Brief Analysis of the article by Funnell, Corballis and Gazzaniga "Functional specificity of the human corpus callosum"

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In this text we will start by analysing the conclusions reached by the authors. In the end of our work we will return to these conclusions from a critical perspective. The middle of the work consists in a brief description of the experiment.

Introduction

According to the authors the functional and anatomical organisation of the corpus callosum is relatively well-known. Regarding anatomical connections they say that:

> "Post mortem research on human and monkey brains has revealed that the corpus callosum is topographically organised, with anterior fibres connecting the frontal regions of the two hemispheres and posterior fibres connecting the posterior cortical structures." (p.925)

In part according to this topographical organisation but also consistent with results coming from the study of patients with mal-functions in specific areas of the corpus callosum, we can also deduce the functional role of its fibres.

> "Research has revealed that the anterior midbody transfers motor information, the posterior midbody transfers somatosensory information, the isthmus transfers auditory information and the splenium transfers visual information."

The patient under analysis, VP, had her corpus callosum cut except for two small areas in the rostrum and splenium, which are easily seen in a MRI study. The conclusions drawn from the experiments done by the authors on VP do not question this general picture but turn it more precise.

What their experiment shows (as we will see) is that, contrary to patients with a completely disconnected corpus callosum, VP is able to transfer visual and phonological information connected with words, but not other visual information (connected with colour, shape or size of objects).

They then *i*) argue, on the basis of several reasons, that only the splenium (and not the rostrum) fibres are involved in this capacity; *ii*) suggest that the splenial fibres might connect "the visual form word area to homologous regions" (925) in both hemispheres; and *iii*) they raise the question of the type of transfer that is provided by splenial fibres, more specifically, if it is a letter-by-letter transfer, or by the contrary, a word-by-word transfer, and, in the last case, if some additional information (phonological or semantic) might also be transmitted at the same time. We will start by giving a general description of the experiment and then we will analyse these conclusions in turn.

Brief description of the experiment

We should start by saying that the experimental evidence for the transfer of information in patients with spared regions of the corpus callosum was sparse until some time ago. However, in1989, Gazzaniga and colleagues have found, in a study also with patient VP, that regarding matching word pairs that were independently presented to both hemifields, 'her performance was better than expected by chance' (920).[1]

Later on, a similar experiment using word compounds (like breakfast or headstone) was made both on VP[2] and on a patient, JW, having a complete callosotomy[3]. In this case the results were much more telling since only VP could successfully complete this particular test. Strongly suggesting that her spared fibres were indeed transmitting word specific information.

In the article under analysis, it is reported how several attempts were made to exchange visual information between the two hemispheres, and how it was verified that VP could only apparently transmit information related to words. The different attempts can be categorised broadly as word and non-word related. The first task proposed to VP had to do mainly with shape, colour, and size of the stimuli. The others involved language specific tasks.

In all the tasks, VP was asked to centre her vision in an x in the centre of a computer screen. We should also note that her fixation on the centre of the screen was not monitored in any of the tasks.

In the **first task**, several stimuli were presented simultaneously to both her hemifields.[4] The task consisted in VP determining whether the stimuli were equal or different. Apparently, VP answered independently of her awareness of any difference. It was not the awareness of seeing any difference or similarity between the stimuli that was relevant but only the rate of correct judgements that are reported by Gazzaniga and colleagues.

In no case was VP's accuracy "significantly better than chance" (p.922). According to the authors,

> "The lack of transfer suggests that neither subcortical pathways nor VP's spared callosal fibres are sufficient for transfer of colour, size or shape information" (p.922)

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[1] We are not sure if the authors are here suggesting some connection with blindsight experiments in which the subject does not perceive (consciously) an object in his visual blind field, but can nevertheless accurately 'guess', in particular cases, some of its features. In this experiment considerations about the awareness of VP of her capabilities was not addressed. However, the fact that VP is required to respond even when her responses are at chance level, suggests that indeed there is a string resemblance with blindsight cases.

[2] Funnell, Corballis, Gazzaniga, "Cortical and subcortical interhemispheric interactions following partial and complete callosotomy", in *Arch Neurol* (in press).

[3] Kingstone, Gazzaniga, "Subcortical transfer of higher order information: more illusory than real? *Neuropsychology,* 1995, 9:1763-6.

[4] The images in this first test were divided into three blocks. On the first block small circles (1.5° diameter) with different colours (red, green or blue) were presented to VP. Her task was to say if the circles had the same colour or not. The second block used circles once again but this time differing in size (1°, 1.5° or 2° in diameter). The third block used different shapes (circles, squares and triangles) all of the same colour.

Also, to "rule out different degrees of interhemispheric transfer in different regions of the visual field" the stimuli were presented in different places of the screen, although the position of each presented stimulus always mirrored the position of its pair. The minimum distance from the fixation point was of 2°, and the maximum was of 5° (2.5 and 5.5° respectively, if we consider the centre of the stimulus image and not its periphery).

In the **second task** an item appeared (for 150 ms) in one of the hemifields and then, 150 ms later, two objects would appear (also for 150 ms) in the opposite hemifield. Only one of them matched the item previously shown and VP was then asked to point up or down, to the matching object. She used the hand ipsilateral to this last presentation.

The items could differ in shape (circle, square or triangle) and colour (red, blue or green). But also in mode of presentation. Although the alternative would always be presented as a picture (for instance ■ or ▲) the initial item would sometimes be presented as a description (for instance 'red square' or 'blue triangle').

When the first item was presented as a picture VP was only slightly above chance level (177 correct answers in 324 trials) but when using words as the initial item she was 'significantly better than chance' (p.923) (208 correct answers in 324 trials). Which shows that VP exhibits some information transfer specific to words but not specific to shape and colour.

The **third task** is specifically related to language. VP was presented with pairs of words, each word was presented in a different hemifield. Then she was asked to decide if the pair rhymed or not. There were four types of word pairs, since word pairs could rhyme both visually or orally.[5]

The responses of VP were analysed 'using a hierarchical χ^2 analysis' but we didn't understand fully what are the implications and assumptions that this analysis involve. It seems clear, however, that there is a big asymmetry between VP's rate of correct responses depending on the word pairs rhyming or not according to sound (which is the common way of judging rhymes). Visually rhyming word pairs also had some small influence in the rate of correct replies. However, because we didn't understand the way of treating the it is difficult for us to understand precisely these particular results.[6]

In the **fourth task,** VP was required to identify a word – named 'secret word' – that had previously been shown to the contralateral hemifield. The task was complicated by the introduction of a third word used to signal the secret word. This "substitute word" was also presented to the hemifield that did not make the recognition.

After the secret and substitution word were presented to one hemifield a list of ten words were presented to the other hemifield among which the secret word was presented. VP would then have to signal the secret word by saying the substitute word. 16 lists of 10 words were presented and in 8 of them VP successfully responded with the substitution word. In another 4 lists she identified the secret word but was unable to say the substitution word. There is no information about whether VP misidentified the secret word in the remaining lists or if she simply failed to identify it at all.

[5] "The first type were pairs of words that looked and sounded like rhymes (e.g. tire and fire). The second type were word pairs that looked as if they should rhyme but did not (e.g. cough and dough). A third category consisted of words that did not look as if they should rhyme but did (e.g. bake and ache). The forth category were pairs of words that neither looked nor sounded like rhymes (e.g. keys and fort)." (p.923)

[6] It would seem for instance, on a first look, that VP was nearly at chance level in the case of word pairs that rhymed orally.

Commentary

In the beginning of our text we have identified three main conclusions that the authors have derived from this experiment. Now we will present the arguments for each of them. Later on we will make some short comments on what appeared to us to be some weaknesses of the experiment.

Lets recall that the first conclusion was that it was the splenium fibres in VP that transfer word related information.

It seems absolutely clear that the spared fibres are located in the rostrum and splenium regions.[7] However the precise location of the spare fibres seems more uncertain and the authors say that it is 'likely' that one of the spared areas was indeed in the 'ventroposterior region of the splenium'. They argue for that on the basis of the way in which the severing operation was performed on VP.[8]

The authors then argue that the rostrum areas are not expected to transmit visual information. They present two reasons for that. The first is that, since the rostrum connects frontal brain regions, it 'is unlikely to be involved in the transfer of visual information.' On the other hand they also support this assertion on the results of a previous study:

> "After reviewing the literature on patients with splenial lesions, Suzuki and colleagues concluded that the anterior to middle portion of the splenium is involved in transfer of picture information and the ventroposterior portion is involved in transfer of letter information." (p.925)

They also say that 'the importance of the posterior part of the corpus callosum for the transfer of visually presented words has long been recognised", notably in studies made by Dejerine in the last century.

The second main claim that the authors make is that "it is likely that splenial fibres connect the visual word form area to homologous regions in the contralateral hemisphere." (p.925) And they add that

> "Investigations with patient VP suggest that her spared splenial fibres terminate in the visual word form area" (p.925)

We did not understand this claim. Does this mean that experiments with VP support the hypothesis that there is a specific visual word area or just that, if there is such a region, then it is likely that the splenium fibres connect them in both hemispheres?

Finally the authors note that the nature of the information transfer through the splenial fibres is not clear. They suggest it might work by transferring letters or entire words. In the case of word transfer they suggest it might include 'phonological and semantic information'. In this

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[7] The authors affirm that a MRI study made on VP "had revealed spared fibre in the rostrum and the splenum" p.921 (Vide also legend of Fig. 1 and page 925: "VP's spared callosal fibres are in the rostrum and the splenium.").

[8] "The anterior and posterior sections were both performed [sectioned] from a central craniotomy. The spared fibres are therefore *likely* to be those most distal from the point of surgical entry. Because of the shape of the corpus callosum, this would result in sparing of the fibres in the ventral parts of the corpus callosum. In the anterior section the sparing would *probably* include the most rostral fibres, and in the posterior section it would be the fibres in the ventroposterior region of the splenium." (p. 925, italics added)

study there was evidence for the transfer of phonological information (in the case of rhyming word pairs) and it should be easy to test if there is some transfer of semantic information.

Regarding the small criticisms we might make to this experiment perhaps the most obvious is the absence of any measurement of eye movement. Also, in the first experiment, it is not clear that having a fix grid where the circles are displayed is more advantageous than using a random but symmetric location. This would allow a more thorough testing of possible transfer of shapes / colours restricted to certain areas of the visual field. The connection with blindsight was also not explored, nor VP's actual awareness of her performance mentioned. In the fourth experiment the fact that the list of words is presented to both hemifields diminishes the importance of VP's rate of correct replies. Since VP most probably understands the rationale that underlies the experiments, and since the experiment is reproduced several (16) times, it is easy to see that she will be expecting to see the matching word mostly in the hemifield where the secret and substitute words were not presented. Presenting the subsequent list of words to both hemifields introduces an unnecessary element to ponder. Perhaps most importantly is the fact that we cannot argue for the absence of information transfer based on the absence of judgement (although the converse is true).[9] Although this does not undermine the experiment (specially because there is no better way of testing information transfer between the two hemispheres), it introduces an important caveat to its conclusions, and makes it desirable the search for a new way of testing information transfer.

A more important type of criticism regards the type of word information that is transferred through the corpus callosum. The authors consider only two hypothesis, letter-by-letter or word-by-word transfer. But it is not absolutely clear that the brain must use the same coding to transfer information between the hemispheres that we do to transmit information through sheets of paper. The existence of aphasias in sign language parallel to aphasic problems in vocal language suggests that the brain might code language in a way completely unrelated to the way in which we use roman letters and words. The study of subjects with ideographic languages, language in other animals and some philosophical rethinking of what is characteristic of language might be necessary until we have a more clear understanding of the ways in which language related information is coded and transferred inside the brain.

[9] Note that the authors assert that some kinds of information are not transmitted. They consider for instance a "finding that there is transfer of some types of information (words) but not others (colour, shape, size)." (p.925)