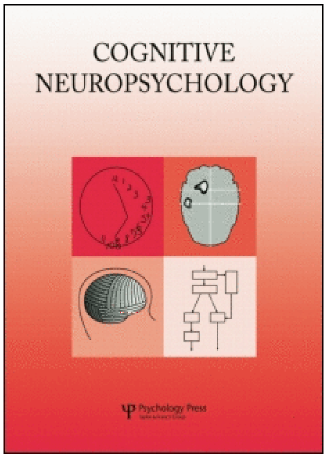

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Nouns, verbs, objects, actions, and the animate/inanimate effect

Yanchao Bi
State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing, China; Cognitive Neuropsychology Laboratory, Harvard University, Cambridge, MA, USA

Zaizhu Han and Hua Shu
State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing, China

Alfonso Caramazza
Cognitive Neuropsychology Laboratory, Harvard University, Cambridge, MA, USA; University of Trento, Trento, Italy

We report an aphasic patient, Z.B.L., who showed a significant advantage for verbs compared to nouns in picture-naming tests. Within the object class, he performed better on animate things than on nonliving things in picture naming as well as in an "attribute judgement task". This pattern of performance is contrary to the central prediction of a recent proposal (Bird, Howard, & Franklin, 2000), which attributes noun–verb dissociation in aphasic patients to deficits in processing certain kinds of semantic features. This model proposes that conceptual representations of verbs have a lower proportion of sensory features than do representations of nouns; the same is proposed for inanimate versus animate items within the noun category. Noun deficits are assumed to arise due to impairment for the processing of sensory features. The model predicts that if a patient is more impaired for nouns than for verbs, he will also display more difficulty with animate than with inanimate objects. Contrary to predications derived from this theory, Z.B.L. performed better with animate than inanimate nouns.

Introduction

Category-specific deficits in brain-damaged patients have played an important role in the development of cognitive theories about the lexical and the semantic systems. For instance, some brain-damaged patients are disproportionately impaired for words/objects in certain conceptual categories, such as living things, nonliving things, or body parts (see Capitani, Laiacona, Mahon, & Caramazza, 2003, for an extensive review). Such patterns of impairment have motivated and constrained cognitive theories about the structure of the semantic system (e.g., Caramazza & Shelton,

Correspondence should be addressed to Zaizhu Han, State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing, 100875, P.R. China (E-mail: zzhhan@bnu.edu.cn).

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1998; Hillis & Caramazza, 1991; Sacchet & Humphreys, 1992; Tyler & Moss, 2001; Warrington & Shallice, 1984). This paper deals with another compelling kind of category-specific deficit: disproportionate impairment for certain grammatical classes. There are report of patients who are more impaired at producing verbs than at producing nouns (e.g., Berndt, Mitchum, Haendiges, & Sandson, 1997; Caramazza & Hillis, 1991; McCarthy & Warrington, 1985; Rapp & Caramazza, 1998) and, conversely, patients who are more impaired for nouns than for verbs (e.g., Bates, Chen, Tzeng, Li, & Opie, 1991; Shapiro, Shelton, & Caramazza, 2000; Zingeser & Berndt, 1988, 1990).

The underlying causes of such noun/verb dissociations are controversial. Because a common proxy for studying noun/verb production has been naming object pictures and action pictures, these results contain a confound between grammatical category (noun/verb) and conceptual category (object/action). Therefore two lines of hypotheses have been developed for such dissociations: one attributing the dissociations to selective conceptual deficits for actions or objects, and the other attributing the dissociations to a grammatical processing in the lexical system. There is now mounting evidence that the patients with noun/verb (object/action) dissociations are not a homogeneous group, and the effects can be attributed to different causes (see discussion in Laiacona & Caramazza, 2004). Some cases may best be explained by conceptual variables (e.g., Berndt et al., 1997; Marshall, Pring, Chiat, & Robson, 1996a, 1996b), and some are better accounted for by grammatical dimensions, such as selective deficits to the morphosyntactic operation for nouns or verbs (e.g., Shapiro et al., 2000). What is important, then, is to evaluate specific theories about the conceptual organization or grammatical processing by identifying the range of profiles that a theory can explain. The approach we take in the current article is to test the explanatory power of one specific conceptual theory for the noun/verb dissociation, the "*extended sensory/functional theory*" (ESFT, Bird, Howard, & Franklin, 2000), with the data of one patient whose deficit seemed to be (at least partly) of conceptual origin.

ESFT is based on an influential theory about the organization of the conceptual system, the *sensory/functional theory* (SFT), which was motivated by category-specific deficits for living things or artifacts (Gainotti & Silveri, 1996; Hart & Gordon, 1992; Shallice, 1988; Silveri & Gainotti, 1988; Warrington & McCarthy, 1983, 1987; Warrington & Shallice, 1984; but see Caramazza & Shelton, 1998, for a critique). SFT makes the following assumptions: (a) Concepts are distributed over sets of modality-specific features, including sensory and functional features; (b) concepts of animate things (living things) have a higher proportion of *sensory* features than do concepts of artifacts (nonliving things) and that artifacts have a higher proportion of *functional* features than do animate things; (c) damage to a particular type of feature will more strongly affect categories for which that feature type is more important (having higher proportions). Therefore, damaging the sensory features will result in more severe deficits in processing living things, and damage to functional features will be correlated with more severe deficits in processing artifacts (nonliving things). Bird and colleagues (2000) extended the second assumption of SFT in order to include verb concepts to account for the grammatical category differences and specifically for verb processing deficits. Their model, ESFT, assumes that the concepts of animate things, inanimate things, and verbs are located at points along a continuum reflecting the size of the ratio of sensory to functional features. Both types of nouns (animate and inanimate) have more sensory than functional features, with the sensory-to-functional ratio larger for animate items, and verbs have fewer sensory than functional features. Thus, an impairment in processing sensory features is expected to cause the greatest difficulty for animate objects, less difficulty for inanimate objects, and the least difficulty for verbs. Bird and colleagues also assert that, according to their rating results, depictable action verbs have significantly lower imageability than both types of nouns. Patients who display imageability effects would thus tend to have more severe verb-naming deficits. Proponents of ESFT propose that such conceptual differences are the origins of noun–verb dissociations observed in the literature, when other extraneous factors, such as lexical frequency, are controlled for. That is, disproportionate impairment of noun production is due to a specific deficit to sensory features, and a verb-specific impairment is the result of an imageability effect. The model therefore predicts that if a patient is better with verbs than with nouns, she will also be better with inanimate than with animate nouns (referred to as the *animacy effect*). However, because of the imageability difference between nouns and verbs, if a patient is more impaired for verbs than for nouns, she may not necessarily show a reverse animacy effect.

There are variants of the featural theories that also explain the category-specific semantic effects by the featural-composition differences across categories, but are different from SFT in the details about the actual feature compositions of various categories (e.g., Martin, Ungerleider, & Haxby, 2000). Among them, one that explicitly considers the noun/verb dissociation is the "*featural and unitary semantic space*" (FUSS) theory, which was proposed by Vigliocco and colleagues (Vigliocco, Vinson, Lewis, & Garrett, 2004; also see Vigliocco & Vinson, in press; Vinson & Vigliocco, 2002; Vinson, Vigliocco, Cappa, & Siri, 2003). FUSS differs from ESFT in the types of features being considered (sensory/function vs. visual/other perceptual/motoric/functional) and how the feature norms were collected (hypothesized vs. speaker generated). A further difference is that FUSS assumes an intermediate lexical semantic layer between concepts and lexical representations, which also give rise to noun/verb (object/action) dissociations. Therefore FUSS makes complicated predictions about the patterns of performance accompanying a noun/verb dissociation, depending on whether the deficit is located at the conceptual level or the lexical semantic level. Given that the focus of the current article is on the ESFT, we do not discuss our data directly in the framework of FUSS but only do so indirectly by conducting post hoc analyses.

What is the evidence for these featural theories about the conceptual system? In particular, proponents of the ESFT (and SFT) have argued that the assumption about the organization and representation of conceptual features of living and nonliving things gains support from empirical evaluations of object concepts. For instance, Farah and McClelland (1991) asked normal subjects to underline visual and functional features in definitions of living and nonliving things and found that the ratio of visual to functional features underlined was much higher for living than for nonliving things. The observations that some patients with category-specific deficits show associations of deficits between body parts and artifacts, or between musical instruments and animate objects, is also claimed to be consistent with the SFT. The argument is that body parts have a higher proportion of functional features, while musical instruments have more sensory features. This predicts that damage to sensory-feature processing would cause more impairment to the categories that rely more heavily on those sensory features, including animate objects and musical instruments; in contrast, damage to functional-feature processing would more severely impair the processing of artifacts and body parts, concepts that have primarily functional features. Supporting the extension of the sensory-to-functional ratio difference between animate and inanimate objects to verbs, Bird and colleagues (2000) cited associations between noun deficits and animacy effects (A.L., Ferreira, Giusiano, & Poncet, 1997; I.O.L., Shelton, Fouch, & Caramazza, 1998). The argument is that since sensory features are more important for animate than for inanimate objects, and are least important for verbs, damage to sensory-feature processing would lead to less difficulty with inanimate than with animate objects and even less difficulty with verbs. Bird and colleagues (2000) bolster this contention by a detailed analysis of three patients (M.L., J.S., and N.T.) with this pattern.

Dawson, 1996; McRae, de Sa, & Seidenberg, 1997; see extensive and detailed studies by Cree & McRae, 2003). The sensory-to-functional ratios for animate and inanimate objects used in Bird and colleagues' (2000) simulation model were based on averaging the results of three studies, each of which employed very different methods and obtained very different results. Although there have been further norming studies (Vinson & Vigliocco, 2002) supporting the assumption that action verbs have smaller ratios of sensory to functional features, the most direct argument based on the association between a noun deficit and an animacy effect is still not conclusive. Of the three patients with "noun deficits" who were systematically studied by Bird and colleagues, only one (M.L.) was significantly better at verb naming on one of the two noun/verb naming tests. None of the patients showed a noun/verb difference in a naming to definition task. And only one other patient (N.T.) showed a significant animacy effect in noun naming. It is therefore not clear how reliable these associations are.

Two cases in the literature do not support ESFT's predictions. J.J. (Hillis & Caramazza, 1991) showed a reverse animacy effect (was better at naming animate than inanimate items) but did not have a verb deficit according to post hoc observations. E.A. (Laiacona & Caramazza, 2004), who did show an association between noun-deficit and animacy effect, was equally impaired with visual-perceptual knowledge and functional knowledge, contrary to predictions derived from ESFT. In this paper we further report a case that more directly challenges the central prediction made by the ESFT. We report the performance of a patient, Z.B.L., who is more impaired in naming object pictures with nouns than in naming action pictures with verbs and is more impaired in processing inanimate objects than animate objects, contrary to what ESFT predicts. The experiments involved two lines of testing: First, we established that Z.B.L. was better at producing verbs to action pictures than at producing nouns to object pictures in two picture-naming experiments—referred to as noun/verb (object/action) naming tasks. Second, to examine the prediction that a noun deficit is associated with the animacy effect, we tested Z.B.L.'s performance with animate and inanimate things in both naming and attribute judgement tasks.

METHOD

Case report

Z.B.L. is a 50-year-old, right-handed man with a high-school education; he formerly worked in the public relations department of a company. Mandarin Chinese is the only language he speaks. He suffered his first stroke in October 1997 and a second stroke in December of the same year. A magnetic resonance imaging (MRI) scan performed at the acute stage of the second stroke revealed a lesion in the territory of the left posterior cerebral artery, involving the occipital lobe and extending intor Hsrefac of hhe take, just take it, because the floor is slippery, he fell down, at almost the same time of falling down, laughed there, eventually everything is solved nicely.)

Tests for the present study were conducted between three and six years after the last insult, between July 2000 and October 2003. During this time the patient's performance remained stable.

Background: Repetition, lexical decision, and auditory comprehension

In the preliminary screening test in July 2000, Z.B.L. was perfect in a repetition task with both words and nonwords (40/40). He was also flawless in an auditory lexical-discrimination task (25/25), in which he was asked to tell whether two syllables were the same or different (to create the different trials, the vowel, the consonant, or the tone of the syllables were varied). He performed perfectly in an auditory word–picture matching task in which he matched one spoken word to two pictures (50/50, foils being semantically, phonologically, or visually related), in an auditory sentence–picture matching task in which he matched one spoken sentence to two pictures (20/20), and in an auditory word–lexical-decision task (20/20, foils being pseudo-compounds such as "tea–row"). He made a few errors in an auditory word–picture verification task, in which he judged, with "yes" or "no" responses, whether a spoken word matched a picture (148/162). Collectively, these data suggest that Z.B.L.'s auditory comprehension was only mildly impaired.

EXPERIMENT 1: NOUN/VERB (OBJECT/ACTION) NAMING I

Method

Procedure

The test included 34 object pictures and 34 action pictures. Most of the object pictures were taken from Snodgrass and Vanderwart (1980) and the action pictures from Zingeser and Berndt (1990). The set of target names (nouns) for the object pictures and target names (verbs) for the action pictures were matched on the following variables: word surface frequency, word token frequency in the particular grammatical class (Yu, Zhu, Wang, & Zhang, 1998), number of syllables, name agreement, and familiarity ratings (see Table 1; all ts < 1). The name agreement and familiarity ratings were obtained from the naming responses and familiarity judgements (on a scale of 1 to 5) made by 16 undergraduate students at Beijing Normal University. A total of 14 of the 34 words in each set are disyllabic compounds, which is the most common type of word in Chinese. For these compound words, the internal structure was also matched. Both the noun compounds and the verb compounds were composed of a verb morpheme ($/_{\text{v}}.$) plus a noun morpheme ($/_{\text{n}}.$)—for example, scarf$/_{\text{n}}.$ (wrap$/_{\text{v}}.$–towel$/_{\text{n}}.$) versus fencing$/_{\text{v}}.$ (beat$/_{\text{v}}.$–sword$/_{\text{n}}.$). Since neither nouns nor verbs are morphologically inflected in Chinese, there was no need to have

Table 1. *Stimuli for Noun/Verb Picture-naming Task I*

		N	*Naming agreement*	*Conceptual consistency*	*Familiarity*	*Token frequency*	*Surface word frequency*
Monosyllabic	V	20	.81	.88	4.41	128	150.5
	N	20	.86	.9	4.37	121.25	156.75
Compound	V(vn)	14	.79	.97	4.53	6.33	6.83
	N(vn)	14	.79	.9	4.43	6.7	6.7

Note: V = verb. N = noun. vn = verb–noun.

two sets of nouns matching the cumulative and surface frequencies of the verbs as in Zingeser and Berndt's (1990) Noun/Verb Picture Test. Each picture was printed on a piece of paper and was presented to Z.B.L., without a time limit, until he responded. The noun pictures and the verb pictures were assigned to two sessions using the ABBA method. The two sessions were separated by one week. The first complete response was scored. The full test (two sessions each test) was administered to Z.B.L. twice, once in 2000 and once in 2003.

Results

In both the 2000 and 2003 tests, Z.B.L. was able to correctly name more verb pictures than noun pictures. He responded correctly to 15/34 nouns and 26/34 verbs in 2001, $\chi^2(1) = 7.43$, $p < .01$, and 14/34 nouns and 23/34 verbs in 2003, $\chi^2(1) = 4.80$, $p < .05$. Table 2 shows a breakdown by error type in the 2003 test. Most of his errors were semantic (substitutions of semantically related words) and circumlocutory (descriptions or incomplete sentence frames). A few errors were phonologically related words or “don't know” responses. His circumlocutory errors tended to describe the actions assoc 2to.s3242.i0(c)18.2(t28-310.8(th)15.1(e)-2t-3eT92to)-r-3eg8(s)12e0(a)11first9sob1-586cand5-

Results

Z.B.L. was significantly better at producing verbs in the action-naming block (24/30) than he was at producing nouns in the object-naming block (11/30), $\chi^2(1) = 11.59$, $p < .001$. Z.B.L.'s tendency to describe the target objects using associated verbs is more evident here. A total of 13 out of the 14 circumlocutory errors in the object-naming block involved related actions. For instance, he said "这是那个，蒸，就是热东西，是小个的，不是大个的，小饭锅。" (For the target "steamer/pot": "This is that, to steam, to heat stuff, is small one, not big one, small rice pot"). By contrast, his circumlocutions for the action-naming block did not involve apparent use of concrete nouns. Furthermore, there were five pairs of objects and actions in this and the previous noun/verb (object/action) naming test where the names were either homonyms (画-painting/to paint) or differ only by one functional morpheme (e.g., the brush, 刷, vs. to brush, 刷子). Z.B.L. named correctly all verb (action) instances but two noun (object) instances.

Noun/verb (object/action) naming: Discussion

These two noun/verb (object/action) picture-naming tests showed that Z.B.L. made frequent semantic errors in naming and was significantly worse at naming object pictures using nouns than he was at naming action pictures using verbs. First, his performance in oral naming was significantly worse than his performance in auditory word comprehension tasks (perfect in word-to-picture matching and above 90% correct in word–picture verification). It is likely that he is impaired in lexical retrieval for oral output. More importantly in the current context, what is the origin of the noun/verb (object/action) difference in naming? In the next section we test ESFT's assumptions that disproportionate noun (object) impairment is the result of deficits for processing sensory features, which would be expected to be associated with an animacy effect within the noun (object) domain.

EXPERIMENT 3: SEMANTIC CATEGORIES I—PICTURE NAMING

Method

Procedure

To determine whether Z.B.L. showed a semantic category effect in object naming, he was tested with Snodgrass and Vanderwart's (1980) pictures on two separate occasions in 2000 and 2003. We used a Chinese-normed version of the picture set (Shu, Cheng, & Zhang, 1989), which includes 232 of the Snodgrass and Vanderwart pictures, having excluded items that are unfamiliar in the Chinese culture. Each picture was printed on a sheet of paper and was presented to Z.B.L. There was no time limit, and the first complete response was recorded. The whole set was completed in three sessions on each occasion.

The materials selected for testing the animacy effect avoided items that have not been consistently associated with other animate or inanimate categories. For instance, musical instruments reportedly behave more like animate things (living things) for patients with category-specific deficits, and body parts reportedly behave more like artifacts (e.g., Dixon, Piskopos, & Schweizer, 2000; Warrington & McCarthy, 1987). Also, for some patients the performance on fruits and vegetables parallels that with animals (e.g., Laiacona, Barbarotto, & Capitani, 1993), while for some, it parallels the performance with artifacts (e.g., Caramazza & Shelton, 1998; Hillis & Caramazza, 1995). Indeed, while Bird, Howard, and Franklin (2001) included animals, fruit/vegetables, musical instruments as "animate" items in their modelling, in at least one set of items (Gainotti & Silveri, 1996) on which they tested the patients' performance, musical instruments were considered as inanimate items. To avoid complication, we first considered Z.B.L.'s performance for only those categories that behave unambiguously along the animate/inanimate dichotomy in the literature. Animate things included four-legged animals, birds, and insects ($N = 51$); inanimate categories included nonliving things (clothing, furniture, kitchenware, tools,

Table 3. *Overall analysis of Z.B.L.'s responses in Snodgrass and Vanderwart (1980) picture naming*

	Animate objects	*Inanimate objects*	*Example*
Correct	29	61	
Errors			
Semantic	13	29	Fox → "dog"; whistle → "flute"
Phonological	0	1	Mountain (da4 shan1) → "(da4 shan4)
Circumlocutory	8	37	Giraffe → "a kind of animal, eat grass, very tall, cannot run fast"; pan → "something you cook with"
Others	1[a]	12[b]	Leopard → writes "leopard", says "an animal, eats people"; tie → gestures wearing a tie

[a]Error type: written response. [b]Error types: 4 don't knows, 4 gestures, 4 written responses.

vehicles, and other man-made objects; $N = 140$). Regression methods were then used to confirm the categorical effects using these different ways of animate/inanimate categorization.

Results

Z.B.L.'s overall naming performance on animate and inanimate object pictures is shown in Table 3. There was a nonsignificant trend indicating better performance with animate than inanimate items, $\chi^2(1) = 2.65$, $p = .10$. Because items from different categories in the picture set are not well matched on relevant variables such as familiarity and word frequency, we carried out several analyses following conventional methods of balancing for these factors.

Analysis 1: Breakdown by familiarity (after Caramazza & Shelton, 1998)

We first classified items by familiarity ratings according to the norms in Shu and colleagues (1989), where a 5-point scale was used. High-familiarity items were defined as items with ratings higher than 3.0; low-familiarity items as those with ratings of 3.0 or lower. The familiarity ratings of the animate and inanimate items were not well matched after this rough division (animate, 2.79/3.57; inanimate, 2.51/4.18). Nevertheless, we can see that while Z.B.L. showed an overall familiarity effect, he was worse at naming inanimate items for both high-familiarity, $\chi^2(1) = 4.06$, $p < .05$, and low-familiarity cells, $\chi^2(1) = 2.60$, $p = .1$, even though in the high-familiarity cells inanimate items were more familiar than animate items (see Table 4).

Analysis 2: On subsets balancing confounded factors (after Funnell & Sheridan, 1992)

This analysis employed a method parallel to that used by Funnell and Sheridan (1992) to study both animacy and familiarity effects in naming. In their study, a set of animate and inanimate items of low familiarity and word frequency (Funnell & Sheridan's Appendix 2) was selected. Another set of items was selected to be matched on familiarity rating and frequency (Funnell & Sheridan's Appendix 3). We used items similar to those in their appendices, with some

Table 4. *Analysis of Z.B.L.'s responses in Snodgrass and Vanderwart picture naming*

	Animate objects	*Inanimate objects*
Breakdown by familiarity[a]		
High familiarity	67% (19/28)	47% (58/124)
Low familiarity	43% (10/23)	19% (3/16)
Subset matched on familiarity and frequency[b]		
Low familiarity/low frequency	58% (7/12)	20% (2/10)
Matched familiarity & frequency	68% (17/24)	28% (7/24)

Note: Snodgrass and Vanderwart, 1980. Values are percentage correct (numbers in parentheses).
[a]After Caramazza & Shelton, 1998. [b]After Funnell & Sheridan, 1992.

adaptations for Mandarin Chinese. For the low-familiarity/frequency set, two items in Funnell and Sheridan's Appendix 2 set were not included in the Chinese version of the Snodgrass and Vanderwart (1980) items. We call this set of items Set 1. We also constructed a Set 2, whose items were matched on familiarity with more items ($N = 24$ for each group), paralleling Funnell and Sheridan's Appendix 3. Results of t tests reveal that the two sets adapted for Chinese have animate and inanimate items that are well matched on word frequency, number of syllables, and familiarity (all $ts < 1$). On this subset, Z.B.L. was worse with inanimate artifacts than with animate items for both subsets: Set 1, $\chi^2(1) = 3.32$, $p = .06$; Set 2, $\chi^2(1) = 8.01$, $p < .005$ (see Table 4).

Bird and colleagues (2000) pointed out that imageability plays a role in naming (also see Franklin, Howard, & Patterson, 1995). We found that imageability and concreteness ratings were matched between animate and inanimate items in our Set 1, but not in Set 2. To eliminate the potential confounding of imageability and concreteness effects, we discarded the four artifacts of lowest imageability and the four animate objects of highest imageability. The remaining 20 items match well on concreteness, imageability, frequency, number of syllables, and familiarity (all $ts < 1$). Z.B.L.'s performance was still better on the animate items than on the inanimate items (15/20 for animate and 6/20 for inanimate), $\chi^2(1) = 8.12$, $p < .005$.

Analysis 3: Regression analyses

To further establish the animacy effect by excluding any potential contamination from other variables, we carried out multiple logistic regression analyses. The dependent variable was Z.B.L.'s oral naming score for a particular picture (1 for correct and 0 for incorrect). The predictors covered five properties of the target picture, including animacy category (animate vs. inanimate), log value of the word frequency, number of syllables of the picture name, familiarity, and name agreement. The last two values were obtained from the Chinese norms of the picture set (Shu et al., 1989), and word frequency from Yu et al. (1998).

We adopted two ways of coding the animacy category. In one, we considered only unambiguous inanimate/animate items (191 items in total) as we did earlier: Animates include animal, bird, and insect; inanimates include tools, furniture, kitchen items, clothing, and vehicles. In the other coding, we followed Bird et al.'s (2000) categorization scheme: Animates include animals, birds, insects, vegetables, fruits, plants, and musical instruments; Inanimates include tools, furniture, kitchen items, clothing, vehicles, body parts, and all others; there were 235 items in total.

Using our coding, the animacy category was shown to be a significant predictor of the naming performance. When all five variables were entered into the model simultaneously using the "enter method", the effect of animacy category was significant ($p = .005$), along with familiarity ($p = .003$) and word frequency ($p < .000$). If we enter all the other variables first and then entered the animacy category, the explanatory power of the regression model was significantly increased: R^2, .138 $\rightarrow$ .175; $\chi^2(1) = 8.22$, $p = .004$.

A similar pattern was observed using Bird et al.'s (2000) animacy coding method in their modelling. In the simultaneous-entering model, the effect of the animacy category was marginally significant ($p = .079$); when animacy category was entered after all other variables were entered, the improvement of the regression model's explanatory power was also marginally significant, R^2, .163 $\rightarrow$ .174; $\chi^2(1) = 3.171$, $p = .075$.

EXPERIMENT 4: SEMANTIC CATEGORIES II: ATTRIBUTE JUDGEMENT

The previous three experiments investigating the noun/verb (object/action) and the semantic category effects all employed an oral picture-naming task. We found that Z.B.L. made predominantly semantic errors in this task and that he showed disproportionate impairment to inanimate things. It should be noted that semantic errors in such a production task may originate from deficits at two distinct levels: the conceptual level and the lexical level (see a detailed discussion in Caramazza & Hillis, 1990). Since Z.B.L. showed a semantic categorical effect in naming objects (better performance on animate items than inanimate items), the impairment presumably lies at least partly in the conceptual system. To replicate this reverse animacy effect observed in picture naming and to tap more directly into the conceptual knowledge of these items, the following attribute judgement task was employed.

Method

Procedure

This task was a Chinese adaptation of the Attribute Processing Task 1: Central Attributes in Caramazza and Shelton (1998), which was designed to examine whether a patient is impaired at verifying object attributes or properties. The task includes true or false statements about objects—for example, “a rooster has a short curly tail”, “a rooster is a farm bird”, “a bottle has a hole in the top”, and “a bottle can be electrical”. Participants are asked to respond “yes” or “no” to the statements. The statements ask about both visual and nonvisual properties of animate and inanimate objects. The animate category includes animals, birds, and insects. The inanimate category includes tools, clothing, fruits, vegetables, and other man-made objects. Because we did not place fruits and vegetables in the inanimate category in the Snodgrass and Vanderwart (1980) picture-naming task, in this attribute judgement task we did not analyse the trials for fruits and vegetables.

The test was adapted for Chinese speakers performance of the 7 control participants, his impairment for inanimate objects was still highly significant, $\chi^2(1) = 24.37$, $p < .0001$, but not for animate objects, $\chi^2(1) = 1.40$, $p = .24$. When we compared Z.B.L.'s performance on animate and inanimate objects directly, the correct proportion of inanimate objects was significantly lower than the correct proportion of animate objects (119/143 vs. 115/158), $\chi^2(1) = 4.72$, $p < .05$. Furthermore, there was a marginally significant trend for his performance on nonvisual features to be better than his performance on visual features, $\chi^2(1) = 3.77$, $p = .0522$. The difference was carried mainly by the inanimate objects: animate items, $\chi^2(1) = 1.26$, $p = .26$; inanimate items, $\chi^2(1) = 3.23$, $p = .07$.

Semantic categories: Discussion

For pictures of animate and inanimate items that were matched on frequency, familiarity, word length, and imageability, Z.B.L. correctly named more animate than inanimate items. The same pattern was also observed in an attribute judgement task that tapped knowledge about visual and nonvisual features of animate and inanimate concepts. This confirms the view that the reverse-animacy effect observed in picture naming has, at least in part, a conceptual origin. For inanimate items, the performance of Z.B.L. was significantly worse than both that of the control participants and his own performance on animate items. Furthermore, contrary to the predictions derived from the SFT (and ESFT), Z.B.L. was not worse at verifying nonvisual (functional) attributes than at verifying visual (sensory) attributes. If anything, he showed a near-significant trend of being better with nonvisual features than visual features for inanimate objects. In sum, Z.B.L.'s performance directly challenges ESFT's assumptions that disproportionate noun (object) impairment is due to selective sensory feature deficit, which would also cause an animacy effect.

Before discussing the implication of our data for other featural theories of the noun/verb dissociation, we consider whether Z.B.L. performed better with verbs (actions) simply because he was better at processing abstract things. In a study of semantic jargon, Marshall and colleagues (1996a, 1996b) reported a case (R.G.) showing an association between a reverse concreteness/imageability effect (better with abstract things than concrete things) in noun processing and better performance with verbs, leading the authors to propose that concepts are represented in "distributed semantic networks" (Allport, 1985), where the relative sparing of verbs over nouns could be explained by the relative sparing of certain kinds of abstract properties that are more crucial to verbs. We carried out post hoc analyses of Z.B.L.'s performance on the Snodgrass and Vanderwart (1980) picture-naming task to test this possibility. Among the 232 items he was asked to name, 86 of the erroneous items and 90 of the correct items have imageability and concreteness ratings in the MRC Psycholinguistic Database (Coltheart, 1981; Wilson, 1988). Contrary to Marshall and colleagues' prediction, positive imageability and concreteness effects were observed. Mean imageability ratings for correct and erroneous items were 603 and 594, respectively, $t(174) = 2.41$, $p < .05$, and concreteness ratings were 607 (correct) and 597 (erroneous), $t(174) = 2.69$, $p < .01$. Therefore the relative preservation of verb naming in Z.B.L. cannot be explained by the factor concreteness (see Bedny & Thompson-Schill, 2006, for convergence neuroimaging evidence).

Can the results reported here be explained by the featural and unitary semantic space (FUSS) theory? We noted in the Introduction that this theory assumes two levels of representations where the noun/verb (object/action) effects could be located: the conceptual system that is organized by feature types (e.g., visual perceptual, nonvisual perceptual, motoric) and the lexical semantic system that is organized by feature properties (e.g., shared, correlated, or distinctive). At the conceptual level, damage to one type of feature (e.g., visual) would be expected to affect differentially nouns and verbs in proportion to the importance of that feature type for a given grammatical category. To test this prediction, we pulled together all the items that Z.B.L. named across repeated administrations (478 nouns/objects and 98 verbs/actions) and classified them into 17 categories according to FUSS. Most items were in the set reported in Vinson and colleagues (2003); those items not in their set (13%) were classified using their criteria. We then correlated Z.B.L.'s correct naming percentages on these 17 categories (e.g., tool action: 38%) with the proportion of weighted visual features in that category (tool action: 11.7) reported by FUSS. Z.B.L.'s naming performance did not correlate with the proportional weights of visual feature in these categories (visual: $R = -.19$, $p = .48$), or with any other feature types' proportional weights (Rs $< .2$; ps$>.5$). Interestingly though, when we looked at only the nouns (objects) pictures, Z.B.L.'s naming performance correlated with the "other perceptual" feature weights negatively ($r = -.84$, $p < .05$) and the motoric feature weights positively ($r = .83$, $p < .05$). This effect is consistent with the hypothesis that the sensory/motor feature composition differences underlie the categorical representations of nouns (objects) concepts and that Z.B.L.'s worse performance with certain categories of nouns (objects) can be explained by a selective impairment for *nonvisual* perceptual features. Note that there was no correlation between noun (object) naming performance and the proportion of "visual" features ($r = .24$, $p = .61$), consistent with the result of our Experiment 2 (see Table 5). Crucially, no such trends were observed on verb (action) items (rs $< .22$; ps $> .5$). That is to say, while featural type composition of object concepts seemed to play a role in Z.B.L.'s categorical effects on noun (object) naming, such dimensions cannot explain Z.B.L.'s performance on verbs (actions).

At the lexical semantic level—the binding site of the distributed conceptual features to linguistic information—FUSS is no different from other feature-distance theories such as Organized Unitary Conceptual Hypothesis (OUCH; Caramazza, Hillis, Rapp, & Romani, 1990). Here nodes cluster together in proportion to the degree of feature overlap (weighted by the relative importance of a given feature in distinguishing among concepts), resulting in what Caramazza et al. (1990) referred to as "lumpy" semantic space. Proponents of FUSS have argued that this level of representation corresponds to the "convergence zones" in the model proposed by Damasio et al. (Damasio & Damasio, 1994; Damasio et al., 2001). Based on featural norm analyses object nouns were found to cluster away from action nouns and action verbs, with the last two clustered together. It is then possible to lesion the lexical semantic space such that object nouns are affected more than action verbs and action nouns (see Vinson & Vigliocco, 2002). However, because FUSS was not the focus of the current article, items in the various categories sanctioned by this theory were not matched on any potentially confounding variables, such as word frequency and naming agreement, and therefore the results do not provide conclusive evidence for or against the theory.

GENERAL DISCUSSION

We reported a case showing a pattern of performance that is inconsistent with expectations derived from the ESFT, a theory that assumes that the noun/verb (object/action) dissociation emerges from a particular way of damaging the conceptual system. To recapitulate, the model makes the following assumptions: (a) Concepts are represented in the brain by different types of features, such as sensory and functional features; (b) certain classes of concepts (animate things, artifacts, action verbs) rely more heavily on certain types of features than do other classes; and (c) such a distribution of feature types is adequate to explain observed category-specific semantic deficits (in animate things or artifacts) and noun-specific deficits. The model predicts that if a patient is more impaired for nouns than for verbs, he will also be more impaired for animate than for inanimate objects. However, Z.B.L., who showed a reverse-animacy effect (better with animate things than inanimate things), was worse at naming nouns (objects) than verbs (actions), providing a clear challenge to the theory's assumption about how noun/verb (action/object) naming dissociations emerge from the proposed conceptual organization. It is not obvious how the other featural theory briefly considered here, FUSS, can account for the performance of our patient, if only a conceptual deficit is assumed.

Of course, given that Z.B.L. is impaired both at the conceptual level and at the (output) lexical level, it is possible that the animacy effect and the noun/verb effect originate from two separate levels of deficit. His performance could then be explained by theories that assume that noun/verb differences are captured at least partly by the lexical system (e.g., FUSS; Caramazza & Hillis, 1991). Be this as it may, the crucial point here is whether there exist theories about the conceptual representations of inanimate and animate objects and actions that can account for Z.B.L.'s poor performance with artifacts compared to animate objects and actions at one level of deficit—the conceptual level. The failure of one particular conceptual theory (ESFT) to account for the data does not mean that the pattern shown by Z.B.L. is not conceptually based. Without positive evidence showing that Z.B.L. is indeed more impaired with *grammatical* tools and actions. For instance, in a lesion study, Tranel and colleagues (2003) reported that among 26 patients with impaired action concepts, only 6 also had impairment with tool concepts. Our finding that Z.B.L.'s artifact naming is worse than naming of both animate items and actions further confirms that "tool"/"manipulable artifacts" and "action" are not necessarily associated. From the literature it can be gleaned that the left posterior middle temporal gyrus (area MT) plays an interesting role in this context. Of the 6 patients in Tranel et al.'s (2003) study who showed a deficit of both action knowledge and tool knowledge, 4 had lesions that included

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APPENDIX A

Stimuli in Noun/Verb Naming 1: Matched object/action pictures

Noun			*Verb*		
Target	*Meaning*	*Pronunciation*	*Target*	*Meaning*	*Pronunciation*
牛	cow	/niu2/	开	open	/kai1/
鱼	fish	/yu2/	按	press	/an4/
梨	pear	/li2/	擦	rub	/cha1/
书	book	/shu1/	插	insert	/cha1/
熊	bear	/xiong2/	缝	sew	/feng2/
钟	clock	/zhong1/	搅	stir	/jiao3/
鼓	drum	/gu3/	锯	saw	/ju4/
鹿	deer	/lu4/	哭	cry	/ku1/
树	tree	/shu4/	爬	climb	/pa2/
杯	cup	/bei1/	跑	run	/pao3/
嘴	mouth	/zui3/	砌	build	/qi4/
门	door	/men2/	掐	pinch	/qia1/
脚	foot	/jiao3/	扫	sweep	/sao3/
包	bag	/bao1/	梳	comb	/shu1/
灯	light	/deng1/	刷	brush	/shua1/
虾	shrimp	/xia1/	撕	slip	/si1/
猪	pig	/zhu1/	抬	lift	/tai2/
笔	pen	/bi3/	喂	feed	/wei4/
花	flower	/hua1/	闻	smell	/wen2/
碗	bowl	/wan3/	指	point	/zhi3/
吊车	crane	/diao4che1/	浇花	water	/jiao1hua1/
围巾	scarf	/wei2jin1/	做饭	cook	/zuo4fan4/
补丁	patch	/bu3ding1/	踢球	kick-ball	/ti1qiu2/
剪刀	scissors	/jian3dao1/	滑冰	ice-skating	/hua2bing1/
滑梯	slide	/hua2ti1/	抽烟	smoke	/chou1yan1/
算盘	abacus	/suan4pan2/	喝水	drink	/he1shui3/
熨斗	iron	/yun4dou3/	击剑	fence	/ji1jian4/
提包	handbag	/ti2bao1/	跳绳	rope skipping	/tiao4sheng2/

(*Continued overleaf*)

(Appendix A Continued)

Noun			*Verb*		
Target	*Meaning*	*Pronunciation*	*Target*	*Meaning*	*Pronunciation*
吸管	sucker	/xi1guan3/	滑雪	ski	/hua2xue3/
抽屉	drawer	/chou1ti4/	射箭	shoot	/she4jian4/
插头	plug	/cha1tou2/	举重	weight lifting	/ju3zhong4/
睡衣	gown	/shui4yi1/	划船	row	/hua2chuan2/
拖鞋	slipper	/tuo1xie2/	看书	read	/kan4shu1/
闹钟	clock	/nao4zhong1/	骑车	bike riding	/qi2che1/

APPENDIX B

Stimuli in Noun/Verb Naming II: Objects and actions in the same pictures

Noun			*Verb*		
Target	*Meaning*	*Pronunciation*	*Target*	*Meaning*	*Pronunciation*
叶	leaf	/ye4/	吹	blow	/chui1/
箱子	box	/xiang1zi0/	抱	carry	/bao4/
锅	pot	/guo1/	做饭	cook	/zuo4fan4/
眼泪	tear	/yan3lei4/	哭	cry	/ku1/
剪子	scissors	/jian3zi0/	剪	cut	/jian3/
锹	shovel	/qiu1/	挖	dig	/wa1/
游泳池	swimming pool	/you2yong3chi2/	跳水	dive	/tiao4shui3/
画	picture	/hua4/	车	draw	/hua4/
车	car	/che1/	开车	drive	/kai1che1/
面包	sandwich	/mian4bao1/	吃	eat	/chi1/
花	flower	/hua1/	浇(水)	water	/jiao1shui3/
摇篮	cradle	/yao2lan2/	摇	rock	/

(Appendix B Continued)

Noun			*Verb*		
Target	*Meaning*	*Pronunciation*	*Target*	*Meaning*	*Pronunciation*
马	horse	/ma3/	骑	ride	/qi2/
铃	bell	/ling2/	摇	rock	/yao2/
针	needle	/zhen1/	缝	sew	/feng2/
刮胡刀	razor	/gua1hu2dao1/	刮	shave	/gua1hu2zi0/
枪	gun	/qiang1/	射击	shoot	/she4ji1/
椅子	chair	/yi3zi0/	坐	sit	/zuo4/
绳	rope	/sheng2/	跳	skip	/tiao4/
床	bed	/chuang2/	水池	sleep	/shui4jiao4/
水池	sink	/shui3chi2/	洗	wash	/xi3/
电视	TV	/dian4shi4/	看	watch	/kan4/
秤	scale	/cheng4/	称	weight	/cheng1/
球	ball	/qiu2/	接	join	/jie1/