Localization of bran functions: research and analysis

Adult brains show localized functions, for example with speech processes being concentrated in areas in the left hemisphere and with executive functions concentrated in the pre-frontal cortex. How does this organization come about? Is it because these functions are localized from birth?

The functioning and processes of the brain is a very complex subject. Years of studies and experiments are yet to answer all the questions we have, although modern technology like brain imaging and MRI's has come a long way to try to understand the way our brains work and their development. The matters we will be looking at is how the brain functions are organised, exploring localisation and the strengths and limitations to this, and could this localization have be set in shape from the birth of a human brain. To do this we will be focusing on modulization and innate modularity and the theories behind them.

Cognitive development of the brain starts as a baby grows in the womb and the genetic makeup of the parents entwine and start to create a genetic blueprint. As there is a limited environment in the womb, the effect that environment will have on the baby will be limited. Because of this, the post-natal stage of brain development is probably the considered the more important of the two. The human brain does most of its advance development outside of the womb, only creating the basic connections and functions inside the womb. This can be seen using brain mapping of a baby at different stages of their infancy; as a neonate the baby as very few connections and as they get older, the dendritic trees of neurons can be seen extending creating much more connections. Huttenlocher (1990) reported a steady increase in the number of synapses in several regions of

the cerebral cortex……in parts of the visual cortex, the generation of the synapses begins around the time of birth.

(Mareschal et al., 2004, p. 122)From this we can see that there are limited functions and connectivity in the brain at birth and soon after birth these connectivities rapidly start to expand. So for these functions to be localised from birth would mean having all the right connections in place for this to be possible. So from this alone we can assume that these functions are localized through influence of their environment after birth and not set in place at birth.

During the early stages of a babies postnatal brain development , the brain holds the ability of plasticity which allows change and adaption for diiferent parts of the brain. At this time plasticity limits the functions in the brain are not yet identified as this capability allows for various parts of the brain to take on diverse functions in cases of localized brain damage. As the child turn into n adult the brain becomes more set and let plastic and damage to the brain in this state is a lot harder to recover from. As the brain continues to mature, its neural pathways separate and functions localise, making it much harder to ‘ transfer’ functions from one section of the brain to another. Parts of the brain are allocated with certain functions; language and speech is located predominantly in the left hemisphere and cognitive functions in pre-frontal cortex. (Mareschal et al., 2004, p. 123) Along with the separation of the neural pathways and brain development comes functional specialization. Lewkowitz and Turkewitz (1981) study in the early 1980s supported this claim. They showed that new-born babies visual preferences were significantly affected by previous auditory stimulus. Also studies by

Meltzoff and Borton (1979) show that independent pathways in infants between 3 and 5 months of age are used to receive information from different senses. These processes of separating neural pathways to create a localized functioning of the brain are linked to ‘ selectionism’ which originates from Darwin’s theory of selection, in this case showing that the pathways that were ‘ weaker’ or used less are eliminated and die off while those that are frequently use are strengthened in order to function a lot quicker. Although there is little understand and much speculation about this process. (Mareschal et al., 2004, p. 124-5) By dividing the brain into cognitive modules, this helps us to try to understand the structures and functions of the brain. There is a lot of speculation as to whether these do modules exist, they provide a basis for potential explanation of brain functioning. Scientists, Fodor and Karmiloff-Smith share very contrasting views and theories on brain functioning; although they both believe there are such things as cognitive module, they have conflicting views on how they are developed. Fodor (1983) had a nativist perpective and argued that modularity of the brain is ‘ innate’. He believed that humans are born with the innate capacity to develop information processing systems that allow them to make sense of the world, in which they have evolved. (Mareschal et al., 2004, p. 127) He believed that the brain has the ability to function in a particular way and the environment cannot affect this. This statement can easily be scrutinised as early we discussed that genes ‘ always’ interact with their environment. Therefore, for the functioning of the brain to not be affected by the environment would mean that certain genes do not interact with their environment. Fodor claimed that this happened as a direct outcome of the evolution of our species. (Mareschal et al., 2004, p. 127) One

piece of evidence that is useful in showing a weakness in Fodor’s theory is that of Self-organization. The Self-organizing system is based on the ability of the brain to sort information into structures when in a particular environment. (Mareschal et al 2004, p. 132), According to Keslo 1995, Johnson 1997 (cited in Mareschal et al 2004), Brain development at all of the stages requires a certain amount of self-organisation. Self-organisation is based on the theory of Hebb (1949) which claims that for localized functions to work at the same time and to create particular pathways, an important rule of repetition comes into play. The Hebb rule states that the connections created by neurons to transmit information are joined by its repeated use and so support the theory of ‘ selectionism’.

Karmiloff-Smith (1992) on the other hand, argues that cognitive modules created through development and the effect of environment interaction and stimulation. A strong indicator for Smith is the plasticity of the brain, that certains parts of the brain may take up the function of another part of the brain if needed at an early age, which challenges the nativist idea of innate local functioning. This debate between Fodor and Karmiloff-Smith is ongoing. Petersen et al. (1990) conducted an experiment using a PET machine, where they presented native and foreign speakers with English words. The test shown that particular parts of the cortex in native speakers responded to English words. This implies that the exposure to same the environment led to the development of a specific processing area in the cortex of their left hemisphere to process English language. This experiment supports the ‘ modulization theory. (Mareschal et al., 2004, p. 130) While there is much complex data to consider, there appears to be more evidence in favour of

Karmiloff-Smith’s (1992) theory which is best demonstrated with experiments and studies carried out on the ability for children to learn language. Nativists like Chomsky (1965) claim that language is innate and supporting this claim further Pinker (1994) claims that pidgins and creoles are some of the evidence for this. His claim is drawn from the evidence which shows that children are able to create grammatically correct language though they never heard it being spoken before. Chomsky’s argument from the ‘ poverty of the input’ suggesting that children can create a ‘ new language’ such as well formulated, never before heard question. He also claims that the brain has a special set of genes allowing language to develop in a particular cortical region. In contrast to Pinker’s claim, the evidence from neuroscience and particularly the study carried out by Neville et al. (1998) illustrates that though in adulthood there are specialist cortical regions processing language, it wasn’t destined from birth that these functions were processed in these parts of the cortex. The experiment Neville et al. carried out with his participants, showed that in the deaf participants, the identical area of language processing was stimulated as in the hearing participants and in further still, a larger part of the right hemisphere was activated. Findings like this show that different parts of the brain can support language related information processing. (Mareschal et al., 2004p. 140) Reilly et al. (1998) provides further evidence. They conducted a study carried out on children with localized brain damage in the area of language processing. This occurred soon after or during birth. The study showed that while the learning ability of the children was not continuous but in fact varied, it presented a pattern of constant functional regaining of the damaged area, which were taken over by another area of the cortex. Another study for adults revealed

that localized lacerations causing specific loss of certain capabilities are mostly permanent. This suggests that in adulthood the plasticity of the brain reduces the functions cannot be relocated elsewhere.

Johnson et al. (1996) study regarding the practical ability of pre-frontal cortex appears to support modularization. The study involving infants, revealed results suggesting that cognitive and behavioural development of infants is associated with the pre-frontal cortex especially when it comes to learning new abilities in initial stages of development. This demonstrates that the pre-frontal cortex activity is more general in early development and is able to take on other functions. Changes in these functions in the cortex are further focused and localized and the role of pre-frontal cortex reduces. It is very difficult to prove one theory as correct and the other as incorrect, as they both share areas that can be supported by some research or studies. Although a lot of evidence appears to be in favour of the modularization theory, there is a lot evidence that backs the innate modularity theory also. Both having strengths and weaknesses, but neither have enough evidence to completely contradict the other. In this case it would be safer to say that evidence shows that some functions are localized from birth, but have the potential to adapt if necessary while other functions appear to be unable to interchange and can only operate in there localized region. The reason for this appears to be circumstantial. Depending on factors such as age, damage, purpose, function and environment. It has been made know that not all functions are localized at birth and that there is much growth, development and connections made after birth that allows many areas of the brain to take part in one function and allowing the brain to expand and

change. The evidence shown in this essay clearly shows that modularization is supported more than innate modularity. Even with the aid of current technology, scientists are still unable to stipulate which of the theories is the most accurate and the unending dispute is so yet to be settled. Word count: 1809 References Mareschal, D., Johnson, M. H. and Grayson A, (2004) ‘ Brain and cognitive development’ in Oates J. and Grayson A. (eds) Cognitive and Language Development in Children, Oxford, Blackwell/The Open University