AN ATTRIBUTE IS WORTH MORE THAN A CATEGORY: TESTING DIFFERENT SEMANTIC MEMORY ORGANISATION HYPOTHESES IN RELATION TO THE LIVING/NONLIVING THINGS DISSOCIATION

J. Frederico Marques
Universidade de Lisboa, Portugal

The present paper contrasted categorical and featural hypotheses of semantic memory organisation in relation to the living/nonliving things dissociation phenomenon. In the three experiments reported, normal subjects decided if word pairs representing living, nonliving, or both (mixed pairs) shared a particular perceptual (i.e., four legs, size, and hardness) or functional attribute (i.e., dangerousness, speed, and usefulness). The overall pattern of results is more in accordance with a general featural perspective and also emphasises the role of functional attributes. Both a categorical perspective and an attribute-category connection hypothesis have more difficulties in explaining the observed data. Implications for the study of semantic memory organisation and for the explanation of living/nonliving things dissociation cases are also considered.

INTRODUCTION

The study of brain-damaged patients exhibiting impaired knowledge of living things and relatively preserved knowledge of nonliving things has been one of the most fruitful types of cognitive impairment cases, particularly in terms of theoretical implications for the discussion of semantic memory organisation in the field of cognitive neuropsychology and cognitive science. The first clinical observations of these category-specific impairments were reported by Nielsen in 1946 (Forde & Humphreys, 1999), and Warrington and Shallice (1984) provided the first systematic empirical study of these patients. Since then a considerable number of other cases have been reported, also including a significant, although smaller, number of cases exhibiting the opposite dissociation (i.e., impaired knowledge of nonliving things and relatively preserved knowledge of living things). In general terms, these patients exhibit selective difficulties in different picture and/or word tasks such as naming, definition, or matching stimuli that either affect living or nonliving items (see, for example, Caramazza, 1998; Forde & Humphreys, 1999; or Gainotti, 2000, for a review).

The main characteristics of this dissociation in terms of aetiology and brain areas implicated is of
general agreement in the cognitive neuropsychology field but the same cannot be said for the explanations proposed for this phenomenon in terms of the organisation of semantic memory. Part of the observed dissociation can surely be attributed to input modality and input characteristics, but from this common ground the distinct proposals present different models of semantic memory at a representational level, both in terms of number of memory storages considered and principles of memory organisation.

In the present paper we considered this last aspect and evaluated different perspectives and models of semantic memory organisation. These perspectives and models are presented in Table 1, together with reference to their authors and their proposed basis for the living/nonliving dissociation.

As presented in Table 1, two main perspectives have been put forward to account for the living/nonliving things dissociation cases: That they reflect an underlying organisation in terms of attributes or that they reflect a direct organisation in terms of taxonomical categories.

The attribute or featural hypothesis is first associated with the seminal work of Warrington and Shallice (1984) and considers that differences in attribute composition and organisation can be found between taxonomical categories and are responsible for the observed category deficits. Warrington and Shallice (1984) first proposed that perceptual attributes would be crucial for the identification of living things, whereas functional/associative attributes would have the same role for nonliving things. In a revised version of this model, which tries to accommodate more “fine-grain” categorical dissociations, Warrington, Shallice, and McCarthy (McCarthy & Warrington, 1988; McKenna & Warrington, 1993; Shallice, 1988; Warrington & McCarthy, 1987) further considered that the predominance of the different attributes would depend upon their relevance to the acquisition and comprehension of the particular stimuli considered. In this revision a more flexible composition of attributes is thus proposed, with the sensory/functional considered in terms of differential weightings of sensory and motor channels of information (McKenna & Warrington, 1993; Warrington & McCarthy, 1987).

Farah and McClelland (1991) also considered the perceptual/functional distinction but stated their hypothesis in terms of the ratio between the two types of attributes for living and nonliving things. Perceptual attributes were represented in a much higher ratio for living things and were also more represented overall (Farah & McClelland, 1991; but see Caramazza & Shelton, 1998; or McRae, De Sa, & Seidenberg, 1997, for a different computation). This different ratio and composition would determine the role of the two types of attributes in distinguishing between the two categories, and ultimately the category deficits, in terms of

Table 1. Models of semantic memory organisation and basis for the living/nonliving things dissociation

<table>
<thead>
<tr>
<th>Model</th>
<th>Main principle of semantic organisation</th>
<th>Basis for the living/nonliving things dissociation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warrington, Shallice, McCarthy, and associates</td>
<td>Attributes</td>
<td>1. Perceptual/functional attributes.</td>
</tr>
<tr>
<td>Farah and McClelland</td>
<td>Attributes</td>
<td>2. Attributes associated with stimulus knowledge.</td>
</tr>
<tr>
<td>Gonnerman and Devlin and associates</td>
<td>Attributes</td>
<td>Perceptual/functional ratio.</td>
</tr>
<tr>
<td>Moss and Tyler and associates</td>
<td>Attributes</td>
<td>Perceptual/functional ratio; attribute correlation and distinguishing attributes.</td>
</tr>
<tr>
<td>Caramazza and Shelton and associates</td>
<td>Categories</td>
<td>Perceptual/functional attributes; functional emphasis and form-function interrelation.</td>
</tr>
</tbody>
</table>

1 The term “functional/associative” denotes attributes that reflect the function of items or other associative and nonperceptual properties, and that explain the composed designation. However, for simplification the term “functional” will be used from now on to designate these attributes. Whenever the term is used with a different meaning this is explicitly stated.
what we could describe as an attribute-category connection hypothesis. From Farah and McClelland’s (1991) model and data this connection would be stronger in the case of perceptual attributes plus living things than in the case of functional attributes plus artefacts.

Gonnerman, Devlin and associates (Devlin, Gonnerman, Andersen, & Seidenberg, 1998; Gonnerman, Anderson, Devlin, Kempler, & Seidenberg, 1997; McRae et al., 1997) also considered an attribute-category connection hypothesis, and in both directions (i.e., perceptual for biological kinds and functional for artefacts), and further proposed that whereas attribute correlation would be larger for biological kinds (especially correlation between perceptual attributes), artefacts would have more individual distinguishing attributes.

One last model is also included in a featural perspective. Within this perspective, Moss and Tyler (Moss, Ostrin, Tyler, & Marslen-Wilson, 1995; Moss, Tyler, & Jennings, 1997; Tyler & Moss, 1997) emphasised functional attributes and form-function interrelations as the main factors responsible for the living/nonliving dissociation. The importance of functional attributes could be seen in the fact that functional primes were significant for both living and nonliving things in lexical decision tasks. Functional information would also be relatively resistant to brain damage in relation to perceptual information (Moss et al., 1995; Tyler & Moss, 1997). As for form-function interrelations (Moss et al., 1997; Tyler & Moss, 1997; also De Renzi & Lucchelli, 1994), there would be a stronger and more general dependence for artefacts than for living things, where they would be limited to biological function properties. These factors (i.e., functional information relevance, and form-function dependence in the case of artefacts) would explain the smaller number of nonliving things impairments, as the activation of functional attributes would compensate losses in perceptual attributes. For living things this compensation would not occur. Biological function attributes would have limited usefulness in maintaining knowledge of individual living things, since these attributes are true of all members and do not allow us to distinguish between them (Tyler & Moss, 1997). More recently, these authors (Tyler, Moss, Durrant-Peatfield, & Levy, 2000) have separated functional attributes from other associative nonperceptual attributes and considered that their claims apply to the first only.

The final model presented in Table 1 is the only representative of the second major perspective, that is, a categorical hypothesis where category deficits reflect a direct organisation in taxonomical categories. Caramazza and Shelton (1998) have recently defended this proposal, considering that evolutionary pressures would have resulted in the development of specialised networks for distinguishing evolutionary important categories such as animals, plant life, body parts, or even tools (Caramazza & Shelton, 1998; Shelton & Caramazza, 2000; Shelton, Fouch, & Caramazza, 1998). This domain-specific theory (Caramazza & Shelton, 1998; Shelton et al., 1998) was supported by several cases where category seemed the main determinant of the observed deficits that affected functional and perceptual attributes equally (e.g., Caramazza & Shelton, 1998; Samson, Pillon, & De Wilde, 1998). Another support can be found in cases where the specificity of categories spared or impaired (e.g., Hart, Berndt, & Caramazza, 1985; Hart & Gordon, 1992; Kay & Hanley, 1999; Shelton et al., 1998) seems very difficult to explain according to a shared subset of attributes or considering attribute interrelations (Caramazza, Hillis, Leek, & Miozzo, 1994). At least, no satisfactory explanation in terms of feature organisation (e.g., different attributes, weighting, or interrelations) has yet been presented for these cases.

Beyond impairment cases, other evidence in terms of brain imaging studies (e.g., Damasio, Grabowski, Tranel, Hichwa, & Damasio, 1996; Martin, Wiggs, Ungerleider, & Haxby, 1996; Moore & Price, 1999; Mummery, Patterson, Hodges, & Price, 1998; Perani et al., 1999; Thompson-Schill, Aguirre, D’Esposito, & Farah, 1999; Vandenbergh, Price, Wise, Josephs, & Frackowiak, 1996) and priming studies (Moss et al., 1995; Moss & Tyler, 1995; Thompson-Schill & Gabrieli, 1999; Tyler & Moss, 1997) seem more in accordance with a featural perspective. In brain imaging studies, however, some of the data is
clearly explicable by both accounts (e.g., Damasio et al., 1996; Vandenberghe et al., 1996) and consideration of all types of evidence seems difficult for either proposal. Moreover, materials and tasks used are not always comparable and very often do not allow for a comparison between the two perspectives and their different specifications. For example, some studies used attributes (Thompson-Schill et al., 1999), others used exemplars (e.g., Damasio et al., 1996; Martin et al., 1996; Moore & Price, 1999), and still others used both but with different materials and sometimes different tasks (e.g., Mummery et al., 1998; Perani et al., 1999; Vandenberghe et al., 1996). This raises the question of comparability of items (and sometimes also of tasks), and the present data from brain imaging studies do not allow us to evaluate without bias which level of organisation—featural or categorical—is more important. In a recent study, Devlin et al. (2002), using both PET and fMRI techniques, have found no evidence for either proposal (those they contrast with a unitary distributed system) and further considered that several methodological issues should be taken into account in future neuroimaging studies to resolve these questions.

In general, results from priming studies raise similar problems and as a whole seem inconclusive. For example, Moss et al. (1995) used a lexical decision task and compared category coordinate (e.g., aeroplane-train) and functional instrumental primes (e.g., broom-floor), considering pair associative strength. Results showed independent priming of functional instrumental primes in all situations, whereas category coordinate effects were more dependent on associative strength. In this study, however, perceptual primes were not used, functional instrumental primes were only used with artefacts, and neither functional nor category primes corresponded to the same materials. Other priming studies have similar problems, either by not considering the different types of attributes and/or category primes (Moss & Tyler, 1995; Thompson-Schill & Gabrieli, 1999; Thompson-Schill & Kan, 2001), or by not considering the living/nonliving distinction in a systematic manner (Moss et al., 1995; Moss & Tyler, 1995; Tyler & Moss, 1997). Although failing to consider this last aspect, Tyler and Moss (1997, Experiment 1) did evaluate functional, perceptual, superordinate, and category coordinate primes for the same targets, both living and nonliving, with a lexical decision task. However, all primes were equally significant for the two types of items.

The comparison between the different featural and categorical perspectives was probably not the main objective of either the brain imaging studies or the priming studies, which partially explains this inconclusive state of affairs. Another important reason is the current level of development of the proposed models themselves. As some of their proponents have acknowledged (e.g., Caramazza & Shelton, 1998; Farah & McClelland, 1991; Shallice, 1988), several models have been loosely defined or simplified, making it more hard to find cases and experimental situations that can contrast predictions.

In a previous study designed to evaluate these different models (Marques, 2000), we did contrast featural and categorical perspectives with the same materials and task, using the release from proactive interference (PI-release) paradigm (Wickens, 1970; Wickens, Born, & Allen, 1963) combined with cue presentation. This was done by cueing perceptual and functional attributes that ran opposite to the living-nonliving distinction (animals vs. artefacts), and by comparing PI-release in this condition with a standard categorical PI-release situation (i.e., the same materials but no cues). Recall data and PI-release effects obtained were more in accordance with a feature-based organisation of semantic memory, and especially with models that emphasise the role of functional over perceptual attributes (Moss & Tyler, 1995; Tyler & Moss, 1997; Tyler et al., 2000). Conversely, the categorical perspective (Caramazza & Shelton, 1998; Shelton et al., 1998) and other featural perspectives, especially the ones that emphasised the role of

---

2 Script relations were also used as functional primes but are not relevant to the present discussion.
perceptual attributes in the representation of living things and functional/associative attributes in the case of nonliving items (e.g., Farah & McClelland, 1991; Gonnerman et al., 1997), have more difficulty in explaining the data obtained (Marques, 2000).

The present study further expands this evaluation using the same principle—to contrast featural and categorical perspectives with the same materials and task—but with a different task and measure; a word pair decision task and reaction time measure (RT).

Rationale and overview of the experimental study

In the experiments reported participants had to decide if word pairs representing living, nonliving or both (mixed pairs) shared a particular perceptual (i.e., four legs, size, and hardness) or functional attribute (i.e., dangerousness, speed, and usefulness). Each experiment had a $3 \times 2 \times 2$ factorial design with variables (all within-subjects) type of pair (all living, all nonliving, mixed), attribute (perceptual, functional), and answer (yes, no).

In terms of RT differences, distinct patterns of results can be expected from the various perspectives and models presented, provided that the subject processes both elements of the pair (to allow for contrast between homogeneous and mixed pairs). For this reason only “yes” answers are considered in terms of predictions as they imply that the subject processes the two elements of the pair whereas that may not be the case for “no” answers.

If a categorical perspective such as Caramazza and Shelton’s (1998) proposal is defended we can expect that RT will be consistently higher for mixed than for homogeneous pairs, independently of feature decision (categorical hypothesis). In fact, if category is the main principle of semantic organisation we can expect that all decisions that involve members of different domains such as living and nonliving things will take longer to compute in relation to decisions that only involve members of the same semantic domain.

On the contrary, if a featural perspective is defended as the basis for the living/nonliving things distinction, we can expect that RT differences will be dependent on attribute domains (not on categories) and, as such, RT for mixed pairs will not be systematically higher than for homogeneous pairs (featural hypothesis).

Within the featural perspective, further distinctive patterns of results can be expected from the models presented. Models such as those of Farah and McClelland (1991) or Gonnerman, Devlin, and associates (Devlin et al., 1998; Gonnerman et al., 1997) would predict that RT for perceptual decisions would be lower for living pairs (both models) and RT for functional decisions would be lower for nonliving pairs (especially Gonnerman et al.) (attribute–category connection hypothesis).

If a more flexible composition or multiple attribute is defended instead, as it is the case of Warrington, Shallice and McCarthy’s second formulation (McCarthy & Warrington, 1988; McKenna & Warrington, 1993; Shallice, 1988; Warrington & McCarthy, 1987), we can expect that RT differences of different perceptual and functional decisions will occur depending on the specific features and pairs tested (flexible composition hypothesis).

Finally, proposals such as Moss and Tyler’s (e.g., Moss & Tyler, 1995; Tyler et al., 2000), which emphasise functional attributes, will predict that functional decisions will entail lower RT, independently of the pair tested (functional emphasis hypothesis).

These different predictions were evaluated in three experiments in which one perceptual and one functional decision were contrasted. Experiment 1 contrasted the perceptual attribute “having four legs” and the functional attribute “dangerousness.” Experiment 2 contrasted the perceptual attribute “size” and the functional attribute “speed.” Finally, Experiment 3 contrasted the perceptual attribute “hardness” and the functional attribute “usefulness.” Each experiment thus provides a replication of the same design to evaluate the distinct featural and categorical hypotheses with different pairs of perceptual and functional attributes.
EXPERIMENT 1

In Experiment 1, these hypotheses were evaluated with the perceptual attribute “having four legs” and the functional attribute “dangerousness.”

Method

Participants and design. Thirty-eight undergraduate students participated for partial fulfilment of an introductory psychology course requirement but two subjects were discarded from the analysis as they had fewer than 50% correct responses (total \( N = 36 \)).

We used a 3 × 2 × 2 factorial design with variables type of pair (all living, all nonliving, mixed), attribute (having four legs, dangerousness), and answer (yes, no). All variables were manipulated at the within-subjects level.

Materials. Four pairs were considered for each of the possible combinations of the three variables (type of pair, attribute, and answer). For dangerousness, “potential danger” norms (5-point rating scale) were used from a previous study (Marques, 2000, Experiment 2) and for four legs, norms were also collected (this item has four legs, yes or no) from five subjects who otherwise did not participate in the experiment. In both cases, there were only significant differences between yes and no sets and, as such, attribute familiarity was controlled for across the three types of pair (both in terms of mean familiarity and standard deviation). Item familiarity was also controlled for (Portuguese Familiarity Norms from Marques, 1997), and no significant differences were found across all sets (i.e., type of pair, attribute, and answer) in terms of mean familiarity and standard deviation. Associative strength between the elements of each pair was also controlled for (although a posteriori), with all pairs but one (i.e., bed-sofa; although association was low) showing no association (Portuguese Associative Strength Norms from Marques, 2001). An analogous procedure was also considered in the other two experiments to control attribute and item familiarity and associative strength. Each participant answered a total of 48 items, 24 concerning dangerousness and 24 concerning having four legs (a list of all stimuli is presented in Appendix A). The two decisions were made separately and were counterbalanced. In each decision items were presented randomly. For each decision the stimuli sequence was as follows: Slide 1—push any key to start; Slide 2—fixation point 1900 ms; Slide 3—prime (e.g., dangerous) 1900 ms; Slide 4—blank slide 100 ms (for cleaning the memory buffer); Slide 5—pair (end after correct answer); Slide 6—blank 100 ms. All materials were mounted on computer-presented slides with the Superlab for Windows software.

Procedure. Participants were tested individually and were informed that the purpose of the experiment was to evaluate the processing speed of different types of pair classifications. An example of the slide sequence for each decision was also presented, with no reference to timings. Participants trained on the task with a four-trial training block; the decision was words ending with the same letter. The experimental block was composed of the dangerousness decision block (answer yes if the two items are dangerous for humans) and the four legs decision block (answer yes if the two items have four legs), which were introduced one at the time with examples that were not included in the experimental materials. Order of presentation of the two blocks was counterbalanced between subjects. Answers were given in a two-button response box with the preferred hand being attributed to the “yes” button and the other to the “no” button (right hand was preferred for 95% of the participants and a similar percentage was observed in all experiments). As mentioned in the previous section, the pair remained on the screen until the subject made the correct decision and as such feedback was provided for each decision.

Results and discussion

Mean RTs by type of pair, attribute, and answer were calculated from correct responses. The per-

---

3 I thank one of the anonymous referees for suggesting this control of the materials.
percentage of correct responses was fairly high both for yes and no answers (respectively 70% for yes and 74% for no answers). However, as only “yes” answers were considered in the hypotheses, these RTs alone are the target for analysis. RTs exceeding 3000 ms were eliminated from the analyses (outliers corresponded to 4% of responses) but were not counted as errors. Mean RTs (and their standard deviation) and error rates by attribute decision and pair type are presented in Table 2 (all tables present data by subjects).

Results were analysed both by subjects and by items. For the subject analysis the data were pooled for each subject over the various items in each combination of type of pair and attribute decision. For the item analysis the data were pooled for each item across subjects. In each case an analysis of variance (ANOVA) was performed considering pair type and attribute. As pair type and attribute were manipulated at within-subject level, the subject analysis was performed considering a repeated measures design, while a between-factor design was considered for the item analysis. An alpha level of 0.05 was considered for all statistical tests.

For the subject analysis, main effects were found for attribute, $F(1, 35) = 25.96, \text{MSE} = 11789, \ p = .000$, indicating faster RTs for functional than for perceptual decisions, and for pair, $F(2, 70) = 20.54, \text{MSE} = 59841, \ p = .000$. The post hoc analysis of this latter effect (Scheffé test) showed that RTs to living things pairs were faster than to both nonliving and mixed pairs. The item analysis produced the same results with similar main effects for attribute, $F(1, 18) = 15.25, \text{MSE} = 16366, \ p = .001$, and for pair, $F(2, 18) = 6.73, \text{MSE} = 16366, \ p = .007$. In both analyses no significant interactions were found.

These two RT analyses were complemented by an error analysis both by subjects and by items, where a main effect for pair was found only in the subject analysis, $F(2, 70) = 5.74, \text{MSE} = 0.437, \ p = .005$, indicating more errors for nonliving than for living things pairs (Scheffé test). However, as this result goes in the same direction as the RT difference observed, the data seem free of speed-accuracy tradeoff problems.

Overall, these results show that decisions concerning living things seem faster independently of the attribute tested, and that functional decisions seem faster independently of the pair tested. This pattern of results is more in accordance with a featural hypothesis and especially with a hypothesis that emphasises the role of functional features. In fact, RT for mixed pairs is not systematically higher than for homogeneous pairs, a result more in agreement with a featural perspective. Furthermore, functional attributes seem to entail lower RT independent of the nature of the pair tested, a result more in accordance with the functional emphasis hypothesis and one that contradicts the attribute-category connection hypothesis (which indirectly supports a flexible composition hypothesis). These conclusions are further tested in Experiment 2 with other attributes and items.

**EXPERIMENT 2**

Experiment 2 tests the same predictions stated in the introduction and further evaluates the pattern of results obtained in Experiment 1 with two other perceptual and functional attributes, respectively “size” and “speed.”

<table>
<thead>
<tr>
<th>Table 2. Mean reaction times (ms) and standard deviation (RT, SD) and error rates (% error) by attribute decision and pair type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceptual (four legs)</strong></td>
</tr>
<tr>
<td>RT (SD)</td>
</tr>
<tr>
<td>Living</td>
</tr>
<tr>
<td>Nonliving</td>
</tr>
<tr>
<td>Mixed</td>
</tr>
</tbody>
</table>
Method

Participants and design. Forty-six undergraduate students participated for partial fulfilment of an introductory psychology course requirement but four subjects were discarded from the analysis as they had fewer than 50% correct responses (total $N = 42$).

A $3 \times 2 \times 2$ factorial design with variables type of pair (all living, all nonliving, mixed), feature (size, speed) and answer (yes, no). All variables were manipulated at the within-subjects level.

Materials. As in Experiment 1, four pairs were considered for each possible combination of the three variables and pairs were controlled for in terms of item familiarity (Portuguese Familiarity Norms from Marques, 1997). Associative strength between the elements of each pair was also controlled for with all pairs showing no association (Portuguese Associative Strength Norms from Marques, 2001). For feature size, reported size norms (1–20 rating scale, following the Sailor & Shoben, 1996, procedure) were used from a previous study (Marques, 2000, Experiment 3). For feature speed, norms were obtained from a sample of 11 undergraduate students, who were asked to give the approximate mean speed per hour (km/hr) of several living and nonliving items, and who otherwise did not participate in the experiment. Item and decision task (perceptual and functional) construction followed the same arrangement as Experiment 1 (a list of all stimuli is presented in Appendix B).

Procedure. Procedure was the same as in Experiment 1 with respect to general instructions, slide sequence on each decision, training, answer mode, and recording. The experimental block was composed of the size decision block (answer yes if the two items are bigger than humans) and the speed decision block (answer yes if the two items are faster than humans), which were introduced and presented in the same manner as in Experiment 1.

Results and discussion

Mean RTs by type of pair, attribute, and answer were calculated from correct responses. The percentage of correct responses was fairly high both for yes and no answers (75% for yes and 62% for no). As in Experiment 1, only RTs for “yes” correct answers were considered for analysis and RTs exceeding 3000 ms were eliminated but were not counted as errors (outliers corresponded to 3% of responses). Mean RTs (and their standard deviation) and error rates by attribute decision and pair type are presented in Table 3.

Results were analysed in the same manner as in Experiment 1. For the subject analysis, main effects were found for attribute, $F(1, 41) = 8.59, MSE = 109230, p = .005$, indicating faster RTs for functional than for perceptual decisions, and for pair, $F(2, 82) = 5.76, MSE = 36776, p = .005$. The post hoc analysis of this latter effect (Scheffé test) showed that RTs to mixed pairs were slower than those to both nonliving and living things pairs. A significant interaction between attribute and pair was also found, $F(2, 82) = 3.76, MSE = 41394, p = .03$, showing that functional decisions were faster than perceptual decisions, especially for nonliving pairs. The item analysis only confirmed the main effect found for attribute, $F(1, 18) = 5.58, MSE = 15864, p = .03$, all other effects being nonsignificant.

Similarly to Experiment 1, an error analysis was also done by subjects and by items. Significant

<table>
<thead>
<tr>
<th>Table 3. Mean reaction times (ms) and standard deviation (RT, SD) and error rates (% error) by attribute decision and pair type</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Perceptual (size)</strong></td>
</tr>
<tr>
<td>RT</td>
</tr>
<tr>
<td>Living</td>
</tr>
<tr>
<td>Nonliving</td>
</tr>
<tr>
<td>Mixed</td>
</tr>
</tbody>
</table>
effects, were found only in the subject analysis, namely a main effect for attribute, \( F(1, 41) = 5.40, \) MSE = 0.661, \( p = .03, \) indicating more errors for functional decisions, and an attribute \( \times \) pair interaction, \( F(2, 82) = 6.47, \) MSE = 0.382, \( p = .002, \) indicating more errors for mixed than for living things pairs in the case of perceptual decisions (Scheffé test). Both these results go in the same direction as the RT differences observed, so the data seems free of speed-accuracy tradeoff problems.

Overall, the strongest result, confirmed by both analyses, is that functional decisions seem faster. The subject analysis also showed that RTs to mixed pairs were the slowest and that functional decisions were especially faster than perceptual decisions in the case of nonliving things. This pattern of results confirms the importance of functional features observed in Experiment 1 but, at the same time, seems in accordance with a taxonomical perspective and also gives some support to an attribute-category connection hypothesis. In fact, RT for mixed pairs is higher than for homogeneous pairs, a result more in agreement with a taxonomical perspective, and functional attributes seem to entail lower RT, especially in the case of nonliving things, a result that is predicted by the attribute-category connection hypothesis, although this is not accompanied by full confirmation of their main prediction (i.e., faster perceptual decisions for living things). These conclusions are further tested in Experiment 3 with other attributes and items.

**EXPERIMENT 3**

Experiment 3 constitutes a final evaluation of the pattern of results obtained in the two previous experiments, with still two other perceptual and functional attributes, “hardness” and “usefulness.”

**Method**

*Participants and design.* Forty-two undergraduate students participated for partial fulfilment of an introductory psychology course requirement but four subjects were discarded from the analysis as they had fewer than 50% correct responses (total \( N = 38). \)

A 3 \( \times \) 2 \( \times \) 2 factorial design with variables type of pair (all living, all nonliving, mixed), feature (hardness, usefulness) and answer (yes, no). All variables were manipulated at the within-subject level.

*Materials.* As in Experiment 1, four pairs were considered for each of the possible combinations of the three variables and pairs were controlled for in terms of item familiarity (Portuguese Familiarity Norms from Marques, 1997). Associative strength between the elements of each pair was also controlled for, with all pairs showing no association (Portuguese Associative Strength Norms from Marques, 2001). The hardness and the usefulness norms (5-point rating scale in both cases) were obtained with the same sample of 11 undergraduate students tested for the speed measurement, who otherwise did not participate in the experiment. Item and decision task (perceptual and functional) construction followed the same arrangement of the previous experiments (a list of all stimuli is presented in Appendix C).

*Procedure.* Procedure was the same as in Experiment 1 with respect to general instructions, slide sequence on each decision, training, answer mode, and recording. The experimental block was composed of the hardness decision block (answer yes if the two items are hard) and the usefulness decision block (answer yes if the two items are generally useful), which were introduced and presented in the same manner as in Experiment 1.

**Results and discussion**

Mean RTs by type pair, attribute, and answer were calculated from correct responses. The percentage of correct responses was high for both yes and no answers (86% for yes and 83% for no). As in the previous experiments, only RTs for “yes” correct answers were considered for analysis and RTs exceeding 3000 ms were eliminated but not counted as errors (outliers corresponded to 3% of responses). Mean RTs (and their standard
deviation) and error rates by attribute decision and pair type are presented in Table 4.

Results were analysed in the same manner as in Experiment 1. In the subject analysis, main effects were found for attribute, $F(1, 37) = 4.30, \text{MSE} = 648960, p = .045$, indicating faster RTs for functional than for perceptual decisions, and for pair, $F(2, 74) = 4.11, \text{MSE} = 197167, p = .02$. The post hoc analysis of this latter effect (Scheffé test) showed that RTs to nonliving pairs were faster than to both mixed and living pairs. A significant interaction between attribute and pair was also found, $F(2, 74) = 17.44, \text{MSE} = 5439111, p = .000$, showing that RTs to nonliving pairs were especially faster than the other pairs for perceptual decisions and that functional decisions were especially faster than perceptual decisions for living pairs (Scheffé test).

The item analysis confirmed these results, with main effects found for attribute, $F(1, 18) = 12.79, \text{MSE} = 68529, p = .002$, and for pair, $F(1, 18) = 4.06, \text{MSE} = 21741, p = .035$, and also for the pair × attribute interaction, $F(2, 18) = 8.55, \text{MSE} = 45813, p = .002$. Error analysis by items and by subjects only produced a significant main effect in the latter analysis, $F(2, 74) = 17.49, \text{MSE} = 8.29, p = .000$, corresponding to more errors for living and mixed pairs than for nonliving pairs. However, as this result goes in the same direction as the RT difference observed, the data seems free of speed-accuracy tradeoff problems.

Overall, these results show that decisions about nonliving pairs seem faster, independent of the attribute tested (although this difference was more accentuated for perceptual decisions) and also that functional decisions seem faster, independent of the pair tested decisions (although this difference was more accentuated in the case of living pairs).

These results seem more in accordance with a featural perspective (as RTs to mixed pairs are not systematically higher), and especially a perspective that emphasises the role of functional attributes. Also, the interaction pattern observed contradicts the attribute-category connection hypothesis and indirectly supports a flexible composition hypothesis. This is generally the same pattern of results observed in Experiment 1, and also in Experiment 2 in the case of functional attributes.

A final analysis of this global pattern of results was done with the data from the three experiments (both by subjects and by items) using Experiment (1, 2, or 3) as a random factor. For the subject analysis, main effects were found for experiment, $F(2, 115) = 3.57, \text{MSE} = 2292330, p = .03$, indicating faster RTs in Experiment 2 compared with Experiment 1 (Scheffé test), and for attribute, $F(1, 2) = 18.61, \text{MSE} = 4564218, p = .049$, indicating faster RTs for functional decisions. Significant interactions were also found between experiment and pair, $F(4, 230) = 13.50, \text{MSE} = 632330, p = .000$, and between experiment, attribute, and pair, $F(4, 230) = 9.30, \text{MSE} = 390530, p = .000$. Post hoc analysis of these effects (Scheffé test) showed in the first case that RTs to living things pairs were especially faster than RTs to both nonliving and mixed pairs in Experiment 1. In the second case, RTs to living pairs were faster than those to nonliving pairs for perceptual decisions, and functional decisions were faster than perceptual decisions for nonliving pairs in Experiment 1; functional decisions were faster than perceptual decisions for living pairs, and nonliving pairs were faster than living pairs for perceptual decisions in Experiment 3 (Scheffé test). The item analysis confirmed the main effects obtained for experiment, $F(2, 54) = 18.60, \text{MSE} = 233021,$

---

**Table 4.** Mean reaction times (ms) and standard deviation (RT, SD) and error rates (% error) by attribute decision and pair type

<table>
<thead>
<tr>
<th></th>
<th>Perceptual (hardness)</th>
<th>Functional (usefulness)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RT        (SD)   % error</td>
<td>RT        (SD)   % error</td>
</tr>
<tr>
<td>Living</td>
<td>1657.99   437.77   25.00</td>
<td>1384.05   360.54   19.08</td>
</tr>
<tr>
<td>Nonliving</td>
<td>1395.43   353.24   3.29</td>
<td>1459.81   408.28   7.89</td>
</tr>
<tr>
<td>Mixed</td>
<td>1564.79   471.52   15.13</td>
<td>1454.26   373.67   15.13</td>
</tr>
</tbody>
</table>

472 COGNITIVE NEUROPSYCHOLOGY, 2002, 19 (5)
\( p = .000 \), (indicating faster RTs in Experiment 2 in relation to both Experiment 1 and 3, Scheffé test), and for attribute, \( F(1, 2) = 22.72, \text{MSE} = 373934, p = .04 \), in the subject analysis. An interaction was also found between experiment and pair, \( F(4, 54) = 4.11, \text{MSE} = 51519, p = .001 \), but post hoc analysis (Scheffé test) did not show any relevant significant differences.

These results confirm the analyses done in each experiment and further provide a more general pattern of effects that is more in accordance with a featural perspective and particularly with models that emphasise the role of functional attributes. In fact, RT for mixed pairs is not systematically higher than for homogeneous pairs, a result more in agreement with a featural perspective. Moreover, the strongest result is that functional attributes seem to entail lower RT independently of particular pair tested, a result that supports the functional emphasis hypothesis, is acceptable within a flexible composition hypothesis, and which contradicts the attribute-category connection hypothesis. These conclusions are analysed further in the General Discussion.

**GENERAL DISCUSSION**

The present paper evaluated different hypotheses regarding semantic memory organisation in relation to the living/nonliving dissociation phenomenon. This evaluation was done using a word pair decision task with perceptual and functional criteria. Both decisions were made on all living, all nonliving, and mixed pairs. In the three experiments that were carried out a diverse pattern of results was found in terms of both attribute and pair type. However, consideration of the different data obtained seems more in accordance with some of the hypotheses and models contrasted than with others.

At a more general level, results are more in accordance with a featural hypothesis than with a categorical hypothesis. The latter predicted that RT to mixed pairs would always be higher than RT to homogeneous pairs, whereas the featural hypothesis considered that such a result would depend on the specific features tested (although no specific prediction was proposed at this level). In fact, the pattern predicted by the categorical hypothesis was not observed. The comparison of mixed pairs with living and with nonliving pairs was inconsistent in terms of the particular attributes tested and was nonsignificant when considered in a more general analysis. Overall, the differences observed suggest that performance was more dependent on the specific attribute decisions than on whether the items belonged to the same category or not.

The absence of relevant error trends in terms of the variables tested confirms this analysis, and at the same time is an argument against explanations of the observed effects exclusively in terms of item selection or difficulty of attribute decisions between pairs or their individual elements. It is true that complete control between sets would only be obtained if RT to the different pairs and their single members were evaluated as other lexical variables influence RT. However, the fact that attribute and item familiarity were controlled for in the various experiments, and the use of different analyses in terms of RT and errors, seem to show that these effects are not very important. It is obvious that some decisions may be more time-consuming than others and that further testing considering different attributes and items is needed. Also, in the present experiments only animals and artefacts in general were tested and, as such, plant life or body parts, other important categories of Caramazza and Shelton’s proposal (Caramazza & Shelton, 1998; Shelton & Caramazza, 2000; Shelton et al., 1998), need to be evaluated too. However, these facts alone seem insufficient to explain the observed results.

It is also possible that there might be some kind of hierarchical organisation at an attribute level (i.e., some attribute decisions are more general than others)\(^4\). However, I think the differences found

\[4 \text{I thank one of the anonymous referees for this suggestion.}\]
between attributes and experiments in the present study are very difficult to frame without equivocation in terms of hierarchical levels. Moreover, recently Solomon and Barsalou (2001) have demonstrated empirically that attributes should be viewed very specifically (e.g., mane different for horse and lion), an idea also defended by Shelton and Caramazza (2000), which considers that there is little redundancy in the attributes represented between categories.

Although, at a more general level, a featural hypothesis receives support, not all featural models and predictions are equally supported by the results. The attribute-category connection hypothesis (e.g., Farah & McClelland, 1991), which especially predicted lower RT for perceptual decisions in the case of living things and also lower RT for functional decisions in the case of nonliving things, is not supported by the results. On the contrary, the overall pattern from the three experiments is more in accordance with a flexible composition hypothesis (e.g., McKenna & Warrington, 1993; Shallice, 1988), which considers that the perceptual-functional difference for the two categories will depend on the specific attributes tested. The functional emphasis hypothesis (Tyler & Moss, 1997) is also supported by the results, with a general trend observed in the three experiments for lower RT in the case of functional decisions, the strongest and most similar result that all experiments and analyses provide. However, it should be noted that the functional features manipulated do not always correspond to biological function features in the case of living things (dangerousness, speed, usefulness). Thus a more restrictive view of functional emphasis (Tyler et al., 2000), although not directly tested, does not seem supported.

The present results, both at the general level and at the level of the different featural hypotheses, are in accordance with the results obtained by Marques (2000) with another paradigm and measure, which gives the conclusions extra support. However, the measures used in the present study and the pattern of results obtained point to other considerations for the comparison of models of semantic memory organisation and for the explanation of the living/nonliving things dissociation phenomenon.

Concerning the first aspect, if it is true that results from the two studies contradict both a categorical position and an attribute-category connection hypothesis, it is also true that the support they give to their more direct counterpart (respectively the featural position and the flexible composition hypothesis) relies partially on the fact that the latter are not so compelling and precise in terms of the results predicted. So, it would seem rather that the results from these two studies point out that a featural hypothesis is more adequate to describe semantic memory organisation, but they are still far from telling us in what ways this attribute information is organised. The attribute-category connection is probably too simple to explain this organisation (although it may explain some results and cases observed), but a flexible composition hypothesis needs further specification to offer a testable model and more than a general explanation of semantic memory organisation.

The support to the functional emphasis hypothesis found in both studies joins the group of priming results presented by Moss and Tyler (Moss et al., 1995, 1997; Tyler & Moss, 1997) and indicates that their hypothesis merits further evaluation. The exploration of attributes in connection with the proposed form-function relations for nonliving things and biological function attributes for living things seem to be two promising lines of research in this direction. Furthermore, these explorations, together with other proposals of attribute relations (e.g., Devlin et al., 1998; Gonnerman et al., 1997), might just bring about the kind of specification that the more general flexible composition hypothesis need. In this sense, the present results are silent to other dimensions of semantic memory organisation and to the multiple vs. unitary semantics debate. They are compatible with the multiple semantics view of Warrington, Shallice, and associates (e.g., Shallice, 1988; Warrington & McCarthy, 1994) and can readily be explained in a unitary framework such as the OUCH (Caramazza, Hillis, Rapp, & Romani, 1990) or others (e.g., Devlin et al., 1998; Tyler et al., 2000).

A final point concerns the relation of the present results with the living/nonliving dissociation patient literature, from which this discussion was
originally derived. These results (and also the results from Marques, 2000) can be readily integrated with those cases that seem to demonstrate impaired vs. spared performance patterns related to attributes, but seem more difficult to fit with the cases that show impaired vs. spared performance patterns related to categories (see case revisions by Caramazza, 1998; Forde & Humphreys, 1999; Gainotti, 2000). However, considering that the flexible attribute hypothesis (supported by the present results) still needs further specification, we can argue that it can also encompass the latter type of cases, although not explaining their eventual evolutionary motivation. Categories would simply correspond to the fact that we can identify clusters of items in terms of attributes (and attribute correlations) and that some of those clusters are more salient in our environment than others (Marques, 2000).

The fact that the present models do not seem to explain all the different cases in the literature may also argue for a different type of experimental approach in terms of the exploration of deficits presented by the patients. The general approach that was followed here, to contrast specific featural and categorical hypotheses with the same materials and task, is not usual in the study of neurological patients with category-specific deficits. In these studies, hypotheses generally come after the description and characterisation of the deficits, and this has been a fruitful approach for theorisation about semantic memory organisation. Perhaps to move forward it is also the time to consider the reverse order (i.e., hypothesis and testing) in a more systematic manner, although bearing in mind the limitations of testing neurological patients. The present study also seems to present a possible way to test these patients, especially if the less demanding recall data is considered instead of the RT measure. This possibility contrasts with the use of the PI-release paradigm, which poses very high cognitive demands for this patient population (Marques, 2000) and would be extremely difficult to apply.

REFERENCES


APPENDIX A

Word pairs (English equivalents) used in Experiment 1

<table>
<thead>
<tr>
<th>Perceptual attribute (four legs)</th>
<th>Functional attribute (dangerousness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td>Nonliving</td>
</tr>
<tr>
<td>Yes pairs</td>
<td></td>
</tr>
<tr>
<td>Raccoon</td>
<td>Bed</td>
</tr>
<tr>
<td>Horse</td>
<td>Sofa</td>
</tr>
<tr>
<td>Zebra</td>
<td>Dresser</td>
</tr>
<tr>
<td>Buffalo</td>
<td>Stool</td>
</tr>
<tr>
<td>Goat</td>
<td>Armchair</td>
</tr>
<tr>
<td>Pig</td>
<td>Cupboard</td>
</tr>
<tr>
<td>Sheep</td>
<td>Couch</td>
</tr>
<tr>
<td>Deer</td>
<td>Locker</td>
</tr>
<tr>
<td>No pairs</td>
<td></td>
</tr>
<tr>
<td>Cow</td>
<td>TV Set</td>
</tr>
<tr>
<td>Ostrich</td>
<td>Lamp</td>
</tr>
<tr>
<td>Duck</td>
<td>Screen</td>
</tr>
<tr>
<td>Camel</td>
<td>Refrigerator</td>
</tr>
<tr>
<td>Peacock</td>
<td>Bookshelf</td>
</tr>
<tr>
<td>Hippopotamus</td>
<td>Ashtray</td>
</tr>
<tr>
<td>Frog</td>
<td>Carpet</td>
</tr>
<tr>
<td>Owl</td>
<td>Trunk</td>
</tr>
</tbody>
</table>

| Living                           | Nonliving                            | Mixed |
| Leopard                          | Pistol                               | Lion |
| Elephant                         | Hammer                               | Needle |
| Hawk                             | Scissors                             | Knife |
| Gorilla                          | Fishhook                             | Crocodile |
| Bear                             | Saw                                  | Fox |
| Tiger                            | Whip                                 | Axe |
| Shark                            | Rifle                                | Sword |
| Panther                          | Baton                                | Eagle |
| Butterfly                        | Doll                                 | Wolf |
| Wild Boar                        | Cannon                               | Ball |
| Canary                           | Syringe                              | Gun |
| Panda                            | Telephone                            | Turtle |
| Bee                              | Baseball Bat                         | Balloon |
| Ant                              | Book                                 | Snake |
| Rhinoceros                       | Bell                                 | Nightingale |
| Snail                            | Machine-gun                          | Blade |
## APPENDIX B

### Word pairs (English equivalents) used in Experiment 2

<table>
<thead>
<tr>
<th>Perceptual attribute (size)</th>
<th>Functional attribute (speed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td>Nonliving</td>
</tr>
<tr>
<td>Yes pairs</td>
<td></td>
</tr>
<tr>
<td>Whale</td>
<td>Refrigerator</td>
</tr>
<tr>
<td>Hippopotamus</td>
<td>Truck</td>
</tr>
<tr>
<td>Rhinoceros</td>
<td>Ladder</td>
</tr>
<tr>
<td>Walrus</td>
<td>Submarine</td>
</tr>
<tr>
<td>Gorilla</td>
<td>Piano</td>
</tr>
<tr>
<td>Shark</td>
<td>Cupboard</td>
</tr>
<tr>
<td>Buffalo</td>
<td>Elevator</td>
</tr>
<tr>
<td>Elephant</td>
<td>Wardrobe</td>
</tr>
<tr>
<td>No pairs</td>
<td></td>
</tr>
<tr>
<td>Fly</td>
<td>Desk</td>
</tr>
<tr>
<td>Pig</td>
<td>Needle</td>
</tr>
<tr>
<td>Bull</td>
<td>Button</td>
</tr>
<tr>
<td>Lizard</td>
<td>Freezer</td>
</tr>
<tr>
<td>Cricket</td>
<td>Ship</td>
</tr>
<tr>
<td>Dromedary</td>
<td>Pencil</td>
</tr>
<tr>
<td>Deer</td>
<td>Cigarette</td>
</tr>
<tr>
<td>Rabbit</td>
<td>Berth</td>
</tr>
</tbody>
</table>

## APPENDIX C

### Word pairs (English equivalents) used in Experiment 3

<table>
<thead>
<tr>
<th>Perceptual attribute (hardness)</th>
<th>Functional attribute (usefulness)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td>Nonliving</td>
</tr>
<tr>
<td>Yes pairs</td>
<td></td>
</tr>
<tr>
<td>Hippopotamus</td>
<td>Dagger</td>
</tr>
<tr>
<td>Gorilla</td>
<td>Hammer</td>
</tr>
<tr>
<td>Cricket</td>
<td>Screw</td>
</tr>
<tr>
<td>Crab</td>
<td>Brick</td>
</tr>
<tr>
<td>Wild Boar</td>
<td>Gun</td>
</tr>
<tr>
<td>Langoustine</td>
<td>Locker</td>
</tr>
<tr>
<td>Crocodile</td>
<td>Jug</td>
</tr>
<tr>
<td>Shark</td>
<td>Ring</td>
</tr>
<tr>
<td>No pairs</td>
<td></td>
</tr>
<tr>
<td>Cockroach</td>
<td>Desk</td>
</tr>
<tr>
<td>Octopus</td>
<td>Glove</td>
</tr>
<tr>
<td>Spider-Crab</td>
<td>Glass</td>
</tr>
<tr>
<td>Worm</td>
<td>Pillow</td>
</tr>
<tr>
<td>Squid</td>
<td>Scarf</td>
</tr>
<tr>
<td>Bat</td>
<td>Vase</td>
</tr>
<tr>
<td>Toad</td>
<td>Sweater</td>
</tr>
<tr>
<td>Armadillo</td>
<td>Hoe</td>
</tr>
</tbody>
</table>