Executive Dysfunction in Depression

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Abstract

Depression: a psychoneurotic disorder often associated with symptoms such as:
- Markedly diminished interest or pleasure in activities
- Feelings of worthlessness or excessive guilt
- Fatigue or loss of energy
- Diminished ability to think or concentrate
- Recurrent thoughts of death, suicidal ideation

Executive Function:

Executive functions are the higher-order processes that enable us to plan, sequence, initiate, and sustain our behavior towards some goal, incorporating feedback and making adjustments along the way. Tasks which have required executive functioning have been shown to activate regions that include the frontal lobe, thalamus, and basal ganglia.

Past research has strongly suggested that subjects with depression perform significantly worse than controls on tasks which require executive functioning. The reason as to why this particular aspect of cognitive functioning is impaired in people with depression however is not clearly understood. Through the use of functional Magnetic Resonance Imaging (fMRI), we seek to understand the difference in activation patterns in regions of the brain involved in executive functioning, which may suggest a causal link between reduced performance and motivational differences.

Objective

This research study was designed to study:
1) The behavioural / performance levels of the depressed population
2) The functional activation differences in the depressed population
3) Ultimately, to determine whether executive functioning deficits are related to some form of dysfunction in the frontal lobe regions.

In our pilot study, results have shown that subjects affected by depression perform worse on tests which task their executive functioning and also a reduced number of responses to stimuli. We expect the same reduced performance level and responses from depressed subjects as our preliminary results suggest. What we expect functionally is a change in the activation patterns in the brain. We hypothesize that the activation levels of the frontal lobe, thalamus, and basal ganglia to be higher in the depressed subjects than control subjects.

Methods

Participants for the study were recruited through the University of Michigan Depression Center, which includes pre-treatment depressed patients and non-depressed controls. Diagnosis of depression was determined through standardized tests and unstructured clinical interviews conducted by a faculty psychiatrist or psychologist. Demographic factors such as age, education level, verbal IQ, handedness, and level of depression were controlled for.

Participants who volunteered to engage in the study underwent a Functional Magnetic Resonance Imaging (fMRI) scan using a research-dedicated GE Signa 3 Tesla Scanner. While in the scanner, subjects viewed visual stimuli through display goggles attached to the head coil, and used a handheld key press device for the Go/No-Go Executive Functioning Task.

Tasks

Behavioral Tasks:
- Beck Depression Inventory-II
- Hamilton Rating Scale for Depression

fMRI Tasks:
- Go/No-Go (Executive Functioning):
  - Targets: X, Y, & Z
  - Cues: X, Y, & Z

The Go/No-Go Executive Function Task is a three-part task that demands rapid, selective motor response and inhibition to visual cues.

P1: (Easy) Subjects are presented letters and told to respond to X, Y, and Z any time they see it flash up on the screen.

P2: (Intermediate) Subjects are presented with letters and told to respond only to X and Y in alternation.

P3: (Difficult) Subjects are presented with letters and told to respond to X, Y, or Z only if the previous letter they responded to was not the same letter they were about to respond to.

Behavioural Results

The behavioural data did not reach statistical significance due to the small number of subjects. However, the general trends of the data on the go/no-go executive functioning task appear to support the claim that depression affects executive functioning.

On the easiest section of the task, where the subjects were required to respond to X, Y, and Z regardless of presentation, there was no significant difference in performance.

In following with our hypothesis, the behavioural data confirmed that executive functioning is impaired significantly in depressed subjects, often resulting in overinhibition. This is supported by the reduced number of responses by depressed vs. the much greater amount of responses by control subjects. In addition to an overall decrease in responses, depressed subjects had a tendency to perform worse as the inhibition task became progressively more difficult, which suggests an overall decrease in the performance of executive functioning.

Functional Results

The functional data from the fMRI scans suggests that there is a significant difference between activation patterns in depressed subjects vs. controls.

Of particular interest is the increase of activation in regions that are involved in executive functioning, perhaps suggesting an overactivation of the executive functioning processes results in excessive inhibition.

The activation in the brains of depressed patients show an overall increase in activation as compared to depressed. Select images show particular regions of interest:

Figure 1: MT
Figure 2: dorsal anterior cingulate and SMA
Figure 3: dorsal anterior cingulate

Conclusions

In conclusion, executive functioning is impaired significantly in depressed subjects, often resulting in overinhibition. Further research will be necessary to understand why these particular regions are overactive, and whether this abnormality in activation is a cause or result of depression.