

Chapter 12: Hypernotes

📖 WWW 📖 12:1

Browne's *Religio Medici* was a success even before it was published. Having been written between 1634 and 1636 it circulated in several manuscript copies, and was only published properly after two pirated editions came out in 1642.

The term 'Vulgar' in the popular title of the *Pseudodoxia epidemica...* is used in the old sense of 'In common or general use'.

📖 WWW 📖 12:2

The phrase "enumeration of many unconnected particulars" comes from Dr Johnson's biography of Browne (see p.xvi of the Wilkin edition).

Joubert's *Popular errors* is criticised by Browne (see de Rocher, 1989 p. xvi at the very beginning of the *Vulgar errors*. "Laurentius Joubertus, by the same title [*Popular errors*], led our expectation into thoughts of great relief; whereby notwithstanding, we reaped no advantage, it answering scarce at all the promise of the inscription" (Wilkin, 1852 vol I, p.4). Although the Popular errors proposed to answer many questions, Joubert's plans were greater than the reality, and while we have an outline of the final thirty books in six parts, only the first five were actually published. Unfortunately the question on the use of the left hand was raised but, as far as I can tell, never answered.

On reading the scientific notebooks of Darwin Barrett et al., 1987 I have been struck by how much Darwin himself was a part of the tradition of cataloguing popular beliefs, and then asking whether or not they may find any form of support. The notebooks are a marvellous mixture of careful observation, natural history and theoretical speculations and insights, coupled with the writing down of 'vulgar errors' of all sorts; thus we find several comments from Darwin's hairdresser (a Mr Willis of Great Marlborough Street, it would seem), who talked to Darwin about the fact that black hair is stronger than other colours (p.338) and of the breeding habits of dogs (p.385). There are also the beliefs of Darwin's father ("My father has somewhere heard (Hunter?) that pulse of new born babies of labouring classes are [sic] slower than those of gentlefolks"; p.530), of his father's friends ("My father says on authority of M^r Wynne that bitch's offspring is affected by previous marriages with impure breed"). There are also accounts of pure Lamarckism ("A cat had its tail cut off at Shrewsbury & its kittens (in number 3) had all short tails"; p.525), and other miscellaneous but probably untrue facts ("I have read paper somewhere on horse being insane at the sight of anything scarlet" p.523). Darwin had read the *Religio Medici* only relatively recently (p.550 of

notebook M) , and might therefore also have read the *Vulgar Errors* in the newly published 1836 edition of the complete works by Wilkins.

☞WWW☞ 12:3

The Royal Society was founded in 1660, and itself was somewhat credulous in its early days Bennett, 1962 p.17 . Browne’s son Edward was elected FRS in 1668, at the age of 23.

Joseph Needham called Browne “the father of the static aspect of physico-chemical embryology” (Needham, 1934 vol 1, p.112), and describes the significance of Browne’s experiments on eggs as being “quite overlooked”, particularly in his willingness to put any disputed point “to the test of ‘ocular aspection’ ” (Needham, 1931 vol 1, p.137).

☞WWW☞ 12:4

Often unsophisticated philosophers and practitioners of science pretend that science is only based upon evidence and experiment (and the modern quasi-religion of ‘evidence-based medicine’ particularly makes a fetish of it). In practice good scientists reject many experimental studies in advance because logic and reason mean they are unlikely to be successful, and topics of study are chosen (and given particular credence) because earlier authorities have particularly vouched for them as important, and such authorities are especially likely to be believed until strong evidence makes it necessary to reject them.

☞WWW☞ 12:5

The explanation of the badger's legs is given as a footnote in Wilkin’s edition of the *Works* 1852.

☞WWW☞ 12:6

Ulisse Aldrovandi¹ (1522-1605) was an Italian naturalist, who according to Gould Gould, 1997 p.210, “wrote the great compendia that pulled together all available knowledge about animals – ancient and modern, story and observation, myth and reality, human use and natural occurrence”.

In his edition of the *Works*, Wilkin (1852) reprints a long series of marginal comments from the copy of the *Vulgar Errors* owned by Dr Christopher Wren, the Dean of St. Paul’s and the father of the great architect. On the question of lobsters he writes, “This never happens [i.e. one is longer than the other], but when one is by chance wrung off, when they are young, by a bigger lobster, which growing out again, can never reach the greatness of the other: the fisherman finde this continually to be true...”

In discussing the movement of animals, Browne describes to movement of most animals as “*per diametrum*”, that is, on the diagonal, moving a front leg and the opposite side rear leg at the same time (although that in fact is not how most animals do move, see Stewart and Golubitsky (1992a). As a result he does concede that it might just about make sense to have

¹ Aldrovandus in the *Vulgar errors*.

legs of the same length as it were across the diagonal, but that there could be no sense in having legs on one side of different length to those on the other side.

As a medical student I had a friend who claimed to have had a goldfish which had a stroke and perpetually swam in a circle. Fortunately this wasn't too limiting in the bowl in which it lived. He also claimed it was a happy coincidence that the stroke was on the correct side, or it would have perpetually swam into the side of the bowl; a moment's reflection however shows that whichever side was paralysed, the fish soon have settled down into a stable circular motion.

Richard Dawkins makes the argument for symmetry in the external form of animals using the same argument: "any major departure from left/right mirror symmetry may result in the animal going round in circles when it should be pursuing the shortest distance between two points" (Dawkins, 1997 p.208-9).

WWW 12:7

A variant of the myth, which is clearly a variant of the shield theory, but has several original aspects, can be found in the web-site (www.scican.net/~ptjones/left.html) on left-handedness written by Tracy Jones, herself a left-hander:

"In the bronze age, it was believed left-handed soldiers were martyrs; this was because they couldn't possibly survive warfare, since their shield couldn't be held over their heart in battle (of course, we now know the heart is more centrally located)".

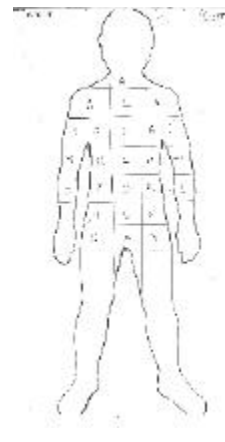
WWW 12:8

The respondents answered by pointing at a diagram in which, it must be said, the areas to the left and right are extremely small, so that the heart would be far too lateralised. The authors of the survey clearly had not thought very hard about their question since they had to admit that *none* of the areas was uniquely correct for a subsequent question about the position of the gall-bladder! The sample size overall was 299, and groups AB, C1, C2 and DE was 40,58, 74 and 125 (Edinburgh International Science Festival, 1993).

SHOW CARD B

Q2 Looking at this picture could you point out to me where you think the following parts of the body are? (PROMPT IF NECESSARY: I am interested in your thoughts even if you are not at all certain) READ OUT LIST OF PARTS OF THE BODY AND WRITE IN LETTER NEAREST TO POINT INDICATED BY RESPONDENT

- Funny bone
- Heart
- Appendix
- Spleen
- Thyroid
- Gall bladder



☞ WWW ☞ 12:9

In the end Sir Thomas Browne does recognise that really the heart is on the left, for after making several provisoes he then comments “And in these considerations must Aristotle be salved, when he affirmeth the heart of man is placed on the left side”. And to disagree with Aristotle, one of the greatest biologists of all time, is probably more than Browne could ultimately stomach.

The position of the heart was very well summarised by the anatomist Galen:

“[the heart] lies rather towards the left, since its tip unlike its base, does not lie precisely midway between the right and the left of the thorax. It is not stretched from head to tip precisely in the median line, but it bends slightly, as I have mentioned, towards the left” (Vinken, 1999 p.76).

☞ WWW ☞ 12:11

In his original description of the pain in 1772, William Heberden (1710-1801) said he chose the name angina pectoris for “the seat of it, and the sense of strangling and anxiety, with which it is attended” (Leibowitz, 1970 p.87).

William Heberden described the pain as “sometimes situated in the upper part, sometimes in the middle, sometimes at the bottom of the os sterni, and often more inclined to the left than the right side. It likewise very frequently extends from the breast to the middle of the left arm”. The Oxford Textbook of Medicine gives a more modern view that the “squeezing, crushing, gripping, band-like, choking, throttling, or ...vice-like [pain]... is typically central and symmetrical”.

Although the pain of angina and myocardial ischaemia is typically central, it can be “sometimes slightly to the left but not 'inframammary' (Henderson, 1996). I have been struggling ever since starting to write this book to find a paper, published I think in the 1970s, which asked why it was that some patients with undoubted myocardial ischaemia did indeed have pain on the left side. The conclusion was that the pain was more to the left in those patients who were most neurotic. It is an intriguing idea, and I wish I could trace the research study which looked at it.

Atypical chest pain, “is characterised by a unilateral left submammary pain, sometimes sharp in quality, which radiates up to the left shoulder and left axilla. It does not bear a close relation to effort and may be sharp in quality. It is asymmetrical and often localised to a small area in the left chest. These symptoms are rarely anginal in quality” (Swanton, 1996).

The nerves which bring sensations from deep inside our bodies are much less precisely localised than those from nearer the surface. The result is that many deep internal pains are central to start with, and only become localised as the disease begins to affect the surface of the body – an example is the pain of appendicitis, where a good diagnostician will look for a history of a severe pain in the *centre* of the abdomen which then moves after a few hours to the *right* lower corner of the abdomen.

Even if the pain after angina or a heart attack is central, that does not mean the control mechanisms are. There seems little doubt that the actions of the heart, speeding up and slowing down, are controlled far more by the right hemisphere than the left, perhaps

suggesting why strong emotional responses can indeed result in heart problems (Wittling, 1995, Wittling et al., 1998).

☞ WWW ☞ 12:12

The heart is a little to the left is by William Sloane Coffin, “a leading activist preacher”, and I merely saw it advertised in the *New York Review of Books*, where its title leapt out. From the advertiser’s blurb the book seems primarily to be concerned with left and right as a metaphor for the struggle between the religious right and the libertarian left.

☞ WWW ☞ 12:13

Hair whorling has often been suggested to be related to twinning (Lauterbach, 1925; Newman, Freeman, & Holzinger, 1966); there are also suggestions that in singletons that the side of the hair whorl is related to right and left handedness (de Zarate & de Zarate, 1991; Friedman, Golomb, & Mora, 1952). For an exceptionally lax definition of mirror-imaging see Golbin *et al* (1993a). Facial and dental mirror-imaging have been reported by Townsend *et al* (1986a). The term has also been applied to differences in cerebral organisation (Sommer et al., 1999). It is possible that ectodermal mirror-imaging does occur, but it seems nothing to do with handedness. An example of what has been called “chiral twins, the rarest kind” is the physicist and science fiction novelist, Gregory Benford, and his brother Jim (Mercola & Levin, 2001: “Greg is right-handed whereas Jim is left-handed, they have birth marks on opposite cheeks, and their peppered gray hair spirals in opposite directions”).

The theory of mirror imaging in twins was probably first enunciated clearly by Newman (1966 pp.185-189).

A comparison of identical twins with a common placenta, amnion and chorion, a common placenta and chorion but separate amnions, or separate amnion, chorion and placentas finds no difference in the rate of left-handedness or of ‘mirror-imaging’, suggesting that discordance in identical twins is nothing to do with the process of splitting, and hence with mirror-imaging (Carlier et al., 1996; Derom et al., 1996).

The meta-analysis of Sicotte *et al* (1999a) found no evidence at all for a higher rate of left-handedness in identical than non-identical twins. They did find a higher rate of concordance (R-R and L-L pairs), but that can still occur even though the rate of left-handedness is the same in the two types of twin.

Strictly the meta-analysis of handedness in MZ and DZ twins is only the end of the line for the mirror-imaging theory of handedness. It is possible that mirror-imaging occurs for situs, for teeth, hair whorls, or whatever, but no study has ever produced any convincing statistics. The only solid epidemiological data on situs inversus could find no association with twinning rates (Torgersen, 1950). However until someone who believes in mirror-imaging produces some convincing statistics then it seems difficult to believe in it, particularly since it makes little biological sense, except in the very unusual case of conjoined twins (Levin et al., 1996).

☞WWW☞ 12:14

Aristotle's ideas can be found in Peck (1953, 717.a.34, 788.a.10). The theory that the testicles act as weights explains castration as working because the removal of the weights closes the internal ducts. That a castrated bull may fertilise a female for a few days after castration was attributed to a delay in the ducts closing off (instead of to the inevitable storage of semen in the seminal vesicles for a few days or weeks). An identical theory was also held by Giles of Rome (Hewson, 1975 p.91). The role of the seminal vesicles was correctly appreciated by Sir Thomas Browne (Wilkin, 1852, *Vulgar Errors* IV, v). Aristotle's theory was part of a broader theory of right and left in biological systems, and he proposed that it was the right side which initiated movement (*De Inc. An.*, 705.b.14; 705.b.30; 706.b.5), which was warmer and less watery than the left (*De Part. An.*, 493.b.19.), and also the stronger (*Hist. An.*, 493.b.19.) For more details see McManus (1979).

☞WWW☞ 12:15

The 2001 articles in *The Observer* and *The Guardian* were based on an article by Ellis and Engh (2000), published several months earlier in the previous year. Although widely reported as showing that left-handers die earlier than right-handers, in fact the overall difference between right and left-handers was non-significant (p.562). The differences only emerged when individuals were classified on a five-point scale from 'extremely right-handed', though 'generally right-handed', 'Ambidextrous', 'generally left-handed' and 'extremely left-handed', the difference in age at death being entirely restricted to the 'generally left-handed' group. Since however this is not a self-rating but a description by a relative, its validity must be somewhat in doubt. Unfortunately the study also, despite having data on the age of *living* relatives, chose only to describe dead ones, thereby suffering from the usual statistical artefact.

Coren and Halpern (1988a) found statistical significance only when they used a rather peculiar test called the Kolmogorov-Smirnov test. However a conventional analysis of their data using a standard t-test finds no difference at all in the average age at death.

The California study (Halpern & Coren, 1991). was carried out by phoning the relatives of people in California who were known to have died recently and asking them about the deceased person's handedness.

The problems of death cohorts is surprisingly common in the medical literature, and can be found in a range of situations, as for instance in claims that women doctors die younger than male doctors (McManus, 1995) or that anaesthetists die younger than other doctors (McManus, 1997a). Both cases are actually due to the fact that in general women doctors or anaesthetists are on average younger than other doctors (McManus, 1997b), women only having entered medical school in large numbers relatively recently, and anaesthetics being a young speciality.

There are several large scale studies of populations which have assessed the Coren-Halpern hypothesis, and in all of them there is either no evidence at all for a decreased longevity of left-handers (Ellis et al., 1998a; Ellis et al., 1998b; Fudin et al., 1993; Hugdahl et al., 1993; Marks & Williamson, 1991; Stellman, Muscat, & Wynder, 1993; Wolf, D'Agostino, & Cobb, 1991) or else there is some evidence but it is at a different age or otherwise does not replicate

the findings of Coren and Halpern (Aggleton, Kentridge, & Neave, 1993). For a critical review of the literature see Harris (Harris, 1993a; Harris, 1993b), and a reply by Halpern and Coren (Halpern & Coren, 1993).

☞ WWW ☞ 12:18

The meta-analysis of the immune data is quite technical, and readers are referred to the original analysis (Bryden, McManus, & Bulman-Fleming, 1994a). Although there was a very small positive association overall (odds ratio = 1.06, $p < .05$) that did not take into account the likely effects of publication bias which would have resulted in more positive than negative results being published. A more detailed analysis also found that although three conditions did seem to show significant positive associations ('Allergies', 'Asthma', 'Ulcerative colitis / Crohn's disease'), there were also two conditions which showed significant negative associations ('Arthritis', 'myasthenia gravis'). On balance the conclusion has to be that there is no overall support for a simple version of the Geschwind theory. See however the many commentaries on our paper in *Brain and Cognition*, and our replies (Bryden, McManus, & Bulman-Fleming, 1994b; Bryden, McManus, & Bulman-Fleming, 1995).

☞ WWW ☞ 12:19

A variant on the theory of Neanderthal's being left-handed is that they were ambidextrous (de Kay, 1994 pp.28-32), although the provenance suggests this is probably another myth caught in the process of creation.

Stan Gooch's theory still has its followers, as seen for instance in an article in *The Times* in 2001 (Howard, 2001).

☞ WWW ☞ 12:23

The claim is often made that Mensa members are more likely to be left-handed (e.g. Clarke (1993 p.3) and Perelle & Ehrman (1993b)).

The original research on handedness and intelligence was published in the *Mensa Research Journal* (see Perelle & Ehrman, 1982) and found 20% of members were “non-righthanders”. A replication (Storfer, 1995) found that 11.4% of male and 10.5% of female members were left-handed, which does not differ from population estimates. The possibility that left-handers may have different patterns of intellectual ability has been put forward particularly by Benbow (1986b), although a subsequent review of the field by O'Boyle and Benbow (1990 p.364) concluded that,

“the findings ... have a distinctly piece-meal flavour to them ... To is, it seemed that for each piece of data confirming a relationship between hand preference and a corresponding ability or talent, there appeared to be at least one other result that ... failed to replicate the original finding ...[or] postulated some new ... variable to moderate the connection ... or ... flatly contradicted the notion that any such relationship existed”.

Peters (1992b) came to a similar conclusion. The most recent large study to be thrown into the melting pot on this issue is that of Halpern *et al* (1998a) who looked at 174,000 applicants to US medical schools and found the left-handers had a higher verbal reasoning score (but not higher scores on writing, biological or physical sciences). They also found that left-handers were more likely to be accepted at medical school, a phenomenon I have never found any

evidence for in our UK studies (McManus et al., 1995; McManus & Richards, 1984; McManus, Richards, & Maitlis, 1989).

The two large scale population studies of handedness and intelligence are by Hardyck *et al* (1976), and McManus and Mascie-Taylor (1983). see also McManus *et al* (1993c).

There is no doubt that at the very bottom end of the distribution of intellectual ability left-handedness is associated with serious mental retardation (Pipe, 1990). The causal relation is probably that the disruption of early brain development both causes impaired cerebral functioning and an increased rate of left-handedness due to pathological factors. In other words these individuals are not of low intellectual ability *because* they are left-handed. It is a similar process to that by which almost any biological stressor causes an increased incidence of *situs inversus* (Wehrmaker, 1969).

☞ WWW ☞ 12:24

The results of the survey of dot.com directors is unlikely to be statistically significant since there were only 101 directors in the survey overall (Cassy, 2000).

The finding of an increased rate of left-handers in architects (Peterson & Lansky, 1974) was also found in another relatively small study (Gotestam, 1990); however it failed to replicate in the larger study of Wood and Aggleton (1991a).

☞ WWW ☞ 12:26

I looked at seventeen different web-sites devoted to handedness that I found via www.google.com, using the search terms “famous left handers”. Only one artist was included on all of the lists, Leonardo. All but one site included Picasso in its list. Although lists often claimed things such as “Left-handed dominance is very common among artists, particularly painters”, a total of only fifteen artists was actually mentioned on any of the lists. Given the hundreds, probably thousands, of separate artists to be found in any decent art library, it is probably more correct to follow the list which admits, “There are not many left-handed artists, but several are world famous” (www.baylorhealth.com/proceedings/12_4/12_4_flatt.htm). That said, several on this list certainly do not fit my concept of “world famous”. The artists named are:

Leonardo	17
Picasso	16
Michelangelo	14
Raphael	10
Paul Klee	8
Holbein	7
Escher	5
Durer	2
Ronald Searle	2
Sebastiano del Piombo	2
Raoul Dufy	1
Edwin Landseer	1
LeRoy Neiman	1
Milton Caniff	1
Bill Maudlin	1

I have not attempted to check all of these, but I should say that there is clear photographic evidence that Paul Klee painted with his left hand (Güse, 1991; Klee, 1970; Lanchner, 1987), and that I am not convinced from the hatch marks in the drawings of Sebastiano del Piombo that he was left-handed (Hirst, 1981).

Picasso is also included on web-sites about handedness produced by academics where he is included in the lists of famous left-handers (e.g. www.indiana.edu/~primate/left.html, and duke.usask.ca/~elias/left/famous.htm).

Popular books for left-handers also claim that Picasso was left-handed (Paul, 1990 p.14; Langford, 1984 p.100; Fincher, 1977 p.27; Lindsay, 1980 p.5), and the idea is also repeated in books for teachers on teaching the left-handed (Clarke, 1993 p.3; Paul 1993d has photographs of both Picasso and Einstein on its cover). Picasso features also in scholarly books produced by academics, as for instance in Richard Gregory's *Mirrors in mind* (Gregory, 1998c), in an article by the psychiatrist Pierre Flor-Henry who cites Picasso as one of the many geniuses who are left-handed (Flor-Henry, 1991 p.416), by Csikszentmihalyi (1998b), who mentions Picasso as being left-handed, and by Stan Coren who mentions Picasso's left-handedness on at least two occasions (Halpern & Coren, 1990, Coren, 1992 p.52).

"No artist has been photographed as abundantly and as often as Picasso". (Bernadac, 1991). Photographs of Picasso carrying out the various activities can be found in a range of books: Baldassari, 1997; Bernadac, 1991; Bozo et al., 1986; Daix, 1993; Duncan, 1958; Duncan, 1996; Jardot, 1959; Penrose, 1971; Rubin, 1980:

In his studio in Clichy, 1901, Bozo et al, 1986 p.273.

Self-portrait with a palette, in oils, palette in left hand, 1906, Rubin, 1980 p.79

Painting Guernica, 1937, Bozo et al, 1986 p.289

In studio in Antibes, 1946, Bozo et al, 1986 p.294

Filming of *le mystere Picasso* by Clouzot, 1955, Bozo et al, 1986 p.301; see also Penrose, 1971 fig 224
 Writing signature, Antibes, 1957, Penrose, 1971 fig 219
 Drawing in sketchbook, 1957, Duncan, 1958
 Cutting out clay pattern of fish, 1957, Duncan, 1958
 Painting on ceramic dish, 1957, Duncan, 1958
 Shooting revolver, 1957, Duncan, 1958
 Painting on sculpture, 1957, Duncan, 1958
 Holding skipping rope, 1957, Duncan, 1958
 Scratching on slides, 1967, Baldassari, 1997

In passing it is also worth noting for the record that we also have photographs showing that Picasso was also right-eye dominant (Duncan, 1958), but that he crossed his left arm over his right arm (e.g. Bernadac, 1991), and crossed his left leg over his right. Arm-folding in general does not correlate with handedness and is not a marker of left-handedness (McManus & Mascie-Taylor, 1979).

WWW 12:27

In *Drawing with the right side of the brain*, Picasso's ability is of course attributed to his being left-handed and hence using the right side of the brain to draw. Picasso is also quoted on p.74 (Edwards, 1989) as saying "Painting is a lie that tells the truth". That is probably so. But that Picasso was a left-hander is a lie with no truth.

WWW 12:28

Interestingly although Picasso is included in the de Kay's later *The natural superiority of the left-hander* of 1979, he is not included in *The world's greatest left-handers* of 1985 (de Kay, 1994).

Many photographs can be found of Bob Dylan playing guitar right-handed (Sandson, Wen, & LeMay, 1992), and there is also a photograph of him playing table tennis backstage, with the bat held clearly in his right hand (Gross & Alexander, 1978).

WWW 12:29

There are several books with pictures of Einstein writing at a blackboard using his right hand or writing on a note pad with his right hand. In one book there is a picture of him writing with his left hand at a blackboard but all of the writing is in mirror image, and the same picture occurs in other books with normal writing. Witelson *et al* (1999b) suggest that "There is evidence to suggest that Einstein was not consistently right-handed", and cite Winokur (1984). However in that book the only activity Einstein does with his left hand is to hold his pipe, a non-skilled activity, like holding a cigarette, that many right-handers do with their left-hand. In the three pictures in which he is writing he uses the right hand, he stands in front of a blackboard in one picture holding chalk in his right hand, and in the two pictures of him lighting his pipe the match is held in the right hand. The Winokur book does show that Einstein clasped his hands with his left thumb on top, but that is irrelevant to his handedness since hand-clasping is unrelated to handedness (McManus & Mascie-Taylor, 1979).

One of the few books to note that there is precious little evidence that Einstein was left-handed is Rutledge and Donley (1992 p.30), who accept that most of the evidence is very indirect, usually being based on claims that Einstein learned to read and write at a late age. They do claim that Einstein was left-eye dominant, there apparently being photographs of him looking through telescopes and microscopes with his left eye, but since 20% of right-handers are left-eye dominant, that is hardly compelling evidence for left-handedness. Either way, it didn't stop his publishers putting Einstein along with Benjamin Franklin and the usual suspects on the cover of the book.

☞ WWW ☞ 12:30

I have looked in the earlier popular books on handedness and the only one in which I can find a reference to Franklin is Wile 1934 pp. 356-7, who quotes the *Petition* in its entirety but makes no suggestion that Franklin was left-handed.

References to Franklin's left-handed are found, once again, by de Kay 1994 in *The Natural Superiority of the Left-hander* (1979), and in *The world's greatest left-handers* (1985), where he spins an elaborate story about Franklin's left-handedness helping him as a printer because he could read mirror-script more easily. An academic who claims Franklin is left-handed is Coren (1992 p.280). A recent occurrence of a left-handed Franklin is on the cover of *The left-handers 2001 desk calendar*, which offers "365 days of left-handed legends, lore and more" – but mostly legends, it would seem..

Not all authors do claim that Franklin was left-handed, and in particular Barsley. wrote, "The American genius Benjamin Franklin was *not* himself a left-hander" (my emphasis), but gives no reasons for saying it, although his books are generally well-researched. Barsley argues that the *Petition of the left hand* was "a serious attempt to recommend ambidexterity to the teaching profession" (Barsley, 1970 p.85; Barsley, 1966 p.129). It is however more than possible that Franklin simply liked a practical joke. Certainly the *Petition of the left hand* was not Franklin's first of its genre, for eleven years earlier in 1768 he published in *The Tatler* a *Petition of the letter Z* (Bigelow, 1887vol IV), addressed to the Censor-General, taking up the case of the letter Z, which is "of as high extraction and has as good an estate as any other letter of the Alphabet", and pointing out that "there is therefore no reason why he should be treated as he is, with disrespect...". The *Petition* ends with a prayer, unsuccessful, "that the Alphabet may by your censorial authority be reversed...".

It should also be said that I can find no reference to Franklin being left-handed in Clark's biography (Clark, 1983), and it seems unlikely that he would have omitted it if there were solid evidence to support it.

The portrait of Franklin by Chambertin was painted while Franklin was in London in 1762. Chambertin had "a reputation for accurate likenesses". A very popular mezzotint was also made from the portrait by Edward Fisher, and it also shows Franklin as right-handed (and the artist must therefore have reversed the portrait during its production; Labaree et al., 1966 p.xv). Franklin himself commented on the Chambertin portrait (Van Doren, 1939 p.431), and if it were inaccurate it is unlikely it would have been reproduced and distributed by the Franklin family.

Lindsay's later book, *Left is right: the survival guide for living lefty in a right-handed world* (1996), which looks like a different book but actually bears an uncanny overlap with the earlier *The left-handed book* (1980), repeats the old stories about Franklin being left-handed but this time does *not* show the Chambertin portrait. Perhaps a covert admission that the original was in error?

☞WWW☞ 12:34

The modern popularity of the question probably stems to a large part from David Feldman's book called *Why do clocks run clockwise? and other imponderables* (Feldman, 1987). The answer is a mere eight lines long and tells the standard story about sundials. It is attributed to Henry Fried, an American horologist, but I have not been able to find where it was published. A much earlier comment on the problem is due to Mach (1914 p.338) who comments in a footnote that, "By the direction in which its hands move the watch proclaims its descent from the sundial and its discovery in the northern hemisphere".

The answer quoted by the New Scientist reader was submitted to *New Scientist's Last Word* column by Mike Thomson of Cardiff (*New Scientist*, 24th April 1999). He is far from alone in proposing this explanation of the clockwise direction of clocks.

☞WWW☞ 12:35

Although it is generally assumed that early clocks were mostly large public clocks, Landes (2000 p.83) points out that some horologists think that small domestic clocks would also have been made but that it is only the larger clocks which have survived.

Details of the Queens' College sundial can be found at www.quns.cam.ac.uk/Queens/Misc/Dial.htm, and in Scarr (1988b). Should you still doubt that vertical sundials go anti-clockwise then you can get an interactive view of the new vertical sundial in Foundress Court of Pembroke College, Cambridge. (www.uk.research.att.com/sundial). If the British weather allows you then two observations an hour or two apart should easily show the movement of the shadow.

☞WWW☞ 12:36

In his *Italian Journey* in September 1786, Goethe (1970pp. 59-61) describes the complex calculations he went through to use the *hora italica*, which is more confusing than it seems at first sight, since the hour of sunset varies throughout the year, and hence midnight is not at a fixed numerical time.

A further unusual feature of Uccello's clock is that the numerals on the left-hand side, such as XVIII are upside down. Nowadays they would be one way up on the right hand side and the other way up on the left hand side, so that both seemed approximately upright when viewed from a normal position. This may reflect the fact that some early clocks did not have a fixed dial and rotating hands, but instead a fixed hand or pointer and a rotating dial. If Uccello had been copying such a dial then it would make sense for all the numbers to be in the same relation to the one before, so that they were the correct way up as they went past the pointer. However even if the dial in the Botticelli clock did rotate in such a fashion, there is of course no way the one painted in fresco on the wall of the cathedral could do so. An

additional problem of interpretation, as Christine Pleines pointed out to me, is that even though the numbers on a rotating dial are ordered in an anti-clockwise direction, the dial itself would in fact rotate clockwise.

I cannot help noting that I found an illustration of Ucello's clock on an Australian web-site (www.uq.net.au/iacobus/uccello/clock.html) devoted to the artist. However it had been mirror reversed, so that the clock went clockwise. I can only presume that the person setting up the site thought that the anti-clockwise image had itself been inadvertently reversed and corrected the supposed error.

☞WWW☞ 12:37

The church of Ognissanti was damaged by flooding in the 1960s and as a result Botticello's fresco has been moved to the convent next door. For a detailed picture of the clock see Bo and Mandel (1978 Plate XXV). Lightbown (1989 p.76) points out that the time on the clock is exactly sunset, which is corroborated by the angle of the golden light in the scene.

Illustrations of all of the types of clock mentioned can be found in Simoni (1965).

☞WWW☞ 12:38

For details of the process of lock-in see the articles by Arthur (1990a, 1989, 1988c). Arthur explicitly uses the example of Ucello's clock:

“When Paolo Ucello designed the clock in 1443, a convention for clockfaces had not emerged. Competing designs were subject to increasing returns: the more clockfaces of one kind were built, the more people became used to reading them. Hence it was more likely that future clockfaces would be of the same kind. After 1550, ‘clockwise’ designs displaying only 12 hours had crowded out other designs.” Arthur, 1990a p.82.

No references are given to support this claim. The claim about stabilisation by 1550 is probably correct for the clockwise direction, but not for clocks with 12 hours displayed (Simoni, 1965).

It has often been noted that with regard to video-tape formats, BetaMax was undoubtedly superior technically to VHS, but VHS won hands down. Victory does not always go to the best. In the long run both however will inevitably be replaced by DVD.

The problem for the ants is that the pheromone trail laid down is too permanent (Bonabeau, Dorigo, & Theraulaz, 2000). As a result computer algorithms for numerical optimisation which simulate the process lay a virtual pheromone trail which ‘evaporates’ to prevent the system getting stuck in early solutions.

☞WWW☞ 12:39

The date of the earliest clock is still not clear, but Landes (2000 p.9) cites the paper by Thorndike (1941) which suggests that a mechanical clock was in existence by 1271. It would seem that this early clock was conceived to have a wheel that would rotate once in twenty

four hours (“between sunrise and sunrise”), rather than our current system of rotating in twelve hours, and hence twice very day. The system of having twelve hours on a clock or watch is, the more one thinks of it, extremely strange, and if it were not that we are all totally immersed in it almost from birth, it would surely cry out for an explanation.

☞WWW☞ 12:40

Although not reported in the original paper (Price & Gilden, 2000), the authors also found the interesting result that the bias was identical in right and left-handers (D M Gilden, personal communication, 2000).

☞WWW☞ 12:41

I have based most of this account on the very clear descriptions provided by Martin Gardner (1990b) in his book *The Ambidextrous Universe* and by Richard Gregory (1998c) in his book *Mirrors in Mind*. I find myself entirely convinced by Gardner’s account. Gardner however regards an earlier account of Gregory’s as “confusing” (p.22 of revised edition), and Gregory is equally critical of Gardner (Gregory, 1998c pp. 98-99). My personal view is that Gardner is correct about the nature of the *optical* problem, whereas Gregory understands that there is also a *psychological* problem which he accounts for satisfactorily. Maddox (1991b) has also stressed the separation of physics and psychology, of “the reflection of light in mirrors and what observers construe of the images they see”.

I have purposely been a little vague when talking about buttons on clothes as there is a bizarre difference between men's and women's clothes. Buttons on men's clothes are held in the right hand, while the 'hole' is held in the left hand; for women it is the opposite. Quite why this is so has been speculated on many times. The most prevalent theory says that buttons are easier for right handers to do up if they hold the fiddly little bit, the button, in their more skilled hand, the right – again the principle that the left hand *holds* while the right hand *does*. That women’s clothes are the other way around is said to be that in Victorian times the majority of women with large numbers of buttons would have someone to dress them, and therefore the design was reversed. Whether there is historical evidence for this I am not clear, and neither whether it shows any cross-cultural uniformity. It would benefit from systematic research.

For a recent cultural history of mirrors, their origins and their meanings see Melchior-Bonnet (2001).

☞WWW☞ 12:43

Notice that the image in the mirror is not a real image, since it could not be projected onto a screen. Instead it is a virtual image, one that *looks* as if it exists. It occurs because the divergent rays of light are focussed onto the retina of the eye by the lens in the eye. When light entering the eye has actually bounced off several objects then the brain cannot tell where it is has truly come from and instead simply ‘projects’ its origin back to where it would have come from if it had always been travelling in a straight line. The dotted lines in the figure show the backward projections of the lines of light entering the eye, behind the mirror, from where they seem to come.

WWW 12:45

The mirror problem also shows the difficulty in trying to describe the world relative to ourselves. As we saw earlier, left and right look different from the point of view of different people – and hence the audience’s left and right in a theatre is not the same as the actor’s ‘stage right’ and ‘stage left’. The actors have turned around through 180 degrees relative to the audience so that you can see them and they can see you – for otherwise the play would be a bit difficult to understand. But left and right as descriptions can then be very confusing.

WWW 12:46

Although two simple mirrors at right angles is the easiest way to make such a mirror, any curved *concave* mirror (i.e. one that is bent inwards upon itself) has the same property, as was recognised by both Plato and Lucretius.

A further variant of this situation is seen in the ‘mirror’ that we can produce by pointing a video-camera at our self and then looking at our image on a monitor screen. This system behaves exactly like the double mirror system. When we wave our right hand at the figure on the TV screen that figure waves their right hand back at us. What has happened here is that in order to see ourselves on the monitor we have had to rotate the camera through 180 degrees relative to ourselves – the camera’s right hand side is on our lefthand side, and so on. So the system has done a double reversal and everything seems back to normal².

WWW 12:48

The three-mirror situation is intriguing. If you look directly at just one wall, front and back will be reversed and the image will be mirror-reversed. If you now look directly into the join of the walls, front-back and right-left are reversed, and the result is an image in the correct orientation. If you now look into the corner of the room where all three mirrors meet at right angles, you will again see a mirror-image reversal; one mirror reverses front-back, a second right-left and the third top-bottom, resulting in a mirror-image object (which is also upside down).

² There is actually a series of reversals here, because the lens of the camera reverses left and right (but also top and bottom), and the monitor has also been turned around from the direction of the camera.

References

- Aggleton, J. P., Kentridge, R. W., & Neave, N. J. 1993, "Evidence for longevity differences between left handed and right handed men: an archival study of cricketers", *Journal of Epidemiology and Community Health*, **47**, 206-209.
- Arthur, W. B. 1988c, "Self-reinforcing mechanisms in economics," pp. 9-31 in *The economy as a complex evolving system*, P. W. Anderson, K. J. Arrow, & D. Pines, eds., New York: Addison-Wesley.
- Arthur, W. B. 1989, "Competing technologies, increasing returns, and lock-in by historical events", *Economic Journal*, **99**, 116-131.
- Arthur, W. B. 1990a, "Positive feedbacks in the economy", *Scientific American*, **262 (February)**, 80-85.
- Baldassari, A. 1997, *Picasso and photography: The dark mirror*, Paris: Flammarion.
- Barrett, P. H., Gautrey, P. J., Herbert, S., Kohn, D., & Smith, S. 1987, *Charles Darwin's Notebooks, 1836-1844*, Cambridge: Cambridge University Press.
- Barsley, M. 1966, *The left-handed book: An investigation into the sinister history of left-handedness*, London: Souvenir Press.
- Barsley, M. 1970, *Left-handed man in a right-handed world*, London: Pitman.
- Benbow, C. P. 1986b, "Psychological correlates of extreme intellectual precocity", *Neuropsychologia*, **24**, 719-725.
- Bennett, J. 1962, *Sir Thomas Browne*, Cambridge: Cambridge University Press.
- Bernadac, M.-L. 1991, *Faces of Picasso*, Paris: Editions de la Réunion des Musées Nationaux.
- Bigelow, J. 1887, *The complete works of Benjamin Franklin*, New York: G P Putnam's Sons.
- Bo, C. & Mandel, G. 1978, *L'opera completa del Botticelli*, Milan: Rizzoli Editore.
- Bonabeau, E., Dorigo, M., & Theraulaz, G. 2000, "Inspiration for optimisation from social insect behaviour", *Nature*, **406**, 39-42.
- Bozo, D., Besnard-Bernadac, M.-L., Richet, M., Seckel, H., & Marceillac, L. 1986, *The Musée Picasso, Paris: Paintings, papiers collés, picture reliefs, sculptures, ceramics*, London: Thames and Hudson.
- Bryden, M. P., McManus, I. C., & Bulman-Fleming, M. B. 1994a, "Evaluating the empirical support for the Geschwind-Behan-Galaburda model of cerebral lateralization", *Brain and Cognition*, **26**, 103-167.
- Bryden, M. P., McManus, I. C., & Bulman-Fleming, M. B. 1994b, "GBG, BMB, R&L, X&Y ... Reply to commentaries", *Brain and Cognition*, **26**, 312-326.
- Bryden, M. P., McManus, I. C., & Bulman-Fleming, M. B. 1995, "GBG, hormones, genes, and anomalous dominance: A reply to commentaries", *Brain and Cognition*, **27**, 94-97.
- Carrier, M., Spitz, E., Vacher-Lavenu, M. C., Villegier, P., Martin, B., & Michel, F. 1996, "Manual Performance and Laterality in Twins of Known Chorion Type", *Behavior Genetics*, **26**, 409-417.
- Cassy, J. 2000, "Dot.com directors hang on to their suits", *Guardian*, **August 31st**, 22-22.

- Clark, R. W. 1983, *Benjamin Franklin: A biography*, London: Weidenfeld and Nicolson.
- Clarke, G. 1993, *Left-handed children: The teacher's guide*, London: Left-Handers Club.
- Coren, S. 1992, *The left-hander syndrome: the causes and consequences of left-handedness*, London: John Murray.
- Csikszentmihalyi, M. 1998b, "Creativity and genius: A systems perspective," pp. 39-64 in *Genius and the mind: Studies of creativity and temperament*, A. Steptoe, ed., Oxford: Oxford University Press.
- Daix, P. 1993, *Picasso: Life and art*, London: Icon Editions.
- Dawkins, R. 1997, *Climbing Mount Improbable*, London: Penguin Books.
- de Kay, J. T. 1994, *The left-hander's handbook (incorporating The left-handed book, 1966; The natural superiority of the left-hander, 1979; The world's greatest left-handers, 1985, and Left-handed kids, 1989)*, New York: Quality Paperback Book Club.
- de Rocher, G. D. T. 1989, *Popular Errors; Laurent Joubert*, Tuscaloosa: University of Alabama Press.
- de Zarate, J. C. O. & de Zarate, C. O. O. 1991, "Hair whorl and handedness", *Brain and Cognition*, **16**, 228-230.
- Derom, C., Thiery, E., Vlietinck, R., Loos, R., & Derom, R. 1996, "Handedness in Twins According to Zygosity and Chorion Type: A Preliminary Report", *Behavior Genetics*, **4**, 407-417.
- Duncan, D. D. 1958, *The private world of Pablo Picasso*, New York: Ridge Press.
- Duncan, D. D. 1996, *Picasso paints a portrait*, New York: Harry N Abrams.
- Edinburgh International Science Festival 1993, *How much do Scots know about their own bodies? A survey on public awareness of the body*, Edinburgh: News Release, 1st Feb 1993.
- Edwards, B. 1989, *Drawing on the right side of the brain: A course in enhancing creativity and artistic confidence. Revised edition*, New York: Perigee Books.
- Ellis, L. & Engh, T. 2000, "Handedness and age at death: New evidence on a puzzling relationship", *Journal of Health Psychology*, **5**, 561-565.
- Ellis, P. J., Marshall, E., Windridge, C., Jones, S., & Ellis, S. J. 1998a, "Left-handedness and premature death", *Lancet*, **351**, 1634-1634.
- Ellis, S. J., Ellis, P. J., Marshall, E., Windridge, C., & Jones, S. 1998b, "Is forced dextrality an explanation for the fall in the prevalence of sinistrality with age? A study in northern England", *Journal of Epidemiology and Community Health*, **52**, 41-44.
- Feldman, D. 1987, *Why do clocks run clockwise? and other imponderables*, New York: Harper and Row.
- Fincher, J. 1977, *Sinister people: The looking-glass world of the left-hander*, New York: G P Putnam's Sons.
- Flor-Henry, P. 1991, "Sinistrality and psychopathology," pp. 415-440 in *Left-handedness: Behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.
- Friedman, J. H., Golomb, J., & Mora, M. N. 1952, "The hair whorl sign for handedness", *Diseases of the Nervous System*, **13**, 208-216.
- Fudin, R., Renninger, L., Lembessis, E., & Hirshon, J. 1993, "Sinistrality and reduced longevity: Reichler's (1979) data on baseball players do not indicate a relationship", *Perceptual and Motor Skills*, **76**, 171-182.
- Gardner, M. 1990b, *The new ambidextrous universe: revised edition*, New York: W H Freeman.

- Goethe, J. W. 1970, *Italian Journey*, translated by W.H. Auden and Elizabeth Mayer, London: Penguin.
- Golbin, A., Golbin, Y., Keith, L., & Keith, D. 1993a, "Mirror imaging in twins: biological polarization - an evolving hypothesis", *Acta Genet Med Gemellol*, **42**, 237-243.
- Gotestam, K. O. 1990, "Lefthandedness among students of architecture and music", *Perceptual and Motor Skills*, **70**, 1323-1327.
- Gould, S. J. 1997, *Dinosaur in a haystack: Reflections in natural history*, London: Penguin Books.
- Gregory, R. 1998c, *Mirrors in mind*, London: Penguin Books.
- Gross, M. & Alexander, R. 1978, *Bob Dylan: An illustrated history*, London: Elm Tree Books.
- Güse, E.-G. 1991, *Paul Klee: dialogue with nature*, Munich: Prestel.
- Halpern, D. F. & Coren, S. 1988a, "Do right-handers live longer?", *Nature*, **333**, 213-213.
- Halpern, D. F. & Coren, S. 1990, "Laterality and longevity: is left-handedness associated with a younger age at death?," pp. 509-545 in *Left-handedness: Behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.
- Halpern, D. F. & Coren, S. 1991, "Handedness and life span", *New England Journal of Medicine*, **324**, 998-998.
- Halpern, D. F. & Coren, S. 1993, "Left-handedness and life span: a reply to Harris", *Psychological Bulletin*, **114**, 235-241.
- Halpern, D. F., Haviland, M. G., & Killian, C. D. 1998a, "Handedness and sex differences in intelligence: Evidence from the Medical College Admission Test", *Brain and Cognition*, **38**, 87-101.
- Hardyck, C., Petrinovich, L. F., & Goldman, R. D. 1976, "Left-handedness and cognitive deficit", *Cortex*, **12**, 266-279.
- Harris, L. J. 1993a, "Do left-handers die sooner than right-handers? Commentary on Coren and Halpern's (1991) 'Left-handedness: A marker for decreased survival fitness'", *Psychological Bulletin*, **114**, 203-234.
- Harris, L. J. 1993b, "Reply to Halpern and Coren", *Psychological Bulletin*, **114**, 242-247.
- Henderson, A. H. 1996, "Chest pain," pp. 2165-2169 in *Oxford textbook of medicine*, 3 edn, D. J. Weatherall, J. G. G. Ledingham, & D. A. Warrell, eds., Oxford: Oxford University Press.
- Hewson, M. A. 1975, *Giles of Rome and the mediaeval theory of conception*, London: Athlone Press.
- Hirst, M. 1981, *Sebastiano del Piombo*, Oxford: Clarendon Press.
- Howard, P. 2001, "Neanderthal revolutionary or Cro-Magnon fascist, on your head be it", *The Times*, **20th July**, 20-20.
- Hugdahl, K., Satz, P., Mitrushina, M., & Miller, E. N. 1993, "Left-handedness and old age: Do left-handers die earlier?", *Neuropsychologia*, **31**, 325-333.
- Jardot, M. 1959, *Pablo Picasso: Drawings*, New York: Harry N Abrams.
- Klee, P. 1970, *Unendliche Naturgeschichte*, Basel: Schwabe.
- Labaree, L. W., Boatfield, H. C., Fineman, H. H., & Hutson, J. H. 1966, *The papers of Benjamin Franklin: volume 10, January 1, 1762, through December 31, 1763*, New Haven: Yale University Press.
- Lanchner, C. 1987, *Paul Klee*, New York: Museum of Modern Art.

- Landes, D. S. 2000, *Revolution in time: Clocks and the making of the modern world*, London: Viking.
- Langford, S. 1984, *The left-handed book*, London: Granada Publishing.
- Lauterbach, C. E. 1925, "Studies in twin resemblance", *Genetics*, **10**, 525-568.
- Leibowitz, J. O. 1970, *The history of coronary heart disease*, London: Wellcome Institute of the History of Medicine.
- Levin, M., Roberts, D. J., Holmes, L. B., & Tabin, C. 1996, "Laterality defects in conjoined twins", *Nature*, **384**, 321-321.
- Lightbown, R. 1989, *Sandro Botticelli: Life and work*, London: Thames and Hudson.
- Lindsay, R. 1980, *The left-handed book*, New York: Franklin Watts.
- Lindsay, R. 1996, *Left is right: The survival guide for living lefty in a right-handed world*, Englewood Cliffs, NJ: Gilmour House.
- Mach, E. 1914, *The analysis of sensations*, 5 edn, Chicago: Open Court.
- Maddox, J. 1991b, "The semantics of plane-mirror inversion", *Nature*, **353**, 791-791.
- Marks, J. S. & Williamson, D. F. 1991, "Left-handedness and life expectancy", *New England Journal of Medicine*, **325**, 1042-1042.
- McManus, I. C. 1979, *Determinants of laterality in man*, University of Cambridge: Unpublished PhD thesis.
- McManus, I. C. 1995, "Increased mortality in women doctors [letter]", *Lancet*, **345**, 796-797.
- McManus, I. C. 1997b, "Anaesthetists are younger than other doctors [letter]", *British Medical Journal*, **315**, 314-314.
- McManus, I. C. 1997a, "Which doctors die first? Recording the doctors' sex might have led authors to suspect their conclusions [correspondence]", *British Medical Journal*, **314**, 1132-1132.
- McManus, I. C. & Mascie-Taylor, C. G. N. 1979, "Hand-clasping and arm-folding: a review and a genetic model", *Annals of Human Biology*, **6**, 527-558.
- McManus, I. C. & Mascie-Taylor, C. G. N. 1983, "Biosocial correlates of cognitive abilities", *Journal of Biosocial Science*, **15**, 289-306.
- McManus, I. C. & Richards, P. 1984, "An audit of admission to medical school: 1. Acceptances and rejects", *British Medical Journal*, **289**, 1201-1204.
- McManus, I. C., Richards, P., & Maitlis, S. L. 1989, "Prospective study of the disadvantage of people from ethnic minority groups applying to medical schools in the United Kingdom", *British Medical Journal*, **298**, 723-726.
- McManus, I. C., Richards, P., Winder, B. C., Sproston, K. A., & Styles, V. 1995, "Medical school applicants from ethnic minorities: identifying if and when they are disadvantaged", *British Medical Journal*, **310**, 496-500.
- McManus, I. C., Richards, P., Winder, B. C., Sproston, K. A., and Vincent, C. A. 1993, "British medical students' perceptions of medical school teaching", *Medical Education*, in press.
- McManus, I. C., Shergill, S., & Bryden, M. P. 1993c, "Annett's theory that individuals heterozygous for the right shift gene are intellectually advantaged: Theoretical and empirical problems", *British Journal of Psychology*, **84**, 517-537.
- Melchior-Bonnet, S. 2001, *The mirror: A history (translator K.H. Jewett)*, New York: Routledge.

- Mercola, M. & Levin, M. 2001, "Left-right asymmetry determination in vertebrates", *Annual Review of Cell and Developmental Biology*, **17**, 779-805.
- Needham, J. 1931, *Chemical embryology*, Cambridge: Cambridge University Press.
- Needham, J. 1934, *A history of embryology*, Cambridge: Cambridge University Press.
- Newman, H. H. 1911, "Symmetry reversal and mirror-imaging in twins and double monsters," pp. 164-189 in *The Physiology of Twinning*, Chicago: The University of Chicago Press.
- Newman, H. H., Freeman, F. N., & Holzinger, K. J. 1966, *Twins: A study of heredity and environment*, Chicago: The University of Chicago Press.
- O'Boyle, M. W. & Benbow, C. P. 1990, "Handedness and its relationship to ability and talent," pp. 343-372 in *Left-handedness: Behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.
- Paul, D. 1990, *Living left-handed*, London: Bloomsbury.
- Paul, D. 1993d, *Left-handed helpline: An essential guide for teachers, teacher trainers and parents of left-handed children*, Manchester: Dextral Books.
- Peck, A. L. 1953, *Aristotle: Generation of Animals*, Cambridge, MA: Loeb.
- Penrose, R. 1971, *Portrait of Picasso*, 2 edn, London: Lund Humphries.
- Perelle, I. B. & Ehrman, L. 1982, "What is a lefthander?", *Experientia*, **38**, 1257-1258.
- Peters, M. 1992b, "Are there more lefthanders among the mathematically gifted? Benbow's evidence is weak", *Canadian Journal of Psychology*, **???**, ???-???
- Peterson, J. M. & Lansky, L. M. 1974, "Left-handedness among architects: Some facts and speculations", *Perceptual and Motor Skills*, **38**, 547-550.
- Pipe, M.-E. 1990, "Mental retardation and left-handedness: evidence and theories," pp. 293-318 in *Left-handedness: behavioral implications and anomalies*, S. Coren, ed., Amsterdam: North-Holland.
- Price, C. M. & Gildea, D. L. 2000, "Representations of motion and direction", *Journal of Experimental Psychology Human Perception and Performance*, **26**, 18-30.
- Rubin, W. 1980, *Pablo Picasso: A retrospective*, New York: Museum of Modern Art.
- Rutledge, L. W. & Donley, R. 1992, *The left-hander's guide to life: A witty and informative tour of the world according to southpaws*, New York: Penguin.
- Sandson, T. A., Wen, P. Y., & LeMay, M. 1992, "Reversed cerebral asymmetry in women with breast cancer", *Lancet*, **339**, 523-524.
- Scarr, M. M. 1988b, *The Dial in Old Court, Queens' College Cambridge: Its background, history and use*, Cambridge: Queens' College.
- Sicotte, N. L., Woods, R. P., & Mazziotta, J. C. 1999a, "Handedness in Twins: A Meta-analysis", *Laterality*, **4**, 265-286.
- Simoni, A. 1965, *Orologi Italiani dal cinquecento all' ottocento*, Milan: Antonio Vallardi Editore.
- Sommer, I. E. C., Ramsey, N. F., Bouma, A., & Kahn, R. S. 1999, "Cerebral mirror-imaging in a monozygotic twin", *Lancet*, **354**, 1445-1446.
- Stellman, S. D., Muscat, J., & Wynder, E. L. Left-handedness and risk factors in a group of hospitalised patients. 1993.

- Stewart, I. & Golubitsky, M. 1992a, *Fearful symmetry: Is God a geometer?*, Oxford: Blackwell.
- Storfer, M. D. 1995, "Problems in left-right discrimination in a high-IQ population", *Perceptual and Motor Skills*, **81**, 491-497.
- Swanton, R. H. 1996, "Angina and unstable angina," pp. 2321-2331 in *Oxford textbook of medicine*, 3 edn, D. J. Weatherall, J. G. G. Ledingham, & D. A. Warrell, eds., Oxford: Oxford University Press.
- Thorndike, L. 1941, "Invention of the mechanical clock about 1271 AD", *Speculum*, **16**, 242-243.
- Torgersen, J. 1950, "Situs inversus, asymmetry and twinning", *American Journal of Human Genetics*, **2**, 361-370.
- Townsend, G. C., Brown, T., Richards, L. C., Rogers, J. R., Pinkerton, S. K., Travan, G. R., & Burgess, V. B. 1986a, "Metric analyses of the teeth and faces of South Australian twins", *Acta Genet Med Gemellol*, **35**, 179-192.
- Van Doren, C. 1939, *Benjamin Franklin*, London: Putnam.
- Vinken, P. 1999, *The shape of the heart*, Amsterdam: Elsevier.
- Wehrmaker, A. 1969, "Right-left asymmetry and situs inversus in *Triturus alpestris*", *Wilhelm Roux' Archiv für Entwicklungsmechanik*, **163**, 1-32.
- Wile, I. S. 1934, *Handedness: Right and left*, Boston: Lothrop, Lee and Shepard.
- Wilkin, S. 1852, *The works of Sir Thomas Browne (revised version of 1836 edition)*, London: Henry Bohn.
- Winokur, M. 1984, *Einstein: A portrait*, Corte Madera, CA: Pomegranate Artbooks.
- Witelson, S. F., Kigar, D. L., & Harvey, T. 1999b, "The exceptional brain of Albert Einstein", *Lancet*, **353**, 2149-2153.
- Wittling, W. 1995, "Brain asymmetry in the control of autonomic-physiologic activity," pp. 305-357 in *Brain asymmetry*, R. J. Davidson & K. Hugdahl, eds., Cambridge, MA: MIT Press.
- Wittling, W., Block, A., Schweiger, E., & Genzel, S. 1998, "Hemisphere asymmetry in sympathetic control of the human myocardium", *Brain and Cognition*, **38**, 17-35.
- Wolf, P. A., D'Agostino, R. B., & Cobb, J. 1991, "Left-handedness and life expectancy", *New England Journal of Medicine*, **325**, 1042-1042.
- Wood, C. J. & Aggleton, J. P. 1991a, "Occupation and handedness: An examination of architects and mail survey biases", *Canadian Journal of Psychology*, **45**, 395-404.