

## Comprehension Regularity in Broca's Aphasia? There's More of It Than You Ever Imagined

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We analyze the comprehension data in Broca's aphasia, pooled together by Berndt, Mitchum, and Haendiges (1996). We show that once analyzed properly, these data have statistical structure that is very similar to that revealed by the analysis in Grodzinsky, Pinango, Zurif, and Draï (1999). The suggestion that the latter authors doctored the data to obtain a desired outcome is as false as the claim that the data in Berndt et al. show no regularity. Comprehension scores in Broca's aphasia do have statistical structure, which correlates with syntactic structure. Thus, the role of Broca's area and its vicinity in language processing can be made more precise.

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Grodzinsky, Pinango, Zurif, and Draï (1999, GPZD henceforth) examine the available comprehension data of certain syntactic constructions in Broca's aphasia, with two related issues in mind, one diagnostic and one analytic. Rigorous diagnosis, so the claim goes, may lead to selection of patients for experimental purposes that will give a clearer view of brain/language relations. Further, certain group analyses may discover otherwise indiscernible statistical structure. In GPZD we show that once both diagnosis and analysis are done properly, a crisp and interpretable statistical structure emerges from the data, which further corresponds to syntactic structure.

Berndt and Caramazza (1999, BC) challenge these claims, arguing that they are both false, that there is no regularity in the data, and that the regulari-

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ties we discovered are due to a selection of patients that was tailor-made to obtain our results. BC's condemnation of our diagnostic methods is taken up by Zurif and Pinango (this issue). Yet, since BC say that no statistical regularity exists in "real," "undoctored" data, we decided to examine the data set that BC themselves commend, namely, the data presented by Berndt, Mitchum, and Haendinges (1996, Berndt et al. hereafter).

Recall that Berndt et al. (and BC) argue against a generalization regarding the comprehension performance of Broca's aphasics, and the apparent lack of generalization in their data is championed as yet another "empirical demonstration" against group studies in neuropsychology. However, do their data indeed lack structure, as they claim? That is, if the Berndt et al. data are subjected to the same group analysis as in GPZD, is no meaningful statistical regularity found? We show that when the Berndt et al. data are analyzed as they are, that is, even if GPZD's (sound) diagnostic considerations are dropped, the group results still have a lot of structure, contrary to BC's claims. We then compare their analyzed data set to ours and conclude that it is in fact quite similar to that discovered in GPZD and is different just in that it is not as crisp. When the composition of the data is changed on *independent* (i.e., principled diagnostic) grounds, as we did in GPZD, clearer statistical structure emerges. Thus, two completely independent considerations (diagnosis and analysis) work in tandem, to give a clearer picture of the syntactic abilities supported by neural tissue in and around Broca's area.

Berndt et al. chose to focus on the active/passive contrast. We followed suit for practical reasons: the amount of available data from aphasia on these structure exceeds any other set of syntactic types. It is important to emphasize, though, that this choice is unfortunate, because the syntax of the passive construction is not well understood (see Fox & Grodzinsky, 1998, for a recent review). In any event, we subjected the Berndt et al. data (composed of 64 separate measurements of performance)<sup>1</sup> to the same treatment we gave ours: we divided up performance levels to 10 bins of 10 percentage points each and counted the number of cases per bin for actives and for passives. The results are in Table 1 and its associated graph.

Looking at Table 1 and the associated curves, certain important properties emerge (missed completely by both Berndt et al. and BC):

1. The curves for active and passive are different in curvature and average (78.4% for active, 63.1% for passive<sup>2</sup>), reflecting differential performance between the two syntactic types, rather than random behavior.

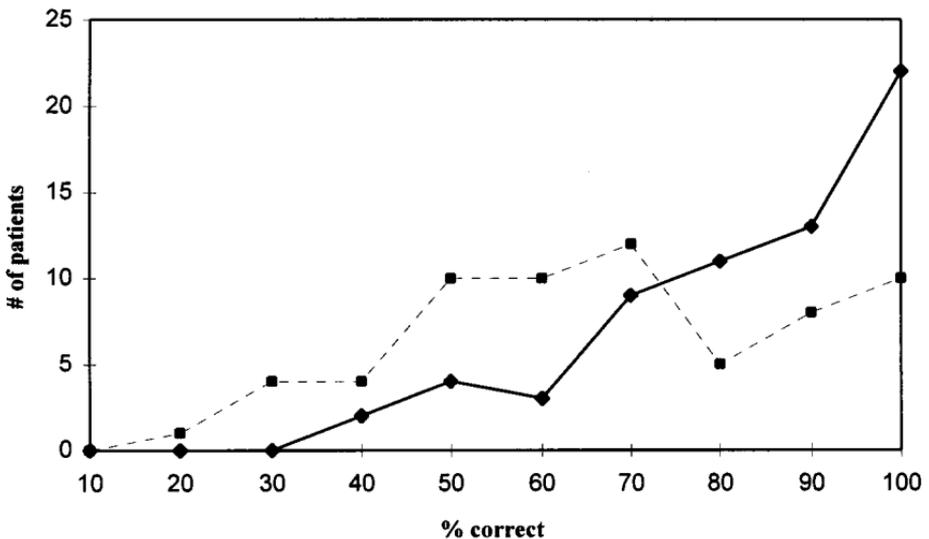
<sup>1</sup> Importantly, certain patients (like VS) were tested more than once, and each testing session was counted separately. Thus, the 64 cases did not represent 64 different patients, but rather, 64 different testing sessions. See GPZD for more on this point.

<sup>2</sup> Calculation of exact averages was not possible, because Berndt et al. do not report them and present their data as imprecise histograms. We thus made the reasonable assumption that data in each bin cluster around its middle. Thus, all the data in the 20–30% bin, for example, were taken to be at 25%, and so on. On this (uniform) assumption, we obtained the averages above.

TABLE 1  
Berndt et al. Data

Percentage Correct:	No. of patients								
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Actives	0	0	2	4	3	9	11	13	22
Passives	1	4	4	10	10	12	5	8	10

active (full line) vs. passive (dashed), Berndt et al. 1996



2. Forty-six patients are in the above-chance range (70–100% correct) for actives, but only 23 for passive; that is, the likelihood to get actives right was in a 2:1 ratio to that of passives.

3. Half the passive cases (32) fall between 40 and 70% correct (i.e., closely around chance) but only a quarter (16) of the actives; that is, the likelihood to be at-chance in passive was at a 2:1 ratio to that of actives.

4. In the below-chance range (0–40%) there are nine cases for passive, but only two for actives (9:2).

5. The passive scores are skewed upward, that is, while the middle (around chance) range appears binomial, the higher end has 2.5 times cases than the lower end.

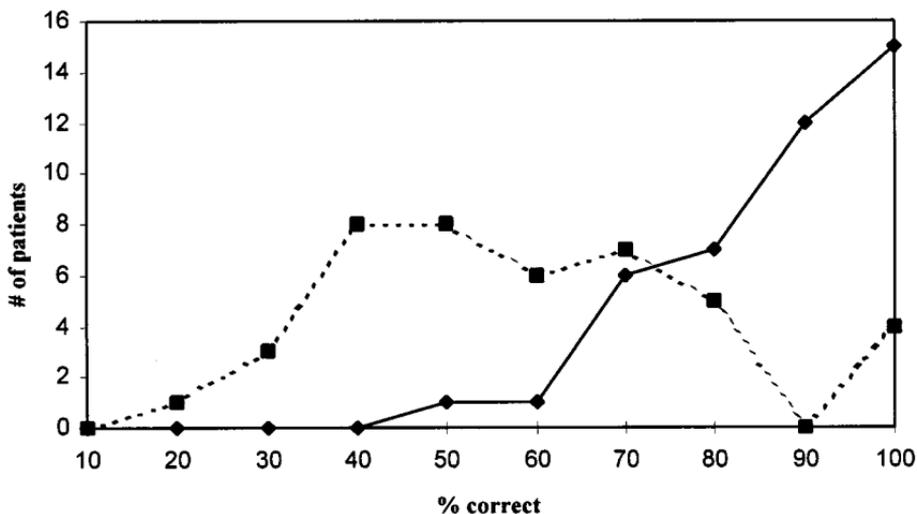
Next, compare these scores and curves to those GPZD present (for 42 different patients) (Table 2).

The two curves are similar in many respects; that is the Berndt et al. data are fairly close to ours, with the notable difference that their passive scores are skewed upwards. Critically, there are several important statistical properties that emerge from both data sets:

TABLE 2  
GPZD's data

Percentage correct:	No. of patients								
	10-20	20-30	30-40	40-50	50-60	60-70	70-80	80-90	90-100
Actives	0	0	0	1	1	6	7	12	15
Passives	1	3	8	8	6	7	5	0	4

active (full line) vs. passive (dashed), Grodzinsky et al. 1999



a. In both, active is different from passive—the curve for active is concave, for passive it is convex (excepting in the Berndt et al. data, the high tail end of the passive scores).

b. The means are different: active is above-chance, and passive is at chance (78.4:63.1 in the Berndt et al. data, 83.1:55.3 in GPZD).

c. The likelihood of getting an active correctly, compared to a passive is 2:1 in the Berndt et al. data, and almost 4:1 (34:9) in GPZD.

d. In chance territory, the pattern is reversed: the likelihood of being at chance in passive (compared to active) is 2:1 in the Berndt et al. data and over 3:1 (29:8) in GPZD.

The similarity between the two is striking, although clearly, GPZD present a picture that is much more focused. The reason for the difference between the two is simple: the latter is based on a more precise clinical diagnosis, whose lesion localizing value is higher. The statistical picture that emerges is crisper, indicating once more that properly diagnosed Broca's aphasia correlates strongly with a syntactically selective comprehension deficit. However, even an inaccurate arrangement of data, such as in Berndt et al., has

most of the relevant properties, because it contains enough Broca's aphasics that depict a reasonably clear picture, which both Berndt et al. and BC try to obfuscate. Still, and that is the main moral of the story, if you choose your data correctly and analyze them properly, you have a chance to discover something important. In our case, the conclusion is that in the comprehension of Broca's aphasics, there is strong statistical regularity which corresponds to linguistic regularity.

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