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An independent academic psychologist, based in England, who has written extensively on different areas of psychology with an emphasis on the critical stance towards traditional ideas.

A complete listing of his writings at http://kmbpsychology.jottit.com.

CONTENTS

1. ASPECTS OF CREATIVITY

1.1. INTRODUCTION

Gino and Ariely (2012) summarised the areas of research in psychology on creativity as:

- Evaluation of creativity - ie: definition and measurement.
- Cognitive and motivational processes that lead to creative ideas.
- Factors that aid creative problem-solving.
- Personality types and creativity.

Problem-solving and creativity can occur by analysis or insight. "Analysis entails the application of knowledge and logic to the situation at hand, typically resulting in the solution being worked out incrementally. In contrast, solution through insight often comes about as a surprise to the individual, perhaps because insight is brought about through processes outside of conscious awareness and control..." (Weisberg 2013 p1).

Those who view insight as a "special-process" to analysis vary from researchers who feel insight is a variation on analysis ("business-as-usual") (Weisberg 2013).

Problem-solving and creativity by insight with the "Aha!" or "Eureka!" moment was first introduced by Gestalt psychologists at the beginning of the twentieth century (eg: Koffka 1935) [1].

They outlined the stages of the insight experience as:

a) Impasse - A feeling of no hope of solution as traditional methods have failed, and all possibilities have been exhausted.

b) Restructuring of the problem - Because of the

[1] "A sudden comprehension that solves a problem, reinterprets a situation, explains a joke, or resolves an ambiguous percept" (Kounios and Beeman 2009).

impasse the individual conceptualises the problem in a different way.

c) "Aha!" moment - A solution suddenly comes to mind.

d) Certainty - Without testing it, there is the feeling that insight has produced a solution to the problem [2].

While Wallas (1926/1970) produced a stage model of the creative process based on interviews with highly creative individuals - preparation, incubation, intimation (a feeling that the problem is about to be solved), and illumination ("Aha!" moment). Much focus has been on the stage of incubation, and what can be done to aid it. Some researchers suggested that simply taking a break from the activity is key, while others disagree, as in whether an "Aha!" moment is necessary (Fryer 2012).

1.2. MEASUREMENT ISSUES

Fryer (2012) asserted: "One can think of the measurement of creativity on two levels. The first concerns pure research, in which the aim is to make discoveries that can usefully contribute to the body of knowledge in this field. The second concerns applied research – using what is known about the nature and development of creativity to evaluate, for example: human performance and achievements, education and training, and contextual and environmental factors" (p21).

Insight in the laboratory is often tested using compound-remote-associate (CRA) problems (Mednick 1962) - eg: what word is common to pine, crab, and sauce? [3] (Weisberg 2013).

Neuroimaging studies tend to record brain activity using insight to solve problems and compare it with using analysis. After subtracting the latter, the location of insight in the brain is left. Weisberg (2013) criticised this idea because, for example, it is difficult to isolate the two methods of problem-solving and creativity.

Fryer (2012) outlined two key problems with measuring both types of creativity:

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[2] However, it is possible to have false insight (Weisberg 2013).
[3] Answer = apple.

a) Creativity is a multi-dimensional "fuzzy concept" - but "no more difficult to address than any other fuzzy concept", like play or love.

Besemer and Treffinger (1981), for example, found 125 criteria for assessing creative [4] work which were reduced to three categories - novelty (ie: originality), resolution (ie: how well the solution fits the problem), and elaboration and synthesis (ie: combination of "unlike elements").

b) Unchallenged assumptions about creativity - eg: "that originality is a necessary criterion of creativity". The assumptions held will influence the research questions posed.

1.3. CREATIVITY AND MENTAL ILLNESS

The link between mental illness and creativity is established in the popular imagination, and is partly supported by research. For example, mania is associated with better creative performance (eg: more and original ideas to solve problems) and depression with poorer performance (eg: Ghadirian et al 2001).

Schizophrenic spectrum disorders also show a varied relationship with creativity. Individuals with schizophrenia are less creative, but those with schizotypal personality disorder are more creative [5]. However, the definition of creativity varies between studies (eg: "artistic creativity" or "everyday creativity") (Rodrigue and Perkins 2012).

Consequently, Rodrigue and Perkins (2012) focused on divergent thinking - defined as "the use of generative, flexible responses that redefine or elaborate on an existing problem or idea. They compared twenty-two adult outpatients with schizophrenia from a psychiatric hospital in Lafayette, Louisiana, USA, with thirty students at the local university with a high schizotypy score and thirty students with a low schizotypy score (control group) on the Millon Clinical Multi-axial Inventory-III (MCMI-III) (Millon et al 1997) [6].

Divergent thinking was measured by the Abbreviated Torrance Test for Adults (ATTA) (Goff and Torrance 2002). This involved three sessions of three minutes in which to

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[4] Distinctions can be made between creative work, creative behaviour, and the creative process, for example (Fryer 2012).

[5] Both groups experience magical or bizarre thinking (which can be associated with creativity), but individuals with schizophrenia also have other cognitive problems (eg: related to memory and attention) which limit creativity (Rodrigue and Perkins 2012).

[6] These students were the extreme scorers from a pool of 359 undergraduates on an introductory psychology course.

give solutions to a problem (that are scored on criteria like originality and flexibility producing a creativity index).

The outpatients had a significantly lower creativity index score than the other two groups, but, contrary to predictions, there was no difference between the two groups of students. Rodrigue and Perkins (2012) admitted that the outpatients and students were not matched for age or educational level, nor did the researchers control for medication among the schizophrenia sufferers. Also the different student groups were based on a self-reported questionnaire.

1.3.1. Eccentricity

High creativity can go hand in hand with eccentricity. The connection may be via schizotypal characteristics like "magical thinking", unusual perceptual experiences, mild paranoia, and solitariness (Carson 2011a).

Such characteristics may be inherited. Kinney et al (2001), for example, found these types of behaviour among thirty-six adopted offspring of biological parent(s) with schizophrenia as compared to adoptees from non-schizophrenic biological parents. The individuals showing schizotypal characteristics were higher scorers on the measures of creativity.

The "shared vulnerability" (Carson 2011b) of schizotypal characteristics/eccentricity and creativity has the underlying mechanism of cognitive disinhibition. This is the "failure to ignore other information that is irrelevant to current goals or to survival" (Carson 2011a p25). Usually cognitive filtering or inhibition is a helpful way to cope with the amount of sensory information, but not so for creativity.

Carson et al (2003) found more cognitive disinhibition among creative than non-creative individuals using a latent inhibition task. This measures the ability to ignore distractions.

Other key characteristics are high intelligence and high working-memory capacity (Carson 2011a).

Other brain differences in creative individuals include less dopamine (D2) receptors in the thalamus (eg: de Manzano et al 2010), or genetic differences (eg: neuregulin 1 gene; Keri 2009) [7]. Both these differences have been found in individuals with schizophrenia (carson 2011a).

Creativity often involves insight or the "Aha!"

[7] Murphy et al (2013) felt that the genes related to dopamine had more to do with verbal fluency than originality (which is a better indicator of creativity).

experience. Electroencephalography (EEG) measures of brain activity show a period of alpha brainwaves before the moment of insight and then a burst of gamma brainwaves at the "Aha!" moment (eg: Kounios and Beeman 2009) [8]. The alpha waves suggest that the brain is focusing on internally generated stimuli rather than externally stimuli (Carson 2011a).

1.4. TIME OF DAY

Over a 24-hour period there are many physiological changes including, for example, to body temperature or digestion. These are known as the circadian rhythms. There are also differences in alertness or arousal. The most obvious being between sleep and wakefulness.

Cognitive functions like attention, memory, and decision-making have been found to vary between individuals over the day. These functions are better during peak arousal. So "morning types" ("larks"), who have peak alertness in the morning, perform best on cognitive tasks then as compared to in the afternoon and evening, while "evening types" ("owls") perform best in the afternoon or evening ("synchrony effect") (Wieth and Zacks 2011).

Wieth and Zacks (2011) showed that problem-solving performance can vary between the optimal and non-optimal times of the day depending on the type of task. Problems requiring insight to solve them are performed better at the non-optimal times (eg: by "morning types" in the evening), while analytic problems are best solved at the optimal time of the day (eg: "evening types" in the evening).

Wieth and Zacks (2011) used 428 US students in Michigan in their quasi-experiment [9]. All participants attempted three insight problems and three analytic problems (table 1.1) with four minutes allowed for each one [10]. Participants were tested either in the morning (between 8.30 - 9.30am) or in the afternoon (between 4 - 5.30pm). The problems were scored as correct (1) or not (0) [11].

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[8] Kounios and Beeman (2009) pointed out from their work: "Although the experience of insight is sudden and can seem disconnected from the immediately preceding thoughts, these studies show that insight is the culmination of a series of brain states and processes operating at different time scales" (p210). The researchers reported distinct patterns of brain activity about one second before solving problems by insight which were not seen in solving problems analytically. The patterns suggested the priming of the brain.

[9] It is a quasi-experiment because participants could not be randomised into morning or evening type.

[10] The order of the six problems was randomised between participants to deal with order effects.

[11] The experimental design was a mixed independent (time of day) and repeated measures (type of problems).

- Insight: Prisoner problem

A prisoner was attempting to escape from a tower. He found in his cell a rope that was half long enough to permit him to reach the ground safely. He divided the rope in half, tied the two parts together, and escaped. How could he have done this?

- Analytic: Age Problem

Bob's father is 3 times as old as Bob. They were both born in October. 4 years ago, he was 4 times older. How old are Bob and his father?

Table 1.1 - Example of problems used by Wieth and Zacks (2011).

Then the participants completed the Morningness-Eveningness Questionnaire (MEQ) (Horne and Ostberg 1976), which is a self-reported measure of the optimal time of day (table 1.2). From the scores, the participants were divided into groups for analysis: "evening types" (n = 195), and "morning types" (n = 28) ("chronotypes") with the remainder in the middle (n = 205).

- Approximately what time would you get up if you were entirely free to plan your day?

  (5) 5 - 6.30am
  (4) 6.30 - 7.45am
  (3) 7.45 - 9.45am
  (2) 9.45 - 11am
  (1) 11am - noon

- Approximately what time would you go to bed if you were entirely free to plan your evening?

  (5) 8 - 9pm
  (4) 9 - 10.15pm
  (3) 10.15pm - 12.30am
  (2) 12.30 - 1.45am
  (1) 1.45 - 3am

Higher score = morning type.

Table 1.2 - Two items from the MEQ.

The number of correct solutions to insight problems was significantly better for both morning and evening types at the non-optimal time of the day (42% vs 33% correct at the optimal time), but there was no difference in time of day for the analytic problems (47% correct at the optimal time of the day vs 43% at the non-optimal time) (table 1.3). At the non-optimal time of the day,

individuals are less focused which gives the opportunity for an "Aha" experience needed with insight problems (Rodriguez 2012). It seems that individuals are less able to ignore distractions during the non-optimal phase, which is a disadvantage for analytic problems requiring concentration, but an advantage for insight problems if the mind can wander.

Chronotype	Optimal time of the day	Best at solving insight problems	Best at solving analytic problems
Morning	AM	PM	no difference
Evening	PM	AM	no difference

Table 1.3 - Different chronotypes and problem-solving found by Wieth and Zacks (2011).

1.5. DARK SIDE OF CREATIVITY

Individuals, organisations, and societies have always and do benefit from new ideas and creative thinking. However, Gino and Ariely (2012) pointed out the "hidden cost" of creativity - namely increased dishonesty or unethical behaviour. Creativity depends on divergent thinking (the ability to produce multiple solutions to a particular problem) and cognitive flexibility ("the ability of individuals to restructure knowledge in multiple different ways depending on changing situational demands"; Gino and Ariely 2012). These components are involved in the ability to produce self-serving rationalisations (ie: justifications) for cheating, dishonesty, or unethical behaviour. Faced with ethical dilemmas, for example, individuals manage the desire to maximise self-interest while maintaining a positive view of themselves through those rationalisations (Mead et al 2009). "Such self-serving justifications can help individuals convince themselves that their behaviour is in fact morally appropriate and, as a result, that there is no need to negatively update their moral self-image. As a result, any situation in which there is room to justify potential dishonest or self-interested behaviour is likely to promote dishonesty..." (Gino and Ariely 2012 446).

For example, Snyder et al (1979) offered participants individually the opportunity to watch a film in one of two rooms - either with an individual with a physical disability or with an able-bodied individual. Where the same film was shown in both rooms, the participants were more likely to sit with the former. But

if the films were different, the participants were more likely to choose to sit with the able-bodied individual, and justified the behaviour afterwards by saying that they preferred that film (table 1.4).

Snyder et al (1979) were interested in "detecting motives that people wish to conceal": "The strategy involves asking people to choose between two alternatives, one of which accidentally happens to satisfy the motive that we suspect is present but hidden. For instance, we think that most people wish to avoid contact with the physically handicapped but do not want to admit it. If we give a person a choice between sitting next to a handicapped person or sitting beside a normal one, he may choose the handicapped so as to conceal his desire to avoid. However, if we ask a person to choose between two movies, one of which apparently by accident happens to entail sitting next to a handicapped person, the other next to a normal, he can avoid the handicapped while appearing to exercise a preference for a movie" (p2297).

The researchers recruited 24 individuals at Dartmouth College, New Hampshire, USA, under the cover story of a study of people's reactions to old silent comedy films. Half the participants were given the choice of watching the same film in one of two rooms - either with a male confederate wearing a metal leg brace ("physically disabled") or not (able-bodied). This was the "same movie" condition. In the "different movie" condition, different films were in each room ("slapstick" or "sad clowns"), and this was counterbalanced (ie: half the time "slapstick" was shown in the room with the "disabled" confederate and half the time it was "sad clowns").

In the "same movie" condition, 58% (7 of 12) of participants sat in the room with the "disabled" individual compared to 17% (2 of 12) in the "different movie" condition ($p<0.05$).

Table 1.4 - Details of Snyder et al (1979).

1.5.1. Experiments by Gino and Ariely (2012)

Gino and Ariely (2012) showed the "dark side of creativity" in five experiments. They proposed three hypotheses:

1. Creativity will be positively associated with dishonest behaviour on ethical dilemmas.

2. This relationship will hold for dispositional creativity and in situations encouraging creativity.

3. Creativity is linked to dishonest behaviour by the ability to self-justify such behaviour (ie: via moral flexibility).

Gino and Ariely (2012) began with a pilot study to see if individuals working in highly creative jobs were more morally flexible than those in non-creative jobs. Ninety-nine employees in an advertising agency in the southern USA rated the level of creativity required in

their jobs (out of 10), and self-rated for eight ethically questionable behaviours (eg: "take home office supplies from work") (out of 7). There was a significant positive correlation between creativity and likelihood to behave dishonestly. This was preliminary evidence (from a non-experimental study) of hypothesis 1.

Experiment 1

This experiment investigated the relationship between creative personality and dishonest behaviour. Ninety-seven students from the southeastern USA completed three questionnaires about creativity (table 1.5) online one week before taking three tests described as measures of problem-solving and perception (table 1.6). Each test had the opportunity to cheat.

- Creative Personality Scale (Gough 1979) - individuals choose from a list of thirty adjectives those that best describe them (eg: insight, inventive).
- Creative Behaviour Inventory (Hocevar 1980) - individuals score seventy-seven activities that they have or do engage in as adolescents or adults (eg: painting an original picture).
- Creative cognitive style (Kirton 1976) - five items rated on seven-point scale (eg: "I prefer tasks that enable me to think creatively").

Table 1.5 - Three questionnaires about creativity used in Experiment 1.

Using individual measures, and overall, an individual's creativity was significantly positively associated with cheating (table 1.6).

1. Perceptual task - a number of dots were flashed on a screen divided into two halves. Individuals had to say which half had more dots. But the participants received a greater reward for right side than the left having more dots. The instructions were ambiguous, such that participants could cheat and say the right side irrelevant of the correct answer.

2. Problem-solving task - participants had five minutes to complete twenty visual problems (which was not enough time). Then they wrote the number completed on a score sheet (with a small monetary reward for each problem solved). The participants could lie about the number completed as it appeared that experimenters would not know (but actually there was a unique code number to allow checking).

3. Multiple-choice task - participants answered fifty questions like "how far can a kangaroo jump", and then copied their answers on to a sheet with the correct answers visible.

Table 1.6 - Three tasks used in Experiment 1.

	Creative Personality Scale	Creative Behaviour Inventory	Creative Cognitive Style
Problem-solving task	+0.53	+0.42	+0.35
Multiple-choice task	+0.31	+0.25	+0.25
Perceptual task	+0.33	+0.25	+0.23

(Data from Gino and Ariely 2012 table 2)

Table 1.6 - Significant correlations between measures of creative personality and cheating on tasks in Experiment 1.

Experiment 2

This experiment investigated whether a situation encouraging creativity leads to dishonest behaviour. One hundred and eleven more undergraduates from the universities in Experiment 1 were randomly assigned to a condition that encouraged creativity or not (independent groups design). Creativity was encouraged by a priming task [12] - ie: unscramble twenty sentences (of which twelve contained words related to creativity). The control group had twenty sentences without any creative words.

Dishonest behaviour was measured by cheating on the problem-solving task from Experiment 1. Participants in the creative priming condition overstated the number of problems solved significantly more than those in the control group (mean: 2.71 vs 1.09; $p<0.01$), and significantly more participants in this group overstated their performance (49% vs 27% respectively; $p<0.05$).

Experiment 3

This experiment investigated the likelihood of dishonest behaviour by varying the opportunity to justify it. Where there is less room to manoeuvre, more moral flexibility (ie: creativity) will be need to justify dishonest behaviour. One hundred and forty-five individuals from a city in northeastern USA were to privately roll a die and report the number. Different rewards were given depending on the number - ie: more money for a higher number. In the low-justification condition, participants rolled the die once, and in the

[12] For example, Fitzsimons et al (2008) found that participants shown the logo for Apple computers (associated with creativity) were more creative on subsequent problem-solving tasks than participants seeing the IBM logo or no logo.

high-justification condition, they rolled it a few times to check it was a legitimate die but still reported the first roll. It was predicted that more creativity would be associated with cheating in the low-justification condition because there was less room to manoeuvre, and thus needed more moral flexibility to justify the cheating.

In the high-justification condition, there was no significant difference between creative and non-creative individuals (based on priming) in reporting the number on the die (mean number self-reported - 5 vs 4.5). But in the low-justification condition, creative individuals were significantly more likely to report a higher number (5 vs 3.5; $p<0.001$).

Experiment 4

This experiment was the same as the previous one but measures of creative personality were compared on the die rolling task. One hundred and fifty-nine individuals in a city in southeastern USA completed the three questionnaires about creativity from Experiment 1 online one week before die rolling. Dispositional creativity was significantly associated with a self-reported higher number on the die in the low-justification condition ($p<0.001$) (and in the high-justification condition this time; $p<0.01$).

Experiment 5

This experiment combined the measures of dispositional creativity from Experiment 1 with the design of Experiment 2. One hundred and eight students in the southeastern USA were divided into four conditions based on online questionnaire responses about creative personality and the priming task for creativity - creative personality/creative priming, creative personality/neutral priming, non-creative personality/ creative priming, and non-creative personality/neutral priming.

Individuals low on dispositional creativity who were primed to be creative were more likely to cheat, but not for individuals high on dispositional creativity primed to be creative (table 1.7).

	Creative personality	Non-creative personality
Creative priming	3	4
Neutral priming	3	0.5

(Data from Gino and Ariely 2012 figure 5)

Table 1.7 - Approximate mean extent of cheating (out of 5) in Experiment 5.

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2. BRAIN ASYMMETRY AND LATERALISATION

2.1. INTRODUCTION

Human anatomical asymmetries describe differences between the two sides of the body, as seen most notably in the brain with hemisphere specialisation (eg: left hemisphere and speech production and perception [13]; right hemisphere and spatial cognition). Corballis (2009) observed: "The asymmetry of the brain raises something of a paradox, since, in most respects, the brains and bodies of most organisms, including humans, are strikingly bilaterally symmetrical. As Palmer (2004) put it, bilateral symmetry is the default condition... Any sensory asymmetry would create an increased risk of predation from the weaker side" (p867).

2.2. HANDEDNESS

Behavioural asymmetries are the manifestation of the differences in the brain as in handedness.

About 10% of men and 5% of women are left-handed, while the remainder are right-handed to some degree (including mixed-handedness) [14], but it depends how handedness is measured (Hartley 1998):

i) Tasks - eg: writing, throwing [15].

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[13] Techniques that deactivate a hemisphere (for example with drugs) have found that when it is the left hemisphere, speech and language is disrupted leading to the estimate that language is a left hemisphere dominant ability in about 97% of right-handed individuals, but in only 60% of left-handed ones (Nettle 2004). Fitch and Braccini (2013) estimated 96% of right-handers have left hemisphere language dominance compared to 76% of left-handers. But neuroimaging has shown how subtle linguistic abilities involve the right hemisphere (eg: understanding of analogies) (Fitch and Braccini 2013).

[14] For example, in a survey of over one million people in the USA, 89.9% of men and 92.4% of women used their right hand for throwing (Gilbert and Wysocki 1992). Depending on the study, the range is 85-95% of humans as right-handed (Fitch and Braccini 2013). A right-handed majority has been inferred from archaeological skeletons and stone tools as dating from 300 000 - 400 000 years ago (Llaurens et al 2009).

[15] The task chosen is key to measuring handedness. "For example, if one wants to assess handedness in the context of the hypothesis of a frequency-dependent advantage of left-handers in fights, tasks should be related to fighting actions. If the aim is to examine brain lateralization related to language, writing handedness is more relevant" (Llaurens et al 2009 p882).

ii) Questionnaires - simple questions about which hand used or more complex questionnaires. For example, the Crovitz-Zener Scale (Crovitz and Zener 1962) or the Edinburgh Handedness Inventory (Oldfield 1971). The former has fourteen activities to which the respondent chooses "right hand always", "right hand most of the time", "both hands equally often", "left hand most of the time", or "left hand always". The responses are transformed into a scale ranging from 14 (always using right hand) to 70 (always using left hand) (Bishop et al 1996).

With the Edinburgh Handedness Inventory, individuals rate their preference on a five-point scale for 10 activities - writing, drawing, throwing, scissors, toothbrush, knife (without fork), spoon, broom (upper hand), striking match (hold match), opening box (lid) (Bishop et al 1996).

Bishop et al (1996) criticised the Crovitz-Zener Scale:

a) That individuals can distinguish between the hand used "always" and "most of the time". "However, until they are confronted by a psychologist bearing a laterality inventory, most people are unaware which hand they use for many activities ; indeed, people are usually encouraged to mime the relevant activity before giving a response to a questionnaire, and may express surprise at the outcome. If many people who are prevented from miming the action cannot tell you whether they habitually hold a toothbrush in the right or left hand, one might reasonably ask whether they are able to judge whether that hand preference applies 'always' or 'most of the time'. Even if people are able to make an accurate judgement of frequency of preferring one side, they may vary in how they interpret quantifiers such as 'most of the time'" (Bishop et al 1996 pp270-271).

b) The final score can be confusing - eg: an individual who responds "right hand most of the time" to all activities could get the same overall score as a person who chooses "right hand always" to most items and left hand responses to a couple of other activities.

The ability to measure handedness depends on the theoretical position taken (Bishop et al 1996):

- "Dichotomy hypothesis" (eg: McManus et al 1988) - handedness is an either/or, and dividing individuals based on writing hand is best way. No sub-groups of right-handers for some things and not others, for example.

- "Degree but not strength hypothesis" (eg: Annett 1970)

- not strength of hand preference, preference for hand for number of activities.

- "Both degree and strength hypothesis" (eg: Crovitz and Zener 1962) - hand preference for each activity and strength of preference in each case.

Using the Edinburgh Handedness Inventory with 51 right-handers, Bishop et al (1996) distinguished "exclusive strong right-handers" (always used right hand for at least eight of ten activities, and usually right hand for rest), "exclusive weak right-handers" (usually used right hand for three or more activities, and always for rest), and "predominant right-handers" (preferred right hand, but used left hand for at least one activity). But the researchers found that the distinction between "always" and "usually" were not helpful, and argued for the "degree but not strength hypothesis".

The two key questions about handedness are - why is it asymmetrical, and why do some individuals prefer the left hand, say? These come together as "why are humans right-handed" (Llaurens et al 2009)?

Handedness has a genetic basis as shown by the fact that two right-handed parents have fewer left-handed offspring (around 10-15%) than two left-handed parents (around 30-40%) and mixed parents (15-25%) (Llaurens et al 2009). "The fact that handedness runs in families is not convincing evidence of a genetic component, since parents also transmit a particular environment to their offspring... [However] Even if the genetic and cultural contributions to transmission of hand preference are not fully determined, these results provide convincing evidence for a significant heritability, allowing the action of natural selection on this trait" (Llaurens et al 2009 p883).

Different methods are used to study the genetic basis of handedness:

i) Family studies - handedness of biological parents and offspring.

ii) Adoption studies - handedness of adopted children and parents. But few studies where adoption occurs before handedness established (Llaurens et al 2009).

iii) Twin studies - identical (monozygotic; MZ) pairs more concordant (same hand preference) than non-identical (dizygotic; DZ) twins (Llaurens et al 2009).

iv) Selective animal breeding - eg: inbred strains of mice and side of the body of certain organs (Layton 1976).

v) Molecular studies - search for specific genes involved.

Handedness is also influenced by environmental factors including (Llaurens et al 2009):

- In utero (womb) environment - eg: testosterone.
- Birth stress - eg: left-handedness due to left hemisphere damage due to oxygen deficiency with premature birth or prolonged labour (Bakan 1971). Not supported by other studies (Llaurens et al 2009).
- Birth weight - an excess of left-handers among low birth weight babies.
- Cultural influences - eg: negative attitude of teachers towards left-hand writing.

2.3. WHY ASYMMETRY?

A landmark in the history of understanding of human brain asymmetries is the case studies of "split brain" patients who had the connection between the two hemispheres (the corpus callosum) surgically cut as a treatment for severe epilepsy (Sperry 1974).

Hemispheric specialisation (or brain lateralisation) increases brain efficiency by avoiding unnecessary duplication of neural circuitry, and by reducing interferences between different brain functions or simultaneous occurrence of incompatible responses (ie: one hemisphere has control over particular actions) [16]. This is a greater benefit that the disadvantage that behaviour is more predictable to others (eg: direction of escape from predators - right hemisphere-dominate individuals move to the right as a preference) (Ghirlanda et al 2009).

Corballis (2009) noted that there is "a trade-off between bilateral symmetry and asymmetry — perhaps too much symmetry leads to difficulties in the neural programming of complex action, and too much asymmetry leads to a vulnerability in an even-handed world where impediments, such as attack from predators, may occur on either side of the organism" (p873).

Furthermore, Corballis (2009) states: "Given the advantages of an asymmetrical brain, the question arises as to why asymmetry has not become fixed in the population. One possibility... is that reversed asymmetry

[16] For example, stuttering has been proposed as a product of such conflict (Corballis 2009).

[left-handedness] may be advantageous so long as it is a minority condition... Alternatively, there may be compensatory advantages more directly associated with the lack of asymmetry [mixed-handedness]" (p874) (eg: creativity). Cerebral symmetry or mixed-handedness is associated with a higher risk of schizophrenia, and/or magical thinking (eg: superstitious) (Corballis 2009). "Human societies have often revered the oddball, especially if associated with mystical or even hallucinatory behaviour, and there is at least some evidence that these characteristics may be associated with the lack of consistent asymmetry... A symmetrical brain may well provide avenues of thought that do not conform to academic expectations, but may nonetheless provide the impetus for significant discovery and leadership" (Corballis 2009 p875).

2.4. NON-HUMAN ANIMALS

Geschwind (1970) argued that brain asymmetry was unique to humans, but this has subsequently been challenged.

Asymmetries have also been reported in non-human animals, like birds, fishes, amphibians, rodents, and primates (Tommasi 2009). Some species do show some evidence of handedness - eg: captive chimpanzees and throwing, or left foot preference for picking up objects by parrots (Corballis 2009). Vallortigara and Rogers (2005) went as far as to say that "the overall similarities across species strongly support the hypothesis of a common origin of lateralisation in vertebrates" (quoted in Corballis 2009).

In a review of studies of primates, Fitch and Braccini (2013) were less convinced. They distinguished four aspects of lateralisation:

i) Manual control (eg: handedness; footedness) - Right-bias in chimpanzees maybe, but it depends on the technique used to establish handedness in primates (eg: bimanual tube task). Food is placed in a tube and the chimpanzee, for example, is observed as to which hand grasps the tube and which hand removes the food. The latter hand is rated as dominant.

ii) Communication - Baboons and chimpanzees show a preference for manual (eg: gestures) and facial communication (eg: asymmetric face movements for production of sounds - right side bias).

iii) Visual processing - Many primates show bias (eg: which eye used to look through hole; eyedness).

iv) Auditory processing/acoustic orientation - Little evidence of, for example, a preferred ear to listen to alarm calls.

If non-human species do show lateralisation, then there must be a genetic/evolutionary basis to it. Annett (2002) proposed the idea of a gene for a "right-shift" and a gene for no preference that are passed down through generations and distributed in populations. This was a theoretical model, and actually finding a specific gene has proved difficult. It is more likely that several genes are involved in handedness (Corballis 2009).

2.5. TESTOSTERONE

A number of hypotheses have been proposed for the role of testosterone and brain asymmetry - what is called the "organisational effects of testosterone" (Pfannkuche et al 2009). These are structural, irreversible changes in the brain in the womb. For example, Geschwind and Galaburda (1985) proposed that increased pre-natal testosterone inhibited growth of the left hemisphere, and the result was greater brain symmetry. Alternatively, Lauter (2007) argued that low and high levels of testosterone produced brain asymmetry and right-handedness, and it is moderate levels that lead to brain symmetry and left- and mixed-handedness.

The amount of testosterone in the womb is linked to asymmetry, but Pfannkuche et al (2009) saw the level of testosterone determining the extent of asymmetry rather than the direction (eg: the degree of right-handed dominance rather than right-handedness over left-handedness) for humans. This conclusion was based on a meta-analysis of studies about lateralisation of motor skills (eg: handedness), language, and visuo-spatial abilities (eg: eye dominance) in humans, other mammals, and birds.

2.6. SOCIAL PERCEPTION

Social perception is the process of perceiving the social world (specifically other people). It involves all senses, but most prominently vision and sound.

Speech perception (ie: what is said) involves the left hemisphere in most righthanded individuals, but the processing the non-verbal aspects (eg: tone of voice) is a right hemisphere ability. For example, Lattner et al (2005) functional magnetic resonance imaging (fMRI) scanned sixteen adults as they rated the naturalness of a voice (ie: human or machine-created). Areas of the right hemisphere were activated by the task.

Other neuroimaging studies have found greater right

hemisphere activity for emotional information contained in the voice (not words), and for speaker identification (ie: familiar voice) (Brancucci et al 2009). Von Kriegstein et al (2003), for example, observed right hemisphere activation in the fMRI scanner when identifying a German speaker, but left hemisphere activity if processing what was being said (even using the same stimulus material in both conditions).

Face perception and processing are abilities with right hemisphere dominance (and left eye superiority) [17]. Different methods have been used to show this. For example, individuals are shown faces using a divided visual field technique (one eye can only see one half of the face). The right half of the face (viewed by the left eye) was perceived as conveying more information. This is confirmed with chimeric faces. This is an artificial face created by the mirror of one side of the face. So chimeric faces made of the combination of the right half are perceived as resembling the original face more than ones made of the left half (Brancucci et al 2009).

Another method uses a tachistoscope. This presents a face for recognition at very fast speeds (milliseconds). When presented to one eye at a time, facial recognition is better with the left eye. But with recognising familiar faces, the right hemisphere superiority is no so clear-cut because semantic (linguistic) informationis retrieved in the process (eg: name of individual) (left hemisphere) (Brancucci et al 2009).

In terms of the emotions of faces, the right hemisphere hypothesis (eg: Campbell 1978) proposes right hemisphere superiority in the perception and production of emotional expressions, while the valence hypothesis (eg: Reuter-Lorenz and Davidson 1981) sees the processing of positive emotions as a left hemisphere ability and negative emotions as right hemisphere. Canli (1999), for example, attempted to reconcile the two theories by suggesting that the former is correct for emotion perception, while the latter accounts for the production of expressions. Neuroimaging studies have confirmed the right hemisphere dominance for face processing (Brancucci et al 2007).

Other right hemisphere lateralisation has been found for gaze perception (the direction that an individual is looking) and perception of gestures (motion perception) (but the left hemisphere is involved in understanding their meaning) (Brancucci et al 2009).

Overall, social perception has a right hemisphere dominance, but with assistance from the left hemisphere

[17] Information from the left eye goes to the right hemisphere and vice versa.

(inter-hemispheric co-operation) because of "the strength and stability of the left-hemispheric asymmetry of language processing" (Brancucci et al 2009 p907).

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