Giftedness and the Brain

Giftedness or genius in children and adolescents is an intriguing phenomenon seeking scientific explanation. What makes a child stand out from their peers as talented? What pushes their performance into the uppermost part of the normal 'bell curve' distribution of different levels of performance, whether it is music, maths, sport or some other domain? Or consider general intelligence: reaching the 97th percentile (IQ > 130) is as unlikely as mental retardation (IQ < 70). Although an empirical definition and 'diagnosis' of talent does not necessarily imply or refer to later academic or professional achievement, the question of what drives such ability is still of interest on a personal and professional level. What can modern methods tell us? While other scientific approaches seek psychological (e.g. working memory capacity), psychosocial (e.g. parents' income), biological (e.g. gender), or genetic (e.g. specific polymorphisms) explanations of giftedness, neuroscientists look for structural and functional brain-related factors covarying with performance with modern brain research seeking to understand the intact cognitive function. Non-invasive methods (e.g. EEG, MRI) allow the observation of brain structures and processes in healthy people as they perform cognitive tasks. However, there is a potential problem here. If the task is too hard or too easy for the person, how do we know they actually perform the cognitive process under examination while their brains are scanned?

The Geschwind–Galaburda model (Geschwind & Galaburda, 1985a-c) represents the classical 'neuronal resource' account of giftedness. It was based on the empirical observation that giftedness was associated to some degree with the male gender, atypical handedness, less expressed functional asymmetry of the hemispheres as measured by visual-hemifield stimulation and dichotic listening tests, and higher prevalence of allergies and myopia. From this pattern, the authors concluded that the right hemisphere was more active in talents (i.e. that talented people show less left-hemispheric dominance and more pronounced interhemispheric exchange). Geschwind and Galaburda speculated that in talents fetal exposure to higher levels of the male sex hormone testosterone might have favoured the relative growth of the right hemisphere and the corpus callosum.

Parts of the model were confirmed in several studies. For example, using fMRI, O'Boyle et al. (2005) reported increased right hemisphere contributions to maths-related tasks in mathematical talents. Alexander et al. (1996) revealed increased activity of the right hemisphere in talents during rest by EEG analysis. However, recent research has challenged the evidence for the almost classical dogma of a higher proportion of male talents. While Benbow (1988) had reported a gender ratio of 15:1 for male mathematical talents, Hyde et al. (2008) recently showed that no gender effects on maths skills could be revealed in any grade and on any level of performance. Research with musical experts provides evidence for the 'neuronal resource' account of exceptional skills; however, it also underlines the general role of years of practice. Since psychophysiological research is correlational and quasi-experimental, it remains unclear whether neurophysiological correlates of musical expertise are a cause or an effect of such training. Evidence is mixed, for example in a magnetoencephalography (MEG) study, the neural response (so called mismatch negativity) to occasional changes in melodic contour or interval was 25 per cent higher in musicians than in non-musicians when they were listening to notes from musical scales whereas no remarkable group differences occurred during pure 'nonmusical' note stimulation. Musicians showed higher grey matter (i.e. neuronal cell somata) density in the left inferior frontal lobe, or Broca's area, an area crucial for language production but also involved in sight-reading of musical notes in professional musicians. Grey matter density in Broca's area was positively correlated with years of musical practice, indicating that the increase may have been an effect rather than a cause.

While the 'neural resource' account aims to point out the high capability of talents, the 'neural efficiency' account addresses differences between the talents and nontalents while working on identical tasks. Obviously, a skilled cognitive system is more efficient – it achieves goals with fewer resources (time, subjective effort) than an unskilled system. But how does cognitive efficiency translate to the neuronal level? Neurocognitive efficiency has primarily been probed by task-related EEG recordings and advanced methods of EEG data analysis. For example, it has been reported that talented individuals showed increased alpha-EEG power, indicating less cognitive effort than in a normal cohort while working on an identical task (Jaušovec 1996). Further evidence for increased neural efficiency in talents was provided by several studies (e.g. Neubauer et al., 2005; Grabner et al., 2006) in which less mental effort in talents was indicated by less event-related desynchronisation of the alpha-EEG in talents as compared to nontalents during identical tasks. Another explanation for higher neurocognitive efficiency in talents is offered by Miller

(1994), who suggested that efficiency might depend on stronger 'myelination', the electrically insulating sheath that allows action potentials to 'leap' along the axon by saltatory transmission.

It's here that we run into that issue again: that differences in brain activation are often related to task difficulty which partly depends on subjective capability. When working on easy tasks, talented participants show less metabolic activation than nontalented participants, providing the evidence for the 'neural efficiency' account. However, applying a more difficult task revealed more activation in talented individuals, supporting the 'neuronal resource' account. In Lee et al.'s (2006) study, increasing task difficulty yielded stronger activation in posterior parts of the fronto-parietal brain network in highly intelligent teenagers than in age-matched peers of average intelligence. Conversely, our own studies on mental arithmetic and mental 3D-rotation in adolescents revealed higher frontal activation in mathematically nontalented participants than in their talented counterparts. It's a mixed picture! Taken together, the neuroimaging findings suggest that talented people are more efficient in their particular domain because they can recruit more neuronal resources for automatic processing prior to frontal activation. Alternatively, their working memory (or frontal brain system) might be more efficient as well. Frontal activation as revealed in neuroimaging studies may be regarded as a general indicator of reaching individual capability limits. In this way, it could allow us to make a distinction between high and low performers.

Comprehensive explanations of giftedness need to explain not only higher performance, but also the high motivation to practise. It is now generally accepted that professional mastership requires dedicated high-quality training of at least 10,000 hours (i.e. nearly two hours per day of practice from the age of 3 to 17 years). Duckworth and Seligman (2005) reported that the individual differences in achievement among the students with the same IQs were explained by motivation, self-discipline and practice. To this extent, our speculation is that the onset of frontal activation, as revealed by neuroimaging studies, may serve as an indicator of the critical transition from optimal medium arousal to stress. An implication of this assumption is the notion that frontal activation does not specifically contribute to solving a task but instead indicates unspecific and potentially disturbing neurocognitive activity at capacity limits.

So what are the lessons of this for the real world? Talented and nontalented individuals are often exposed to the same tasks irrespective of their different capability (e.g. in school classes). Perhaps in such tasks the former achieve good results with very little or medium effort, which reinforces positive attitudes and practising. In contrast, the latter experience stress, or even fail, despite making a strong effort, which reinforces negative attitudes. A possible lesson from psychological and neuroscientific talent research might be the idea that higher motivation – and, consequently, more practice and higher achievement – result from a individualised task selection, ensuring success at an individual's medium levels of arousal and effort, prior to the onset of frontal activation.

(Source: www.bps.org.uk/psychologist/giftedness-and-brain)

1. What is the main focus of research into giftedness or genius in children and adolescents?
A) To determine the genetic factors that lead to talent
B) To understand the brain structures and processes linked to exceptional performance
C) To assess the impact of socioeconomic status on giftedness
D) To identify which talents are most common in the general population

2. According to the Geschwind–Galaburda model, what was found to be associated with giftedness?
A) High levels of testosterone exposure in fetal development
B) Stronger left hemisphere dominance
C) High IQ in childhood
D) Increased motor coordination

3. What does the 'neuronal resource' account of giftedness emphasize?
A) Gifted individuals use fewer brain resources while performing tasks
B) Giftedness is primarily determined by early childhood experiences
C) Giftedness is linked to increased activation in the right hemisphere of the brain
D) Gender and handedness do not influence giftedness

4. How did recent research challenge the Geschwind–Galaburda model's conclusion about gender and giftedness?
A) It found that male gifted individuals are more likely to excel in all areas of talent.
B) It showed no gender effects on mathematical ability at any grade level.
C) It found that females outperform males in music-related tasks.
D) It confirmed that giftedness is predominantly a male trait.

5. What role does 'myelination' play in the neurocognitive efficiency of talented individuals, according to Miller (1994)?
A) It increases cognitive effort during tasks.
B) It enhances the left hemisphere's dominance during cognitive tasks.
C) It reduces the number of neurons needed for task completion.
D) It allows faster transmission of neural signals, improving cognitive efficiency.

6. How do talented individuals perform on easier tasks compared to nontalented individuals?
A) They show more brain activation and take longer to complete the task.
B) They show less brain activation and require less cognitive effort.
C) They require the same amount of effort as nontalented individuals.
D) They perform worse on easy tasks than nontalented individuals.

7. According to the text, what is a critical factor in determining high achievement, beyond innate talent?
A) High IQ
B) Motivation, self-discipline, and practice
C) Genetic predispositions
D) Socioeconomic status

8. What does the text suggest about the relationship between task difficulty and brain activation in gifted individuals?
A) Gifted individuals show more brain activation only when tasks are easy.
B) Gifted individuals perform better when the tasks are harder, regardless of brain activation.
C) Gifted individuals show more brain activation on difficult tasks, which supports the 'neuronal resource' account.
D) Gifted individuals consistently show lower activation than nontalented individuals, regardless of task difficulty.

9. What is the 10,000-hour rule in relation to giftedness and expertise?
A) It suggests that innate talent alone can lead to mastery.
B) It proposes that mastery in a field requires approximately 10,000 hours of practice.
C) It indicates that gifted individuals need far less practice to achieve expertise.
D) It shows that talent can be identified with only a few hours of practice.

10. What does the text suggest about the importance of individualized task selection for gifted and nontalented individuals?
A) It helps ensure success at an individual's medium levels of arousal and effort, leading to higher motivation and achievement.
B) It reduces the need for practice and helps equalize achievement among all students.
C) It minimizes stress for gifted individuals by focusing on easy tasks.

D) It prevents gifted individuals from practicing harder tasks, thus limiting their development