

PATIENTS.DAT

A dataset involving the diagnosis of carpal tunnel syndrome

Stephan M Rudolfer

**Mathematics Department
Victoria University of Manchester
Oxford Road
Manchester
M13 9PL**

TEL: 0161 275 5912

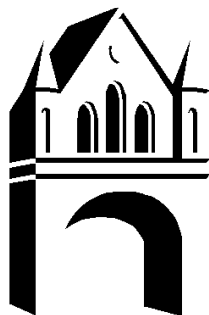
FAX: 0161 275 5819

Email: s.m.rudolfer@man.ac.uk

Webpage:

<http://www.maths.man.ac.uk/DeptWeb/Homepages/smr/>

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Details of the dataset Patients.dat

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1. Medical Background

Carpal tunnel syndrome (CTS) is a cluster of hand symptoms caused by entrapment of the median nerve in the Carpal Tunnel of the wrist (see [Figure 1: Diagram of the Carpal Tunnel](#), p. 3). It is the most commonly seen condition in hospital electromyography (EMG) clinics, to which some patients suspected of having CTS are referred for definitive diagnosis. However, not all patients with suspected CTS are referred to EMG clinics; indeed the majority opinion among orthopaedic surgeons in the UK remains that Nerve Conduction Studies (see Section 2.1.3 ***Nerve Conduction Studies (NCS)***, p. 8, are not necessary for diagnosis, and some believe that they are even counter-productive. If correctly diagnosed, it can be successfully treated: in general terms, (for mild or early cases) a splint to hold the wrist in the neutral position; (for more severe cases) an injection of a steroid into the carpal tunnel; (in the most severe cases) a simple operation to release the median nerve in the carpal tunnel. Unfortunately, however, there is no consensus on how to define mild, moderate and severe CTS, nor on the treatment to give for these three types of CTS. Indeed, the treatment given is mainly determined by the doctor's speciality: an old-school orthopaedic surgeon is more likely to offer surgery regardless of the apparent severity of the condition, while many neurologists and rheumatologists will attempt injection and/or splinting, even in what are clearly very advanced cases. The treatment given is usually successful, provided the diagnosis has been made correctly and the severity of the condition matches the treatment given. However, if the condition is misdiagnosed, then the treatment will not have any effect on the symptoms. For this reason, accurate diagnosis of CTS is most important.

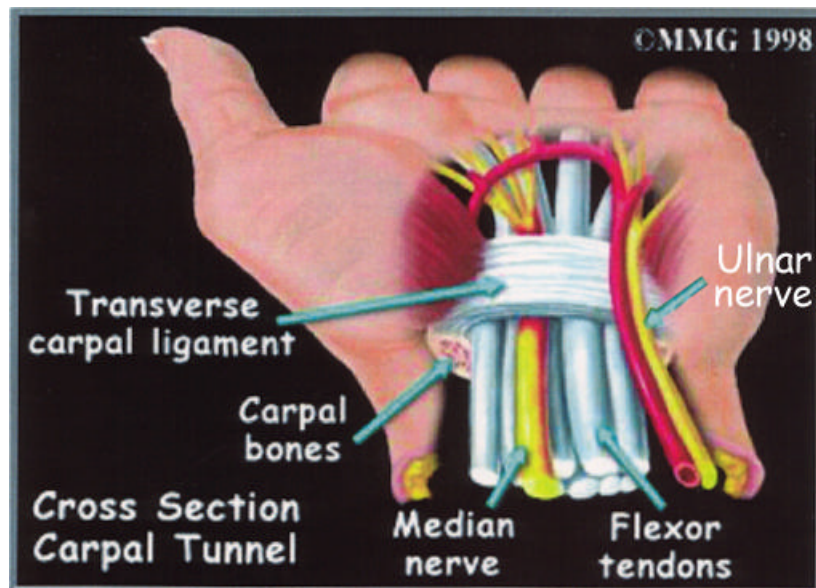


Figure 1: Diagram of the Carpal Tunnel

Typical symptoms of CTS are (some of) numbness, pain, tingling and weakness in the thumb, index finger, middle finger and the thumb-side of the ring finger. The symptoms are usually worse at night, even waking up the sufferer. The commonest way of relieving the symptoms is to shake the hand for a period of less than ten minutes. In fact, the location of symptoms can be much more extensive, with many patients describing numbness of the “whole hand” and a significant proportion experiencing pain even up to the shoulder.

An excellent and comprehensive account of CTS is given in Rosenbaum & Ochoa (1993).

2. The Dataset

The data consist of 853 patients' records taken from the electromyography (EMG) clinics of the late Dr JL James over the period March 1991 to December 1993. Dr James died in December 1993. They represent the observations and measurements made on the patients, together with Dr James' diagnosis of the patient.

To preserve patient confidentiality, all the patients' details which could lead to their being identified have been omitted, each patient being allocated a unique identifier (see Table 1: Group (1) Variables, p. 4).

This dataset has been used for statistical modelling in Rudolfer (2001), Rudolfer *et al.* (1996), Rudolfer *et al.* (1999), and Rudolfer & Peers (1999), and presents interesting medical and statistical aspects (see section 2.3, p. 13).

2.1 Explanatory Variables

These fall into three categories: *History*, *Clinical Examination* and *Nerve Conduction Studies*.

2.1.1 History

The history variables are split into two groups:

- (1) The patient's *identifier, sex, age, handedness, occupation (manual or non-manual), incidental disease and referred side*; these variables refer to the **patient as a whole**.
- (2) The patient's **hand symptoms** *numbness, pain, tingling and weakness*.

	<u>Table 1: Group (1) Variables</u>	<i>In alphabetical order</i>
Variable	Coding	Variable Name
Age	-9: if unknown actual age: otherwise	AGE
Other Incidental Disease	Specifies the disease corresponding to INCDIS = 8: see footnote 2 below	ALINCDIS
Handedness	L: left-handed R: right-handed B: ambidextrous	HAND
Incidental Disease¹	1: Wrist injury: unknown side 2: Arthritis	INCDIS

¹ This character field is of length eight in the dataset (see Table 12, Section 2.4, p. 14), and contains the codes of all the incidental diseases present (no patient had all nine options!). For example, INCDIS = '123' means that the patient had wrist injury (unknown side), arthritis and diabetes.

² If this is the chosen coding, then the variable ALINCDIS (see Table 12, Section 2.4, p. 14) will contain the details of the other Incidental Disease.

	<u>Table 1: Group (1) Variables</u>	<i>In alphabetical order</i>
Variable	Coding	Variable Name
	3: Diabetes 4: Hypothyroidism 5: Wrist injury: left side 6: Osteo-Arthritis 7: Rheumatoid Arthritis 8: Other ² 9: Wrist injury: right side	
Job	1: Manual 2: Non-Manual 9: Unknown or can't be determined ³	JOB
Identifier	An integer between 1 and 853	PATNO
Referred Side⁴	L: Left R: Right B: Both	REFLAT
Sex	1: Male 2: Female	SEX

We now give some of the Group (1) variables' distributions, starting with age.

Two patients had missing age: patients numbers 159 and 792. When these are excluded, we get the following summary statistics for age, classified by sex. It can be seen that there is no great difference between male and female percentiles.

Percentile	Male (269)	Female (582)
100% Max	87	91
99%	83	85
95%	78	79
90%	74	76
75% Q3	62	61
50% Median	51	49
25% Q1	41	39
10%	33	31
5%	29	27
1%	20	23
0% Min	20	17

Table 2 : Distribution of Age by Sex

³ With the increasing use of computers, the distinction between manual and non-manual workers is becoming blurred: a secretary would not previously have been classified as a manual worker, yet she uses her hands a lot for typing, often with resulting Repetitive Strain Injury or CTS. It should be pointed out that the relation between typing and CTS is highly controversial. When the manual status of a patient was unclear, the code 9 was used.

⁴ In general terms, this was taken from the referral letter: if a side was referred to, that was given as the referred side; if both sides were mentioned or if no mention was made of a specific side, then the referred side was given as Both.

Handedness	Frequency	Percent
Bilateral	14	1.64
Left	76	8.91
Right	758	88.86
Unknown	5	0.59

Table 3: Distribution of Handedness

Incidental Disease	Frequency among patients	Percent among patients
Wrist injury: Unknown side	15	1.76
Arthritis	98	11.49
Diabetes	37	4.34
Hypothyroidism	13	1.52
Wrist injury: Left side	31	3.63
Osteo-Arthritis	47	5.51
Rheumatoid Arthritis	23	2.70
Other	160	18.76
Wrist injury: Right side	47	5.51

Table 4 : Distribution of Incidental Diseases

The Other Incidental Disease group was found to be very diverse. In fact, it was often used to give more details of the Other Incidental Disease present, for example, the site of an associated fracture.

Job	Frequency	Percent
Manual	478	56.04
Non-Manual	362	42.44
Unknown	13	1.52

Table 5: Distribution of Job

Sex	Frequency	Percent
Male	270	31.65
Female	583	68.35

Table 6 : Distribution of Sex

The symptoms numbness, pain, tingling and weakness are classified by their *duration*, *first occurrence*, *location*, *symptom relief*, *severity*, and *time of occurrence*. Since these all refer to either the left or right side of the patient, each variable will start with an “L” or an “R”. The *core variable name* (without the L/R prefix or symptom name suffix) and *coding* of the symptom classifiers are given in the following table. A *full variable name* is formed from the core one by prefixing the latter with “L” or “R”, in agreement with the side to which it refers, and suffixing it with the name of the symptom to which it refers. For example, RLOCWEAK denotes the location of weakness of the patient’s right hand.

	<u>Table 7: Group (2)</u> <u>Variables</u>	<i>In alphabetical order</i>
Hand Symptom Classifier	Coding	Core Variable Name
First occurrence	0: Symptom absent 1: less than 3 months ago 2: 3 to 11 months ago 3: 1 to 5 years ago 4: 6 to 10 years ago 5: more than 10 years ago	1ST
Duration	0: Symptom absent 1: At most 10 minutes 2: More than 10 minutes	DUR
Location	0: Symptom absent 1: Digits 1 to 3 2: Digits 4 and 5 3: Digits 1 to 5 4: Other location ⁵	LOC
Other Location	Specifies the location corresponding to footnote 5 above	OL
Other Relieving Factor	Specifies the relieving factor corresponding to footnote 6 below	OR
Symptom relief	0: Symptom absent 1: Shaking the hand 2: Other method ⁶ 3: No relief found	REL
Severity	0: Symptom absent 1: Mild 2: Moderate 3: Severe	SEV
Time of occurrence	0: Symptom absent 1: Day-time 2: Night-time 3: Parts of day and night 4: All the time	TIM

⁵ If this is the chosen coding, then the variable with core name OL (see [Table 12](#), Section 2.4, p. 14) will contain the details of the other location.

⁶ If this is the chosen coding, then the variable with core name OR (see [Table 12](#), Section 2.4, p. 14) will contain the details of the other method of symptom relief.

2.1.2 Clinical Examination

This involves Dr James' observation of the patient, and consists of three variables: *sensory loss*, *wasting* and *weakness*. Note that weakness occurs both as a History Group (2) variable and as a Clinical Examination variable; these two variables have to be given different names.

The following table gives the core variable names, which have to be prefixed by an "L" or an "R" to indicate which side is involved.

<u>Table 8: Clinical Examination Variables</u>			<i>In alphabetical order</i>
Sign	Classifier	Coding	Core Variable Name
Sensory loss	<i>Location</i>	0: Sign absent 1: Digits 1 to 3 2: Digits 4 and 5 3: All Digits 4: Other ⁷	LOCSENL
Wasting	<i>Location</i>	0: Sign absent 1: Thenar Eminence 2: Hypothenar Eminence 3: Other ⁸	LOCWAST
	<i>Severity</i>	0: Sign absent 1: Mild 2: Moderate 3: Severe	SEWAST
Clinical Weakness	<i>Location</i>	0: Sign absent 1: Thenar Eminence 2: Hypothenar Eminence 3: Other ⁹	LCWEAK

2.1.3 Nerve Conduction Studies (NCS)

These involve the use of a specialised piece of equipment, an EMG (Electromyography) machine, which stimulates appropriate nerves in the body and records their responses. The variables recorded are given in the

⁷ If this is the chosen coding, then the variable with core name OLSENL (see [Table 12](#), Section 2.4, p. 14) will contain the details of the other location of the sensory loss.

⁸ If this is the chosen coding, then the variable with core name OLWAST (see [Table 12](#), Section 2.4, p. 14) will contain the details of the other location of the wasting.

⁹ If this is the chosen coding, then the variable with core name OLCWEAK (see [Table 12](#), Section 2.4, p. 14) will contain the details of the other location of the clinical weakness.

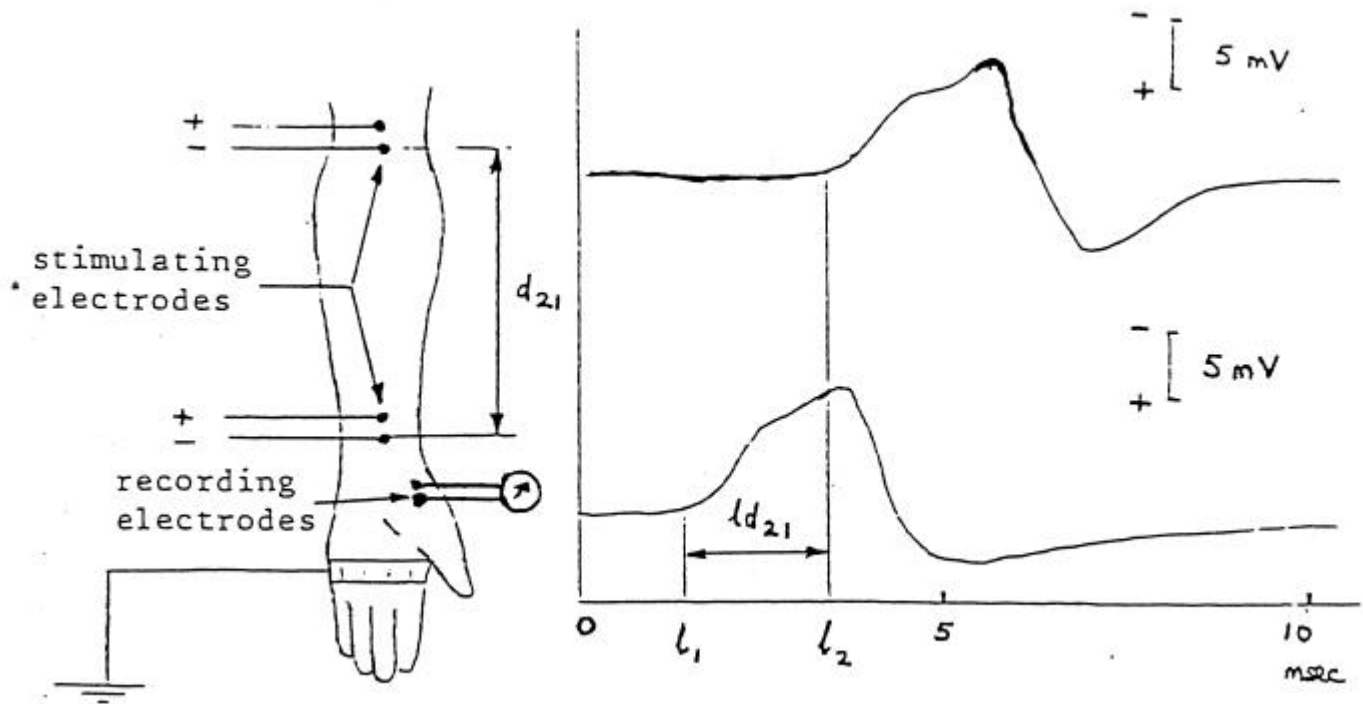
following table. As in the previous section, the core variable names have to be prefixed by “L” or “R” to indicate the side being examined.

<u>Table 9: NCS Variables</u>				
Nerve	Fibres	Measurement	Units	Core Variable Name
Median	Motor	Latency at the Wrist Latency at the Elbow Distance, Elbow to Wrist Conduction Rate, Elbow to Wrist	Milliseconds Milliseconds Centimetres Metres per second	MMLW MMLE MMDEW MMVEW
Median	Sensory	Latency Amplitude Duration	Milliseconds Microvolts Milliseconds	MSL MSA MSD
Ulnar	Motor	Latency at the Wrist Latency above the Elbow Distance, above Elbow to Wrist Conduction Rate, above Elbow to Wrist	Milliseconds Milliseconds Centimetres Metres per second	UMLW UMLE UMDEW UMVEW
Ulnar	Sensory	Latency Amplitude Duration	Milliseconds Microvolts Milliseconds	USL USA USD

Both median and ulnar nerves contain motor fibres (carrying signals from the brain to the muscles) and sensory fibres (conveying messages from the skin receptors to the brain). The characteristics of the responses of these fibres to stimulation contain important information regarding the function of the nerve involved, in particular

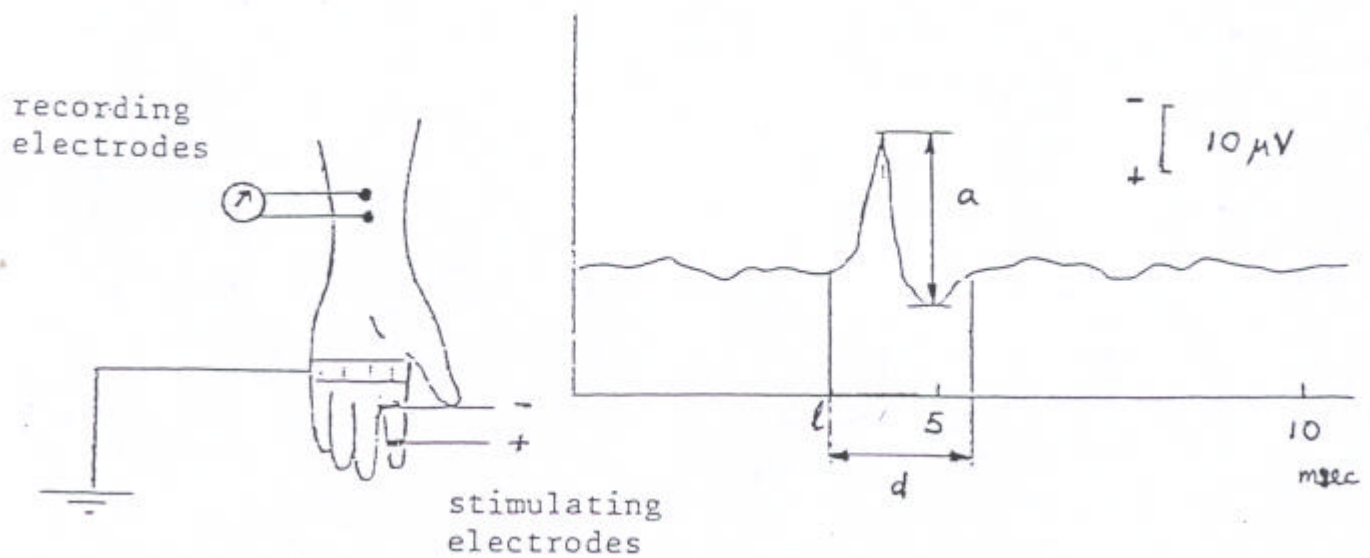
1. Is the nerve normal over the segment being examined?
2. If not, where is the abnormality?

Figure 2- Figure 4 give the electrode configurations and definitions of the nerve conduction measurements. In the case of median sensory studies, the index finger was stimulated by Dr. James. It should perhaps be pointed out that in recent years, more sensitive tests have been developed to show the mildest degrees of median impairment: short segment palm/wrist studies, comparative median/ulnar latencies using the ring finger, inching methods, or Terminal Motor Latency comparisons to the interossei and lumbricals.



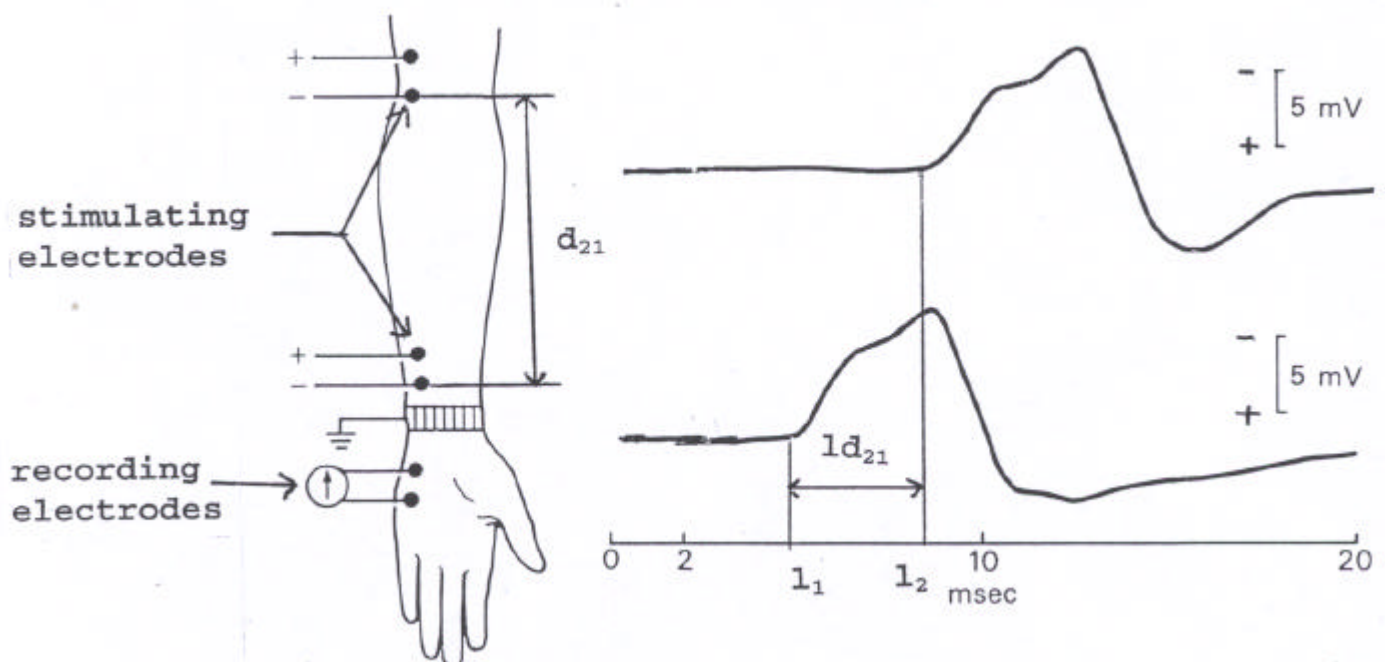
- l_1 = median motor latency at the wrist (milliseconds)
- l_2 = median motor latency at the elbow (milliseconds)
- d_{21} = distance, elbow to wrist (centimeters)
- $ld_{21} = l_2 - l_1$ = median motor latency difference, elbow to wrist
- $r_{21} = 10 d_{21} / l_{21}$ = rate, elbow to wrist (meters/second)

Figure 2: Median Nerve Motor Stimulation



a = median sensory amplitude (microvolts)
 d = median sensory duration (milliseconds)
 l = median sensory latency (milliseconds)

Figure 3: Median Nerve Sensory Stimulation



l_1 = ulnar motor latency at the wrist (milliseconds)
 l_2 = ulnar motor latency above the elbow (milliseconds)
 d_{21} = distance, above elbow to wrist (centimeters)
 $ld_{21} = l_2 - l_1$ = ulnar motor latency difference, above elbow to wrist
 $r_{21} = 10 d_{21} / l_{21}$ = rate, above elbow to wrist (meters/second)

Figure 4: Ulnar Nerve Motor Stimulation

An important feature of the nerve conduction variables is that of **non-response** to stimulus in the median nerve. In cases of more advanced nerve damage, there will be non-response to the electrical stimulus. The values assigned to non-responses are as follows: 99.9 for latencies and durations; 0.0 for amplitudes, distances and conduction rates. Depending on the method of analysis used, it may be sufficient to consider non-response values as extreme values of numerical variables. Alternatively, it may be felt more appropriate to regard variables with non-response as a mixture of a factor (response/non-response) and a numerical value for responses.

Non-recorded ulnar sensory measurements: the ulnar sensories of the first 305 patients were not recorded, but it was later felt that they would be useful for investigating non-CTS abnormalities, and hence were included. Eight patients had unilaterally recorded ulnar sensory measurements.

2.2 Response Variable

The response variable, Dr James' diagnosis, takes eight values, as shown in the following table. Its core variable name is prefixed by "L" or "R" to indicate the side of the diagnosis. Although patients were referred for investigation into CTS, several were found to have non-CTS abnormalities, either alone or in conjunction with CTS, as indicated in the table.

Precise definition of the *severity* of CTS varies from clinician to clinician. It will involve a mixture of history, clinical examination and nerve conduction studies. At one extreme, White *et al.* (1988) defined CTS severity purely in terms of the first and last (mild CTS hands were symptom-free one or more days per week; moderate CTS hands had symptoms daily, awoke the patient from sleep or required modification of daytime activity to reduce the symptoms; severe CTS hands had constant numbness and/or tingling or there was thenar muscle weakness). At the other extreme, Stevens (1997) defines the severity purely in terms of nerve conduction measurements: mild CTS includes prolonged median sensory latency (MSL); moderate CTS in addition involves prolongation of the median motor latency at the wrist (MMLW); severe CTS occurs when the MMLW and MSL are prolonged, with either no median sensory response or low median sensory amplitude (MSA). In between these two extremes, we have Rosenbaum & Ochoa (1993), who define mild CTS as CTS in which the symptoms are transient and may resolve completely, and the nerve conduction abnormalities may resolve completely or partially. They define moderate CTS as having recurrence of hand symptoms many times per week and evidence of local slowing of nerve conduction across the carpal tunnel. Severe CTS occurs according to Rosenbaum & Ochoa (1993) when there is clinical evidence of median nerve damage (weakness and wasting of the thenar muscles). Dr. James determined the severity of CTS in terms of clinical examination and nerve conduction studies, mainly MMLW and MSA (personal communication), although the precise way in which he combined them is probably best described as "clinical judgement".

Value	<u>Table 10: Dr James' Diagnosis</u> Core Variable Name: DRDIAG Meaning
1	NAD (No Abnormality Detected)
2	Mild CTS
3	Moderate CTS
4	Severe CTS

Value	<u>Table 10: Dr James' Diagnosis</u> Core Variable Name: DRDIAG Meaning
5	Non-CTS Abnormality
6	Mild CTS + Non-CTS Abnormality
7	Moderate CTS + Non-CTS Abnormality
8	Severe CTS + Non-CTS Abnormality

The distribution of his diagnoses is given in the table below.

Dr James' Diagnosis	Frequency	Percent
NAD	656	38.45
Mild CTS	571	33.47
Moderate CTS	244	14.30
Severe CTS	85	4.98
Non-CTS Abnormality Alone	64	3.75
Mild CTS + Non-CTS Abnormality	56	3.28
Moderate CTS + Non-CTS Abnormality	16	0.94
Severe CTS + Non-CTS Abnormality	14	0.82

Table 11: Distribution of Dr James' diagnoses

2.3 Interesting Aspects of the Dataset

The diagnosis of CTS is based on a combination of the patient's subjective observations (history), the doctor's subjective observations of the patient's physical condition (clinical signs), and objective measurements (nerve conduction studies). On the one hand, we have the symptomatic presentation of CTS; on the other, the objective assessment of nerve function. The relationship between the two presents much scope for discussion, as may be seen from many issues of EMG journals such as *Muscle & Nerve*. Indeed, it is well-known that a patient can present with CTS-like symptoms, yet have "normal" nerve conduction measurements, and on the other hand, present with very few symptoms yet have "abnormal" nerve conduction measurements. For further references on this topic, see Bland (2000), Stevens (1997), and White *et al.* (1988).

If the non-CTS abnormality group is excluded from investigation, the response variable may be considered to be *ordinal*, which opens up the modelling field to ordinal models such as Proportional Odds.

Non-response to stimulation, as mentioned on p. 12, presents interesting statistical challenges.

2.4 Details of the file *patients.dat*

The data file is about 450 kb large, and can be contained on a floppy disk. It may be obtained by email from the author.

Each patient takes up seven lines in the data file.

<u>Table 12: Details of Data File</u>			
Line number	Column number(s)	Variable name	Variable type
1	1-3	PATNO	Numeric
1	21	SEX	Numeric
1	31-32	AGE	Numeric
1	41	REFLAT	Character
1	53	HAND	Character
1	55	JOB	Numeric
1	57-64	INCDIS	Character
1	66-80	ALINCDIS	Character
2	1	R1STNUMB	Numeric
2	2	RDURNUMB	Numeric
2	3	RLOCNUMB	Numeric
2	4	RTIMNUMB	Numeric
2	5	RRELNUMB	Numeric
2	6	RSEVNUMB	Numeric
2	7	L1STNUMB	Numeric
2	8	LDURNUMB	Numeric
2	9	LLOCNUMB	Numeric
2	10	LTIMNUMB	Numeric
2	11	LRELNUMB	Numeric
2	12	LSEVNUMB	Numeric
2	14	R1STPAIN	Numeric
2	15	RDURPAIN	Numeric
2	16	RLOCPAIN	Numeric
2	17	RTIMPAIN	Numeric
2	18	RRELPAIN	Numeric
2	19	RSEVPAIN	Numeric
2	20	L1STPAIN	Numeric
2	21	LDURPAIN	Numeric
2	22	LLOCPAIN	Numeric
2	23	LTIMPAIN	Numeric
2	24	LRELPAIN	Numeric
2	25	LSEVPAIN	Numeric
2	27	R1STTING	Numeric
2	28	RDURTING	Numeric
2	29	RLOCTING	Numeric
2	30	RTIMTING	Numeric
2	31	RRELTING	Numeric
2	32	RSEVTING	Numeric
2	33	L1STTING	Numeric
2	34	LDURTING	Numeric
2	35	LLOCTING	Numeric

<u>Table 12: Details of Data File</u>			
Line number	Column number(s)	Variable name	Variable type
2	36	LTIMTING	Numeric
2	37	LRELTING	Numeric
2	38	LSEVTING	Numeric
2	40	R1STWEAK	Numeric
2	41	RDURWEAK	Numeric
2	42	RLOCWEAK	Numeric
2	43	RTIMWEAK	Numeric
2	44	RRELWEAK	Numeric
2	45	RSEVWEAK	Numeric
2	46	L1STWEAK	Numeric
2	47	LDURWEAK	Numeric
2	48	LLOCWEAK	Numeric
2	49	LTIMWEAK	Numeric
2	50	LRELWEAK	Numeric
2	51	LSEVWEAK	Numeric
3	1-10	ROLNUMB	Character
3	11-20	RORNUMB	Character
3	21-30	ROLPAIN	Character
3	31-40	RORPAIN	Character
3	41-50	ROLTING	Character
3	51-60	RORTING	Character
3	61-70	ROLWEAK	Character
3	71-80	RORWEAK	Character
4	1-10	LOLNUMB	Character
4	11-20	LORNUMB	Character
4	21-30	LOLPAIN	Character
4	31-40	LORPAIN	Character
4	41-50	LOLTING	Character
4	51-60	LORTING	Character
4	61-70	LOLWEAK	Character
4	71-80	LORWEAK	Character
5	1	RLOCSENL	Numeric
5	2-11	ROLSENL	Character
5	13	RLOCWAST	Numeric
5	14-23	ROLWAST	Character
5	25	RSEVWAST	Numeric
5	27	RLCWEAK	Numeric
5	28-37	ROLCWEAK	Character
5	39	RSCWEAK	Numeric
5	41	LLOCSENL	Numeric
5	42-51	LOLSENL	Character
5	53	LLOCWAST	Numeric

<u>Table 12: Details of Data File</u>			
Line number	Column number(s)	Variable name	Variable type
5	54-63	LOLWAST	Character
5	65	LSEVWAST	Numeric
5	67	LLCWEAK	Numeric
5	68-77	LOLCWEAK	Character
5	79	LSCWEAK	Numeric
6	1-4	RMMLW	Numeric
6	5-8	RMMLE	Numeric
6	9-12	RMMDEW	Numeric
6	13-14	RMMVEW	Numeric
6	15-18	RUMLW	Numeric
6	19-22	RUMLE	Numeric
6	23-26	RUMDEW	Numeric
6	27-28	RUMVEW	Numeric
6	29-32	RMSL	Numeric
6	33-34	RMSA	Numeric
6	35-38	RMSD	Numeric
6	39-42	LMMLW	Numeric
6	43-46	LMMLE	Numeric
6	47-50	LMMDEW	Numeric
6	51-52	LMMVEW	Numeric
6	53-56	LUMLW	Numeric
6	57-60	LUMLE	Numeric
6	61-64	LUMDEW	Numeric
6	65-66	LUMVEW	Numeric
6	67-70	LMSL	Numeric
6	71-72	LMSA	Numeric
6	73-76	LMSD	Numeric
7	1	RDRDIAG	Numeric
7	2-11	RNCTSABN	Character
7	13-16	RUSL	Numeric
7	17-18	RUSA	Numeric
7	19-22	RUSD	Numeric
7	41	LDRDIAG	Numeric
7	42-51	LNCTSABN	Character
7	53-56	LUSL	Numeric
7	57-58	LUSA	Numeric
7	59-62	LUSD	Numeric

3 Acknowledgements

This dataset would never have come into existence without the encouragement and help of Dr JL James. To him, I owe my interest in, and work on, the application of statistics to the field of electromyography, in particular, Carpal Tunnel Syndrome. The laborious task of collecting and checking the data required the invaluable assistance of Dr James' technicians, Mrs Ginny Lockwood, Mrs Louise Mullinger and Mrs Gill Mills, and secretary Mrs Sylvia Hague. The final stage of checking was greatly helped by Martyn Thompson, a recently appointed technician. To them all, my deepest thanks. For expert comments on this document, I profoundly thank Dr Jeremy Bland, Consultant in Clinical Neurophysiology, Kings College Hospital/Kent and Canterbury Hospital

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