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Note

The role of local and global processing in the recognition of living and nonliving things

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Abstract

We report a study on a patient (DW) with integrative visual agnosia and a category-specific recognition impairment for living things. We assessed DW's local and global processing and tested if his integrative agnosia could have led directly to his category-specific impairment. The main findings were: (i) DW was faster at identifying local compared to global letters. (ii) DW showed no local-to-global (or global-to-local) interference effects in selective attention tasks. (iii) DW showed a congruency effect in a divided attention task, suggesting that, when his attention was cued to both levels, he could process information simultaneously and integrate local and global information. (iv) Controls were poorer at naming nonliving compared to living things when presented with silhouettes. These data suggest that local and global information are differentially weighted in the visual recognition of living and nonliving things, and that an impairment in processing the overall shape of an object can lead to a category-specific deficit for living things. Crucially, this implies that category-specific impairments do not necessarily reflect damage to the semantic system, and models of semantic memory based on this assumption need to be revised.

Keywords: Visual perception; Integrative agnosia; Hierarchical processing; Brain injury

1. Introduction

Category-specific recognition and naming impairments have been widely reported in the neuropsychological literature over the past 30 years. In almost all of this work, these impairments have been interpreted in terms of deficits to stored semantic knowledge for particular categories of objects and have been used to constrain theoretical accounts of semantic memory (see Caramazza & Shelton, 1998; Warrington & Shallice, 1984). Indeed, McCarthy and Warrington (1988, p. 428) argued that "for a category-specific deficit to emerge in the first place it is *necessary* that the information should have already been categorised along a semantic dimension". Although many researchers have agreed that category-specific recognition impairments can inform us about semantic memory, the theoretical models that have been developed on the basis of these patients are extremely diverse. For instance, Caramazza and Shelton (1998) argued that we have evolved three functionally and anatomically separate systems for the recognition of animals, plant life and tools, and category-specific impairments reflect selective damage to one of these three systems. In contrast, Warrington and Shallice (1984) argued that living and nonliving things are represented primarily in terms of sensory and functional features, respectively, and that we have evolved separate semantic systems for stored sensory and functional information. According to this account, category-specific impairments for living things emerge following damage to the sensory semantic system and category-specific impairments for nonliving things emerge following damage to the functional semantic system. However, the validity of both of these models rests on the assumption that category-specific impairments reflect damage at the semantic level in object recognition.

Here, we present a follow-up study on patient DW, who was characterised in our previous work (Thomas, Forde, Humphreys, & Graham, 2002) as an integrative visual agnosic. When naming objects DW appeared to have difficulty accessing the overall shape of objects and relied on local features for identification. We suggested that DW's integrative visual agnosia might have

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led to his category-specific impairment for living things because recognition of these items may be more dependent on processing the overall shape of the object rather than the constituent parts. In contrast, nonliving things (e.g. tools, kitchen objects) have more distinctive parts that have been designed for a specific use, and the overall shape of the item is less important. Consistent with this hypothesis, when healthy subjects are asked to list the features of objects taken from living and nonliving categories, they generate significantly more distinctive features for nonliving things (Garrard, Lambon-Ralph, & Hodges, 2001).

We tested DW's local and global processing more systematically in selective (Experiment 1) and divided (Experiment 2) attention tasks using hierarchical letters. In Experiment 3, we tested our hypothesis that local and global information is differentially weighted in the visual recognition of objects from different categories by asking DW and controls to name living and nonliving things when the constituent parts of an object were obscured but overall shape retained in silhouettes.

2. Local and global processing

Navon (1977) presented subjects with hierarchical letters that consisted of large (global) letters formed from small (local) letters. Subjects were faster at identifying the global letters compared to the local letters. In addition, he reported a global-to-local interference effect, i.e. when required to identify the local letter, subjects' reaction times (RTs) were slower if the global letter was incongruent with the local letter. In contrast, when subjects were required to name the global letter, RTs were equivalent when the local letters were congruent and incongruent. These findings led Navon (1977) to propose that global processing occurred before local processing in object recognition, a theory he named 'global-precedence'.

Heinze, Hinrichs, and Scholz (1998) found no difference in RTs when subjects were asked to selectively attend to either the local or global level, but they did find local-to-global interference to be significantly greater than global-to-local interference. Heinze et al. argued that when attention is directed to the global level the attentional 'spotlight' is widened and encompasses both local and global elements. In contrast, when attention is directed to the local level, the attentional spotlight is narrowed, gating global form information. Therefore, local information can interfere with processing of the global structure, but global information does not interfere with local level processing.

Both these theories imply that the direction of the interference effect in selective attention tasks will depend on the level that is processed preferentially. However, Lamb and Robertson (1989) found dissociations between local and global processing in patients with left and right hemispheric damage. Patients with left temporal lesions were faster at detecting letters at the global level compared to the local level, but this global RT advantage significantly decreased for patients with right temporal lesions. Interestingly, both right and left hemisphere damaged patients showed no interference effects, i.e. even though patients with left-hemisphere lesions identified global letters faster than local letters they showed no global-to-local interference. Lamb, Robertson, and Knight (1990) suggested that these patient groups were unable to integrate local and global level information. They proposed that, because the direction of the interference effect did not depend on the efficiency with which patients could process local and global information, there were separate mechanisms for processing local information, global information and for integrating local and global information.

3. Experimental investigations

We have previously described patient DW, in particular his visual perceptual abilities and his ability to recognise and name living and nonliving things (Thomas et al., 2002). DW had a marked category-specific impairment and was significantly worse at naming line drawings of living items compared to nonliving items. He had no impairment to basic visual/perceptual processing but showed the defining features of integrative agnosia: (1) a piecemeal procedure in copying, (2) poor performance on tests with overlapping figures, and (3) difficulty recognising an object when the main feature is obscured.

4. Experiment 1: selective-attention

4.1. Method

DW and eight age-matched control subjects were tested. Subjects were presented with compound letter stimuli constructed of large (global) upper-case letters that in turn were constructed of small (local) upper-case letters. There were 16 stimuli constructed from all combinations of letters A, E, S, and H. Global letters subtended 2.5° vertically at a viewing distance of 50cm. Each task consisted of a set of 16 blocks of the 16 stimuli. The subject was required to indicate whether a target letter (H, A, E, or S) had appeared at a target level (local and global). Only one letter was target per run. Stimuli were presented in a pseudorandom order with at least one non-target stimulus occurring after a target stimulus. Prior to a run each subject was instructed to which target level and letter they were required to respond 'yes' to. Both accuracy and speed of response were emphasised.

4.2. Results

The data from DW and controls (see Fig. 1) were analysed separately using two 2-way between-items ANOVAs on RTs to items with target level (local and global) and congruency (congruent and incongruent) the between-item factors. For DW, there was a main effect of target level [$F(1, 60) = 24.03$, $p < 0.01$]. He

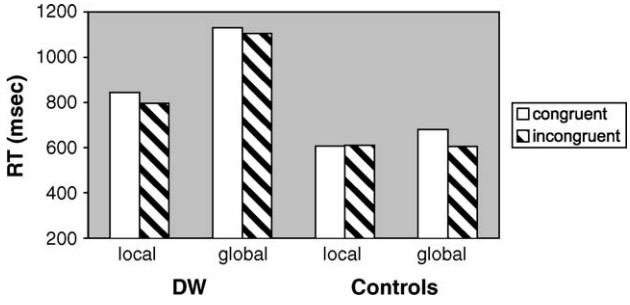

Fig. 1. Mean RTs (ms) for DW and controls to target letters at local and global levels both when the target letter is congruent and incongruent with the non-target level letter (Experiment 1, selective-attention).