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Domain-specific deficits in schizophrenia

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Introduction. Object recognition deficits are well documented in certain neurological disorders (e.g., Alzheimer's disease, herpes simplex encephalitis). Although agnosic problems have been documented in some patients with schizophrenia (Gabrovska et al., 2003), no study has investigated whether such deficits differentially affect specific categories of information (as they sometimes do in neurological cases).
Method. In Part I of this study, we compared object recognition in 55 patients with chronic schizophrenia and 22 age- and NART IQ-matched healthy controls. In Part II, we present a detailed case study of one patient with schizophrenia (DH) who displays a severe category specific semantic knowledge for living things.
Results. Of the patients with schizophrenia, 75% had object recognition below the 5th percentile, and in 11% of cases, a highly specific *classical* category dissociation emerged (5 cases with nonliving deficit and 1 with living deficit); and two other patients showed *strong* dissociation for living things. These findings provide convincing evidence of a *classical* double dissociation across the two categories. In Part II, the in-depth case study of one schizophrenic patient (DH), documented a profound agnosia for living things. While DH displayed intact low level perceptual and spatial ability and could copy drawings, he was severely impaired at naming, picture-name matching, semantic fluency, and could not describe or draw items from memory.
Conclusions. The presence of impaired object recognition in most schizophrenic patients, along with highly selective category specific deficits in a minority, is discussed with reference to similar findings in neurological patients.

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Since Lissauer (1890), disorders of object recognition have been separated into apperceptive and associative agnosias, which essentially represent disorders of perception and memory, respectively. Apperceptive agnosias are an heterogeneous group of disorders in which failure to recognise objects reflects impaired low level form processing. Such patients fail to recognise objects, cannot match shapes, and typically have difficulty with drawing copies of images. By contrast, patients with associative agnosias have (relatively) intact basic form perception, in that they can match objects from different views and can copy quite well, even though they fail to recognise what they have drawn or matched.

Although visual agnosia is not a recognised part of the typical pattern of neuropsychological deficits associated with schizophrenia, it is not without precedent. Using a mixture of group study and single cases, Gabrovska, Laws, Sinclair, & McKenna (2003) examined 41 chronic schizophrenic patients on the Visual Object and Space Perception battery (Warrington & James, 1991). They found that, as a group, schizophrenics were characterised by intact early visual processing (1/41 or 2% < 5th percentile), but impaired performance on higher level tasks involving object recognition and naming (14/41: 34% < 5th percentile). This pattern held true for intellectually preserved patients and was borne out by detailed case studies of four patients. They argued that this pattern of impairment was indicative of a deficit affecting predominantly the semantic levels of visual object processing (i.e., associative agnosia).

Although object recognition deficits have been documented in patients with schizophrenia, no previous study has examined for evidence of category-specificity. Category-specific deficits represent perhaps the archetypal illustration of domain-specific cognitive processes; and describe patients, who following certain forms of acquired neurological damage (resulting from, for example, herpes simplex encephalitis, Alzheimer’s disease), show dissociations in their recognition and naming of living and nonliving things (for reviews, see Capitani, Laiacona, Mahon, & Caramazza, 2003; Laws, 2004a). It is important to establish whether schizophrenia is associated with domain specific deficits for a number of reasons, including the presence of highly specific deficits that cannot be attributed to any general processing decrement; and in a related vein, selectively impaired knowledge domains may inform us about underlying pathology.

Category-specific impairments have formed a pivotal part in the development of models describing the structure and organisation of lexical-semantic memory. For example, such cases raise issues concerning the extent to which they might provide convincing evidence for fractionation of cognitive domains along categorical (or equivalent) or other lines. Theories of category-specificity may be roughly divided into those that assume that category knowledge is organised in functionally and neuroanatomically distinct subsystems or that the neural organisation of conceptual knowledge reflects the statistical co-occurrence of object properties (see Capitani et al., 2003). The former emphasise that knowledge is organised either categorically (e.g., Caramazza & Mahon, 2003); while the latter propose organisation by modality, with living things being separated from nonliving because the former are encoded in a sensory manner while the latter are encoded in terms of functional knowledge (e.g., Warrington & McCarthy 1987; Warrington & Shallice 1984). Those that propose statistical co-occurrence argue that some features are highly correlated and so support each other, while others are more distinctive and therefore more prone to loss following brain injury; and that these vary across living and nonliving things. Nevertheless, contradictory models have been proposed suggesting either that lower levels of neural damage produce nonliving thing deficits because they have more distinctive features and thus, will be more easily lost (e.g., Gonnerman, Andersen, Devlin, Kempler, & Seidenberg, 1997) or will be less susceptible because they have very distinctive form-function relationships (e.g., Moss, Tyler, Durrant-Peatfield, & Bunn 1998).

One reason why category effects are important in the study of object recognition and cognitive architecture, and modularity generally, stems from the attempt to locate the neuroanatomical substrates for different domains or categories of information. The cognitive dissociations across category are frequently accompanied by parallel claims about neuroanatomical fractionations. In a recent review of the neuroanatomical loci, Gainotti (2000) identified 47 case studies of patients with living deficits and 10 with nonliving deficits following neurological damage. The former often appear to be associated with bilateral damage to the inferior temporal lobes and medial structures (hippocampus, amygdala, parahippocampal gyri, e.g., resulting from herpes simplex encephalitis), whereas nonliving cases often present following damage to the territory of the left middle cerebral artery (and therefore the fronto-parietal region of the left hemisphere).

In this context, Part I of the present study examined the object recognition abilities of 55 schizophrenic patients for evidence of category-specificity. Part II presents an in-depth case study of one patient (DH), who presents with a relatively pure form of visual associative agnosia that also has the hallmarks of a category-specific domain impairment.

PART I: GROUP STUDY

Participants

The patient sample consisted of 55 patients (36 male and 19 female) who fulfilled Research Diagnostic Criteria (Spitzer, Endicott, & Robins, 1978) for schizophrenia. They were drawn from a population under the care of one of the authors (P.J.M.). None of the patients had a history of head injury, neurological disorder, and drug or alcohol misuse. The age range was 22–64 years ($M = 43.1$, $SD = 11.67$), and mean estimated premorbid NART IQ (Nelson, 1982) was

101.4 ($SD = 13.55$). Length of illness ranged from 3 years to 40 years ($M = 19.3$, $SD = 9.79$).

Twenty-two healthy control participants were also tested (13 male and 9 female).[1] The control group did not differ significantly from the patients in terms of age ($M = 38.7$, $SD = 11.12$: $t_{76} = 1.36$, $p > .05$) or NART IQ ($M = 107.3$, $SD = 10.31$: $t_{76} = 1.80$, $p > .05$).

Procedure

Subjects were administered the Category Specific Naming Test (McKenna, 1997). This task consists of 60 colour images of living things (30 fruit/vegetables, e.g., mushroom, mango; and 30 animals, e.g., fox, lynx) and 60 images of nonliving things (30 praxic objects with a specific skilled action entailed in their use, e.g., darts, bugle; and 30 nonpraxic objects that do not have a specific action entailed in their use, e.g., cushion, water-butt). The pictures were shown, one at a time graded in order from the easiest to most difficult items (according to test norms from 400 healthy controls).

Results

The mean number of pictures named by the schizophrenic group was significantly lower than for healthy controls: $t_{74} = 7.49$, $p < .001$: $M = 65.74$ (SD = 15.52) vs. 93.10 ($SD = 11.21$). The means and standard deviations for living and nonliving categories are detailed in Table 1, which shows that the patients were worse than controls at naming items in all four subcategories as well as the combined living and nonliving categories; and that both patients and controls showed an advantage for naming living things ($t_{53} = 5.56$, $p < .001$; $t_{21} = 2.1$, $p < .05$).

Correlations revealed no significant relationship between patient length of illness and the number of living ($r = -.23$, $p = .09$) or nonliving items ($r = -.09$, $p = .50$) named or with the living-nonliving difference score ($r = -.19$, $p = .18$).

Analysis of category naming for individual cases

The living and nonliving scores for each patient were compared with those of the matched control group using the Revised Standardised Difference Test (RSDT; Crawford & Garthwaite, 2005) for testing for deficits and dissociations

[1] Studies have documented a sex by category knowledge interaction in healthy subjects (i.e., females better with living things and males better with nonliving things, e.g., Gainotti, 2005; Laws, 1999, 2000, 2004b); however, the males and females reported here showed no differences in naming, NART IQ or age (all Fs < 1), so they were examined as a single group.

TABLE 1
Means and (standard deviations) naming scores for the schizophrenic and control groups

Item	*Schizophrenic patients* (n = 55)	*Healthy controls* (n = 22)	*t-value*	*Effect size*
Animals	18.63 (5.42)	23.91 (4.62)	$t_{74} = 4.00$ $p < .001$	$d = 1.01$
Fruit and vegetables	17.29 (5.53)	23.95 (4.11)	$t_{74} = 5.09$ $p < .001$	$d = 1.29$
Nonpraxic	13.54 (4.49)	20.82 (3.79)	$t_{74} = 6.69$, $p < .001$	$d = 1.58$
Praxic	16.28 (4.24)	24.41 (3.79)	$t_{74} = 7.80$, $p < .001$	$d = 1.97$
Living	35.93 (9.55)	47.86 (5.78)	$t_{74} = 5.45$, $p < .001$	$d = 1.38$
Nonliving	29.81 (7.87)	45.22 (6.91)	$t_{74} = 8.00$, $p < .001$	$d = 2.03$

in single-case studies. It is, of course, possible for patients to be impaired at naming living or nonliving things, but that the *difference* between their scores does not reach significance; conversely, a patient may be severely impaired on both tasks, but still show differential impairment (i.e., significantly worse performance in one category than the other). The RSDT examines whether the discrepancy observed for the patient is significantly different from the discrepancies observed for controls and provides a point estimate of the abnormality of the individual's discrepancy (i.e., it estimates the percentage of the controls that would obtain a more extreme discrepancy).

Following the classification scheme initially proposed by Shallice (1988), we classfied patients into those displaying *classical* or *strong* dissociations. A patient was classified as exhibiting a *classical* dissociation if (a) their performance on one (and only one) of the two categories was signficantly poorer than
Q1 controls (using a modified *t*-test developed by Crawford & Howell, 1998), and (b) if the standardised difference between their performance for the two categories differed significantly from the standardised differences observed in controls. This latter criterion was tested using the RSDT (Crawford &
Q2 Garthwaite, 2005; Garthwaite & Crawford, 2004). The same criteria were used to test for a *strong* dissociation with the crucial difference being that the patients showed a significant standardised difference across categories, but performed significantly worse than controls in *both* categories (see Figure 1). (Programs to run the RSDT analyses can be downloaded from http://www.abdn.ac.uk/%7Epsy086/dept/psychom.htm)

These methods of testing for deficits and for differences (i.e., dissociations) are to be preferred over the use of z and z_D (the z-score for the *difference*) as they treat the statistics of the control sample as statistics rather than as population parameters. Moreover, Monte Carlo simulations show that the RSDT provides excellent control over Type 1 error rate regardless of the N for the control sample, the correlation between tasks, and the distributional characteristics of

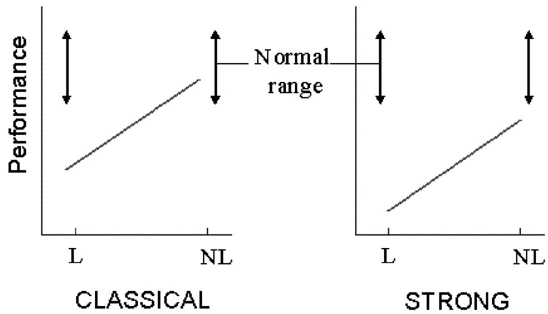


Figure 1. Examples of classifical and strong dissociations (after Shallice, 1988). *Note*: In these examples, the standardised discrepancy between living and nonliving scores is significant (i.e., the discrepancy score in the patient is significantly different from the discrepancy scores in the controls).

Q3 the control data (i.e., they are robust to departures from normality: Crawford & Garthwaite (2005); Crawford, Garthwaite, Azzalini, Howell, & Laws (in press).

Finally, the documentation of dissociations (using these techniques) also potentially permits the documenting of the venerated *double dissociations*. A commonly accepted definition of double dissociation comes from Shallice (1988), who proposed that double dissociations are ''[where] on task I, patient A performs significantly better than patient B, but on task II, the situation is reversed'' (p.235). So, in the current case task I may be living things and task II, nonliving things. The establishing of double dissociations have been central to the development of neuropsychological theory, since they are most often used to underpin arguments that two cognitive abilities are orthogonal and thereby crucial to attempts to fractionate the human mind in a modular fashion.

Results

The majority of patients (42/55: 76%) displayed a naming impairment in one or both categories. Moreover, the analysis revealed six patients (11%) with classical dissociations across category (5 with nonliving deficits and 1 with living deficits, see Table 2). Another two patients also showed strong dissociations (both for living things). Moreover, this cohort of schizophrenic patients also produced evidence of classical double dissociations. For example, see the classical double dissociation between patient EB and patient IC (see Figure 2).

Retest for consistency of deficits. To test for consistency of category effects across time, the patients were retested with all 120 pictures, 2–4 months later. All eight patients showed exactly the same profile, that is, remained impaired in the same manner (classical or strong) at follow-up; and none showed significant change in naming ability across this short time period.

TABLE 2
Background date for the eight patients showing significant dissociations

Patient	*Sex*	*NART IQ*	*Length of illness (years)*	*F, A*	*Living*	*P, NP*	*Nonliving*	*Dissociation type*	*t-value and % of normal population achieving patient discrepancy score (from RSDT)*
BA	F	107	7	25, 22	47	17, 12	29	NL^{cl}	$t = 2.48$, $p = .02$, 1.6%
EB	F	101	16	22, 27	49	10, 16	26	NL^{cl}	$t = 3.28$, $p = .003$, 0.2%
IC	M	108	26	16, 15	31	24, 20	44	L^{cl}	$t = 2.53$, $p = .02$, 0.9%
FD	M	108	17	18, 27	45	16, 11	27	NL^{cl}	$t = 2.48$, $p = .02$, 1.1%
AE	M	106	6	19, 21	40	14, 10	24	NL^{cl}	$t = 2.16$, $p = .04$, 2.1%
JF	M	118	34	19, 22	41	11, 9	20	NL^{cl}	$t = 2.97$, $p = .007$, 0.4%
TC	M	113	26	9, 11	20	16, 13	29	L^{st}	$t = 2.46$, $p = .02$, 1.1%
DH	M	81	6	5, 0	5	5, 4	9	L^{st}	$t = 2.16$, $p = .04$, 2.1%

NL, nonliving deficit; L, living deficit; ^{cl}, classical dissociation; st, strong dissociation.

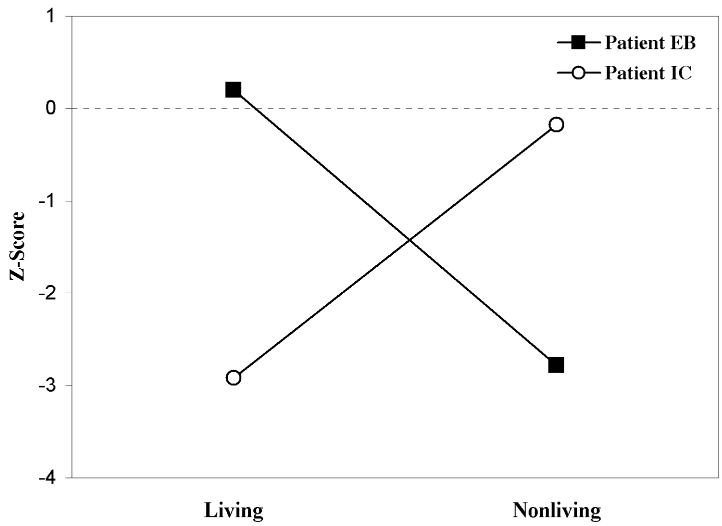


Figure 2. Example of a *classical* double dissociation across category in two patients with schizophrenia (patient EB and patient IC). *Note*: Each patient has one impaired and one normal category performance (when compared to healthy matched controls). Such profiles are typically viewed as indicative of separable underlying processes or modules.

Summary

This study documents that the majority of patients with chronic schizophrenia have severe object recognition deficits and these are sometimes category-specific. Indeed, approximately 15% of schizophrenic patients presented with a category deficit affecting the recognition of living or nonliving things. Moreover, in six cases, the deficits qualified as classical dissociations and together formed classical double dissociations. Moreover, all of the patients showing
Q4 category effects continued to show the effect when rested 2–4 months later. This evidence is the strongest that is used to document dissociations in neurological patients and, if anything, is stronger than that typically presented for neurolo-
Q5 gical cases with category deficits (Laws, in press). Hence, a proportion of schizophrenic patients presenting with such deficits parallel the findings from patients with clear neurological pathology (e.g., herpes simplex encephalitis, dementia of the Alzheimer's type, etc.) who present with category deficits. This level of specificity suggests that lexical-semantics are not (necessarily) compromised in a generalised fashion in patients with schizophrenia. Finally, there was a lack of significant correlation between length of illness and any naming measure. As with recent studies of patients with Alzheimer's disease (for a review, see Laws, Gale, Leeson, & Crawford, 2005), this study of schizophrenic

patients fails to provide any support for the co-occurrence model predictions of category bias change associated with measures of impairment.

PART II: CASE STUDY

Part II of this paper presents an in-depth case analysis of one schizophrenic patient (DH) who presents with a severe agnosia that is category-specific for living things. Our awareness of patient DH emerged as part of the previous investigation. DH's picture naming was worse than any other patient for both living and nonliving things (a *strong* dissociation: see Table 2);[2] however, his responses pointed to an agnosia that was profound and remarkably similar to that in neurological cases. Further testing confirmed that this category-specificity emerged across a range of other tests.

Background

DH is a 38-year-old single man. His education was normal and was completed by obtaining two City and Guilds qualifications. He worked as a warehouseman, but stopped working because of back problems. He first presented to psychiatric services at the age of 24, where he was thought to be simply introverted and socially isolated. Ten years later, however, he presented again and at this time he was experiencing auditory hallucinations. He was lost to follow-up at that time, but resurfaced 2 years later with bizarre persecutory and referential delusions, third-person auditory hallucinations and other ''first-rank'' schizophrenic symptoms (thought broadcasting, thought insertion, and thought withdrawal). He was dirty and dishevelled, and showed flattening of affect and poverty of speech. His positive symptoms improved on treatment with antipsychotic drugs, but he remained severely impaired by negative symptoms. After spending time in a rehabilitation service, he moved into hostel accommodation where he has lived ever since. There is no significant medical history; he has never had a head injury, and no history of drug or alcohol abuse.

A computed tomographic (CT) scan revealed no gross abnormality, with DH's ventricles and sulci being within normal limits for his age; and a single photon emission computed tomography (SPECT) scan revealed no perfusion abnormality and temporal lobe perfusion that was within normal limits.

DH scored 29/30 on the Mini-Mental State Examination (Folstein, Folstein, & Mittugh, 1975). His premorbid IQ, as estimated by the (NART; Nelson, 1982), was 81 and his current full-scale WAIS-R IQ was 69 (Weschler, 1981). DH's verbal IQ of 75 may provide a better indication of his abilities in the light of his agnosic deficits outlined here. He received a score of 23/36 on the Raven's

[2] Of course, the poorer the overall performance, the less likely it becomes that patients will show a classical dissociation.

Progressive Matrices (coloured), which was in line with published norms for his age and IQ.

Visual and spatial perception

Examination on the Visual Object and Spatial Perception Battery (VOSP; Warrington & James, 1991) revealed normal performance on Shape Detection (20/20), Dot Counting (10/10), Position Discrimination (20/20), and recognition of Incomplete Letters (18/20). DH's primary apperceptive and spatial perceptual skills were intact indicating that he can form stable percepts for items.

Copying

Despite often reporting not knowing what a picture represented, DH copied line drawings of objects and animals with reasonable accuracy, even when the structural characteristics of the stimuli were complex (see Table 6). Again, this is evidence that his primary apperceptive and spatial perceptual skills are intact and that he can form stable percepts (for both living and nonliving things).

Object recognition

By contrast, with his primary visual processing abilities, DH showed impairment on all tasks that required item recognition. On the object decision subtest of the VOSP (Warrington & James, 1991), where a real object has to be selected from three distracter nonsense objects, DH scored 13/20 (< 5th percentile cut off of 15). On the Silhouettes task that requires naming of both animals and objects from their silhouettes, DH scored 1/30 (< 5th percentile cut-off of 16). His ability to recognise and name items was further examined on tests of picture naming. On the Graded Naming Test (McKenna & Warrington, 1983), he was severely impaired, not managing to name a single item (0/30).

His naming to verbal descriptions was also impaired (correctly naming only 6/24 descriptions); 5/12 correct responses for nonliving things and 1/12 correct for living things. Hence, DH's difficulty with object identification is not restricted to the visual modality, but extends to naming from verbal descriptions.

Category specificity

Black-and-white line drawings. DH was also shown 260 black and white line drawings from the Snodgrass and Vanderwart (1980) corpus for naming and again, was severely impaired, naming less than 50% (119/260). It was notable that he performed much better with nonliving than living things. He named 21% (21/98) of living things (animals and fruits and vegetables) and of those, only 9.25% (5/54) of animate things (i.e., animals, insects, and birds). By contrast, his naming of nonliving things was much better at 60.5% (98/162).

TABLE 3
Picture naming for DH on two occasions compared with five age- and IQ-matched schizophrenic controls

	DH 1	*DH 2*	*Schizophrenic controls (Means and SDs)*
Living	5	5	25.2 (4.2)
Nonliving	9	8	21.8 (5.9)

Colour images

DH was presented with the 120 colour images from the Category Specific Names Test (McKenna, 1997) on two occasions (separated by 2 months) and his results are outlined in Table 3, where his performance is compared to five matched schizophrenic controls who were matched for age (M = 42.2) and NART IQ (M = 81). Clearly, DH's picture naming was much worse than that of matched schizophrenics and although poor with both categories, he is more impaired with living than nonliving things (especially poor again for animals). Examples of his responses to some of the normatively easier items are presented in Table 4.

TABLE 4
DH's naming and descriptions for normatively easier items from the category-specific naming test

Item	*Description*	*Named 1*	*Named 2*
Cue	For playing pool with	✗	✗
Binoculars	For photographs	✓	✗
Darts	Darts. Play darts with them	✓	✓
Whisk	Whisker. Used for food	✓	✗
Thermometer	Temperature thermometer for measuring weather	✓	✓
Calendar	Calendar for 1988	✓	✓
Skittles	–	✗	✗
Pineapple	Flowers	✗	✗
Sweetcorn	Marrow for eating	✗	✗
Fox	Deer	✗	✗
Whale	–	✗	✗
Bat	Bird. Flies	✗	✗
Squirrel	Rabbit. Walks	✗	✗
Rhinoceros	Cow or a goat	✗	✗

TABLE 5
DH's naming responses for three-dimensional animal models

Panda – dog
Camel – don't know
Goat – don't know
Cow – cow
Kangaroo – don't know
Hippopotamus – don't know
Dog – Alsatian
Horse – don't know
Elephant – don't know
Pig – don't know
Lion – dog
Chicken – don't know
Rabbit – don't know
Tiger – don't know
Monkey – horse
Giraffe – different sort of horse

Naming three-dimensional models

DH's ability to name three-dimensional models of animals was tested to see if the additional visual information would aid his recognition. DH managed to correctly name only 2/16 (12.5%: see Table 5).

Object comprehension

Using the 60 living and 60 nonliving pictures from the Category Specific Naming Test (McKenna, 1997), we also analysed DH's ability to match names to the pictures. On presentation of five pictures of items from within the same category (i.e., fruits and vegetables, animals, praxic, and nonpraxic things), he was provided with a name and asked to point to the named item. Again, he showed much better performance with nonliving (42/60: 70%) than living (24/60: 40%) things. This shows that DH's problem with naming is not restricted to tasks where he has to produce the name, but also when he is required to match a name with a target (amongst related distractors). Moreover, again it reveals a differential problem with living things (14/30 fruit/vegetables and 10/30 animals).

Visual and verbal semantic knowledge

DH was administered the Pyramids and Palm Trees test (Howard & Patterson, 1992) which requires matching a target picture (e.g., Pyramid) to one of two other pictures (Palm trees or fir trees); and scored very poorly (31/52: < 5th percentile for test norms).

On a sentence verification task (Laws, Humber, Ramsey, & McCarthy, 1995), that is, verifying true (Tigers have stripes) and false statements (Tigers have wings), DH again scored very poorly (38/56). His scores on the sentence verification task reflected 24/28 correct for nonliving things and 14/28 for living things.

Semantic fluency

DH produced the following numbers of living items in one minute semantic fluency tasks: animals (8), birds (2), sea creatures (1), breeds of dog (2), fruits (6); totalling 19 living things. By contrast, he produced the following numbers of nonliving things: household items (11), vehicles (9), musical instrument (9), types of boat (2), tools (7); providing a total of 38 nonliving things.

Category sorting

DH sorted pictures of transport, fruit, body parts, clothes, furniture, and tools correctly (two or three categories at a time). However, he did make errors when sorting birds vs. animals

Drawing from memory. DH was asked to draw from memory four living and four nonliving things (that were matched for rated familiarity and visual complexity: see Table 6). The same items were drawn by the five schizophrenic controls. All drawings were shown to five raters to rate for how much the drawing looked like its target (1 no resemblance—9 exact). In each case, the drawing by DH received a lower rating (Living: 1.3 vs. 5.7; Nonliving 3.1 vs. 6.9); and his drawings for living things were rated lower than his drawings for nonliving things.

Providing definitions to name. We tested DH's ability to provide definitions to the names of items. DH was given the names of six living and six nonliving things to define. His descriptions are shown in Table 7. DH's definitions to living things were less detailed and generally worse than for nonliving things. In each case, DH was probed for additional information, so the descriptions are taken as evidence of his full knowledge. This shows that DH's difficulty was not restricted to visual input.

DISCUSSION

Three quarters of the schizophrenic sample displayed an object recognition deficit (i.e., scoring < 5th percentile of healthy control subjects), and moreover, in 15% of cases, the deficits were category-specific. Indeed, in six patients, the category deficit was highly selective and produced a *classical* dissociation. In Part II, we presented a single case study of a severe visual agnosia in a patient (DH) with no diagnosis other than schizophrenia and no history of neurological

TABLE 6
Examples of DH's copy drawing and drawing from memory

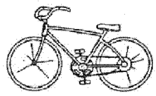
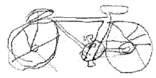
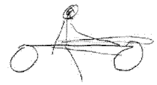
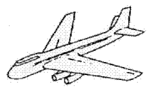
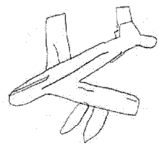
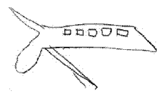
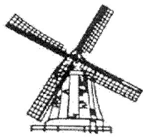
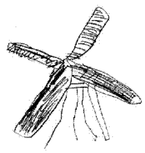
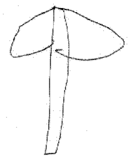
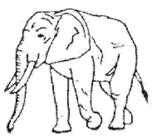
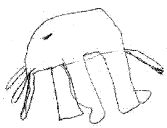
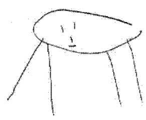
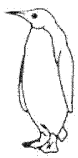
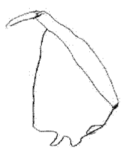
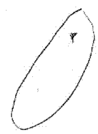
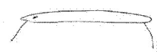
Item	*Original drawing*	*Copy*	*From memory*	*Named*
Bicycle				✓
Airplane				✓
Windmill				✓
Elephant				✗
Penguin				✗
Snail				✗

TABLE 7
Examples of the definitions given by DH to the names of living and nonliving things

Living	*Nonliving*
Alligator – never heard of it.	Accordion – oh yeah, buttons. Piano. Played in pubs. Music sounds like folk music. (Can you tell me anything else?) You put it over your neck with a strap.
Rhino – never heard of it.	Helicopter – flies in the air.
Swan – swims in the water (anything else, what does it look like?) no (what colour is it?) white.	Rolling pin – to do with cookery. For making pastry.
Lobster – fish.	French horn – musical instrument.
Fox – 4 legs.	Motorcycle – drives and wears a helmet. Makes a noise. Has wheels.
Penguin – bird or chocolate (can you describe the bird called penguin?) no, nothing.	Spinning wheel – goes round.

damage. It should also be noted that the category dissociations in all patients (including DH) were consistent across 1–2 months;[3] and so, the dissociations are not a response to short-term fluctuations in psychological status (relating, for example, to symptoms or medication).

Part I of the current study documents marked evidence of *classical double dissociations* across living and nonliving things in a number of patients with a diagnosis of schizophrenia (i.e., cases where patients are severely impaired in one category and *normal* in the other). This evidence is as strong as that which has been presented for category deficits following neurological pathologies such as herpes simplex encephalitis, dementia of the Alzheimer's type, head injury,
Q6 etc. (see Laws, in press). Domain-specific deficits, such as these, are difficult to attribute to a generalised intellectual deficit (often associated with schizophrenia) or other factors that have general consequences for cognitive performance (e.g., medication effects, symptoms, lack of attention).

The incidence of living–nonliving deficits reported here revealed a preponderance of nonliving deficits (3 living–5 nonliving[4]). This differs considerably from the reported 5:1 ratio for living and nonliving deficits reported in
Q7 neurological cases (Laws, in press). Nevertheless, recent studies, using the methods advocated here, have reported more nonliving cases than previous

[3] It is assumed that neurological cases would be consistent across time; however, data on the degree of reliability has not been ascertained for the vast majority of neurological cases for a discussion, see Laws, in press

[4] When the three *strong* dissociations were also included.

studies (Laws et al., 2005; Laws & Satori, 2005). Several factors may underlie these differences, but one relates to the common use of absolute measures to
Q8 document category effects (i.e., simple comparisons of living vs. nonliving scores, using χ^2). When compared to the RSDT method advocated here, the use of χ^2 to make simple within-patient absolute comparisons has been shown to be
Q9 unreliable (Laws et al., 2005; Laws & Sartori, 2005); producing false positive and false negative outcomes and critically, what have been refereed to as *paradoxical deficits* (i.e., cases that superficially look like deficits for one category, but are in fact deficits for the other category).

In Part II, although we tested only one of the patients in greater depth (DH), single cases do provide the most common source of evidence, in neurological studies, for determining whether deficits are selective and thereby, the extent to which domain-specificity permeates cognitive processing. DH showed intact ability on low level perceptual and spatial tasks and could copy drawings. This shows that he can form stable percepts and so, does not have an apperceptive agnosia. By contrast, he was severely impaired at naming items both from picture and from description and had poor semantic fluency. When asked to draw items from memory, DH's drawings were impoverished and rated as worse than those of matched schizophrenic patients. DH's difficulty with recognising objects extended beyond the naming of line drawings to colour photographs and three-dimensional objects. Additionally, his descriptive knowledge of the items was also very poor, as was his ability to match names with pictures. This profile is clearly indicative of an associative agnosia. Moreover, DH's object recognition deficit also *consistently* showed evidence of being category-specific (i.e., his performance was always worse for the category of living things compared to nonliving things). The evidence of category-specificity characterised his performance across a wide range of tasks, including: naming line drawings, colour images, and models; drawing from memory; semantic fluency; comprehension (word-picture matching); and describing to name. The congruency of these findings shows that the category effect is not spurious or an artefact of one specific task procedure or test time.

Although DH showed a consistently greater difficulty with living things, his performance with nonliving things was far from perfect. Nonetheless, this is precisely the kind of *strong* dissociation profile that is characteristic of most (if not all) neurological cases (i.e., showing *relatively* better performance in one
Q10 category rather than classical dissociations; see Laws, in press). It is also true that DH's performance was near floor on the Category Specific Naming Test (McKenna, 1997) in both categories. When a patient's performance on both tasks is extreme (i.e., near floor), the results of any classification method for dissociations should be treated with some caution. Nevertheless, his performance on several other tasks was at a level that was not so close to floor and consistently worse for living than nonliving things.

One possibility that we should consider is that, perhaps because of the interruption of their education, schizophrenic patients (and DH in particular) may never have known or learned the names of many of the items. Other individual difference factors might include age and sex (Coppens & Frisinger, 2005; Gainotti, 2005; Laws, 1999, 2000, 2004b).[5] Although such factors might explain the presence of normal category *biases* in some *normal* subjects, we would not expect them to result in the frequent presence of classical dissociations (in either patients or healthy subjects)—indeed, it would be counter-intuitive for normal factors to produce selective levels of performance that were ''statistically abnormal''. We would therefore argue that our data provide unequivocal evidence for domain-specific deficits in some schizophrenic patients.

As noted above, these highly selective domain specific deficits are comparable with those documented in neurological cases, in patients with no other diagnosis than ''schizophrenia''. Moreover, the in-depth case study of DH revealed an agnosia that is indistinguishable from the form of associative agnosia reported in neurological cases. Although many neurological cases have bilateral damage (e.g., because category effects often follow herpes simplex encephalitis which affects both temporal lobes: for a review, see Gainotti, 2000); some evidence points to greater left than right sided involvement in category
Q11 effects (McKenna & Warrington, 1994, 2000). Intriguingly, a similar proportion of category deficits have been documented on exactly the same task in neurological patients with left-sided brain damage. McKenna and Parry (1994) reported little or no evidence of category deficits in patients with right hemisphere lesions, but an 18% incidence of ''highly circumscribed'' category effects in a left hemisphere group. Although McKenna and Parry used a different method for documenting deficits (by comparing to a normative database of 400 healthy subjects), it is nonetheless notable that only *left*-sided lesions were associated with category effects. In the case of DH, a CT scan revealed no structural abnormalities and a SPECT scan also failed to locate any obvious functional abnormalities for the temporal lobes (or any other brain region) in either hemisphere. This is, however, consistent with the available brain imaging evidence for schizophrenia. A recent meta-analysis of MRI studies (Wright et al., 2000) reported that whole brain volume is reduced by around 2%, and little evidence indicates that the reduction in the size of the temporal lobes is any greater than this (although evidence exists for disproportionate decreases in the

[5] One reviewer pointed to the fact that DH was a warehouseman and so, may have been premorbidly predisposed to perform better with nonliving things. No studies have examined the impact of occupation on category naming (in patients or healthy subjcts); however, occupation may well influence object processing in a similar way that DH's gender might contribute to his better recognition of nonliving things. Nonetheless, the level of DH's deficit is well beyond what might be explained by such *normal* influences.

hippocampus, amygdala and parahippocampal gyrus). The main functional imaging abnormality found in schizophrenia is hypofrontality, which is inconsistently found across the studies, but is supported by meta-analysis (Davidson & Heinrichs, 2003; Hill et al., 2004). Davidson and Heinrichs (2003) also pooled findings on temporal lobe blood flow/metabolism in schizophrenia and found no evidence that it was reduced; though some evidence shows a reduced volume in the temporal lobes with a small effect size (d = .3).

The implications of finding a highly specific cognitive deficit with no obvious underlying neuropathology are more difficult to discern. On the one hand, we have unequivocal evidence of highly selective category deficits, but on the other hand, no obvious underlying neurological pathology. This indicates that, unlike the neurological cases, a palpable brain insult is not required for category effects to emerge from developmental disorders. It is, of course, quite feasible that the (slow) developmental character of schizophrenia means that obvious neural lesions or dysfunction might be difficult to detect using current techniques. Indeed, developmental varieties of disorders present with the same characteristics as acquired disorders, even though they emerge from quite different underlying pathologies (e.g., compare acquired vs. developmental dyslexias).

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REFERENCES

Capitani, E., Laiacona, M., Mahon, B., & Caramazza, A. (2003). What are the facts of semantic category-specific deficits? A critical review of the clinical evidence. *Cognitive Neuropsychology*, *20*, 213–261.

Coppens, P., & Frisinger D. (2005). Category-specific naming effect in non-brain-damaged individuals. *Brain and Langauge*, *94*, 61–71.

Caramazza, A., & Mahon, B. Z. (2003). The organization of conceptual knowledge: the evidence from category-specific semantic deficits. *Trends in Cognitive Sciences*, *7*, 354–361.

Crawford, J. R., & Garthwaite, P. H. (2005). Testing for suspected impairments and dissociations in single-case studies in neuropsychology: Evaluation of alternatives using Monte Carlo simulations and revised tests for dissociations. *Neuropsychology*, *19*, 318–331.

Crawford, J. R., Garthwaite, P. H., Azzalini, A., Howell, D., & Laws, K. R. (in press). Testing for a deficit in single case studies: effects of departures from normality. *Neuropsychologia*.

Crawford, J. R., Garthwaite, P. H., & Gray, C. D. (2003). Wanted: Fully operational definitions of dissociations in single-case studies. *Cortex*, *39*, 357–370.

Davidson, L. L., & Heinrichs, R. W. (2003). Quantification of frontal and temporal lobe brain-imaging findings in schizophrenia: a meta-analysis. *Psychiatry Research: Neuroimaging*, *122*, 69–87.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). ''Mini mental state'': a practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–198.

Gainotti, G. (2000). What the locus of brain lesion tells us about the nature of the cognitive defect underlying category-specific disorders: a review. *Cortex*, *36*, 539–559.

Gainotti, G. (2005). The influence of gender and lesion location on naming disorders for animals, plants and artifacts. *Neuropsychologia*, *43*, 1633–1644.

Gabrovska, V. S., Laws, K. R., Sinclair, J., & McKenna, P. J. (2003). Visual object processing in schizophrenia: evidence for an associative agnosic deficit. *Schizophrenia Research*, *59*, 277–286.

Gonnerman, L. M., Andersen, E. S., Devlin, J. T., Kempler, D., & Seidenberg, M.S. (1997). Double dissociation of semantic categories in Alzheimer's disease. *Brain and Language*, *57*, 254–279.

Hill, K., Mann, L., Laws, K. R., Stephenson, C. M. E., Nimmo-Smith, I., & McKenna, P. J. (2004). Hypofrontality in schizophrenia: a meta-analysis of functional imaging studies. *Acta Psychiatrica Scandinavica*, *110*, 1–14.

Howard, D., & Patterson, K. (1992). *Pyramids and palm trees test.* Bury St Edmunds, UK: Thames Valley Test Co.

Laws, K. R. (1999). Gender affects naming latencies for living and nonliving things: Implications for familiarity. *Cortex*, *35*, 729–733.

Laws, K. R. (2000). Category-specific naming errors in normal subjects: The influence of evolution and experience. *Brain and Language*, *75*, 123–133.

Laws, K. R. (2004a). Strange and neglected domains in category specificity: the 'normal' and the 'nonliving'. *History and Philosophy of Psychology*, *6*, 19–34.

Laws K. R. (2004b). Gender differences in lexical size across categories. *Personality and Individual Differences*, *36*, 23–32

Laws, K. R. (in press). 'Illusions of Normality': A methodological review of category-specific naming. *Cortex*

Laws, K. R., Gale, T. M., Leeson, V. C., & Crawford, J. R. (2005). When is category *specific* in dementia of Alzheimer's type? *Cortex*, *41*, 452–463.

Laws, K. R., Humber, S., Ramsey, D., & McCarthy, R. A. (1995). Probing sensory and associative semantics for animals and objects in normal subjects. *Memory*, *3*, 397–408.

Laws, K. R., & Sartori, G. (2005). Category Deficits and Paradoxical Dissociations in Patients with Alzheimer's Disease and Herpes Simplex Encephalitis. *Journal of Cognitive Neuroscience*, *17*, 1–8.

Lissauer, H. (1890). Ein Fall von Seelenblindheit nebst einem Beitrag zur Theorie derselben. *Archiv für Psychiatrie und Nervenkrankheiten*, *21*, 222–270.

McKenna, P. (1997). *Category specific names test manual*. Hove, UK: Psychology Press.

McKenna, P., & Parry, R. (1994). Category and modality deficits of semantic memory in patients with left hemisphere pathology. *Neuropsychological Rehabilitation*, *4*, 283–305.

McKenna, P., & Warrington, E. K. (1983). *The graded naming test*. Windsor, UK: NFER-Nelson.

McKenna, P. & Warrington, E. K. (2000). The neuropsychology of semantic memory. In L. Cermak (Ed.), *Handbook of neuropsychology* (pp. 331–358).

Moss, H. E., Tyler, L. K., Durrant-Peatfield, M., & Bunn, E. M. (1998). 'Two eyes of a see-through': Impaired and intact semantic knowledge in a case of selective deficit for living things. *Neurocase*, *4*, 291–310.

Nelson, H. E. (1982). *The national adult reading test (NART)*. Windsor,UK: NFER-Nelson.

Nelson, H. E., & O'Connell, A. (1978). Dementia: the estimation of premorbid intelligence levels using the new adult reading test. *Cortex*, *14*, 234–244.

Shallice, T. (1988) *From neuropsychology to mental structure*. Cambridge, UK: Cambridge University Press.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardised set of 260 pictures: norms for name agreement, image agreement, familiarity and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory*, *6*, 174–215.

Spitzer, R. L., Endicott, J., & Robins, E. (1978). Research diagnosis criteria for a selected group of functional disorders. In *Biomedical research*. New York: New York State Psychiatric Institute.

Warrington, E. K., & James, M. (1991). *The visual object and spatial perception battery*. Bury St Edmunds, UK: Thames Valley Test Co.

Warrington, E. K., & McCarthy, R. A. (1987) Categories of knowledge—further fractionations and an attempted integration. *Brain*, *110*, 1273–1296.

Warrington, E. K., & Shallice, T. (1984) Category specific semantic impairments. *Brain*, *107*, 829–854.

Weschler, D. (1981). *Manual for the Weschler adult intelligence scale–revised*. New York: Psychological Corporation.

Wright, I. C., Rabe-Hesketh, S., Woodruff, P. W., David, A. S., Murray, R. M., & Bullmore, E. T. (2000). Meta-analysis of regional brain volumes in schizophrenia. *American Journal of Psychiatry*, *157*, 16–25.

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TABLE 2

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