Using Evidence of Adult Brain Plasticity to Inform Early Identification of Extreme Antisocial Behavior in Children

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As of 2010, approximately 500,000 adult psychopaths were incarcerated for heinous crimes. Historically, incarceration has been the response to extreme antisocial behavior of adult psychopaths, but research consistently shows that punitive measures are ineffective treatment to reform psychopaths. In contrast, current research on the plasticity of the adult human brain argues that the brain can change through adulthood and that therapy should therefore be sought for them. This article highlights brain plasticity in the adult, and argues that teachers should know early markers of psychopathy in order to design interventions for children who display extreme antisocial behaviors, and therefore reduce the likelihood that children with conduct problems will become adult psychopaths.

The brain of a psychopath is wired differently than the brain of an average person: a psychopath experiences dysfunction in many areas of the brain to which most people do not give a second thought. The most notable difference in the brain of a psychopath is dysfunction in the prefrontal cortex, which leaves psychopaths with a lack of empathy and a tendency for impulsivity (Feifer & Leonard-Zabel, 2009). Empathy, or the ability to understand the emotions and feelings of others and to recognize a resemblance between "self" and "other," is crucial to a person's ability to function as a normal human being. Mirror neurons, located in the prefrontal cortex, are linked to empathy because the prefrontal cortex becomes activated both when a person experiences an emotion and when he sees another person experiencing it (Feifer, 2009). The mirror neuron system is dysfunctional in psychopaths, which means they have a hard time being introspective (Feifer & Leonard-Zabel, 2009). This condition is problematic because introspection is a key component of a person's social competence and ability to feel empathy. Psychopaths can also be callous and unemotional because of impairment in the limbic system, which regulates the ability to appreciate and interpret emotion. Lastly, due to a dysfunctional anterior cingulate gyrus, which helps the brain shift attention to appropriate stimuli, most psychopaths find it hard to shift gears: once their mind is set on a task, even if the task is torture until the point of death, they feel the need to complete it (Feifer & Leonard-Zabel, 2009). Are all psychopaths like this? If they are, are they capable of change?

Until the past decade, it was widely assumed that the brain could only undergo structural and functional changes during certain crucial periods of development early in life. However, research in the past ten years has given hope that the human brain is permanently plastic. Studies done on training-induced structural changes in the brain have given the field of psychology a starting point in the area of brain plasticity. Some research has been done at the cellular level, investigating the structural plasticity of interneurons. Researchers Pascual-Leone, Amedi, Fregni, and Merabet (2005) even argue that the concept of brain plasticity in adulthood is crucial to the ability to understand brain functioning. However, as with any new research, there are limitations and disagreements, ranging from the reliability of animal studies to the limitations of Magnetic Resonance Imaging (MRI). Research continues to progress, and with more knowledge comes more practical usage. Specifically, the idea of brain plasticity has become an important topic when working with psychopaths.

There are about 500,000 psychopaths inhabiting the U.S. prison system (Kiehl & Buckholtz, 2010). It costs the government and its citizens around $40 billion per year to maintain this system. Lowering this cost may be accomplished by implementing two objectives. Because it costs about $10,000 per year per person to attempt to treat an individual who has psychopathy, we should look more into the possibility of giving therapy to adult psychopaths, who technically have a mental illness (Kiehl & Buckholtz, 2010). If adult brains are plastic, as much of the current research on brain plasticity supports, the idea of therapy for psychopaths becomes much more appealing with the hope that they might change. Secondly, early identification of markers of psychopathology in children may help educators and parents find strategies to work with them more effectively.

The Individuals with Disabilities Education Act (IDEA) allows schools to identify and provide behavioral services to children with maladaptive behaviors as young as three years old, thereby enabling teachers to provide early intervention to children who display psychopathic tendencies (Hulett, 2009). The intent is to reduce the likelihood that their behaviors will lead to adult psychopathy. However, not all cases of psychopathy are treated in childhood. Because there is research showing the plasticity of the adult brain and because psychopaths have a mental deficiency that deserves attention, the option of therapy at correctional facilities should be offered to adult psychopaths as opposed to condemning them to a life sentence in prison. Therefore, it is imperative that schools maximize cognitive behavioral interventions to modify maladaptive behavior. The remainder

of this discussion will focus on describing what research indicates about brain plasticity to show that the structure and function of the brain can in fact change.

Functional Brain Plasticity

Experiences can have a deeper impact on a person than just shaping the way one thinks. In fact, an experience can cause a functional reorganization of the brain (May, 2011). This means that the brain uses a different part of the brain to perform a task than what it normally would use for the task. This effect is due to the expansion of afferents, or nerves that carry messages to the central nervous system, into subcortical areas previously deprived of afferents (May, 2011). For example, loss of sensory input caused by injury to peripheral nerves has been shown to cause cortical representation fields to reorganize (May, 2011). In other words, one part of the brain was injured, so the rest of the brain made adjustments so that certain tasks could still be performed.

Background

The most crucial period for brain development is infancy. While plasticity is an important quality of the central nervous system of an adult, events that occur in childhood can affect the potential plasticity of the adult brain (Cirulli, Berry, & Alleva, 2003). Adverse events in infancy can hinder the degree to which the adult brain remains plastic, and Cirulli et al. (2003) hypothesize that continued disruptions in the mother-infant relationship might lend a person to be more prone to developing psychopathy later in life. Functional brain plasticity is an inborn trait, but it can either be fostered or hindered in early childhood. However, there are still studies that progress into adulthood and discover examples of the functional plasticity of the adult brain.

An experiment done in 2005 by Pascual-Leone et al. tested what would happen when subjects that normally were able to see were blindfolded for five days. They found that at the end of the five days, the subjects' brains had recruited the primary visual cortex for tactile and auditory processing. This region is not normally used for touch and hearing, but because the primary visual cortex was no longer being used for sight, it underwent a functional change and started to be used for tactile and auditory processes. This study is relevant for psychopathy because it suggests that even if an important functional region in the brain is impaired, (for example, the prefrontal cortex not controlling empathy in psychopaths), the rest of the brain can make up for it by shifting tasks and responsibilities of that region to other, healthy ones.

Another example of the functional plasticity of the adult human brain is shown in a study where the effects of a lesion, or damage to tissue usually caused by trauma, on the brain were observed (Pascual-Leone, 2005). In these subjects, the researchers observed that parallel motor circuits were activated after the lesion to establish an alternative input to spinal motoneurons. This shows that the brain is able to adapt after an injury in a way that keeps the brain running effectively. Pascual-Leone 2005 suggested that when one feels the results of an injury, the symptoms are not the effect of the injury itself, but of plastic changes in the rest of the brain. The process of recovery from a brain lesion like a stroke, outlined in the article mentioned above includes three major steps: initial plastic changes that minimize damage, quick functional improvement as impaired areas of the brain recover from shock, and relearning how to use the brain region.

Regaining hand motor functions after

a stroke was also studied by Pascual-Leone (2005). The study found that for patients who had a stroke, recovery basically involved relearning how to function but with a partially damaged neural network. The main way patients are able to do this is through the brain shifting tasks done in one now-impaired region across a specific neural network so that another part of the brain can learn to do that task.

Structural Brain Plasticity

Within the two kinds of brain plasticity, the topic of structural plasticity is much more debated in the realm of brain sciences. There is a connection between functional and structural plasticity, and it can be explained in a two-step process. Initially, existing neural pathways are unmasked or strengthened. In the second step, new structural changes are established (Pascual-Leone, 2005). Many studies have been done on the effects of training or experience on brain structure in adults, which has been shown to trigger brain plasticity. According to Arne May (2011), most recent studies have shown a direct relationship between brain changes and learning. The decrease in age-related memory deterioration as a result of brain training is an effect that many people are aware of. What some do not realize, however, is that this change also occurs at the structural level in the brain. Enrichment, or training, results in increased production of hippocampal cells responsible for emotional learning and memory and formation of new blood vessels from preexisting blood vessels (May, 2011). Structural changes in the brain such as these begin at the cellular level and have implications for the possibility that psychopaths' brains can change their dysfunctional structure and then potentially correct their behavior.

Interneurons are neurons that form connections between other neurons, and they are a basic structure in the brain that has been shown to undergo structural changes. Cell structures themselves, for example glial cells, are very rigid and do not change their structure. However, these structures are integrated into a larger system that is able to adapt to environmental changes. A main part of this system is the interneuron. When a neuron is structurally remodeled, it can occur in a few ways: dendritic branching, higher quantity of dendritic spines, or a higher density of dendritic arbor (Nacher, Guirado, & Castillo-Gomez, 2013). To change, the interneuron must have an altered environment. For example, many studies have shown that a great amount of stress affects dendritic branching in neurons in the prefrontal cortex, and animals who grow in an enriched environment have more dendritic branching in their visual cortex (Nacher, Guirado, & Castillo-Gomez, 2013). For psychopaths, this "altered environment" could include a combination of prison, therapy, and social conditioning to attempt to create a change in brain structure.

To achieve these structural changes, interneurons recruit the usage of the polysialylated form of the neural cell adhesion molecule (PSA-NCAM). PSA-NCAM has anti-adhesive properties and thus is very helpful in creating structural plasticity in the central nervous system (CNS) (Nacher, Guirado, & Castillo-Gomez, 2013). The presence of PSA-NCAM in the CNS has been tied to creation of neurons from neural stem cells and to neurite and synaptic remodeling. In schizophrenic patients, PSA-NCAM may be involved in alterations observed in neuronal circuits in the prefrontal cortex, amygdala, and hippocampus. Interneurons that show PSA-NCAM have reduced structural

features and synaptic connectivity than interneurons that do not have PSA-NCAM. The existence of this special cell provides researchers with evidence of structural plasticity.

Overall, there are two main aspects of the cellular level of brain plasticity that the author wishes to cover. Interneurons are capable of remodeling dendritic spines under certain external conditions (e.g. stress). In terms of the plasticity of interneurons themselves, PSA-NCAM plays a role. Because of its unique properties and anti-adhesive nature, it can help create structural plasticity in the central nervous system.

Many different training-induced structural changes have been observed in the adult human brain over the past decade. People with navigational experience have been observed to have a larger posterior hippocampus; musically proficient individuals have more volume in motor and auditory areas of the brain; basketball players have an larger cerebellar vermian lobules VI-VII; and golfers have changes in a frontoparietal network of the brain in gray and white matter, which line neurons so messages do not get lost in translation, (May, 2011).

In the same blindfolding study done by Pascual-Leone (2005), tests were also done on early-blind subjects. Since the results of the functional changes that occurred in the blindfolded subjects did not last beyond a few weeks, the scientists were curious if prolonged blindfolding, or in effect early blindness, would result in lasting structural changes. They found that in the early-blind subjects, connectivity between primary somatosensory cortex and early visual cortex had changed and remained that way the rest of their life.

An experiment testing the effects of training on potentially plastic brain structure was covered in a 2011 article by May. The experiment set up a juggling task for its subjects: they were to learn how to juggle three balls for 60 seconds, having no prior knowledge of juggling. The subjects were trained for three months daily to ensure they could perform the task. The researchers did brain scans at three points during the study: before they learned to juggle, right after the three months of training, and three months after the second scan. The results of the training on the subjects' brains as observed in the second scan were an increase in transient gray matter in the extrastriate motion-specific area of the brain. May and other researchers also found that it is the learning of a new task, as opposed to the continued training of a previously-known task, that creates the structural changes they observed. For psychopaths, this means that training them to react in new and socially acceptable ways to certain situations can lead to structural changes in their brains and that perhaps, they will not relapse into their old ways.

The one concern with these structural changes is that they go away once training has stopped. What does this mean for psychopaths? If they go through therapy and their brain begins to change, therapy cannot simply be stopped. The training has to be continual if the structural changes are going to stay. In the blindfolding study, researchers observed that if training was sustained and reinforced, then the development of changes was slower but the structural changes were more permanent (Pascual-Leone, 2005).

Limitations of Study

As with any new field of research, there are limitations, discrepancies, and questions. Questions arise about the reliability of brain plasticity studies because with the brain, it is hard to tell whether structural differences are a precondition for certain behaviors, or if the differences are the result of training and exercise. The two main researchers who challenge the idea of brain plasticity are Cibu Thomas and Chris Baker. They outlined three major areas of concern within this new field of research (2012): the translation of animal studies to humans, limitations of MRI and other brain imaging techniques, and lack of consistency in data.

Animal Studies versus Human Studies

Many studies that support adult brain plasticity have been done on animals because performing brain tests and rehearsing scenarios with animal brains is often easier than with human brains. However, it is unclear to what degree the results of these studies are consistent with humans. For example, a study done in 2009 by Xu et al. on motor learning in mice showed that there were rapid changes in dendritic spines followed by elimination of certain spines. Within sixteen days, the spine density was back to normal. The problem posed by this study is that it is hard to tell what would happen at a larger scale (i.e., in humans) since the scale of changes in the mice was so small. Continued research is needed to verify that these brain changes that occur in animals also may happen in humans. If researchers can verify the credibility of animal studies, mental health agencies will eventually be able to use the evidence that human brains can undergo structural changes to offer appropriate treatment to psychopaths. Until that point, however, there still remain other inconsistencies in brain plasticity research.

Limitations of Magnetic Resonance Imaging

Studying the human brain is a difficult task, given that researchers must use technology and other tools to observe the microscopic changes that occur within it. Magnetic Resonance Imaging technology provides researchers access to a wide variety of information relating to the brain. One big advantage is that MRI can image the whole brain as opposed to certain individual structures of it (Thomas & Baker, 2012). Difficulties occur because of the difference in structural changes in animal brains as opposed to in human brains. In animal brains, the structural changes that occur are sometimes very small. Researchers are unsure whether the equivalent changes occurring in humans will be lost on an MRI scan or will be visible since humans' brains are bigger than animal brains. Other limitations posed by the MRI include scanner noises that corrupt the MRI signal and subjectivity in interpreting results from MRI. The techniques that researchers use to analyze data from MRI scans involve several stages of processing. This is an attempt to reduce the effect that outside noise and other disturbances may have on a scan. For example, outlier data points that may have been caused by a source out of the control of an experiment are removed in an initial analysis of data before further analyses are made. However, not all researchers who collected data on studies supporting brain plasticity performed these statistical corrections (Thomas & Baker, 2012). Because of these potential discrepancies, it is hard to draw solid conclusions from data gathered from MRI scans.

Lack of consistency in data

Thomas and Baker compared various different researchers' work to see if all

of the research is in agreement. They discovered a few problems in both the techniques and the results. For the juggling test described earlier, when the experiment was done by four different groups of researchers, each group found structural brain changes, but some groups found changes in different areas of the brain than others. This is a concern because if the changes are not consistent, being that it is hard to defend them as being a direct result of training. Another problem that Thomas and Baker found was that there has not been any research done in which two test groups are trained on two different tasks and then their brains are tested for changes. This type of study would be very beneficial because then researchers could be sure that structural changes that occur in the brain are related to specific training and are not just an overall effect of exercising the brain (Thomas & Baker, 2012).

Early Intervention

As mentioned earlier, the IDEA provides teachers with a way to identify and provide behavioral services to children who display maladaptive behavioral tendencies. If parents and educators are able to work together to form a plan to treat behavioral and mental conditions early in childhood, not only will the government spend potentially less money on incarcerating psychopaths, but those children will be able to go on to lead productive lives. According to Hulett (2009), a child with a disability is one who has an impairment and needs special education and related services. The IDEA contains six pillars to help meet the needs of these children: an individualized education program, free appropriate public education, a least restrictive environment, appropriate evaluation, active participation of the parent and the student in the education process, and procedural safeguards for all participants. Children whose academic or behavioral challenges impact their education negatively are entitled to special education to meet those needs, and this education, the details of which are outlined in IDEA, will benefit not only the child but also society at large (Hulett, 2009).

Conclusion

Early identification of children who display psychopathic tendencies is crucial to the ability to provide effective treatment. However, not all cases of psychopathy are able to be identified in childhood. For adult psychopaths, a treatment plan must be found as an alternative to, or in addition to, incarceration especially because of some of the evidence related to brain plasticity presented in this article.

Despite some evidence to the contrary, the relatively new idea of brain plasticity shows promise. Baker and Thomas (2013), skeptics of the credibility of structural brain plasticity, admit to finding small structural changes in the brain. If there is even a chance that psychopaths can change the way they think and the way their brain functions, then we should give them the opportunity to do so via therapy. As a society looking to better both individual citizens and the people as a whole, it is unfair to lock up psychopaths, who have been shown to have mental deficiencies, for life without giving them the chance to change. Yes, criminal psychopaths should receive punishment for wrongdoings, however, they also deserve a chance to learn from their mistakes. Offering psychopaths a combination of jail time and opportunity for therapy provides them such a chance. Therapy will need to be constant and consistent so that any structural changes in their brains do not go away. Giving someone who lost their leg a prosthetic leg provides a cure for the condition, but taking away the prosthetic leg would be devastating to that individual. Therapy for psychopaths follows the same idea: they need constant and consistent reinforcement of social norms and socially acceptable ideas, or the changes in their brains may eventually disappear and negate months or years of therapy. Because of the amount of disputes in the new field of brain plasticity, continued research is needed in the area, specifically in the structural category, but we should still make changes that positively affect psychopaths with the reliable information that we do have.

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