" [6]. Although it has been long recognized that AD affects both memory subsystems [7], the present work will be focused on the semantic processing.

From a neuropsychological view, the study of the structure, organization and ulterior- impairment of SM has been guided by the category specific phenomenon. This has been discussed in terms of a functional or anatomical distinction between knowledge of living things (LT; e.g., fruits, vegetables or animals) and non-living things (NLT; e.g., vehicles, tools or buildings); with a relative impairment of the LT domain as the most commonly described profile in the literature [8,9]. The study of category specificity has a great theoretical significance, since it suggests that semantic knowledge has an internal structure, and, additionally, indicates that its components may depend on different neural substrates [10].

Category specific deficits have been mostly reported in focal pathologies, such as traumatic head injury [11] or herpes simplex encephalitis [12]. In addition, they have been also described in people suffering diffuse brain damage [e.g., in patients with AD; [13]]. However, the presence of categorical impairment in AD remains unclear and several studies are inconsistent regarding whether these deficits are present or not in these patients [14]. Thus, while some researches stated that AD patients show a selective deficit in the processing of LT items [15,16], others have described impairments of both domains [17]; additionally, several works have found no category effects in AD patients [7,18].

Several of these inconsistencies could be attributed to different causes: the type of task administered the inclusion or exclusion of problematic categories or the image format of the items utilized. Ulterior methodological problems, such as a lack of control on nuisance variables (NV), or the presence of ceiling effects in healthy participants, can be also mentioned as potential causes of disagreement. A description of these points is hereby provided.

Nuisance variables

It has been demonstrated that NV play an important role in predicting naming accuracy and on the living-nonliving thing dissociations [19]. Age of acquisition [AoA; [20]], familiarity [11], manipulability [21], name agreement [22], typicality [23], visual complexity [24], and word frequency of the items [25], are some of the NV most commonly studied. As a rule, LT items used to be harder to process than NLT items because they present lower AoA, manipulability, name agreement, typicality and word frequency; on the contrary, LT items used to have higher visual complexity. Since

the ratio of LT to NLT disorders has been estimated at 5:1 [9,26], the higher prevalence of deficits in LT could be at least partially explained by a lack (or no appropriated) control of NV [27].

Thus, several studies have found that the disproportionate deficit in the processing of LT disappeared once the items were carefully controlled in NV across domains [18]. Nevertheless, it must be considered that others authors have continued reporting LT impairments after a careful control of NV [28]. In addition, recent works with AD patients have highlighted NV are better predictors of longitudinal deterioration than the semantic domain of the items [i.e., LT/NLT; [29]]; this is true both in picture naming [30] and in verbal fluency tasks as well [19].

Ceiling effects

The occurrence of ceiling effects in healthy participants is closely related to the fact their level of performance is close to 100% of accuracy in some tasks. Accordingly, is not unusual that data gathered from AD patients have been compared with those from controls performing at or near to ceiling [31]. This could have produced spurious results i.e., masking the presence of category effects in controls especially in studies on category specificity [32].

In an attempt to control for ceiling effects and additionally, to optimize the reliability of the results, several authors have increased the difficulty of the tasks; for example, by using low frequency items [33,34]. In others studies, more semantic categories than the six (more) commonly used to evaluate patients (i.e., animals, fruits and vegetables for LT and tools vehicles and furniture, for NLT) have been also considered [35]. In recent studies, not only the number of categories, but also the number of items included in each one has been progressively increased to optimize the reliability of the results [36,37].

Atypical categories, differences in manipulability and "true" semantic domains

As aforementioned, the vast majority of the studies have used the categories of animals, fruits and vegetables for evaluating the LT domain, and tools, vehicles and furniture for assessing the NLT domain [8,38]. However, there are two categories involved in theoretical controversy: body parts and musical instruments [8]. It is reasonable to consider that body parts belong to the LT domain; likewise, apparently musical instruments belong to the NLT domain. Nevertheless, in terms of damage, different studies have observed that both categories fall within the opposite domain [8]. That is, body parts used to fall within NLT domain and musical instruments within LT domain. This controversy has done different studies have excluded these two categories from their observations [39].

Other important topic into the category specific arena has been remarked by Caramazza and co-workers [27,40]. This group of authors has proposed the existence of three "true" semantic domains: Animals, Plant life and Tools. According to this, evolutionary pressures would have led to domain-specific organization of conceptual system. Thus, a semantic structure with plants (source of food and medicine), animals (potential predators and additional sources of food) and tools (manufactured according to different functional purposes) are represented in separate (potentially independent) systems. Accordingly, the only pure category/domain specific impairment will

involve these three domains; although, it is possible body parts can also own a separate domain [40].

Additionally, it has been observed dissociations between small manipulable objects (e.g., tools), and large outdoor objects [e.g., buildings; [41]]. Thus, clear differences in terms of grasping can be observed between, e.g., a saw and a house. Indeed, it has been reported that the manipulability of one object is a variable which impacts on its identification [21]. In order to investigate this topic, is advisable studies include categories and items varying in grasping/ manipulability [38]. Additionally, it seems reasonable that "atypical" categories (i.e., body parts and musical instruments) are not excluded from but included in the studies, in order to elucidate their specific role on category specific effects.

Format of the items utilized

As stated by Laws and collaborators [14], many studies on category specificity in AD have used the corpus of items by Snodgrass and Vanderwart [42]. These simple line drawings of 260 familiar everyday LT/NLT objects have been a useful tool extensively used by studies examining language memory and object processing. Nonetheless, the ecological validity of the mentioned items has been recently questioned [43]. In addition, due to their simplicity for example, to be named for healthy participants the mentioned corpus has been also associated with problems derived from ceiling effects [9]. Thus, the number of works using colored stimuli (e.g. color photographs) has been progressively increasing [35-37,44]. In addition, color stimuli allow, for example, working with categories of theoretical significance, which are difficult to be represented by using line-drawings [e.g., different types of trees or insects; [27,45]].

Type of tasks utilized

The picture naming task has been the most extensively used, and, sometimes, the only one to report category specific effects [31,37,46]; this is clearly related to the fact anomia is one of the earliest hallmarks for many neurological pathologies. However, the presence of "paradoxical dissociations", where a patient can show impairment of one domain on one task (e.g. naming to description), and the reverse pattern on another domain (e.g. semantic fluency), suggests that the direction of category effects could depend on the task performed by the subjects [12]. Thus, it is interesting to use different tasks, in order to increase inter-task consistency; as well as to corroborate the ulterior presence of category effects in tasks other than picture naming [47,48].

Semantic Batteries: Fitness for Use

One of the best strategies for studying category specificity is utilizing semantic batteries [38,49,50,51]. These instruments own important characteristics, such as using the same items presented under different modalities [i.e., visual vs. verbal; [38,51]]. Certainly, the development of a useful neuropsychological tool focused on evaluating semantic knowledge should critically consider the aforementioned theoretical points.

Consequently, one basic factor should be the inclusion of a sufficient number of color images belonging to a wide range of categories; categories with theoretical interest should be also included; thus, body parts and musical instruments have to be considered in

Figure 1: Examples of items of the Nombela Naming Test. (Moreno-Martínez, Montoro & Laws, 2011).

order to clarify their role into living-nonliving thing dissociations; on the other hand, categories such as trees, flowers or insects [27,45]; and NLT which varying in their degree of manipulability [52,53] must be also taken into account. It is also particularly important that items from LT and NLT are closely matched across domain in all the NV knowing to affect semantic processing. Furthermore, the selected items should make difficult healthy people get ceiling effects.

Additionally, the norms on the items (e.g., those from NV) should be gathered from the target population who will be assessed (e.g. young vs. old participants; Spanish vs. French). It is worth considering that several studies in the field have no contemplated this aspect. For example, the Snodgrass and Vanderwart corpus [42] were exclusively designed for American population and, thereby, is likely their cultural characteristics are not directly applicable to other populations [54].

In this context, our group has conducted several normative studies both with pictorial and verbal material focused on Spanish population. This theoretically derived material faces the aforementioned issues and is described hereafter.

Pictorial material

A set of 112 visual items

Moreno-Martínez and Peraita [54] presented a set of 112 items with norms of several NV gathered from a group of elderly Spaniards; this was one of the main novelties of the study, because it should be emphasized many normative studies have been conducted with young students.

The authors selected 14 semantic categories for theoretical and methodologically significant reasons. They included problematic/ atypical categories, such as body parts and musical instruments [55,56]; plant life categories, such as flowers, fruits, trees and vegetables [27] as well as categories differing in their degree of manipulability, such as buildings, kitchen utensils or tools [52]. Seven categories from

the LT domain (animals, body parts, insects, flowers, fruits, trees and vegetables); and seven from the NLT domain (buildings, clothing, furniture, kitchen utensils, musical instruments, tools and vehicles) were included. Subsequently, a set of fifty-six visual stimuli (color photographs) for each of the two domains was selected; photographs for each item were obtained by one of the authors (FJMM) who photographed several items; the remainders were obtained via online sources.

This study gathered norms from AoA, familiarity, manipulability, name agreement and visual complexity; lexical frequency and typicality indexes, from other Spanish studies, were also provided. Concerning validity, the study showed high NV correlations with previous normative works that used color as well as black and white images [42,57,58,59,60]; this means the study shows high convergent validity with other databases. High rates of reliability were found among the NV: Cronbach's alpha coefficients ranged between .83 (name agreement) to .98 (visual complexity and familiarity). In addition, differences in categorical processing with respect to gender were observed: women showed higher ratings for familiarity and manipulability (LT); and with visual complexity (NLT).

A set of 140 visual items: the Nombela naming test

Moreno-Martínez, Montoro et al. [37] Presented the Nombela Naming Test, a set of 140 color visual stimuli. The aim of this study was twofold, (i) to present the items providing different difficulty levels with the objective of avoiding problems relate to ceiling effects; (ii) to provide standards from a group of healthy controls in seven psycholinguistic variables: AoA, familiarity, manipulability, name agreement, typicality, visual complexity, plus lexical frequency indexes derived from internet search hits. Differently to the previously described stimuli set [54], the stimuli by Moreno-Martínez, Montoro et al. [37] were located on a white background to avoid possible influence of context (Figure 1).
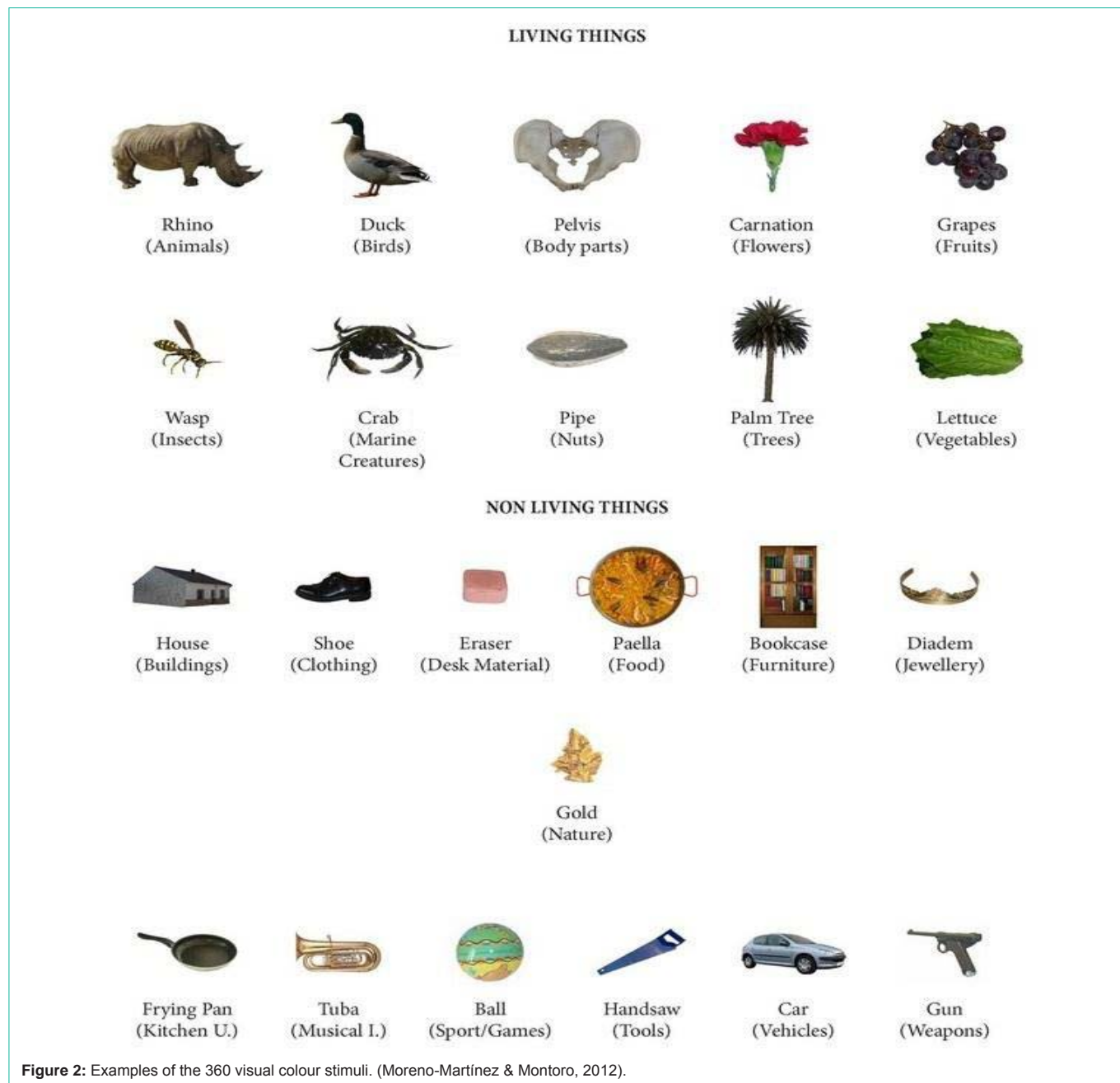
Figure 2: Examples of the 360 visual colour stimuli. (Moreno-Martínez & Montoro, 2012).

The authors reported high correlations with similar works carried out in English [35,42]; this suggests the study has high convergent validity with similar works. Reliability coefficients for NV were also high: Cronbach's alpha coefficients oscillated between .91 (name agreement) to .97 (manipulability and familiarity). The study reported higher familiarity, lexical frequency and typicality for LT items, as well as higher AoA and manipulability for NLT. No domain differences were found for name agreement or visual complexity.

A set of 360 visual items

A more ambitious study was afterward conducted by Moreno-Martínez and Montoro [36]; the author's standardized 360 visual color stimuli (Figure 2) from 23 semantic categories (Table 1). The wide range of semantic categories studied–belonging to LT, NLT and elements of nature is one of the mains contributions of this work. The authors studied seven NV: AoA, familiarity, lexical frequency, manipulability, name agreement, prototipicity, and visual complexity. The 360 items consist of color photographs directly taken by the first author of the study; FJMM owns their copyright and allows the utilisation of the items for scientific proposals.

Correlations with similar studies in English, Italian and Spanish were found [35,37,42,43,61]; this, suggests convergent validity with other normative works conducted in different languages. Regarding reliability of NV, the rates were also high: Cronbach's alpha coefficients ranged between .83 (name agreement) to.98 (AoA and typicality).

Table 1: Categories from the 360 visual items set.

LT	NLT	NATURE
1. Animals	11. Buildings	23. Nature
2. Birds	12. Clothing	
3. Body parts	13. Desk material	
4. Flowers	14. Food	
5. Fruits	15. Furniture	
6. Insects	16. Pieces of jewellery	
7. Marine creatures	17. Kitchen utensils	
8. Nuts	18. Musical instruments	
9. Trees	19. Sports/Games	
10. Vegetables	20. Tools	
	21. Vehicles	
	22. Weapons	

Verbal material

A set of 820 verbal items

One additional normative study was conducted with 820 verbal stimuli, from which were derived norms from five psycholinguistic variables: AoA, familiarity, lexical frequency, manipulability, prototipicity; plus three additional lexical indexes: word length, number of syllables and the proportion of responses citing the example as a member of the category [62]. The 820 words were empirically derived from a previous longitudinal study by Moreno-Martínez and Montoro [19]; in this study, the authors examined semantic fluency performance of demographically matched AD patients and controls over a 2-year period.

Twelve normative studies, covering different languages (English, German, Italian, Portuguese, Russian and Spanish), as well as visual and verbal stimuli, were chosen to establish the validity of the mentioned study. A pattern of high correlations between works suggests similar results in the NV studied, even when different languages and materials are used. Likewise, this also suggests high convergent validity with similar works. NV reliability indexes (Cronbach's alpha coefficients) were also high, ranging from .99 (AoA) to .98 (typicality).

Overall this study represents an incremental contribution to the literature by providing norms for a larger set of words than other studies and by including ratings for variables related to sensorimotor knowledge of objects. A further positive characteristic of this study is that the list of words chosen for the ratings was generated empirically, instead of being selected ad hoc.

Semantic batteries

The Nombela semantic battery

The Nombela battery is an instrument focused to explore categorical semantic impairment in neurologic patients; it also explores categorical effects in healthy participants [38]. The battery consists of nine both verbal and visual tasks which explores the state of semantic knowledge, as well as different levels of processing (i.e., perceptual, lexical and phonological; Table 2). The battery is constructed on a common set of 112 stimuli from 14 semantic

categories: seven LT and seven NLT; their items were taken from the work by Moreno-Martínez and Peraita [54].

The main contribution of this work is having controlled seven NV: AoA, familiarity, lexical frequency, name agreement, prototipicity and visual complexity. This was the first instrument in Spanish that provided norms for such a high number of NV. Additionally, "problematic" categories were incorporated into the study (e.g., body parts and musical instruments); furthermore, items belonging to plant life categories (such as flowers, fruits, trees and vegetables); as well as categories differing in their degree of manipulability (e.g., buildings or tools) were incorporated. These contributions make the battery Nombela a useful instrument in the study of categorical semantic deterioration in Spanish. The results after evaluating a group of healthy elderly and other of AD patients were consistent with previous neuropsychological studies [8,63]; as a rule, the performance of the patient group was lower in all tasks [38].

The Nombela 2.0 semantic battery

A decade later, the battery Nombela was updated [51]; the authors faced some limitations observed in the first version of the instrument [38]. Consequently, the authors conducted several modifications at the original test. Thus, they dealt with ceiling effects and reduced the application time by decreasing the number of tasks. In this study, the authors also reported the performance of two types of patients with semantic impairment (mild cognitive impairment MCI and AD) compared with a sample of healthy elderly.

This new version includes five semantic tasks: generation of verbal definitions, picture naming, naming in response to verbal description, semantic fluency and word picture matching. The battery is constructed on a common set of 98 stimuli which are rated according to Spanish norms; in addition, all of the tasks are matched across domain on AoA, familiarity, lexical frequency, name agreement, prototypicality and visual complexity. Finally, unlikely the first versions, the pictorial images (colored photographs) were placed on a white background to avoid possible influence of context [64,65].

Concerning the clinical aspects, Moreno-Martínez and Rodríguez-Rojo [51] observed better performance of the healthy elderly group in all the semantic tasks. No category specific effects were observed in any of the five semantic tasks. A relevant find, from a clinical view, is that the category fluency and the naming to description tasks were the best to discriminated between patients presenting mild (MCI) and

Table 2: Tasks comprising the first version of the semantic battery Nombela. (Moreno & Cañamón 2005).

1.	Naming in response to verbal description.
2.	Object decision.
3.	Picture naming.
4.	Semantic analogies.
5.	Semantic fluency.
6.	Size ordering task (plus reading the items aloud).
7.	Sorting (Levels: Superordinate-Basic-Subordinate)
8.	Word decision (plus reading the items aloud).
9.	Word-picture matching.

severe (AD) semantic impairment. By contrast, no significant MCI/AD differences were observed with the word picture matching and the picture naming tasks. Finally, the verbal definition task showed no differences between MCI and healthy participants; although these two groups obtained better performance than AD patients. Consequently, the authors proposed this task could be the best to differentiate patients with mild (MCI) and severe (AD) semantic deterioration [51].

Conclusion

The study of category specific effects has been an instructive an enriching topic in neuropsychological arena; this has enabled to postulate semantic knowledge has an internal structure that could depend on different neural substrates. At same time, the research on this subject has progressively revealed different methodological problems with crucial importance on the investigation and on the derived results; the appropriated control on NV or the unwelcome consequences derived from ceiling effects are excellent examples of the stated.

Over time, our research group has conducted several normative studies with verbal and with non-verbal/pictorial material, in an attempt to provide tests and normative material cultural and linguistically appropriate for use with Spanish speakers; this research has been theoretically guided by category specific topic. We believe the present study provides an interesting review on several methodological problems affecting category specific arena and, additionally, presents several normative instruments designed for our group in an attempt to deal with the mentioned obstacles. It is our aim these materials will be useful both for clinical and experimental research, filling an important gap among the neuropsychological Spanish tests.

References

1. Moreno EM, Pelegrín-Valero C, Fernández-Guinea S. Tratamiento de las demencias. In: Arango-Lasprilla JC, Fernández-Guinea S, Ardila A, editors. Las demencias: aspectos clínicos, neuropsicológicos y tratamiento. Santa Fe de Bogotá: Manual Moderno Editorial. 2003; 361–415.

2. Karch CM, Goate AM. Alzheimer's disease risk genes and mechanisms of disease pathogenesis. Biol Psychiatry. 2015; 77: 43-51.

3. Montine TJ, Phelps CH, Beach TG, Bigio EH, Cairns NJ, Dickson DW, et al. National Institute on Aging-Alzheimer's Association guidelines for the neuropathologic assessment of Alzheimer's disease: a practical approach. Acta Neuropathologica. 2012; 123: 1–11.

4. Phillips C, Akif Baktir M, Das D, Lin B, Salehi A. The Link between Physical Activity and Cognitive Dysfunction in Alzheimer Disease. Phys Ther. 2015.

5. Clayton NS, Russell J. Looking for episodic memory in animals and young children: prospects for a new minimalism. Neuropsychologia. 2009; 47: 2330-2340.

6. Nebes RD. Semantic memory in Alzheimer's disease. Psychol Bull. 1989; 106: 377-394.

7. Hodges JR, Salmon DP, Butters N. Semantic memory impairment in Alzheimer's disease: failure of access or degraded knowledge? Neuropsychologia. 1992; 30: 301-314.

8. Capitani E, Laiacona M, Mahon B, Caramazza A. What are the facts of semantic category-specific deficits? A critical review of the clinical evidence. Cogn Neuropsychol. 2003; 20: 213-261.

9. Laws KR. "Illusions of normality": a methodological critique of category-specific naming. Cortex. 2005; 41: 842-851.

10. Thompson-Schill SL. Neuroimaging studies of semantic memory: inferring "how" from "where". Neuropsychologia. 2003; 41: 280-292.

11. Funnell E, Sheridan J. Categories of knowledge? Unfamiliar aspects of living and non living things. Cognitive Neuropsychology. 1992; 9: 135–153.

12. Laws KR, Sartori G. Category deficits and paradoxical dissociations in Alzheimer's disease and Herpes Simplex Encephalitis. J Cogn Neurosci. 2005; 17: 1453-1459.

13. Chertkow H, Bub D. Semantic memory loss in dementia of Alzheimer's type. What do various measures measure? Brain. 1990; 113: 397-417.

14. Laws KR, Adlington RL, Gale TM, Moreno-Martínez FJ, Sartori G. A meta-analytic review of category naming in Alzheimer's disease. Neuropsychologia. 2007; 45: 2674-2682.

15. Montanes P, Goldblum MC, Boller F. The naming impairment of living and nonliving items in Alzheimer's disease. J Int Neuropsychol Soc. 1995; 1: 39-48.

16. Silveri MC, Daniele A, Giustolisi L, Gainotti G. Dissociation between knowledge of living and nonliving things in dementia of the Alzheimer type. Neurology. 1991; 41: 545-546.

17. Moreno-Martínez FJ, Tallón-Barranco A, Frank-García A. Enfermedad de Alzheimer, deterioro categorial y variables relevantes en la denominación de objetos. Revista de Neurología. 2007; 44: 129–133.

18. Tippett LJ, Grossman M, Farah MJ. The semantic memory impairment of Alzheimer's disease: category-specific? Cortex. 1996; 32: 143-153.

19. Moreno-Martínez FJ, Montoro PR. Longitudinal patterns of fluency impairment in dementia: The role of domain and "nuisance variables". Aphasiology. 2010; 24: 1389–1399.

20. Ellis AW, Morrison CM. Real age-of-acquisition effects in lexical retrieval. J Exp Psychol Learn Mem Cogn. 1998; 24: 515-523.

21. Filliter JH, McMullen PA, Westwood D. Manipulability and living/non-living category effects on object identification. Brain Cogn. 2005; 57: 61-65.

22. Gilhooly KJ, Gilhooly ML. Age-of-acquisition effects in lexical and episodic memory tasks. Memory & Cognition. 1979; 7: 213–223.

23. Kiran S, Thompson CK. Effect of typicality on online category verification of animate category exemplars in aphasia. Brain Lang. 2003; 85: 441-450.

24. Humphreys GW, Forde EME. Hierarchies, similarity, and interactivity in object recognition: "Category-specific" neuropsychological deficits. Behav Brain Sci. 2001; 24: 453–509.

25. Oldfield RC, Wingfield A. Response latencies in naming objects. Q J Exp Psychol. 1965; 17: 273-281.

26. Laws KR, Gale TM. Category-specific naming and the 'visual' characteristics of line drawn stimuli. Cortex. 2002; 38: 7–21.

27. Caramazza A, Shelton JR. Domain-specific knowledge systems in the brain the animate-inanimate distinction. J Cogn Neurosci. 1998; 10: 1-34.

28. Zannino GD, Perri R, Carlesimo GA, Pasqualetti P, Caltagirone C. Category-specific impairment in patients with Alzheimer's disease as a function of disease severity: a cross-sectional investigation. Neuropsychologia. 2002; 40: 2268–2279.

29. Moreno-Martínez FJ, Goñi-Imízcoz M, Spitznagel MB. Domain or not domain? That is the question: Longitudinal semantic deterioration in Alzheimer's disease. Brain Cogn. 2011; 77: 89–95.

30. Moreno-Martínez FJ, Rodríguez-Rojo IC. On colour, category effects and Alzheimer's disease: A critical review of studies and further longitudinal evidence. Behavioural Neurology. (In Press).

31. Moreno-Martínez FJ, Laws KR. An attenuation of the 'normal' category effect in patients with Alzheimer's disease: a review and bootstrap analysis. Brain Cogn. 2007; 63: 167-173.

32. Laws KR, Gale TM, Leeson VC, Crawford JR. When is category specific in Alzheimer's disease? Cortex. 2005; 41: 452-463.

33. Fung TD, Chertkow H, Murtha S, Whatmough C, Péloquin L, Whitehead V, et al. The spectrum of category effects in object and action knowledge in dementia of the Alzheimer's type. Neuropsychology. 2001; 15: 371-379.

34. Whatmough C, Chertkow H, Murtha S, Templeman D, Babins L, Kelner N. The semantic category effect increases with worsening anomia in Alzheimer's type dementia. Brain Lang. 2003; 84: 134-147.

35. Adlington RL, Laws KR, Gale TM. The Hatfield Image Test (HIT): a new picture test and norms for experimental and clinical use. J Clin Exp Neuropsychol. 2009; 31: 731–753.

36. Moreno-Martínez FJ, Montoro PR. An ecological alternative to Snodgrass & Vanderwart: 360 high quality colour images with norms for seven psycholinguistic variables. Plos One. 2012; 7: 1–9.

37. Moreno-Martínez FJ, Montoro PR, Laws KR. A set of high quality colour images with Spanish norms for seven relevant psycholinguistic variables: The Nombela naming test. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn. 2011; 18: 293–327.

38. Moreno FJ, Cañamón S. Presentación y resultados preliminares de la Batería Nombela (I): Un nuevo instrumento para evaluar el deterioro semántico categorical. Revista de Psicopatología y Psicología Clínica. 2005; 10: 205–219.

39. Garrard P, Patterson K, Watson PC, Hodges JR. Category specific semantic loss in dementia of Alzheimer's type. Functional-anatomical correlations from cross-sectional analyses. Brain. 1998; 121: 633-646.

40. Shelton JR, Fouch E, Caramazza A. The selective sparing of body part knowledge: A case study. Neurocase. 1998; 4: 339-351.

41. Warrington EK, McCarthy RA. Categories of knowledge. Further fractionations and an attempted integration. Brain. 1987; 110: 1273-1296.

42. Snodgrass JG, Vanderwart M. A standardized set of 260 pictures: norms for name agreement, image agreement, familiarity and visual complexity. J Exp Psychol Hum Learn. 1980; 6: 174–215.

43. Viggiano MP, Vannucci M, Righi S. A new standardized set of ecological pictures for experimental and clinical research on visual object processing. Cortex. 2004; 40: 491-509.

44. Zannino GD, Perri R, Salamone G, Di Lorenzo C, Caltagirone C, Carlesimo GA. Manipulating color and other visual information influences picture naming at different levels of processing: Evidence from Alzheimer subjects and normal controls. Neuropsychologia. 2010; 48: 2571–2578.

45. Zannino GD, Perri R, Pasqualetti P, Di Paola M, Caltagirone C, Carlesimo GA. The role of semantic distance in category-specific impairments for living things: evidence from a case of semantic dementia. Neuropsychologia. 2006; 44: 1017-1028.

46. Tippett LJ, Meier SL, Blackwood K, Diaz-Asper C. Category specific deficits in Alzheimer's disease: fact or artefact? Cortex. 2007; 43: 907-920.

47. Moreno-Martinez FJ. Size matters: a study on naming and size knowledge in dementia of the Alzheimer type. Neurocase. 2010; 16: 494-502.

48. Moreno-Martínez FJ, Laws KR. No category specificity in Alzheimer's disease: a normal aging effect. Neuropsychology. 2008; 22: 485-490.

49. Hodges JR, Graham N, Patterson K. Charting the progression in semantic dementia: implications for the organisation of semantic memory. Memory. 1995; 3: 463-495.

50. Laiacona M, Barbarotto R, Trivelli C, Capitani E. Dissociazioni semantiche intercategoriali: descrizione di una batteria standardizzata e datinormativi. Neurologia e Psichiatria. 1993; 54: 209–248.

51. Moreno-Martínez FJ, Rodríguez-Rojo IC. The Nombela 2.0 semantic battery: an updated Spanish instrument for the study of semantic processing. Neurocase. 2015.

52. Magnié MN, Besson M, Poncet M, Dolisi C. The Snodgrass and Vanderwart set revisited: Norms for object manipulability and for pictorial ambiguity of objects, chimeric objects and nonobjects. J Clin Exp Neuropsychol. 2003; 25: 521–560.

53. Catricalà E, Della Rosa PA, Ginex V, Mussetti Z, Plebani V, Cappa SF. An Italian battery for the assessment of semantic memory disorders. Neurol Sci. 2013; 34: 985-993.

54. Moreno-Martínez FJ, Peraita H. Un Nuevo conjunto de ítems para la evaluación de la disociaciónser vivo/ser no vivo con normas obtenidas de ancianos sanos españoles. Psicológica. 2007; 28: 1–20.

55. Barbarotto R, Capitani E, Laiacona M. Living musical instruments and inanimate body parts? Neuropsychologia. 2001; 39: 406-414.

56. Laws KR, Gale TM, Frank R, Davey N. Visual similarity is greater for line drawings of nonliving than living things: the importance of musical instruments and body parts. Brain Cogn. 2002; 48: 421-424.

57. Bunn EM, Tyler LK, Moss HE. Category-specific semantic deficits: the role of familiarity and property type reexamined. Neuropsychology. 1998; 12: 367-379.

58. Cuetos F, Ellis AW, Alvarez B. Naming times for the Snodgrass and Vanderwart pictures in Spanish. Behav Res Methods Instrum Comput. 1999; 31: 650-658.

59. Pérez MA, Navalón C. Normas españolas de 290 nuevos dibujos: Acuerdo en la denominación, concordancia de la imagen, familiaridad, complejidad visual y variabilidad de la imagen. Psicológica: Revista de metodología y psicología experimental. 2003; 24: 215–242.

60. Sanfeliú MC, Fernández A. A set of 254 Snodgrass-Vanderwart pictures standardized for Spanish: Norms for name agreement, image agreement, familiarity, and visual complexity. Behav Res Methods, Instruments, Computers. 1996; 28: 537–555.

61. Brodeur MB, Dionne-Dostie E, Montreuil T, Lepage M. The Bank of Standardized Stimuli (BOSS), a new set of 480 normative photos of objects to be used as visual stimuli in cognitive research. PLoS One. 2010; 5: e10773.

62. Moreno-Martínez FJ, Montoro PR, Rodríguez-Rojo IC. Spanish norms for age of acquisition, concept familiarity, lexical frequency, manipulability, typicality, and other variables for 820 words from 14 living/nonliving concepts. Behav Res Methods. 2014; 46: 1088–1097.

63. Martin A, Caramazza A. Neuropsychological and neuroimaging perspectives on conceptual knowledge: an introduction. Cogn Neuropsychol. 2003; 20: 195-212.

64. Biederman I. Recognition-by-components: a theory of human image understanding. Psychol Rev. 1987; 94: 115-147.

65. Tanaka J, Weiskopf D, Williams P. The role of color in high-level vision. Trends Cogn Sci. 2001; 5: 211-215.