Preserved thematic and impaired taxonomic categorisation: a case study.

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The present paper seeks to understand more about categorisation and its relation to naming. A patient with language impairments (LEW) was examined in a three-part investigation of his ability to make classification decisions. The first part demonstrated LEW's inability to make taxonomic classifications of shape thus confirming his previously documented impaired perceptual categorisation. The second part demonstrated that, despite LEW's inability to perform simple taxonomic classifications, he could reason analogically as well as a 4/5 year-old child. It is therefore argued that taxonomic classifications cannot be driven by the development of analogical reasoning. The third part more directly contrasted thematic and taxonomic classification. LEW showed a preference for thematic classification. In fact, there was no evidence of any substantial ability to make taxonomic colour classifications despite evidence for good preservation of the associated object-colour knowledge.

The inability to carry out tasks requiring categorisation is a common consequence of aphasia (Vignolo, 1999). Therefore, it is not a surprise that categorisation tasks historically assumed considerable importance for the study of aphasia. In particular, impairments on categorisation tasks were considered crucial to the debate concerning the relationship between impaired language and thought. Different opinions were strongly expressed in the early days of modern neuropsychological research. Wernicke, for example, considered aphasia a disorder of the Wortklangbild (image of the sound of words) -what we would call now a lexical impairment. Contrary to Wernicke (1874), Hughlings Jackson (1879) famously declared that aphasics were “lame in thinking”. The argument was considered one of the most crucial in neuropsychology and surfaced many times in the subsequent 100 years (Marie, 1906; Head, 1926; Goldstein, 1948; Geschwind, 1974; Vignolo, 1999).

On the view that related aphasia to conceptual impairment, the two disorders have been seen to variously derive from a more general impairment in the use of symbols (Finkelnburg, 1870 see Vignolo, 1999), or from impaired abstraction and categorisation capacity (Goldstein, 1924, 1948; Teuber and Weinstein, 1956). Indeed, Goldstein (1948) considered that a loss of abstract processing could explain impairments in all categorisation tasks (for a comprehensive recent review of his work see Noppeney & Wallesch, 2000). Goldstein (1948) remarked on the particular difficulty amnesic (anomic) aphasics show when categorisation requires the ability to think abstractly. The present study is an attempt to elaborate the position put forward by Goldstein and, in particular, to examine the categorisation of an aphasic patient (LEW) who has difficulty in naming objects. In examining that position, we will predominantly contrast types of classification task rather than types of object-knowledge. The latter tasks are frequently used in the approach to aphasic conditions that could be considered the modern counterpart of the position held by Wernicke. For some recent empirical work in that tradition, examining aphasic patients in picture-word matching tasks, see Chertkow, Bub, Deaudon and Whitehead (1997).

The categorisation tasks employed by Goldstein were used in a few subsequent studies. For example, De Renzi et al (1972) asked patients to sort skeins of coloured wool in the classical Holmgren Test. They were able to rule out performance on the Weigl test as a predictor of the ability to categorise colours. However, they concluded that the "reason for aphasics' poor performance is not clear (p 147)". Impaired categorisation was also restricted to anomic aphasia by Caramazza and colleagues (Whitehouse, Caramazza & Zurif, 1978; Caramazza, Berndt & Brownell, 1982). While Broca's aphasics had no difficulty with a categorisation task, anomic aphasics were substantially impaired (Whitehouse et al, 1978). Similarly, in the task of discriminating between a cup and a bowl (Labov, 1973), Caramazza et al (1982) found that anomic aphasics were impaired and relied on the crude visual similarity of the presence or absence of a handle to make categorical judgements. Caramazza et al (1982) commented that "the strongest statement that can be made at this time is that the type of semantically based deficit we have uncovered appears to be associated with some types of posterior pathology, but not with all posterior lesions (p186)".

A little more progress on clarifying the limits of categorisation in anomic aphasia was made by Roberson, Davidoff and Braisby (1999). In their examination of the conceptual abilities of LEW, Roberson et al noted two contrasting patterns of performance. Whereas, the patient was able to divide objects by some categorisation instructions, he seemed unable to do so, and even bewildered by others. The categorisation task at which LEW succeeded was where he was asked to sort pictures of animals into those that were foreign from those that were British. His excellent performance on this categorisation task was accompanied by failure at perceptual categorisation tasks (sorting colours and facial expressions) into as many groups as he thought appropriate. These apparently easy perceptual tasks he found extremely difficult despite his excellent colour vision, acuity and otherwise excellent comprehension (see Druks & Shallice, 2000). Roberson et al ruled out two alternative explanations of LEW's failure at perceptual categorisation. First, the failure was not one of capacity limitation. For example, it was not confined to colour categories that required sorting on the three dimensions of hue, brightness and saturation. LEW was also unable to sort colours that differed simply by hue. Second, his failure was not due to his weakened visual short-term memory.

The apparently simple tasks of colour sorting completely defeated LEW unless the stimuli were arranged so that categorisation could be achieved by his intact perceptual (colour) discrimination. Thus, if colour samples were presented for which the within-group similarity was much greater than the between-group similarity (i.e., narrow ranges of reds, greens, yellows and blues), he sorted them into four groups without error. Nevertheless, his performance was abnormal because he used a slow pairwise comparison for each stimulus; the colour groups did not "pop-out". His abject failure was for tasks where within-group colours had a wide range of lightness and saturation; in those situations, assessing visual similarity is extremely difficult. In any case, even if LEW could have computed visual similarity, it is not a procedure that would have resulted in normal colour categories. In terms of perceptual discrimination (calculated from CIE co-ordinates see Wyszecki & Stiles, 1982), a colour that we call pink could be closer to a colour we call yellow than to a colour we would call red.

The failure of LEW at perceptual categorisation tasks is extremely important and leads directly to the present wider examination of his classification ability. Despite what might appear otherwise, the critical aspect of perceptual categorisation is that it depends on language. To understand the connection, it is necessary to realise that the difficulties LEW showed for perceptual categorisation are totally compatible with the philosophical position concerning, what is called, "vagueness" (Osherson & Smith, 1997). Vagueness is inherent in tasks that ask for categorisation from continuous variables because they fundamentally reduce the ways in which categorisation can be achieved (Dummett, 1975; Wright, 1975). Dummett (1975) holds what might be thought to be an extreme position but it is one from which we want to argue.

Dummett contended that **purely** perceptual categories are an impossibility because categorisation from continuously varying stimuli cannot be achieved solely by perceptual means. If purely perceptual categories were possible, it would imply that colour is immune to what is classically known as the Sorites paradox; it is not. The paradox becomes apparent from a thought experiment. Suppose we alter a colour (say, one that we would call red) by imperceptibly reducing the wavelength. We would be forced to call the second colour by the same name (i.e., red). The process could then be repeated by again reducing the wavelength by an imperceptible amount. Again, we would have to admit that the third colour should be given the same name as the second. Continuing this procedure many times, one would have to finally, and paradoxically, admit that blue colours should be called red. According to Dummett, this paradox can only be avoided by introducing some non-perceptual mechanism (e.g., names or rules) into the categorisation process. Thus, we would argue that colour categorisation is essentially a rule-governed procedure. Colours may be assigned to a category on the basis of similarity but it is similarity to an arbitrarily defined (named) colour (see Roberson et al, 1999).

The present sets of investigations will consider the Jackson/Goldstein position that the aphasic patient has lost the ability to think abstractly. In particular, we will consider LEW's ability to achieve taxonomic classifications. Thus, we will give LEW tasks that tap the distinction between rule-based (taxonomic) and associative (thematic) learning systems (Sloman, 1996). Rule-based systems operate on symbolic structures whereas associative systems reflect the similarity structure of acquired knowledge and relations of temporal and spatial contiguity. The two types of classification directly relate to a distinction between abstract and concrete thought processes (Goldstein, 1948).

Our new investigation is in three parts. In all parts, we will give LEW tasks that tap the distinction between rule-based and associative (thematic) learning systems (Sloman, 1996). The first part of the investigation confirms LEW's status as having difficulty with taxonomic (rule-based) classification for continuously varying stimuli. The previous examples of his difficulty with colour categorisation are supplemented by evidence of his impairment in shape categorisation. The second part concerns different views that are current for the role of similarity and analogical reasoning in achieving rule-based thought (Sloman & Rips, 1998; Gentner & Medina, 1998). We investigated analogical reasoning because Ratterman and Gentner (1998) argued that relational labels invite children to notice patterns and hence to make analogies or comparisons. It gives evidence for at least some preserved analogical reasoning in LEW. The view taken in the second part is that the ability to reason by relational alignment (analogies) is insufficient to explain performance on taxonomic tasks. Thus, we address and question the belief that the acquisition of rules might be bootstrapped from similarity judgements (Ratterman & Gentner, 1998). Gentner has argued that language plays a critical part in acquiring rules but it is unclear whether that should be a necessary part or rather that language directs the child's attention to the critical aspects of the similarity judgement. So, we will assess whether LEW's language impairment has affected more than the taxonomic problem given to him in the colour sorting and facial expression sorting tasks of our previous study (Roberson et al, 1999). The question that LEW will help address is whether similarity judgements might be achieved in a patient incapable of making perceptual categorisations. If this can be shown, then there would be an argument for believing the two types of thought are different in kind. At least, analogical reasoning would not be sufficient for taxonomic thought.

The third part of our investigation also concerns the type of thought process that is impaired in LEW. When LEW succeeded on sorting tasks such as dividing animals into British vs foreign, he was asked how he did the task. His answer was "zoo". If by "zoo" he meant that these animals were found in a zoo, his thought process was of an associative type. Is he, therefore, like children in biasing his sorting by thematic rather than taxonomic cues? Taxonomic categories are here defined as rule-based categorisation. Taxonomies are often considered as hierarchies of classification (Murphy, 2002) but taxonomies defined simply as rules for class determination is more appropriate to the distinctions made in development (Smiley & Brown, 1979; Markman & Hutchison, 1984) upon which we base our investigation. Markman (1989; Markman & Hutchison, 1984) has shown that two- and three-year-old children do not have a natural bias to sort taxonomically. Instead, without a noun prompt, children have a tendency to make a thematic choice.

In this section, we will also show that apparently similar categorisation tasks (object-colour, object-size) may be failed or passed according to whether they can be accomplished without taxonomic classification. Furthermore, we will show that, in LEW's case, failure at object-colour classification tasks does not result from a loss of knowledge about object-colour (Lewandowsky, 1908/Davidoff & Fodor, 1989; Luzzatti & Davidoff, 1994; Miceli et al, 2001).

LEW

LEW's neuropsychological and clinical profiles have been documented elsewhere (Roberson et al, 1999; Druks & Shallice, 2000). In brief, he had a stroke that left him with a moderate right-sided motor weakness and close to the profile of high-level Wernicke's aphasia. LEW had modest formal education, leaving school at 14 years. Druks and Shallice (2000) reported his current Verbal IQ as 71 and his Performance IQ as 83. On the spoken presentation of the word/picture matching task of the PALPA (Kay, Lesser& Coltheart, 1992), he scored 33/40 when examined by Druks and Shallice (2000); on our re-testing, his performance was very similar scoring 35/40 at the beginning of testing and 37/40 when re-tested a year later.

LEW is severely anomic and it is his naming to visually presented stimuli that is the main interest for the current investigation. He was tested with several stimulus sets by Druks and Shallice (2000). He scored 11% and 26% correct respectively on two administrations of the 60 object PALPA set and 16%

correct on 90 common household objects. He was similarly impaired on naming verbs (actions in pictures) scoring 9% and 20 % correct. Druks and Shallice (2000) report LEW to be substantially better at naming to definition.

In the current testing, LEW showed again very limited ability to produce a name to a visually presented stimulus. He scored only 2/30 on the Graded Naming Test (McKenna & Warrington, 1983). There was no evidence of category preservation; LEW correctly named only 1/30 fruit and vegetables, 2/30 non-praxic objects, 0/30 praxic objects and 4/30 animals from the McKenna (1997) corpus. In line with the testing in Roberson et al (1999), LEW only named 1/11 basic colours correctly. His correct response was 'blue'; to the others, his responses were "I know it but can't say". He pointed to 7/11 correctly making the following errors: yellow for white; black for brown; blue for grey and green for blue.

LEW was given the full set of objects (nouns) and verbs from Druks and Masterson (2000). The test allows analysis by five variables that have been considered important if semantic deficits underlie impaired name retrieval. For nouns, he scored 47/162 correct and verbs 17/100 correct with no evidence of any predictive value (see Table 1) for any of frequency, familiarity, age-of-acquisition, imageability or visual complexity in analyses of correct and incorrect noun items ($F(4,640) < 1$) and verb items ($F(4,392) < 1$). There was no difference in correct scores for a frequency matched set of 100 nouns and verbs; chi-sq(1) = 2.36, $p > .1$. Errors were, as in Druks and Shallice (2000), for nouns, attempts at circumlocutions, attempts to gesture and occasional semantic errors; for verbs, there were mostly omissions.

Table 1 about here

Part 1: Impaired perceptual categorisation

Experiment 1: Shape sorting

The influence of naming on shape categorisation was recently investigated by Roberson, Davidoff and Shapiro (2002). Their task used stimuli taken from Rosch (1973). Rosch argued for a universal basis for shape categorisation from the relative ease that names were associated to "basic" shapes by speakers of a language that possessed no shape terms. Roberson et al (2002) were unable to replicate Rosch's main findings with speakers of a different language that also contains no shape terms. As part of that study, Roberson et al gave Rosch's stimuli to their subjects with the instructions to sort them into groups. The speakers of the language without shape terms found the task very difficult and were unwilling to see the stimuli as similar in the same way as controls.

Controls

Ten male controls without brain damage who were matched for age and academic background.

Stimuli

The stimuli consisted of three prototypes (square, circle and triangle) and six transformations on each taken from Rosch (1973). The stimuli are shown in Figure 1. The same transformations were performed on each prototype.

Figure 1 about here

Procedure

The 21 stimuli were arranged at random on a table in front of LEW and he was instructed to put them into groups. As he did not spontaneously put them into three groups, the stimuli were rearranged and he was instructed to make three groups. He was then instructed to make three groups each being made up only of circles, triangles or squares. The instructions to the controls were identical except that the testing was discontinued if they made three groups each of only one shape.

Results

LEW was again bewildered by the task. Initially, he picked up one of the circles and found four other circles that he considered should go with it. He then declared that all the rest should be considered another group. His response to the instruction to form three groups was similar. He formed one group of three circles. He then formed another group of three circles and a triangle, then declared that all the rest of the stimuli should be allocated to the third group. LEW was most uncertain when asked to make groups only of squares, triangles and circles. He made one group of 4 circles another of 3 squares and a triangle; the third group contained 6 triangles and two squares. He refused to classify, despite repeated requests, 3 of the circles and 2 of the squares.

Rather to our surprise, only two of the controls spontaneously sorted the shapes into the three groups as designated by Rosch (1973). The others sorted the shapes into 4-7 piles. On being requested to sort the shapes into only three groups, all but one control made the groups as designated by Rosch (1973). The deviant control still continued to make groups containing stimuli of all three shapes. However, on being asked to group the stimuli into squares, circles and triangles, his sorting was without error.

Given our matched controls natural disinclination to sort the shapes as designated by Rosch, we ran 10 further controls from an undergraduate population. Only three of the controls spontaneously sorted the shapes into the three groups. The number of groups, for the other controls ranged from four to six with only around half of the groups containing all the same shape type. Nevertheless, on being instructed to form three groups, all 10 controls showed errorless performance. Controls were asked to explain their initial groupings and many said that the task looked so simple that they thought " it must be a trick task".

Experiment 2: Implicit shape categorisation

In Roberson et al (1999), LEW was found to have implicit knowledge of colour boundaries despite his inability to make use of them to sort colours. A task taken from Sophian (2000) was used to investigate whether LEW also had implicit knowledge of shape. The original intention was to use the within- vs cross-category distinction to assess shape recognition as used for colours in Roberson et al (1999). In that task, implicit categories were established for LEW by his superior recognition performance with cross-category distracters. A square was morphed into a triangle but controls refused to allow the equal morphed steps as psychologically equal. Moreover, controls always judged shapes from the same category as more similar than any comparison drawn from different categories. The difficulty in making purely perceptual categories for shapes was thus similar to the difficulty we previously reported for facial expressions in Roberson et al (1999).

As it would prove little to show that LEW gave superior performance with cross-category stimuli if they could not be perceptually matched to within-category alternatives, we turned to a more basic type of shape similarity. It would appear that we understand the similarity of shapes transformed by scale without the allocation of attentional resources (Biederman & Cooper, 1992; Stankiewicz & Hummel, 2002). We therefore argued that if LEW could assess the similarity between shapes that varied in scale, then he demonstrated at least some (implicit) understanding of shape. The task employed was that used by Sophian (2000) with 4-to-5 year-old children.

Procedure

A rectangle was presented at the top of a sheet of paper and two further rectangles at the bottom. One of the lower rectangles was an exact copy of the original but scaled down by 1/3 and the other matched the scaled-down replica on one dimension (height or width) but had a height/width ratio either greater or smaller than the original.

Sets were made up following the criteria of Sophian (2000). There were 4 'close contrast' pairs with a smaller distracter ratio, 4 'close contrast' pairs with a larger distracter ratio, 4 'far contrast' pairs with a smaller distracter ratio and 4 'far contrast' pairs with a larger distracter ratio. In 'close contrast' pairs, the distracter had a height/width ratio either 2/3 as large or 4/3 as large as the target. In 'far contrast' pairs the distracter had a height/width ratio either 1/2 as large or 2/1 as large as the target.

Sophian (2000) provided children with a story to encourage matching. LEW was given instructions for the task directly asking him to say which items had the same shape.

Results

LEW scored 16/16 correct. Thus, under direct perceptual matching conditions he can accurately decide which non-identical stimulus matched the target stimulus exactly in shape. Once again, he succeeded at a task when his knowledge is accessed implicitly but, as Experiment 1 showed, failed when asked to make an explicit categorisation in the same domain.

Overview Part 1

Experiment 1 provided further evidence that LEW is incapable of making explicit categorisation of stimuli that he cannot name. In Roberson et al (1999), we showed that he could not sort colours, now we show that he also cannot sort shapes. However, as reported for colour in Roberson et al (1999), Experiment 2 showed that LEW does have some implicit understanding of shape categories. Why these aspects are not available to him in explicit tasks remains to be discovered.

Despite the fact that we used the most common geometric shapes (squares, circles and triangles) as our stimuli, LEW did not seem able to show any explicit understanding of their taxonomy. His performance gives further evidence against the view that these basic shape categories are innately prescribed as suggested by Rosch (1973). LEW's data rather support the view, driven by cross-lingual evidence (Roberson et al, 2002), that shape categories are organised with respect to the meaning ascribed by the shape terms of the speaker's language.

Somewhat as a surprise, age and educationally matched controls also showed some disinclination to sort Rosch's shapes into three groups. Even undergraduates were inclined to make more than three groups though here it was because they thought that the three-group allocation was too obvious. The controls' performance shows that a sorting task is, as Goodman (1972) warned, inherently open-ended. Indeed, our stimuli provide rather good evidence for Wittgenstein's (1953) stricture (see Gentner & Medina, 1998) that "what counts as the same or similar cannot be established independently of our rule-governed behaviour".

Part 2: Preserved analogical reasoning

In Part 2, we ascertain the status of LEW's analogical reasoning in the context of his impaired taxonomic classification shown in Part 1 and in Roberson et al (1999). We investigated analogical reasoning because Ratterman and Gentner (1998) argued that relational labels invite children to notice patterns and hence to make comparisons. Thus, they argued that language also encourages a modification of thinking for this type of task. Gentner argues (Namy & Gentner, 2002) that hearing common labels asks children to embark on a comparison that helps promote abstract thought.

The age at which analogical reasoning develops and is affected by labels is greater than that currently found for the acquisition of colour labels (Davidoff, 1991; Ratterman & Gentner, 1998). So, it might be a reasonable assumption that, as LEW cannot make use of colour labels, he would also not be able to make use of relational labels. However, as we inferred above, there are different views as to whether the similarity judgements used in analogical reasoning are the same as those required for rule-based thought (Sloman & Rips, 1998, Gentner & Medina, 1998).

In Experiment 3, LEW was given a close version of the tasks used by Ratterman and Gentner (1998). The subsequent two experiments consider potential artefacts that could have allowed him success at the analogical reasoning tasks.

Experiment 3: Analogical judgements and the role of labels

Experiment 3 was directed by Rattermann and Gentner's finding that young children have greater difficulty making choices based on relational size (e.g., the smallest item in a set) with rich objects (varying on many dimensions, including size) than with sparse objects (varying only in size). Young children (3 and 4-years-old) were unable to resist matching by overall object similarity, rather than relational size. Not until 5 years of age were children able to overcome the temptation to match objects and choose by relational similarity. However, younger children made more relational choices when prompted with the labels ‘big’, ‘little’, ‘tiny’ or ‘mommy’, ‘daddy’, ‘baby’. In Experiment 3, LEW was tested on his ability to make relational matches for sets of rich or sparse stimuli that he was unable to name, both without labels and with the “family” labels: ‘mummy’, ‘daddy’, ‘baby’. Subsequently, he was also tested with “size” labels: ‘big’, ‘middle sized’ and ‘small’.

Stimuli

Two sets of stimuli were created following Rattermann and Gentner (1998). Rich stimulus sets contained three objects that varied along multiple dimensions including size within the two sets (e.g., a large black hat, a medium sized red rose and a small white door). Sparse stimulus sets contained three simple sparse objects that were identical in all respects except size within the two sets (e.g., patterned squares). See Figure 2 for examples of rich and sparse sets. In both cases, the size of stimuli was in monotonic order, from smallest to largest.

Figure 2 about here

LEW was asked to map monotonic changes in size between a triad of objects in front of the experimenter and a triad of objects in front of him. A cross-mapping was created by staggering the sizes of the objects as illustrated in Figure 2, where objects, change monotonically in size from left to right.

Procedure and Rationale

The experimenter and LEW sat opposite each other and the experimenter explained “I’m going to point to one of the three things on my card while you watch me. If you think about the thing I’m pointing to, you’ll be able to guess which is the equivalent one in your set.” If LEW were to use a relational rule to make his decision, when the experimenter pointed to the middle object in her set, LEW should also choose the middle object. However, if LEW’s decisions were based on overall similarity, then he would choose the object on the left (the smallest object). Feedback was either “yes, that’s the one” or “no, I was thinking of another one”.

In the first part of Experiment 3, no labels for the stimuli were given. There were 12 trials for each set of stimuli. LEW completed all 24 trials on 4 different occasions. In the second part of Experiment 3, on separate occasions, LEW was given “family” labels for the stimuli. Following Rattermann and Gentner (1998), the experimenter used the labels “daddy”, “mummy”, “baby” to label the large, medium and small stimuli. The experimenter again sat opposite LEW with a card from each set between them. The experimenter explained “I’m going to point to the daddy/mummy/baby object on my card while you watch me. Can you find the daddy/mummy/baby one in your set?” In all other ways, the procedure for the second part of the experiment was the same as for the first part.

On further subsequent occasions, LEW was tested with the “size” labels: ‘big’, ‘middle sized’ and ‘small’. The experimenter again sat opposite LEW with a card from each set between them. The experimenter explained “I’m going to point to the big/middle sized/small thing on my card while you watch me. Can you find the big/middle sized/small one in your set?” The procedure was again similar except that the testing was in three sessions with a total of 36 trials/condition.

Results

Table 2 shows results for LEW for sparse and rich stimuli with and without labels compared to those made by 3, 4 and 5-year-olds in Rattermann and Gentner (1998).   LEW performed above chance in all conditions. In the no label condition, his scores resembled those of 4- and 5-year-old children though his better performance in the sparse condition did not reach reliable levels (chi-sq (1) = 2.92, $p = .135$ (two-tailed). LEW did not show the same pattern of improvement that Ratterman and Gentner (1998) found for 3-year-olds when prompted with “family” labels. LEW seemed confused by the labels “daddy”, "mummy", "baby" in that these resulted in decreased (albeit not reliably so) performance. However, with size labels, LEW's performance improved in both conditions. For the sparse condition, ceiling effects prevented a significant improvement (chi-sq (1) = 2.13, p = .145 (two-tailed) but not for the rich condition (chi-sq (1) = 5.17, p = .023 (two-tailed). For the rich condition, errors were always to the identical object; this was also the predominant error in the sparse condition.

Table 2 about here

Discussion

Overall, LEW showed a similar pattern of performance to that of young children, and the addition of meaningful labels for stimuli induced a similar increment in performance. Ratterman and Gentner (1998) suggested that children succeeded with plain stimuli because they had some understanding of the relative size of objects, but failed on the complex set because the object identity match over-rode the relative size match. The same explanation could well hold for LEW. However, in reviewing LEW's pattern of performance, it was wondered whether two alternative explanations might be offered for the occasions where he failed to reason analogically. First, with the rich set of stimuli, the real life size of the objects might have caused LEW to make the wrong judgement where it conflicted with the relative size of the pictures (e.g., because a house is larger than a rose). Second, with the sparse set of stimuli, as they were always in monotonic order, he could have succeeded in the task by selecting the stimulus in the same position as that in the experimenter's set, without having a real understanding of the relative size of the objects. Ratterman and Gentner (1998) do not discuss this second possibility but it would seem a potential strategy that could be adopted for the task.

Experiment 4: Analogical reasoning with abstract shapes

To rule out the first of these alternative explanations for LEW's success at the analogical reasoning task, a set of abstract plain and coloured stimuli were created for Experiment 4 such that the coloured stimuli were multi-coloured and had complex abstract shapes. Examples of the stimuli are shown in Figure 3.

Figure 3 about here

Stimuli and Procedure

Cards were made up of a similar size to those used in Experiment 3 and presentation conditions were identical to those in the no-label condition in that Experiment.

Results

LEW was above chance in all conditions. LEW made few errors in the sparse condition scoring 81% correct, he scored 63% in the rich condition; this difference approached reliability (chi-sq (1) = 4.17, $p = .068$ (two-tailed). Errors were again to point to the identical object.

Discussion

LEW continued to be worse at the complex task even with abstract stimuli for which he could have no existing size representation - suggesting that his poorer performance on the original rich set in Experiment 3 was not due to confusion over the real-life size of objects.

Experiment 5: Analogical reasoning with non-monotonic stimuli

A further test was carried out, using the stimuli used in Experiment 3 taken from Ratterman and Gentner (1998), to examine the effect of using a non-monotonic order of presentation.

Procedure

The procedure was similar to that of the no-label condition of Experiment 3 except that LEW's and the experimenter's stimuli were presented in non-monotonic order. Testing was confined to one session for the rich stimuli and three sessions for the sparse stimuli.

Results

LEW was above chance in all conditions. For the sparse set of stimuli, LEW made 75% correct choices, for the rich set he made 56% correct choices; clearly a similar pattern of performance to that found in Experiment 3 (see Table 2) with the original monotonic order.

Overview Part 2

In all of the experimental conditions LEW performed well above chance. He is able to reason analogically at least to the ability of a 4/5 year-old child and does not make all judgements on the basis of perceptual similarity between objects. Indeed, LEW showed evidence of analogical reasoning even with randomly arranged stimuli, he is not any worse with abstract rather than real-life stimuli and he can improve on the tasks with the assistance of (some) labels. However, like children, his analogical reasoning can get confused by complex stimuli and can be distracted by object similarity. Yet, there is no doubt that a 4/5 year-old child could sort colours. So, LEW's results would imply that the linguistic abilities required for analogical reasoning are not those required for taxonomic classification.

Our results do not directly assess whether or not relational (analogical) reasoning is primary (Goswami, 1996) or whether it is bootstrapped from similarity judgements (Gentner, 1988). We are more concerned with whether the use of labels in analogical reasoning serves the same role as in colour sorting and other taxonomic classifications. In fact, even Ratterman and Gentner (1998) do not wish to claim that language is "the only path to relational competence". However, they argue that the use of labels is to promote alignment on dimensions; this progressive alignment is held to be sufficient for simple analogical comparisons (Kotovsky & Gentner, 1996). From the performance of LEW, we would argue that analogical reasoning is an intellectual achievement quite separate from perceptual categorisation. Thus, analogical reasoning could be merely helped by language (Gentner & Medina, 1998) but, for perceptual categorisation, language is essential. Our results would favour that interpretation giving language a unique role only in taxonomic classification.

Part 3 Taxonomic vs Thematic Classification

In Part 2, we argued for a distinction between rule-based and similarity-based reasoning. In Part 3, we make a similar distinction between rule-based and thematic associations. The distinction is not new; it is not even new for considerations of aphasic patients. Wernicke's aphasics have long been known to have difficulty with conceptual as opposed to thematic relationships (Bisiacchi, Denes & Semenza, 1976; Gardner & Zurif, 1976; Melice-Ledent et al, 1976; Semenza et al, 1980) and the reverse has been claimed for more anterior patients (Semenza, Bisiacchi & Romani, 1992). However, the particular difficulty in making conceptual classifications is not restricted to Wernicke's aphasics. Even with an intact ability to make conceptual classifications, patients might prefer to classify thematically (as for example in Zurif et al, 1974). Nevertheless, Semenza (1999) concluded that it is patients with lesions located more posteriorly in the left hemisphere that are significantly more likely to have problems with conceptual classification

Semenza (1999) argues for the importance of intact classification for good naming.

However, Goodglass and Baker (1976) found superordinate classification resistant to damage in aphasics with naming disorders. Semenza argues that task difficulty was not controlled in Goodglass and Baker and, if this is controlled, a clear double dissociation is shown between the two tasks. Indeed, Semenza et al (1992) demonstrated that there was a direct relationship between the ability to use nouns and the ability to form a category irrespective of the aphasic classification of the patient (see also Wayland & Taplin, 1982; Gainotti et al, 1986). Furthermore, good naming ability did not necessarily imply intact semantic representations.

We will examine LEW's performance on two tasks (classification by similarity or by name, and odd-one-out) that while asking for taxonomic decisions are, in part, potentially soluble by thematic associations. The line of investigation began as a result of asking LEW to sort items from the Snodgrass and Vanderwart (1980) corpus into animals, furniture and clothes. He had performed flawlessly at the apparently more difficult task of dividing animals into "British" vs "foreign", so we expected the task to be carried out without error. Indeed, he made no mistakes with the animals but several items of furniture were placed with clothes. In a repetition of the task, where the labels "furniture" and "clothes" were explicitly given to LEW, similar mistakes still occurred pointing to a difference between this case and what one might expect if the problem was a visual-verbal disconnection as might occur in optic aphasia.

Experiment 6: Classification by similarity or by name

The task was based on Experiments 1-3 of Markman and Hutchinson (1984). In these experiments, they investigated the young child's bias towards memory structures based on thematic rather than taxonomic associations (Inhelder & Piaget, 1964; Smiley & Brown, 1979). Markman and Hutchinson (1984) investigated whether hearing a novel or basic level name (Rosch et al, 1976) would cause children to shift from thematic to taxonomic classification. For simple tasks such as those in Markman and Hutchinson, adults make taxonomic choices but even children as old as six might prefer thematic choices as, in fact, adults may do if a task is difficult or items strongly associated (Smiley & Brown, 1979; Lin & Murphy, 2001). In our experiment with LEW, we considered only the difference between a condition where no name was given compared to that of being given the basic level name.

Controls

Twelve male adults slightly older than LEW but with the same educational background (mean age = 68.5 years, SD = 6.78 years) were used as controls.

Stimuli

Twenty-two triads were constructed closely based on the stimuli in Experiments 1-2 in Markman and Hutchinson (1984). Each triad consisted of three coloured photographs of common objects arranged to form a triangle. A standard object (e.g., police car, tennis shoe) was placed at the top of the triangle and a taxonomic choice (e.g., saloon car, high-heeled shoe) or thematic choice (e.g., policeman, foot) placed at the two lower apices. The taxonomic choice was to the left of the standard for half the triads and to the right for the other half.

Procedure

The experiment consisted of two sessions (No Word and Basic Word) administered on different days. The No Word condition was given first. Pointing at the standard object, LEW was instructed "to find another one the same as this". The same procedure was given in the Basic Word condition except that LEW was told "this is a car (shoe etc). Can you find another one?"

Results

In the No Word condition, LEW made 16/22 thematic choices. In the Basic Word condition, LEW made 4/22 thematic choices. A McNemar test for the significance of changes gave Chi-sq (1) = 11.08, $p < .001$. Controls made very few thematic choices (on average 2.25 thematic choices in the No Word Condition and 0.33 thematic choices in the Basic Word Condition). Six controls made no thematic choices in the No Word Condition and 9 none in the Basic Word Condition. LEW made more thematic choices than controls in both conditions (both $ps < .001$).

Discussion

LEW's scores resembled the performance of the 4-year-old children in Markman and Hutchinson (1984, Experiment 3). Those children made 25% taxonomic choices in the No Word Condition and 62% taxonomic choices in the Basic Word condition; LEW made 28% in the No Word condition and 82% in the Basic Word Condition. Thus, unlike normal adults but like young children, LEW is influenced by the object's label in making choices in the Markman and Hutchinson task. He is clearly capable of recognising that visually different exemplars of a category can be given the same name and acting accordingly in response to the instruction to find another car (shoe) etc. However, Experiment 6 does not allow us to conclude that LEW is capable of making taxonomic classifications without being given labels. He can make an apparently taxonomic decision based on the label "car" but then his good performance on the PALPA Test would predict that he could match the word "car" to pictures of cars. He could not do the same for colours and the label "red". Therefore, we carried out Experiment 7 where the classification was based on three different (colour, size and function) object properties that have an increasing likelihood of allowing a thematic solution to an odd-one-out decision.

Experiment 7: Odd-one-out Tasks

The task used in Experiment 7 asks for a taxonomic decision in an odd-one-out paradigm. LEW could sort pictures of animals into "British" vs "foreign" (Roberson et al, 1999). However, there are reasons to investigate the intact status of the types of knowledge that might be presumed responsible for his good performance. The work of the Konstanz group (Cohen et al, 1976; Kelter et al, 1976, Cohen, Kelter & Woll, 1980; review in Vignolo, 1999) distinguishes between types of categorisation tasks. Their tasks, similar in design to those used in the Pyramids and Palm Trees Test (Howard & Patterson, 1992), ask the patient to decide which two out of three pictures go together. They found that aphasic patients were considerably more impaired if the connection was “perceptual” rather than “situational”. For example, aphasics failed to connect that a snowman should go with a swan because both are white but succeeded in a task that required putting together a guitar and a bull because both are connected with Spain. Thus, the Konstanz group made, from many studies, the perhaps rather surprising conclusion that it is visual knowledge about objects that is impaired in aphasia. In Experiment 7, we consequently contrasted two aspects of visual knowledge about objects (colour, size) with that of function.

Standardisation of Task

Our examination of LEW employed an odd-one-out task commonly used to assess the status of intact knowledge (Warrington, 1975). The particular task used with LEW investigated knowledge from both pictures and words as in Hillis and Caramazza (1995). Stimuli were taken from Snodgrass and Vanderwart (1980) and were used both in their pictorial form and as words. Three odd-one-out conditions were given: colour, size and function. Each stimulus was only used in one task and hence some preliminary balancing of task difficulty was required.

For standardisation, a trial consisted of three pictures (words) presented on a computer screen at the apices of an equilateral triangle. The task was standardised by twelve undergraduate control subjects who were asked to select the picture (word) they believed to be the odd-one-out according to the condition (colour, size or function) of the experiment. They were asked to respond as accurately and as quickly as possible. Responses were made via keys arranged in the same pattern as the stimuli on the screen. Each subject carried out all six conditions with pictures and words blocked. The order of each condition within each block was controlled. The stimuli within each condition were presented in a random order.

Latencies were analysed within a Block (Pictures vs Words) x Condition (Colours vs Size vs Function) analysis of variance. There were no effects that even approached significance. However, a similar analysis for accuracy revealed an effect of Condition $F(2,22 = 7.46, p < .01)$ due to the relative ease of the colour judgement. In consequence, triads were removed from each Condition to balance the level of accuracy. It was only necessary to remove three triads to ensure that another similar analysis produced no effects that approached significance. However, to further ensure equivalence, the remaining 21 triads for each Condition were administered in the same way to a different set of 12 standardisation subjects. No significant effects were observed for either accuracy or latency. A further analysis incorporating the order of Block (Picture vs Words) also revealed no significant main effects or interactions.

Controls

The same 12 controls were used as in Experiment 7.

Procedure

Some changes to the procedure were necessary to administer the odd-one-out task to LEW. He was unable to use the keyboard set-up properly without the use of his right hand, so pictorial stimuli were presented on cards on a table in front of the patient. The stimuli were in the same pattern as on the computer screen; accuracy was recorded. A similar procedure was followed for the words but LEW's impaired reading was supplemented by the words being also read aloud by the experimenter who simultaneously pointed to each word. Controls followed the same procedure except that they read the words themselves.

The stimuli were divided into two blocks with the pictorial and word form for a particular item in different blocks. The first block consisted of 10 picture triads and then 11 word triads for colour followed by the same procedure for size and then function. The second block consisted of 11 words and then 10 pictures for function followed by the same for size and then colour. The one hour interval between blocks was filled with an unrelated task of freesorting facial expressions. At regular intervals within each condition LEW was reminded of the criterion for deciding which was the odd-one-out.

Results

LEW showed no evidence that he could judge which object of the triad was a different colour to the other two (see Table 3). The dramatic difference between Conditions was independent of the form (picture or words) of presentation. Performance in the colour odd-one-out tasks was at chance and accordingly worse than the standardisation group (pictures: $t(20) = 22.50$, $p < .001$, words: $t(20) = 27.50$, $p < .001$) and the controls (ps < .001 for both pictures and words). There was a similar but less dramatic pattern of performance against the standardisation group for the size judgements (pictures: $t(20) = 12.91$, $p < .001$, words: $t(20) = 10.83$, $p < .001$). Comparison to the controls for size judgements gave a reliable difference for pictures ($p < .007$) but not for words ($p > .05$). The pattern for function judgements was different with LEW not differing from the standardisation group for pictures: $t(20) < 1$. He was somewhat impaired on function judgements from words: $t(20) = 3.33$, $p < .01$ but not to the same extent as for colour and size judgements. Against the control group, there was clearly no difference for either pictures or words (both ps > .1).

Table 3 about here

The data were also inspected to verify whether LEW's judgements reflected item difficulty. His good performance with function items and his poor performance with colour items prohibited any sensible analysis for those conditions but an analysis was carried out for size. Omitting the middle item, the 21 items were divided into equal groups of easy and difficult items according to controls' performance. LEW obtained reliably higher scores for the easy items (pictures: Chi-sq (1) = 9.89, $p < .01$, words: Chi-sq (1) = 7.50, $p < .01$).

Discussion

LEW performed rather badly at the odd-one-out tasks except for function judgements. He was impaired by much the same extent whether tested from words or pictures (see Hart & Gordon (1990) for a similar finding in a similar task). However, in the function Condition, his performance did not differ from that of the controls.

LEW has been previously examined in an investigation of his poor naming (Druks & Shallice, 2000). As a part of that investigation, his knowledge about living kinds was examined reasonably comprehensively and LEW found to have to have access to a large amount of associated information. LEW's poor performance on the odd-one-out tasks might seem at variance with those findings. However, they are not. It is our contention that his extant associated knowledge would not help him in a task requiring rule-based knowledge. These odd-one-out tasks require the abstraction of a concept; this is particularly the case for colour (redness etc). LEW may be able to imagine the colours of the objects but he cannot name those colours. So, to solve the task, he must allocate the object-colours –that are not identical- to the same category. As Lange (1936/1988 p88) put the theory of Gelb and Goldstein…. "(for us) The concrete colour ..is not considered separately but …as representative of a certain colour category, of redness, yellowness, blueness etc. This conceptual or categorical behaviour is impossible for the patients."

LEW's comprehension was reported to be good (Druks & Shallice, 2000) but there are indications within their report of somewhat impaired performance that is compatible with our findings on the odd-one-out task. Object-colour knowledge was not tested but LEW was asked to show on a tape measure the size of household objects. His overall performance was equivalent to controls but only after disregarding 10 items for which LEW was clearly deviant. Our task of size judgements would be more even likely to produce errors from LEW. In many cases, he could be inclined to perform the judgement on the basis of largeness or smallness and then he will fail.

The performance on the function odd-one-out task was much better than for size and colour. Evidence that would support his (lesser) difficulty with the function odd-one-out task can also be found in Druks and Shallice (2000). In that study, LEW was assessed several times on versions of the Pyramids and Palm Trees Test. Our own testing of the picture version gave 48/54 (89%) correct; completely in line with the testing of Druks and Shallice (2000). Though it is easy to disregard these few errors, technically this is impaired performance. We would maintain that these errors are meaningful and reflect the number of times idiosynchratic thematic associations might lead LEW to the wrong response. They remind us of the errors LEW made on the furniture vs clothes sorting task (see above). They are also similar to observations made by Goldstein (1948). He commented on a patient that put tools (e.g., hammer) with kitchen equipment in a categorisation task because they were kept together in his house.

There is a separate aspect of LEW's data that requires some comment. His results might be seen as interpretable within arguments about category specific impairments after brain damage. Given the items were taken from the Snodgrass and Vanderwart corpus, colour items were predominantly of living kinds and function items entirely of artefacts; size items were roughly equally of each kind. Such a distinction might prompt consideration of the data from Warrington and McCarthy (1987) who have argued that selective impairment for living kind categories could be associated with loss of sensory as opposed to functional object-knowledge. It is important to stress that the results for LEW on the odd-one-out tasks should not be seen as demonstration of a category specific knowledge deficit for living kinds. For example, in a previous paper (Roberson et al, 1999), we showed just how accurate LEW could be in sorting animals into British vs foreign categories. Nor do we wish to argue that LEW provides evidence for a dissociation between impaired sensory knowledge and preserved function knowledge independent of impairments to living kind categories.

We would rather consider LEW to exemplify the types of categorisation task performed well or badly by aphasic patients; arguments raised earlier by the Konstanz group. However, to remove further doubt, we will present evidence that LEW has considerably preserved knowledge about the visual form of animals even for the type of judgement (colour) that he could only perform at chance in the odd-one-out task.

Experiment 8: Intact Visual Knowledge

Roughly half of the errors that LEW made on the odd-one-out task concerned the colours of animals. In consequence, LEW was given the test developed by Davidoff and Warrington (1999) to assess visual knowledge of animals.

Stimuli and Procedure

The test consists of three sections (colour, parts and shapes); these were administered in that order with two-hour intervals between sections. The test consists of 30 items plus two practice items presented as high quality photographs. For each item, the subject is asked to point to the correct of three alternatives. All the items consisted of the correct animal with two distracters produced in Photoshop from digital versions of the originals. For the parts section, distracters were produced by replacing the correct part with one from another animal. For the shapes section, distracters were produced by altering the relative size of the correct parts (see Davidoff & Warrington, 1999 for full details).

In a subsequent session six months afterwards, LEW was administered the colour section of the test in Davidoff and Warrington (1999) but in a different format. The new format was more similar to that usually given to assess object-colour knowledge (Lewandowsky 1908/ Davidoff & Fodor, 1989; De Renzi & Spinnler, 1967). Line drawings similar in style to the Snodgrass and Vanderwart stimuli were constructed of the animal stimuli. Next to each of these drawings, in crayon, was a 4cm x 4cm square of homogenous colour similar to the colour in the original stmuli. In all other ways, the stimuli were presented in identical fashion to those in Davidoff and Warrington (1999).

LEW was also given a version of a test in Luzzatti and Davidoff (1994) used to assess object-colour knowledge. The test consists of 16 line drawings of vegetables and fruits. Each stimulus was presented crayoned in a homogenous wash with the correctly associated colour and incorrectly with three other colours. LEW's task was to point to the correctly coloured stimulus. One item was omitted as LEW indicated that he did not recognise the stimulus.

Results

For the animal test taken from Davidoff and Warrington (1999), LEW's performance on this difficult test was at the level of age-matched controls (see Table 4) and, if anything, better for colour than the other two sections. LEW's performance on the part and shape sections is, at least, at the level of 15-year-old children (Davidoff & Roberson, 2002). LEW was not disadvantaged by the change in format for the colour section now scoring 28/30 correct.

Table 4 about here

LEW made 5 errors on the four alternative forced-choice task taken from Luzzatti and Davidoff (1994). He pointed to a yellow rather than a green artichoke, a red rather than a brown peanut, a red rather than an orange pumpkin, a yellow rather than a green courgette and a green rather than a purple aubergine.

Discussion

LEW shows rather good knowledge about the appearance of animals. In particular, he showed excellent knowledge of object-colour despite his inability to carry out the odd-one-out colour task. Furthermore, his ability to retrieve the correct object-colour was as good from an isolated patch as it was from a coloured photograph. Thus, the poor taxonomic classification for colour found in Experiment 7 does not result from a defective store of object-colour knowledge.

LEW's performance on the tasks concerned with object-colour shows similarity to the cases described by Beauvois and Saillant (1985) and it is worth pointing to the similarities but also to the important differences. LEW shows what might be thought remarkably good performance on the animal colour task given his abysmal performance on the odd-one-out task that contained many items that concerned animals. Similarly, Beauvois and Saillant (1985) showed that optic aphasics might demonstrate little ability to retrieve object-colour knowledge when asked in the normal fashion (De Renzi & Spinnler, 1967); yet, they could be made to show normal performance with other procedures. The particular procedures used by Beauvois and Saillant to show normal performance concerned the inhibition of verbal associations. When their patients were allowed to use their visual imagery uncontaminated by verbal associations, they showed excellent retrieval for object-colour. Beauvois and Saillant (1985) argued that their cases were examples of optic aphasia caused by a visual-verbal disconnection. LEW certainly does not fit the normal pattern of an optic aphasic (see Druks & Shallice, 2000) not least because his performance on the odd-one-out task was equivalent from pictures and words. However, the principal difference from the cases of Beauvois and Saillant (1985) is that LEW is not failing at object-colour retrieval but at the taxonomic classification of colour.

LEW made a few mistakes on the task of pointing to the correctly coloured vegetable. His knowledge about vegetables is not obviously impaired (Druks & Shallice, 2000); nevertheless, it could be possible that the errors were to items that were a little unfamiliar to him. However, rather than familiarity per se causing the errors, we would think it more likely that the errors reflect the occasions when LEW attempts a verbal classification rather than relying on his visual memory. If for example, he remembers grapes as green, he would then have to match the word "green" to the four colour patches; a task that he finds difficult.

Overview Part3

Part 3 investigated LEW's inclination to sort thematically rather than taxonomically. In Experiment 6, we found that LEW behaved rather like a 4-year-old child in the extent to which he would classify thematically. LEW, like young children, would change to taxonomic choices if asked to classify by name.

Inhelder and Piaget (1964) in their pioneering studies of the development of thought questioned the young child's ability to think taxonomically. They noted that children form groups of tokens into images or geometric structures rather than in groups that follow rules. In fact, LEW behaved with tokens in very much the same way and we noted that Goldstein made similar comment about his patients (see Roberson et al, 1999, p 11). The critical concern is whether LEW is incapable of taxonomic classification or rather whether the experimental conditions prevent the expression of his abilities. For example, it cannot be assumed that LEW (or a child) really believes that cow and milk are in the same taxonomic relation as cow and dog simply because he puts them together in the Markman and Hutchison task (Experiment 6). Thus LEW could merely be vulnerable to the many ways that task demands might encourage or discourage taxonomic choices.

The employment of taxonomic choices by children can be encouraged in other ways than the procedure of adding labels (Markman & Hutchinson, 1984) used in Experiment 6. Requests for identity decisions (Osborne & Calhoun, 1998; Waxman & Namy, 1997), the use of real objects (Deak & Bauer, 1996), the spatial aspects of the task (Markman, Cox & Machida, 1981) and the use of nouns rather than relational language (Dunham & Dunham, 1995) all enhance the proportion of taxonomic decisions. So, it could be that with different tasks and instructions, LEW could show preserved taxonomic skills. Nevertheless, the only evidence we have that LEW possesses any taxonomic abilities is from Experiment 6 and this only shows that LEW can point to different exemplars that correspond to a given label.

Experiment 7 allowed further consideration of the two ways (thematically or taxonomically) of performing matching tasks. For colour and size odd-one-out tasks, thematic associations are largely irrelevant. The tasks require an abstract classification; this is almost always true for colour and mostly the case for size. Of course, the odd-one-out colour task could also be solved by simply naming the object-colour (e.g., red) but this is not something LEW can do. Thus, we would claim that the odd-one-out task for colour, and partly also for size, requires a different procedure than merely inspecting visual memories. So, the fact that LEW has good retrieval of visual object-colour memories (see Experiment 8) does not help him in the odd-one-out task. He performs better on the function task because, though it could be seen as a taxonomic task (which is not a tool etc), it can also be performed by thematic associations. It is only to the extent that the thematic procedure is useful –and it often is- that LEW will achieve good performance.

<u>General Discussion</u>

The present examination of LEW places his previously documented impaired perceptual categorisation (Roberson et al, 1999) into a context of preserved functions. In particular, the new data reinforce the view that taxonomic classification is dissociable from other category sorting tasks. LEW can apparently make sophisticated classifications (e.g., British vs foreign) but these we argue, in his case, to be thematic rather than taxonomic classifications. LEW has also retained some ability to reason by analogy but this does not allow him to succeed in any taxonomic classification.

LEW resembles the type of patient described by Goldstein (1948) who pointed out two characteristics that amnesic (anomic) aphasic patients adopt in categorisation tasks. First, they do not put the categorised items into piles but rather require them all to be visible. Goldstein interpreted this behaviour as an indication that the categorisation was not being driven by an abstract concept. LEW shows exactly this behaviour for the tasks described above and also for the perceptual categorisation tasks in Roberson et al (1999). Second, aphasic patients form idiosynchratic categories. LEW would go wrong in a few object categorisation tasks by basing his classification on his personal knowledge. He, for example, put a shirt with chest-of-drawers presumably based on where they would be kept in his house.

LEW’s profile of preserved and impaired function casts some light on three important and related issues. The first of these concerns a debate about different types of thought processes (Fodor, 1998a; Gentner & Medina, 1998). The second concerns the role of preserved naming in taxonomic classification; the third concerns the type of patient who would show similar disorders of taxonomic classification. Turning to the first of these issues, Fodor (1998a,b) has argued that concepts –of the taxonomic kind- cannot be derived empirically. In contrast and in support of an empiricist position, Gentner and colleagues have shown that similarity judgements can be affected by object similarity and hence argue that similarity may bootstrap the acquisition of rule-based skills. Our data are more amenable to Fodor’s view of the innateness of concepts than the empirical stance of Gentner though, of course, that issue is not directly addressed. LEW is susceptible to the same distractions as are children in his analogical reasoning but nevertheless, like children, he is also somewhat immune from them. The important point is that children at the same level of analogical reasoning as LEW perform very much better at taxonomic tasks. Thus, LEW shows that the ability to make taxonomic classifications does not depend on the ability to reason analogically.

Our data also address the contrast between concrete and abstract thought. Abstract concepts are essentially of the taxonomic type and concrete concepts essentially thematic though the distinctions are not always straightforward. Consider, for example, an apple. Abstract (taxonomic) classification of an apple would be as a fruit. Concrete (thematic) classification of an apple could relate it to another object (e.g., tree). However, two types of fruit (apple and banana) might be classified together by virtue of their being seen together just as LEW classifies animals as foreign because they are in the zoo. Thus, an apparently taxonomic decision can, in fact, be based on a thematic decision. A similar complexity can arise for thematic classification. The fact that an apple is red might be considered a concrete property of an apple. Nevertheless, if the decision to classify an apple is based on redness, then it is a taxonomic decision and one that, in Experiment 7, we saw that LEW failed abysmally.

There are three views about how concrete and abstract concepts might be mentally represented. One suggests that they have essentially the same mental structure except that abstract concepts are more complex (see Breedin, Saffran & Coslett, 1994 for review). The second holds that multiple representations for concrete events make that type of knowledge easier to access. A particularly important variant of this view holds that concrete events may be stored in both visual and verbal forms whereas abstract concepts can only be represented in a verbal form (Paivio, 1971). There is neuroimaging evidence in favour of concrete and abstract meaning being on a continuum (Martin-Loeches et al, 2001) but equally there is also neuroimaging evidence in favour of multiple sites for concrete meaning (West & Holcombe, 2000) or abstract meaning (Kiehl et al, 1999). The third view suggests that abstract and concrete concepts are different in kind; this view appears to have currency only within neuropsychology and, as Breedin et al (1994) report, largely ignored elsewhere.

The best neuropsychological evidence for distinctly separable concrete and abstract concepts is that they are known to double dissociate in naming studies. Aphasics, in general, show a concreteness advantage in word retrieval (Goodglass, Hyde & Blumstein, 1969) but not always (Goldstein, 1948; Warrington, 1975; Warrington & Shallice, 1984; Sirigu, Duhamel & Poncet, 1991; Breedin et al, 1994). For example, Warrington's patient could define an abstract word such as supplication as "making a serious request for help" but could give no definition for the word alligator. Their separation is also confirmed from a study in which there was a selective difficulty in retrieving abstract words without an impairment in comprehension (Franklin, Howard & Patterson, 1995); thus ruling out damage to knowledge structures as causal for an impairment for abstract terms. A similar conclusion was drawn for two patients where the retrieval deficit was limited to written production (Baxter & Warrington, 1985; Hillis, Rapp & Caramazza, 1999). Of course, abstract words are generally less frequent, longer etc but these too have been shown insufficient to explain their difficulty in an anomic patient (Henaff Gonon, Bruckert & Michel, 1989). The taxonomic difficulty will be seen especially for perceptual terms, such as colour, because these are essentially abstract. Colour, for example, only allows for taxonomic classification. For colour, there are not alignable differences (Markman, 2001) or thematic confusions; hence their particular difficulty in categorisation tasks.

We now turn to the second issue that is addressed by LEW's pattern of performance. While we have argued that LEW's data do not support Gentner's view that taxonomic classification might be derived from analogical reasoning, they do support Gentner's view for an important role for language in classification. Gentner contends that language is essential for directing attention to the important stimulus variables used in the acquisition of rule-based behaviour. In fact, we argue that one aspect of language (i.e., naming) is even more critical in classification than the role proposed for it by Gentner.

The relationship between naming and categorisation is not straightforward (Hampton, 2001; Sloman, Malt & Fridman, 2001). The complexity arises because of the many ways that objects may be categorised (decided to be similar). For some tasks, perceptual similarity may be the dominant procedure for categorisation; for other tasks, it could be some functional or contextual similarity. The consequence is that there may be categorisation tasks, including sorting, that for normal individuals are not effected by the names given to objects (Sloman et al, 2001). However, naming and the associated verbal coding are critical to performance in other tasks. For example, in research on eye-witness testimony, the detrimental effects of verbal coding are well-known (Loftus, 1979). Verbal coding of visual stimuli can be automatic (Schiano & Watkins, 1981) with the consequence that existing visual codes may even be lost (overwritten) after naming (Loftus, 1979; Schooler & Engstler-Schooler, 1990). Effects of name dominance can be equally striking after brain damage allowing a patient to produce gestures or drawings that correspond to verbal mistakes rather than to the object presented (Oxbury, Oxbury & Humphrey, 1969; Lhermitte & Beauvois, 1973; Beauvois et al, 1978; Davidoff & Wilson, 1985; Ohtake et al, 2001). These effects are so dramatic as to suggest that it is not only memory codes that are altered by naming but also the processing of current visual stimuli. A similar claim has recently made for perceptual categorisation (Davidoff, 2001). We, therefore consider LEW in the context of his loss of naming.

The naming of objects in aphasia is multi-determined (for recent review see Hillis, 2001) and there are many contributing factors towards an inability to name objects. One of these factors is an impairment resulting from damage to semantics or features of object-knowledge (Katz & Fodor, 1963; Hillis, 2001). Semantic errors in comprehension are generally associated with semantic impairments in naming (Gainotti et al, 1981) but Butterworth, Howard and McLoughlin (1984) caution against making a direct link between the two disorders. LEW does not make a substantial number of semantic errors and we would wish to rule this out as a major cause of LEW's naming disorder. Impaired semantics also cannot be the reason that LEW prefers to make thematic decisions in categorisation tasks. Semantic errors in comprehension and naming may accompany preserved thematic associations (Howard & Orchard-Lisle, 1984) but this is not the case for LEW. For LEW, there was a limited ability to name objects but when given a description of an object's features and functions, his naming showed some improvement (Druks & Shallice, 2000) prompting the claim that LEW's impairment does not stem from a weakened knowledge base. Their conclusion is reinforced from the results of Experiment 8.

Druks and Shallice argue that LEW's naming impairment for concrete objects is at a separate post-semantic stage of word retrieval (Butterworth, 1989; Levelt, 1989) concerned with lemma selection (Kempen & Huijbers, 1983). However, Butterworth et al (1984) explicitly state that these operations act as transcoding devices based on learned associations and not as rule-governed devices. Thus, even granted that impaired lemma selection does contribute towards LEW's naming difficulties, we still need to consider his inability to name what are, in effect, abstract terms such as colours (e.g., red) and shapes (e.g., square).

A disorder that prevents naming would at the very least promote associative (thematic) rather than taxonomic procedures for categorisation. One reason would be the general inclination to solve categorisation tasks verbally (Ashby et al, 1998) and this would be particularly the case for complex multidimensional stimuli. However, it is not the case that LEW's categorisation difficulties are only present for complex stimuli. LEW has difficulties in categorising even the simplest of perceptual stimuli. For these, observation by itself is insufficient to arrive at a categorical solution (Anderson & Fincham, 1996) and therein lies LEW's difficulty. For such classifications, the concept and the name are in effect the same thing and LEW is without names to assist the categorical solution. Where patients such as LEW can name, they can categorise. In an odd-one-out task in which LEW could successfully name each item, he would succeed just as he could succeed when given names in the Markman task (Experiment 6).

We argue that LEW's poor naming ability is critical to the loss of taxonomic classification. Indeed, for patients with selective category disorders (note for example the classic dissociations in Goodglass et al, 1966) one might predict preserved taxonomic abilities only for those categories with preserved naming. However, it must be said that, at present we do not have direct evidence of the taxonomic abilities of patients whose naming loss results from semantic disturbances. Nevertheless, the data available (Semenza, 1999) might prompt the conclusion that, even here, there would be impairments with taxonomic classification.

With respect to the third issue, clearly related to the second issue, concerning the types of patient that would exhibit similar disorders, we would first note they ought not to be rare. With Goldstein, we suggest that disorders of taxonomic classification would be common because naming disorders are common. They may appear less common than they are because so many sorting tasks are soluble by thematic associations. It is only for perceptual categorisations that the taxonomic failure becomes vivid because, for those tasks, there is no other way to the solution. However, before restricting a taxonomic impairment to a naming disorder, it is necessary to rule out other likely candidate populations that might be argued to show the same sort of deficit.

The type of aphasic patient that would show disorders of taxonomic classification has to be one in which language impairment is central. One would not expect impairments of perceptual categorisation where there is merely a problem in production such as shown in the tip-of-the-tongue phenomenon. Indeed, previous research on the impaired perceptual categorisation abilities of aphasic patients has eliminated those with more anterior damage (de Renzi et al, 1972, Caramazza et al, 1982). So, the least likely candidate patients are those whose problems involve the syntactic elements of language however essential they are to linguistic theory. Impaired sentence comprehension is demonstrable in patients with good word comprehension (Caramazza & Zurif, 1976; von Stockert & Bader, 1976) and preserved syntax co-exists with naming impairments (Hodges, Patterson & Tyler, 1994). Furthermore, Varley, Siegel and Want (2001) have shown that severe grammatical impairment does not preclude many abstract reasoning tasks such as theory of mind or playing chess.

Having ruled out impairments associated with anterior lesions as responsible for taxonomic impairment, we now rule out other disorders associated with more posterior damage. The locus of lesion critical for taxonomic classification is the left posterior cortex (Caramazza et al., 1982). The laterality of the lesion makes it unlikely that we would want to consider the data of Caramazza et al (1982), or our own, as evidence for a nonverbal semantic impairment (Chertkow et al., 1997). In any case, LEW exhibits the same poor taxonomic classification in Experiment 7 for both visual and verbal presentations (see McCarthy & Warrington (1988) for a classic example of when that does matter). The types of patient that might seem better candidates are those that have degraded or inaccessible knowledge stores (Warrington, 1975); a disorder often referred to as semantic dementia (Snowden, Goulding & Neary, 1989). Such patients often demonstrate loss of naming and, indeed, difficulty with taxonomic as opposed to thematic relationships (Semenza et al, 1980). However, the generally intact knowledge store of LEW (Druks & Shallice, 2000) does not prevent him making taxonomic errors; clearly the disorders must be different. The same conclusion was drawn by Franklin et al (1995) in considering the selective impairment of the production of abstract words. One is, therefore, driven to the view that applying a name to a class of objects is a theoretically different ability to associating features in object-knowledge. Though here Goldstein (1948) warned of difficulties of interpretation if the naming was by rote (in his word, pseudonaming), rather than reflecting an abstract attitude.

One aspect of knowledge loss deserves further comment. In its severe form, such patients may only be able to retrieve superordinate information such as “animal” or “metal” (Warrington, 1975). The resilience of superordinate information could be due to its early acquisition (Mandler, 1994), the perhaps consequent increase in frequency with which the labels are attached to the object (Funnell, 1995) or because there are natural domains of knowledge (Konorski, 1967; Warrington, 1981; Caramazza & Shelton, 1998). If such domains form natural categories, their mental representations should be available for taxonomic decisions at least between these broad categories. We do not doubt that LEW could successfully classify items into animals vs tools. So, we cannot be adamant that LEW is incapable of making all taxonomic decisions. However, such natural divisions are not available for categories within domains that form continuous variables such as colour or shape; for the inability to make categorical distinctions for these variables we need to look elsewhere.

The critical impairment for LEW we argue to be his anomia but he has lost more than just the names. He, like other patients with colour anomia (Davidoff & Ostergaard, 1984; Davidoff, 1991), also cannot point correctly to a named colour and also cannot benefit from shape category labels in Experiment 1. LEW’s loss, as Goldstein put it, is that of an abstract attitude. LEW’s impairment makes him unable consciously to allocate items to perceptual categories. Hence, we regard his impairment to refer not to a type of knowledge store but to a type of thought.

In summary, we suggest that there are two types of categorisation procedures (taxonomic and thematic) that have separable mental representations. In attempting to distinguish the two types and understanding the processes underlying categorisation, the major problem is that classification (family resemblance) of objects (animals, tools etc) could be obtained from visual similarity, by common habitat, size or a myriad of other associations. It could be even argued that these associations are what constitute the category. Our central thesis is not concerned to demonstrate problems with these thematic types of category. Aphasics may turn out to be over or under inclusive in the features of objects that for them define a category (Grossman, 1978, 1981) or be completely normal except for difficulties derived from word retrieval (Hough, 1993). Our thesis is that there is a type of classification, independent of feature classification, unavailable to aphasics with naming disorders.

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	Nouns				Verbs			
	Correct		Wrong		Correct		Wrong	
	Means	Std Err	Means	Std Err	Means	Std Err	Means	Std Err
FK Frequency	76.62	14.27	61.67	9.12	100.75	25.21	77.08	11.00
Familiarity	4.01	0.22	3.88	0.14	3.83	0.35	4.02	0.15
Age of Acquisition	2.44	0.10	2.51	0.07	2.53	0.17	2.56	0.07
Imageability	5.85	0.08	5.84	0.05	4.50	0.14	4.20	0.06
Visual Complexity	3.75	0.20	3.38	0.13	4.17	0.19	4.24	0.08

Table 1. Correct and wrong naming responses for LEW on The Object and Action Naming battery of Druks and Masterson (2000) analysed by the mean score on 5 variables. Frequency scores are taken from Francis and Kucera (1982). Other scores are based on answers to 7-point scales (1 = lowest) from around 40 informants.

	No Labels		Family Labels		Size Labels	
	Sparse	Rich	Sparse	Rich	Sparse	Rich
LEW	72%	57%	60%	50%	86%	78%
R&G (1998)						
3-year-olds	54%	32%	89%	79%		
4-year-olds	62%	38%	-	-		
5-year-olds	95%	68%	-	-		

Table 2: Percentage correct scores for LEW compared to the developmental data from Ratterman & Gentner (R&G) on analogical reasoning tasks.

	PICTURES			WORDS		
	Colour	Size	Function	Colour	Size	Function
LEW	24	52	81	24	57	67
Controls	86	85	85	81	78	82
Standardisation Sample						
Accuracy	88	83	86	90	83	83
Latency (msec)	3203	2995	3289	3751	3148	3878

Table 3: Accuracy (Percentage correct) scores for LEW and 12 matched controls in odd-one-out tasks. Accuracy and latency scores are also given for the standardisation sample (N = 12). There were 21 triads in each condition.

	NAMING	SHAPE	FEATURE	COLOUR
LEW	0	73	73	87
CONTROLS	100	83	78	83

Table 4: Naming and correct recognition performance (percentage correct) for LEW and Controls in the animal recognition task taken from Davidoff and Warrington (1999). Control scores (N = 10) are from the original paper. The task consists of 30 items in each condition.

Figure 1. The 3 prototype shapes (square, circle, triangle) and 6 transformations used in experiment 1. (a) prototype (b) gap; (c) line-to-curve; (d) single line extended; (e) two-lines extended; (f) irregular figure; (g) freehand.

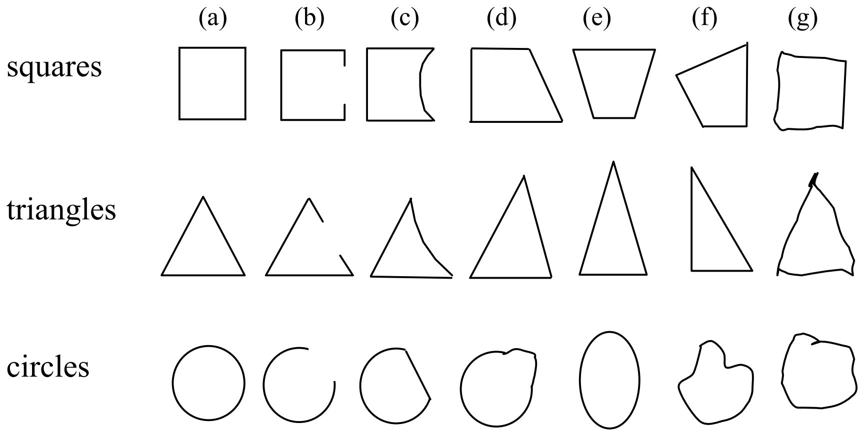

Figure 2. Examples of sparse and rich sets of stimuli used in experiment 3.

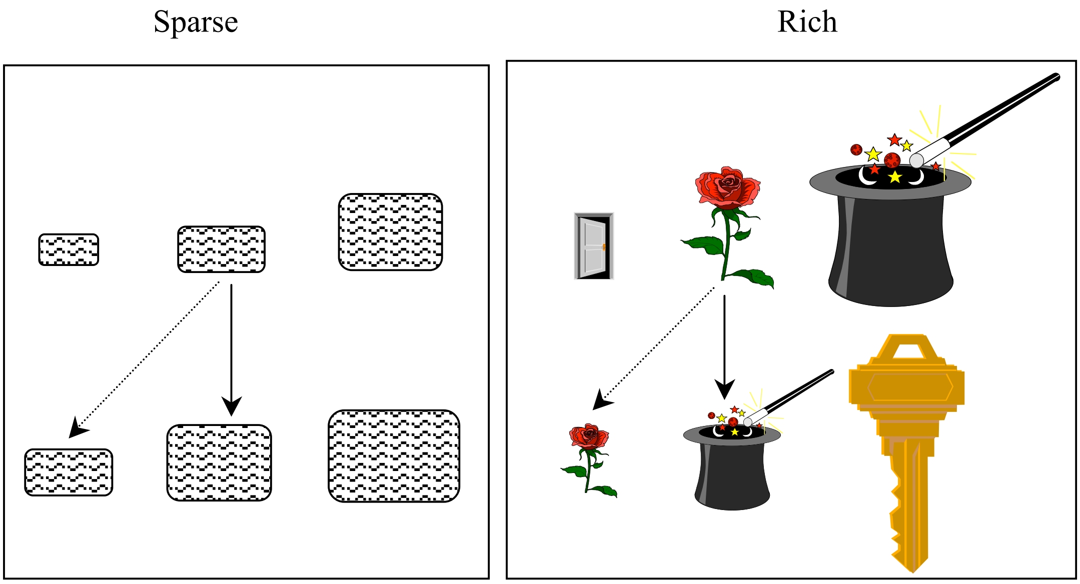

Figure 3. Examples of sparse and rich sets of abstract stimuli used in experiment 4.