The Edinburgh Handedness Inventory: Some bibliometry

A Working Paper

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Abstract

A list has been prepared (appendix A) of 182 articles featuring the Edinburgh Handedness Inventory prominently, ordered by citations received. The article introducing the inventory has been cited an extreme number of times (over 26,000 on the specific date investigated). Another article confirming the relevance of left- and mixed-handedness to neurology has also attracted a great deal of attention. A core set of journals is identified that published many of these articles. Of numeric variables explored, only the age of the article had an influence on the citation counts: unsurprising but the modest degree of influence is more so. A secular trend is exposed of greater multi-authorship, particularly in the peripheral set of journals. It has little benefit in terms of citations. The more productive authors are identified. Evidence is presented that it is the neurological significance of handedness that interests researchers most.

Introduction

The Edinburgh Handedness Inventory (EHI) is the closest there is to a standard measure. It was published in 1971 by Carolus Oldfield, shortly before his death (Oldfield, 1971). It appears at the top of Appendix A, the corpus of articles analyzed for this paper, which is ordered according to citations. On 5th December 2017 it had received no less than 26217[1]. The present paper does not attempt to analyze all these 26000+ citers, but rather a much more manageable and accessible 182 retrieved from PubMed on that date.

Questions about these that present themselves include: can any factors be identified that account for the citation counts? It seems obvious that older publications will have accumulated more citations over time, but can the magnitude of this effect be estimated? A recent analysis of a much larger corpus of 28,131 articles in Information Science found not only a correlation between citation impact and multi-authorship but specified a power law to describe it (Ronda-Pupo & Katz, 2017). Is there such a correlation in the present corpus? Also, it seems likely that longer articles attract more citations. Is that borne out?

Furthermore it is of interest to know which *journals* are publishing these articles. Is there a core of journals that is publishing a lot of them? Do articles appearing in these main journals differ from the rest, for example with respect to citations? And are there especially prolific *authors*?

Can anything be said briefly about the *interests* of the various authors? In other words, do some MeSH (Medical Subject Headings which are tagged on articles) terms occur particularly frequently? It should be pointed out straightaway that a sizeable minority of the publications examine the EHI as a tool for measuring handedness: properties such as reliability and validity (face, content and construct validity).

These sorts of question have become far more amenable with the advance of computer technology, both software and hardware improving as they do all the time.

1 On Google Scholar

Method

The corpus was extracted from PubMed, which does not hold full texts, so these journal articles are selected on the basis of the contents of their titles and/or abstracts.[2] A PubMed search uses a feature called Automatic Term Mapping, which means the closest MeSH (Medical Subject Heading) term(s) to the string entered are picked. For "Edinburgh Handedness Inventory" that is "Functional Laterality". The MeSH term "Humans" was also added to the search as an AND. The 182 articles retrieved were scrutinized to make sure that they did mention the EHI.

They were read into Zotero, which has a plugin that can retrieve the citation counts for a set of articles. Unfortunately either a bug or an overload on Google Scholar meant that nearly half the citation counts had to be retrieved manually one by one. It was Zotero too that converted the result of the PubMed search into the bibliography of Appendix A, with a small modification of the APA csl file to add the citation count.

The computer environment for statistical analysis of the PubMed output was R. Being modular, and since much of the work could not be done in its base package, other packages were installed. For text the *stringr* package was needed to recode the list of authors of an article provided by PubMed as a number of authors. And *splitstackshape* was invaluable for recoding the Pages field as a page count and the Extra field as a citation count.[3] Some of the descriptive plots of distributions could be prepared without it, but the workhorse package used was *rattle*.

Zotero gives a list of MeSH terms occurring in the (Appendix A) corpus of texts, but no indication as to which of them are frequent. The website WriteWords was used to count words and two-word phrases among the MeSH terms, and a hand edited version of these results appears as Appendix D.

Results and Discussion

It could be seen straightaway not only that the Oldfield article is an extreme outlier in terms of citations, but also that there is a second (much more modest) one, in (Szaflarski et al., 2002) whose 417 citations are more than double those of the third most highly cited article. This article confirmed with fMRI the classic findings made with intracarotid sodium amytal of (Branch, Milner, & Rasmussen, 1964) (see also *Brain and Cognition* **33**(1) (1997) *passim*) about atypical language lateralization of left- and mixed-handers. Since outliers distort means and also inferential statistics depending on parametric assumptons, one or both of these outliers were excluded from some of the analyses involving citations.

The next striking fact is that there is a group of five journals amongst the 80 appearing in Appendix C that account between them for over 40% of the 182 articles. They are (Table):

Table. Main or core journals publishing the corpus

Journal	*Number of articles in the corpus*	*Year journal was founded*
The International Journal of Neuroscience	28	1978
Perceptual and Motor Skills	17	1949
Laterality	14	1996
Neuropsychologia	11	1963
Cortex	8	1964

2 Relevant literature in books is not considered

3 It also holds the PubMed ID

The next closest to the core is *PloS One* with 5 articles and then there are four other journals each with 4 articles. *Rattle* was used for some comparisons of the main five journals with the others, with respect, above all, to citations.

First though, there is the matter of the central tendency of citations in the corpus as a whole. The mode for an individual article was 4. This is a little surprising, since it is generally, in similar exercises, zero. That might reflect the highly selected nature of the sample. The median was 20. In view of the contribution Oldfield's 26,000+ would make, the mean would obviously be misleading.

Both outliers were discarded for the comparison of core with periphery. The means (standard deviations) were 31 (35) for the core and 34 (40) for the periphery. Although the direction of the difference is surprising, the high variances led to a very low t of 0.615, which is nowhere near significance. Also, it needs to be remembered that inclusion of the outliers would present a very different picture, as Oldfield's article is in the core (*Neuropsychologia*).

Some Figures depicting distributions of the different variables examined follow. Re-plotting of citation frequency in Figure 1 is to exclude two outliers.

Figure 1

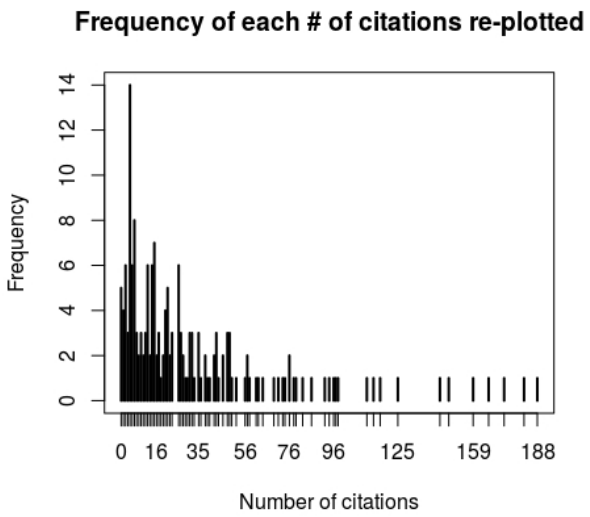

Figure 2

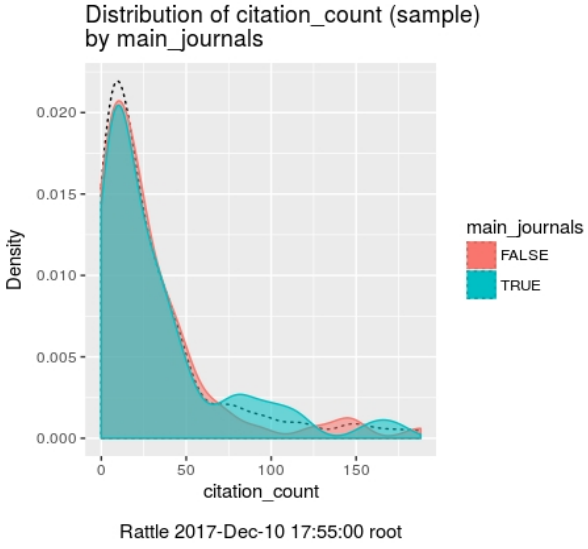

Figure 3

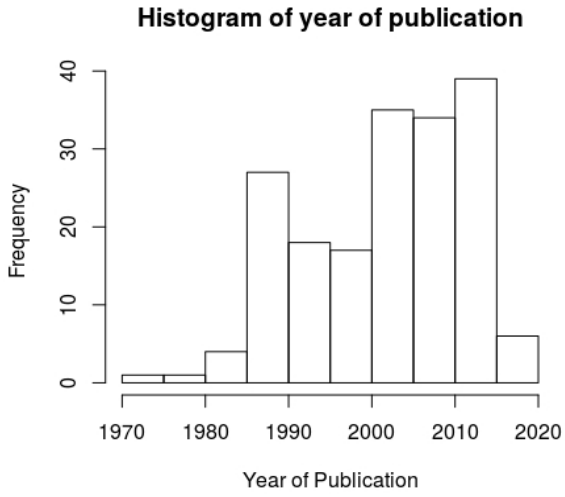

Figure 4

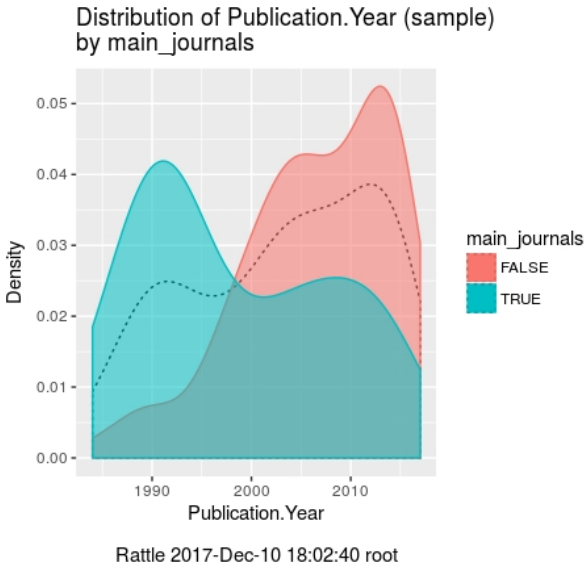

Figure 5

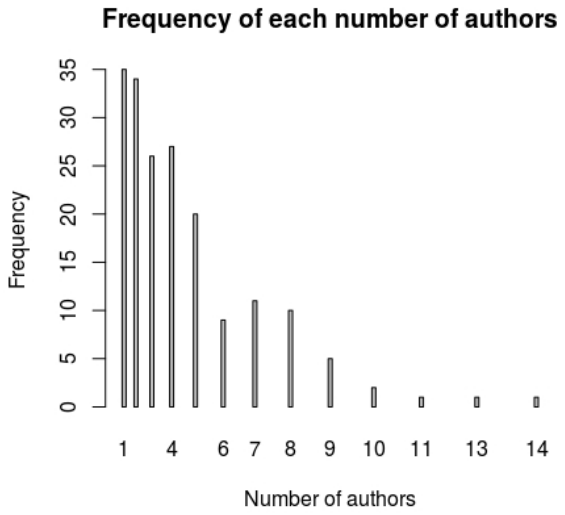

Figure 6

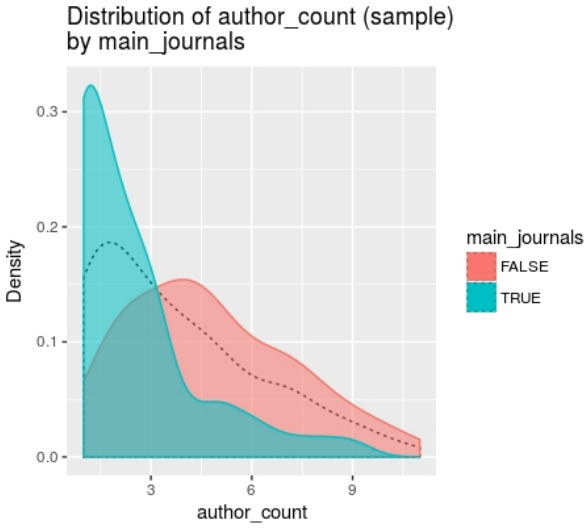

Figure 7

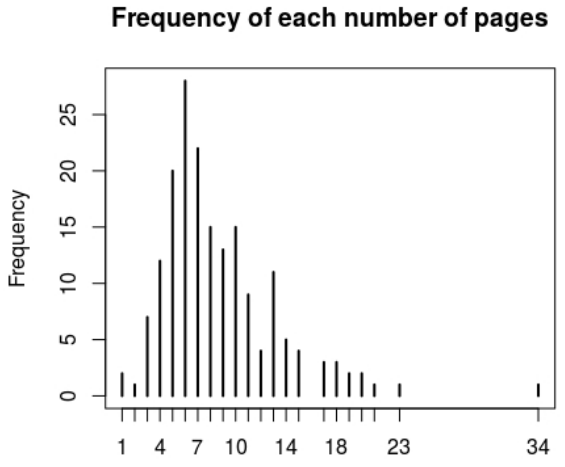

Figure 8

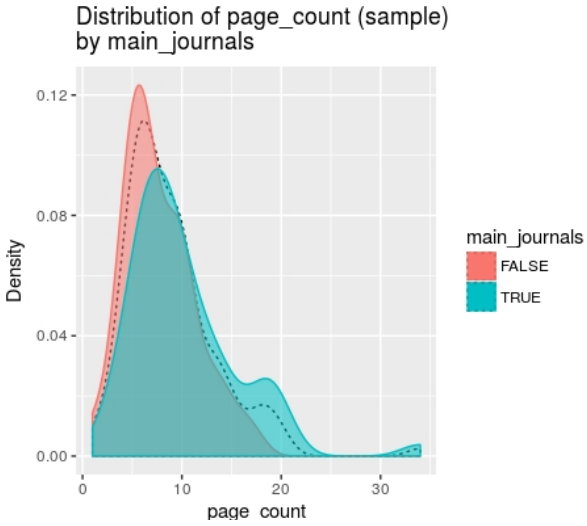

Figure 2 shows how small the citation differences are between core and periphery journals. The median year of publication was 2004 and that can be seen roughly in Figure 3. Figure 4 shows that articles in the core journals tend to be older. Presumably this is to do with the years of founding of the various journals. Of the core only *Laterality* could be described as even close to recent (see the Table on page 2).

Single-authored articles are (just) the mode (Figure 5) but periphery journals have been publishing much more by way of multi-authorship (Figure 6). In this corpus multi-authorship is increasing: year of publication correlates 0.363 with number of authors[4], in other words a secular trend acounts for 13% of variance in number of authors (and this is highly significant statistically). Adding authors for the corpus as a whole there are 703 (rather fewer *distinct* authors) and the median number for an article is three. By far the most productive has been Uner Tan, with no less than 20 articles published in *The International Journal of Neuroscience*. Four authors have three of the corpus to their name (as first authors): Varol Canakci, Senol Dane, J Martin Martins and Steven C Schacter.

As far as the journals go: *Cortex* and *Perceptual and Motor Skills* tend to avoid the extremes of multi-authorship, while there are no single-authored articles at all in *PloS One* or *Neuroimage* (which is one of the four journals to account for 4 articles). *Laterality* shows a high variance in author counts.

Page counts have a mode of 6, a median of 7 and a mean of 8.64 (Figure 7). Articles in core journals tend to be longer (Figure 8). Upon multiple regression to try to explain differences in citation counts, page count appeared at first to have a positive influence on them, but when the long Oldfield article[5] is excluded the correlation is about zero.

Multiple regression also finds weak but statistically significant effects of author count disappearing when both outliers are excluded (the Pearson r is less than 0.1). What does remain highly significant statistically is the influence of year of publication (r = -0.186). It is obvious enough that older publications have had more time to accumulate citations, but even so this factor only accounts for 4% of the variance in citation counts. A lot of older articles have had little impact at first and then been quietly forgotten. Differences between journals have some influence on citation counts. When both outliers are removed F for this is 1.811, $p < 0.01$.

To conclude, it is hoped that the appendices of this paper will attract the most interest from those who have cited the Oldfield article. In particular, the prevalence of neuro- language in appendix D is worth noting. Of course the names of three of the core journals point in the same direction. In appendix A the number of time Oldfield's article has been cited seems astonishing. Perhaps the extreme value theory of Tippett and then Gumbel could shed some light on it, but that is a project for another day.

Summary

A list has been prepared (appendix A) of 182 articles featuring the Edinburgh Handedness Inventory prominently, ordered by citations received. The article introducing the inventory has been cited an extreme number of times (over 26,000 on the specific date investigated). Another article confirming the relevance of left- and mixed-handedness to neurology has also attracted a great deal of attention. A core set of journals is identified that published many of these articles. Of numeric variables explored, only the age of the article had an influence on the citation counts: unsurprising but the modest degree of influence is more so. A secular trend is exposed of greater multi-authorship, particularly in the peripheral set of journals. It has little benefit in terms of citations. The more productive authors are identified. Evidence is presented that it is the neurological significance of handedness that interests researchers most.

4 Pearson r

5 also the 7-page Szaflarski one

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Appendix A. The corpus of articles studied, ordered by citations

26217. Oldfield, R. C. (1971). The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia*, *9*(1), 97–113.

00417. Szaflarski, J. P., Binder, J. R., Possing, E. T., McKiernan, K. A., Ward, B. D., & Hammeke, T. A. (2002). Language lateralization in left-handed and ambidextrous people: fMRI data. *Neurology*, *59*(2), 238–244.

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Appendix B. First-authors of articles in this corpus

1 Argyropoulos V 1
2 Arning L 1
3 Aygül R 1
4 Betancur C 1
5 Biehl K 1
6 Bishop DV 1
7 Boscarino JA 1
8 Brito GN 2
9 Buijsrogge JJ 1
10 Büsch D 1
11 Byrne M 1
12 Canakci V 3
13 Cannon M 1
14 Cantor JM 2
15 Catanzariti JF 1
16 Christman SD 1
17 Ciçek Y 1
18 Civardi C 1
19 Cosenza RM 2
20 Daamen M 1
21 Dalziel SR 2
22 Dane S 3
23 Davidson T 1
24 Deep-Soboslay A 1
25 Demura S 1
26 de Souza MA 1
27 Dingman SM 2
28 Dirnberger G 2
29 Dollfus S 2
30 Doody RS 1
31 Dorthe NJ 1
32 Dragovic M 1
33 Edlin JM 1
34 Ellis SJ 2
35 Escalante-Mead PR 1
36 Espírito-Santo H 1
37 Faglia L 1
38 Farina B 1
39 Fasmer OB 1
40 Fazio R 1
41 Fazio RL 1
42 Fonseca-Pedrero E 1
43 Forbes D 1
44 Friedli WG 1
45 Fry CJ 2
46 Guidetti V 1
47 Gursoy R 1
48 Habib M 1
49 Helleday J 1
50 Henkel V 1
51 Hepper PG 1
52 Holper L 1
53 Ibrahim AI 1
54 Isaacs KL 1
55 Jones SJ 1
56 Jung P 1
57 Kalisch T 1
58 Kang Y 1
59 Karapetsas A 1
60 Keane AM 1
61 Kelley MP 1
62 Kishida M 1
63 Kizilkaya E 1
64 Koeda M 1
65 Kostiukow A 1
66 Krommydas G 1
67 Kucera JD 1
68 Kulaksiz G 1
69 Kutlu N 1
70 Lehnkering H 1
71 Li C 1
72 Lipsanen T 1
73 London WP 1
74 Lugo M 1
75 Maeda RS 1
76 Martin Martins J 1
77 Martins JM 2
78 Mathews GA 1
79 McGee MG 1
80 McKeever WF 2
81 Menning H 1
82 Merckelbach H 1
83 Metalis SA 1
84 Milenkovic S 1
85 Miller SS 1
86 Nagels G 1
87 O'Carroll RE 1
88 Okamoto H 1
89 Okubo M 1
90 Oldfield RC 1
91 Orbak R 1
92 Ozener B 1
93 Papadatou-Pastou M 1
94 Pasinlioglu T 1
95 Pennington N 1
96 Piro J 1
97 Pool EM 1
98 Rahman Q 1
99 Ransil BJ 2
100 Ritov G 1
101 Sahin A 1
102 Saleh S 1
103 Saltzman KM 1
104 Sarubbo S 1
105 Saunders DA 1
106 Schachter SC 3
107 Schade S 1
108 Schürhoff F 1
109 Seidman MD 1
110 Seifert L 1
111 Shobe E 1
112 Slezicki KI 1
113 Smith J 1
114 Somers M 2
115 Spivak B 1
116 Stewart CC 1
117 Sveller C 1
118 Swift-Gallant A 1
119 Szaflarski JP 1
120 Tan U 20
121 Teixeira LA 1
122 Tenconi E 1
123 Tezel A 1
124 Thiel A 1
125 Tokimura H 1
126 Tonetti L 1
127 Triggs WJ 1
128 Uslu H 1
129 Vannest J 1
130 van Schie PE 1
131 Vaughn CL 1
132 Veale JF 1
133 Verdino M 1
134 Verdoux H 1
135 Waal A 1
136 Warren-Gash C 1
137 Wilhelm LA 1
138 Williams SM 2
139 Yildirim M 1
140 Yüksel R 1
141 Zago L 1
142 Zapf AC 1
143 Zetzsche T 1
144 Zimmerli L 1

Appendix C. Journals represented in this corpus

1 Am J Hum Biol 1
2 Angle Orthod 1
3 Ann Agric Environ Med 1
4 Ann Anat 1
5 Ann R Coll Surg Engl 1
6 Appl Neuropsychol Adult 2
7 Arch Neurol 1
8 Arch Sex Behav 4
9 Arq Neuropsiquiatr 1
10 Behav Brain Res 1
11 Behav Genet 1
12 BMJ 1
13 Brain 1
14 Brain Behav Immun 1
15 Brain Cogn 4
16 Brain Lang 2
17 Br J Psychol 1
18 Br J Sports Med 1
19 Can J Ophthalmol 1
20 Cephalalgia 1
21 Childs Nerv Syst 1
22 Chronobiol Int 1
23 Clin Neurophysiol 1
24 Cogn Behav Neurol 1
25 Cortex 8
26 Dent Traumatol 1
27 Dev Med Child Neurol 1
28 Electroencephalogr Clin Neurophysiol 2
29 Epilepsy Behav 1
30 Eur Psychiatry 1
31 Eur Spine J 1
32 Funct Neurol 1
33 Hum Mov Sci 2
34 Int J Neurosci 28
35 Int J Obes Relat Metab Disord 1
36 Int J Psychophysiol 1
37 Int J Rehabil Res 1
38 Ital J Neurol Sci 1
39 J Affect Disord 2
40 JAMA Otolaryngol Head Neck Surg 1
41 J Autism Dev Disord 1
42 J Epidemiol Community Health 1
43 J Mot Behav 1
44 J Nerv Ment Dis 4
45 J Neuroeng Rehabil 1
46 J Neurol Neurosurg Psychiatry 2
47 J Neurosci 1
48 J Occup Med 1
49 J Physiol Anthropol 1
50 J Public Health Dent 1
51 J Trauma Stress 1
52 Laterality 14
53 Methods Inf Med 1
54 Neuroimage 4
55 Neuroimage Clin 2
56 Neurol Med Chir (Tokyo) 1
57 Neurology 3
58 Neurol Sci 1
59 Neuropsychologia 11
60 Neuropsychology 1
61 Neuroreport 1
62 Pediatr Allergy Immunol 1
63 Perception 1
64 Percept Mot Skills 17
65 Physiol Behav 1
66 Physiotherapy 1
67 PLoS One 5
68 Psicothema 1
69 Psychiatry Res 3
70 Psychol Med 1
71 Psychol Rep 1
72 Psychoneuroendocrinology 1
73 Psychosom Med 1
74 Res Dev Disabil 1
75 Restor Neurol Neurosci 1
76 Riv Psichiatr 1
77 Schizophr Res 2
78 Shinrigaku Kenkyu 1
79 Somatosens Mot Res 1
80 World J Biol Psychiatry 2

Appendix D. Frequencies of words and phrases in the MeSH tags.

281	physiology
176	adult
165	male
149	female
114	physiopathology
70	psychology
51	middle aged
46	male adolescent
44	factors
43	sex
42	questionnaires
41	motor
39	tests
36	disorders
35	diagnosis
32	surveys
32	young adult
30	epidemiology
30	genetics
29	brain
29	imaging
28	cerebral
28	psychomotor
27	neuropsychological
25	blood
24	skills
23	psychomotor performance
23	statistics
20	neuropsychological tests
20	sex factors
19	language
16	dominance cerebral
16	methods
15	cortex
15	magnetic resonance imaging
15	motor skills
14	reference values
12	anatomy
12	diagnostic imaging
12	epidemiology
12	intelligence
11	pathology
11	psychometrics
11	risk factors
11	testosterone
10	personality inventory
10	sex characteristics
10	strength
9	age factors
9	perception
9	schizophrenia
8	case control
8	cognition
8	control studies
8	etiology
8	immunology
8	learning
7	epilepsy
7	lobe
7	nerve
7	psychiatric status
7	rating scales
6	adult case
6	child preschool
6	distribution
6	evoked potentials
6	factor analysis
6	follow up studies
6	hand preference
6	motor cortex
6	post traumatic stress disorders
6	preschool
6	surgery
5	analysis statistical
5	brain mapping
5	chi square distribution
5	classification
5	delayed effects
5	electric stimulation
5	hand physiology
5	hand strength
5	innervation
5	male child
5	metabolism
5	pathways
5	physiological phenomena
5	pilot projects
5	reaction time
5	temporal lobe
5	united states
4	acoustic stimulation
4	adult prevalence
4	ancestry group
4	assessment
4	blood supply
4	cerebral cortex
4	continental ancestry
4	dichotic listening
4	language lateralization
4	linear models
4	listening tests
4	migraine disorders
4	motor activity
4	personality disorder
4	retrospective studies

4	task performance
4	treatment outcome
3	activities of daily living
3	adrenocorticotropic hormone
3	aging
3	birth order
3	brain neoplasms
3	brain physiology
3	combat disorders
3	computer assisted tomography
3	cross cultural
3	cross sectional
3	cultural comparison
3	diagnosis epidemiology
3	drug effects
3	foot physiology
3	homosexuality male
3	infant newborn
3	injuries
3	intelligence tests
3	learning disorders
3	logistic models
3	low birth weight
3	mental disorders
3	movement physiology
3	multivariate analysis
3	muscle strength
3	neural inhibition
3	neural pathways
3	personality assessment
3	prenatal exposure
3	prospective studies
3	reflex
3	schizophrenia diagnosis
3	schizotypal personality
3	siblings
3	single photon emission computed tomography
2	adrenal hyperplasia
2	adult risk
2	attention deficit
2	attention deficit disorder
2	attentional network
2	autistic disorder
2	blood hydrocortisone
2	body height
2	body weight
2	choice behavior
2	cognition disorders
2	competitive behavior
2	congenital
2	corpus callosum
2	corticotropin releasing
2	diseases diagnosis
2	family characteristics
2	fingers anatomy
2	gender identity
2	gestational age
2	handedness analysis
2	homosexuality
2	hyperplasia congenital
2	hypersensitivity
2	hypophyseal system
2	hypothalamo hypophyseal
2	image processing
2	innervation physiology
2	intensive treatment
2	language disorders
2	male students
2	mental recall
2	motor neurons
2	muscles
2	neonatal intensive care
2	neoplasms diagnosis
2	neurons
2	neurosecretory systems
2	nursing statistics
2	parents
2	penile erection
2	personality
2	physical therapy
2	physiology hand
2	posture
2	predictive value
2	prefrontal cortex
2	prenatal
2	psychometrics reproducibility
2	questionnaires motor
2	regression analysis
2	risk assessment
2	schizophrenic psychology
2	seasons
2	self
2	sex ratio
2	sexual behavior
2	socioeconomic factors
2	sound localization
2	space perception
2	statistics nonparametric
2	stimulation methods
2	strength dynamometer
2	surgical procedures
2	system diseases
2	tibial nerve
2	transcranial magnetic stimulation
2	turkey epidemiology
2	verbal learning
2	visual perception