Journal of Neurology, Neurosurgery, and Psychiatry 1982;**45**:1125–1129

Axial movements in ideomotor apraxia

K POECK, G LEHMKUHL, K WILLMES

From the Department of Neurology, Technischen Hochschule, Aachen, Federal Republic of Germany

SUMMARY Non-symbolic axial movements were examined and compared to oral and limb movements in a group of 60 aphasic patients (15 of each major subgroup) with exclusively left-sided brain damage. The contention in the literature that axial movements are preserved in patients with ideomotor limb apraxia was not confirmed.

Geschwind has repeatedly maintained that patients with ideomotor apraxia are able to perform correctly whole body movements,[1 2] or, as he later phrased it, axial movements.[3] His contention is that unilateral or bilateral limb movements, which are mediated via the pyramidal motor system, are impaired in ideomotor apraxia. In order to explain the preservation of axial movements he invokes the non-pyramidal motor system as described by Kuypers *et al*,[4] Lawrence and Kuypers[5] and Brinkman and Kuypers.[6] In contrast to the pyramidal system, which is involved in control of discrete movements, especially of the fingers of the opposite side, the non-pyramidal motor system, which arises from multiple sites in the cortex and in particular in the temporal lobe (close to Wernicke's area, according to Geschwind), controls axial muscles, muscles of the eyes, neck and trunk, thus initiating certain coordinated movements of both sides of the body. In support of this theory, Geshwind points out that eye movements are preserved in ideomotor apraxia, the oculomotor system having "no representation at all or at best an exceedingly limited one in the pyramidal system".

This theory is very attractive. However, it is contradicted by an important body of clinical observations: the great majority of patients with (ideomotor) limb apraxia have also oral apraxia in the form of apraxia of buccofacial movements. This has recently been demonstrated in an extensive study of the varieties of motor apraxia by Lehmkuhl *et al*. Typical examples of tasks for oral apraxia are: stick out tongue, blow cheeks, show teeth, smack, hiss, clear throat, wiggle nose. There can be no doubt that these are axial or midline movements, and yet they are severely impaired in most patients with ideomotor apraxia (see also De Renzi *et al*).[7] However, buccofacial movements are not exactly the kind of movements on which Geschwind has based his argument. Therefore, we have conducted an experimental investigation in which limb and oral movements were compared with axial movements of the kind described by him.

Address for reprint requests: Prof Dr K Poeck, Abteilung Neurologie, Klinikum der RWTH, Goethestrasse 27–29, D-5100 Aachen, W Germany.

Received 8 March 1982 and in revised form 1 August 1982.
Accepted 3 September 1982

Subjects and Methods

The study was based on 60 aphasic patients with unequivocal left-sided brain damage. Aetiology was mostly vascular. Subtype of aphasia was established by a neurolinguistic examination with the Aachen Aphasia Test (AAT). This test consists of six subtests. Spontaneous speech is rated on six scales, the other five subjects include the Token Test, repetition, reading and writing, confrontation naming, auditory and reading comprehension.[8–10] The psychometric properties of the AAT have been discussed by Willmes *et al*.[11]

Sample characteristics are given in table 1. None of the patients was bedridden, all were fully alert, co-operative, and they could sit, stand, and walk even though the majority had right-sided hemiplegia. The movements required in testing for ideomotor apraxia of the limbs, as well as of the oral musculature are described in the appendix. In short, these were the same kind of tasks which are generally used in the investigation of ideomotor apraxia. We also gave our patients 13 tasks examining non-symbolic axial movements. These were required both verbally and on imitation; the order of presentation was randomized. Table 2 gives the list of tasks. Execution of all tasks was judged according to the following categories: Correct solution, Augmentation, Fragmentary movement, Perseveration, Other errors. These categories are explained in detail in Poeck and Kerschensteiner.[12] We also gave the tasks for axial movements to 10 patients with right-sided brain damage, verified by CT scan, and to 10 neurological patients without brain damage. There were almost no errors in these control groups.

Table 1 *Sample characteristics*

	Sex			Age (yr.)		Duration (mth)		Aetiology			
	n	*M*	*F*	*MD*	*Range*	*MD*	*Range*	*Vasc.*	*Traum.*	*Tum.*	*Inflam.*
Global	15	7	8	54	31–71	31	4– 66	13	—	1	1
Wernicke	15	11	4	53	41–70	5	1– 31	11	1	2	1
Broca	15	9	6	50	23–73	19	2– 86	14	1	—	—
Amnesic	15	10	5	52	22–72	13	1–107	9	4	2	—

Table 2 *Axial movement tasks*

Lift both shoulders
Turn your eyes upwards
Turn your head to the right
Turn your head to the left
Step forward
Turn the eyes to the right
Bend your head
Turn the eyes to the left
Step backwards
Close your eyes firmly
Open your eyes
Bend your head backwards
Turn your eyes downwards

Results

1 AXIAL MOVEMENTS AND SUBTYPES OF APHASIA

In contrast to the contention in the literature, many of the left-hemisphere patients performed considerably below the maximum score obtainable. Table 3 gives the descriptive statistics for the performance in the four subgroups of aphasia, separately for verbal and imitative tasks. There was great individual variability in performance. In every subgroup we found patients with poor and with good performance. Qualitative analysis of the errors showed predominance of perseveration and augmentation, perseveration being most prominent in the verbal mode of testing, in particular in patients with global and Wernicke's aphasia.

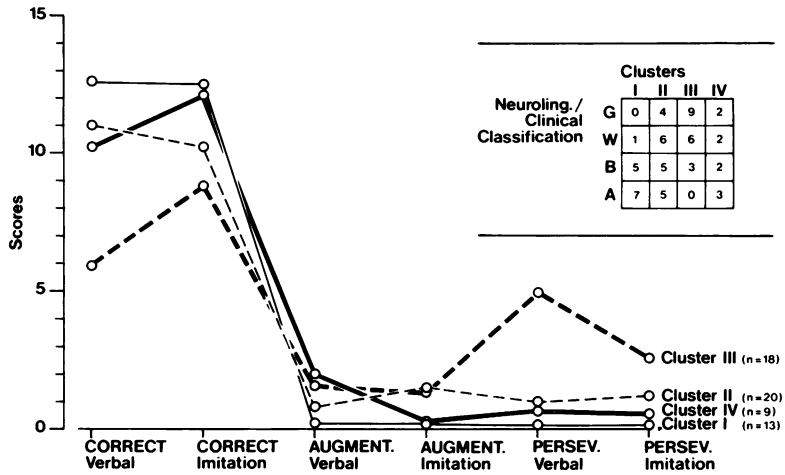
Because of the non-normal distribution of scores, only non-parametric statistical procedures were used for comparing correct and faulty performance across subgroups of aphasics, separately for verbal and imitative mode of presentation (Kruskal-Wallis and U-tests). We also compared both modes for each subgroup (Wilcoxon tests). Type I error was adjusted according to the number of tests performed.[13] Differences between groups of patients were found for the number of correct solutions, both for the verbal and imitative mode as well as for the perseveratory errors when the tasks were given verbally. These differences were present only between global and amnesic aphasia. Comparison of verbal and imitative testing yielded a significant difference only for correct solutions and perseveratory errors in the subgroup with global aphasia. In the verbal mode there were less correct responses and more perseverations.

In order to examine more closely the relation between the profile of response categories and subtypes of aphasia, we performed a partitioning cluster analysis (KMEANS algorithm, Späth).[14] Fragmentary responses and other errors were left out because of very low interindividual variability in the total sample of 60 patients. The figure shows the results of a four-cluster-solution. Different starting partitions yielded the same solution. The essential finding was that the more errors were made, in other words, the more severe the apraxia, the more perseveratory errors were observed (Cluster III). Cluster II, as well as Cluster I containing the least impaired patients, showed a relation to the degree of severity of aphasia, but no evident relation to localisation or size of lesion as far as this can be inferred from subtype of aphasia. Patients in Cluster

Table 3 *Descriptive statistics; 13 axial movements tasks*

	Verbal mode										*Imitative mode*									
(n = 15)	*Correct*		*Fragment.*		*Augment.*		*Persev.*		*Others*		*Correct*		*Fragment.*		*Augment.*		*Persev.*		*Others*	
Global	7·53	(2·26)	0·27	(0·59)	1·33	(1·11)	3·47	(2·26)	0·40	(0·54)	9·60	(1·96)	0·07	(0·07)	1·07	(1·03)	2·00	(1·73)	0·27	(0·50)
	8	4–11	0	0–2	1	0–4	4	0–7	0	0–2	10	7–13	0	0–1	1	0–3	2	0–5	0	0–2
Wernicke	9·00	(3·12)	0·13	(0·35)	1·20	(0·94)	2·53	(2·52)	0·13	(0·27)	9·87	(1·92)	0·07	(0·07)	1·67	(1·59)	1·27	(1·67)	0·13	(0·27)
	10	4–13	0	0–1	1	0–3	1	0–7	0	0–2	10	6–13	0	0–1	1	0–5	1	0–6	0	0–2
Broca	10·53	(2·59)	0·07	(0·26)	1·07	(1·39)	1·33	(1·68)	0	(—)	11·07	(1·49)	0	(—)	0·73	(0·88)	1·20	(1·37)	0	(—)
	12	5–13	0	0–1	1	0–5	1	0–6	0	—	11	8–13	0	—	0	0–2	1	0–5	0	—
Amnesic	11·73	(1·28)	0·07	(0·26)	0·73	(0·88)	0·47	(0·74)	0	(—)	11·73	(1·10)	0	(—)	0·53	(0·83)	0·67	(0·98)	0	(—)
	12	9–13	0	0–1	1	0–3	0	0–2	0	—	12	10–13	0	—	0	0–3	0	0–3	0	—

Upper line in each group: arithmetic mean, SD.
Lower line: median, range.



II and IV were evenly distributed across subtypes of aphasia.

2 AXIAL MOVEMENTS IN RELATION TO LIMB AND ORAL MOVEMENTS

We confined the analysis to non-symbolic movements because all our axial movements were non-symbolic. A task such as asking the patient to assume the position of a boxer[2] requires, in our view, more than just axial movements. Furthermore, analysis was restricted to correct solutions because the problem was to test the assumption that axial movements are preserved in the presence of ideomotor apraxia. For the same reason comparison of the performance of the different groups of patients separately for each set of tasks was not of interest.

The differences in number of items per group of tasks made it necessary to base statistical comparisons on the relative amount of tasks performed correctly. Table 4 gives the descriptive results for each aphasic syndrome and each group of tasks, separately for verbal and imitative testing. Again, nonparametric tests were used (Friedman tests, Wilcoxon tests). The main finding was that there was no significant difference in the performance of axial and buccofacial movements. Both types of movements did not significantly differ from unilateral limb (arm or leg) movements. The only exception found was for global aphasia in the verbal mode of testing. We cannot offer an interpretation for this finding. The scores for bimanual movements were significantly lower than for most of the other types of movement. Presumably this was owing to the greater inherent difficulty of the tasks.

Discussion

The main point of Geschwind's view concerning axial movements is the following: the temporal lobe is a major source of the non-pyramidal system. The temporal lobe also contains Wernicke's area. Access from Wernicke's area to the non-pyramidal system in

Table 4 *Descriptive statistics; scores correct for each body part separately for verbal/imitative mode of presentation; non-symbolic tasks only*

(n = 15)	Arms		Legs		Oral		Bimanual		Axial	
	Verbal (0–10)	Imitative (0–10)	Verbal (0–10)	Imitative (0–10)	Verbal (0–10)	Imitative (0–10)	Verbal (0– 5)	Imitative (0– 5)	Verbal (0–13)	Imitative (0–13)
Global	3·13 (2·45) 3 0–9	7·40 (2·80) 8 0–10	3·93 (2·12) 5 0–7	6·40 (2·03) 6 2–10	3·47 (2·45) 3 0–8	6·87 (1·60) 7 4–9	1·33 (0·82) 1 0–3	2·73 (1·16) 3 0–4	7·53 (2·26) 8 4–11	9·60 (1·96) 10 7–13
Wernicke	4·87 (3·46) 5 0–10	7·80 (1·37) 8 5–10	5·27 (2·40) 5 1–9	8·07 (2·37) 9 2–10	5·53 (1·41) 5 4–9	6·80 (1·66) 7 3–9	2·13 (1·19) 2 1–4	2·87 (0·74) 3 1–4	9·00 (3·12) 10 4–13	9·87 (1·92) 10 6–13
Broca	6·73 (2·12) 7 3–10	8·33 (1·23) 9 6–10	6·40 (1·99) 6 3–10	7·53 (1·85) 8 4–10	5·60 (2·06) 6 1–9	7·27 (1·58) 8 3–9	1·80 (1·08) 2 0–3	3·14 (0·64) 3 2–4	10·53 (2·59) 12 5–13	11·07 (1·49) 11 8–13
Amnesic	7·67 (1·50) 8 4–10	9·33 (0·90) 10 7–10	7·47 (1·55) 8 5–10	8·93 (1·10) 9 7–10	7·47 (1·64) 8 5–9	8·73 (0·46) 9 8–9	2·67 (0·82) 3 1–4	3·73 (0·46) 4 3–4	11·73 (1·28) 12 9–13	11·73 (1·10) 12 10–13

Upper line in each group: arithmetic mean, SD.
Lower line: median, range.

the verbal mode of testing is easier than to the pyramidal motor system. Testing for apraxia, however, also has to include imitative tasks. Limiting the examination to verbal tasks requires rigorous control of the degree of language comprehension deficit in order to arrive at the diagnosis of apraxia. It is not evident why Wernicke's area should be critical in the imitative execution of non-symbolic apraxia tasks. Invoking the preservation of eye movements in the discussion of axial movements of face and trunk implies comparison of two different motor systems. The oculomotor apparatus receives no pyramidal projections, whereas face and trunk musculature receive bilateral pyramidal projections. Therefore, the theoretical basis for the alleged integrity of the axial movements in ideomotor apraxia is open to debate.

Leaving aside these theoretical considerations, our findings demonstrate that axial movements are not, as a rule, preserved in patients with ideomotor apraxia. If certain types of movement are impaired in some patients to a different degree, this only reflects the variability of performance which is common to any neuropsychological syndrome.

We acknowledge the assistance of M Spohrmann.

References

[1] Geschwind N. Disconnexion syndromes in animals and man. *Brain* 1965;**88**:237–94, 585–644.

[2] Geschwind N. The apraxias. In: Strauss EW, Griffith RM, eds. *Phenomenology of Will and Action*. Pittsburgh: Dusquesne University Press, 1967;91.

[3] Geschwind N. The apraxias: Neural mechanisms of learned movement. *Am Sci* 1975; **63**:188–95.

[4] Kuypers HGJM, Fleming WR, Farinholt JW. Subcortico-spinal projections in the rhesus monkey. *J Comp Neurol* 1962;**118**:107–31.

[5] Lawrence DG, Kuypers HGJM. The functional organization of the motor system in the monkey. *Brain* 1968;**91**:1–14, 15–36.

[6] Brinkman J, Kuypers HGJM. Cerebral control of contralateral and ipsilateral arm, hand and finger movements in the split brain rhesus monkey. *Brain* 1973;**96**:653–74.

[7] De Renzi E, Pieczuro A, Vignolo LA. Oral apraxia and aphasia. *Cortex* 1966;**2**:50–73.

[8] Huber W, Weniger D, Poeck K, Willmes K. Der Aachener Aphasietest. Aufbau und Überprüfung der Konstruktion. *Nervenarzt* 1980;**51**:475–82.

[9] Willmes K, Poeck K, Weniger D, Huber W. Der Aachener Aphasietest. Differentielle Validität. *Nervenarzt* 1980;**51**:553–60.

[10] Weniger D, Willmes K, Huber W, Poeck K. Der Aachener Aphasietest. Zuverlässigkeit und Auswertungsobjektivität. *Nervenarzt* 1981;**52**:269–77.

[11] Willmes K, Huber W, Poeck K, Weniger D. Facet theory applied to construction and validation of the Aachen Aphasia test. *Brain Lang*. In press.

[12] Poeck K and Kerschensteiner M: Analysis of sequential motor events in oral apraxia. In: Zülch KJ, Creutzfeldt O, Galbraith GC, eds. *Cerebral localization. An Otfrid Foerster Symposion*. Heidelberg: Springer, 1975.

[13] Kirk RE. *Experimental Design. Procedures for the Behavioral Sciences*. Belmont, Calif.: Brooks/Cole, 1968.

[14] Späth H. *Cluster Analysis Algorithms for Data Reduction and Classification of Objects*. New York: Halsted Press, 1980.

APPENDIX: LIST OF ITEMS OF APRAXIA EXAMINATION

Oral apraxia
- wiggle nose
- show teeth
- stick out tongue
- lick lips
- blow up cheeks
- smack lips
- imitate galloping of horses
- make a funnel with lips
- hiss
- clear throat

Arms (meaningful)
- smoke a cigarette
- drink liquor
- show somebody is nuts
- make a long nose
- to comb ones hair
- wave good bye
- turn down with hand
- make a threatening fist
- brush teeth
- military salute

Arms (meaningless)
- place hand on opposite shoulder
- put back of hand on your forehead
- put hand over ear
- place fist on chest
- draw two crossing lines in the air
- make a circle in the air
- put a hand on your head
- put palm of your hand on neck
- arm on hips
- touch chin with fingertips

Bimanual tasks (meaningful)
- clap hands
- rub hands
- climb up a rope
- thread a needle
- fold hands

Bimanual tasks (meaningless)
- place palm of hand on back of other
- make two circles with thumb and middle finger of both hands

put hands together, palm up
form a circle with the finger tips of both hands
place back of both hands together

Legs (meaningful)
kick a ball
push down gas pedal
pound the floor in rage
clean foot on the mat
push off with scooter
shake a stiff leg
rub out a cigarette
kick away something with the heel
step over an obstacle
brush away something with your foot

Legs (meaningless)
put one foot in front of the other
move foot in a circle
place one foot on top of the other
put one foot behind the other
put foot on heel and move slowly towards tip of toes
tiptoe and turn around
stretch out leg and turn to side
cross legs
have the outer side of foot touch the floor
leave the inner side of foot touching the floor