How Do Receptors Work in the Human Brain?

by

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Introduction

Depression and anxiety medicines are often depicted as a cure for a 'chemical imbalance'. The pharmaceutical companies are very adamant in their commercials about making sure victims of these diseases know that it is not their fault they were born like this. It is often the result of genes that have been carried through parents or a life-altering event that had traumatic effects or a number of other causes.

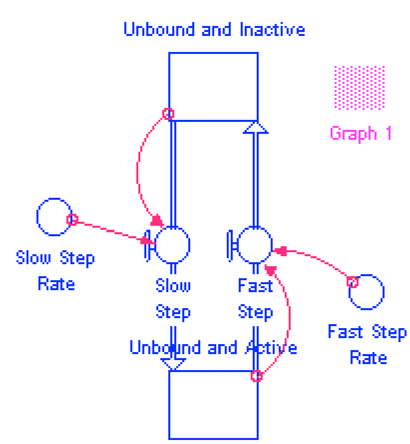
This model aims to prove this chemical imbalance as fact. Commercials are not always trustworthy. Huge corporations are usually not telling the public the entire truth. Fortunately, in this case there is some truth to what they say. This model and paper aims to show what scientists all over the world have already discovered that an imbalance of chemicals in the body can affect human emotions; consequently, being able to create drugs such as Zoloft or Paxil to help people suffering from a mood-altering condition is necessary.

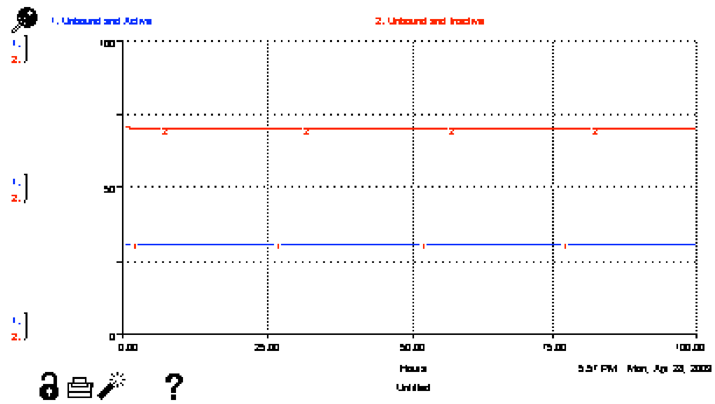
The questions that must be posed are complicated, while at the same time can be answered in a simple way: how do receptors in the brain create mood and how does this equilibrium achieved between the receptors help a person function more normally in life?

The Process of Model Building

This model concentrates on four receptors in the brain—an unbound active and inactive receptor and a bound active and inactive receptor. Natural drugs in the body affect each of these four areas. Drugs attach to different nerve cells and depending on whether they are bound or unbound and active or inactive, send a different message to the brain. The importance behind equilibrium among these four receptor stages will be described in detail later. First, the different stages will be explained based on the order they were developed and the importance on achieving a unique equilibrium at each stage.

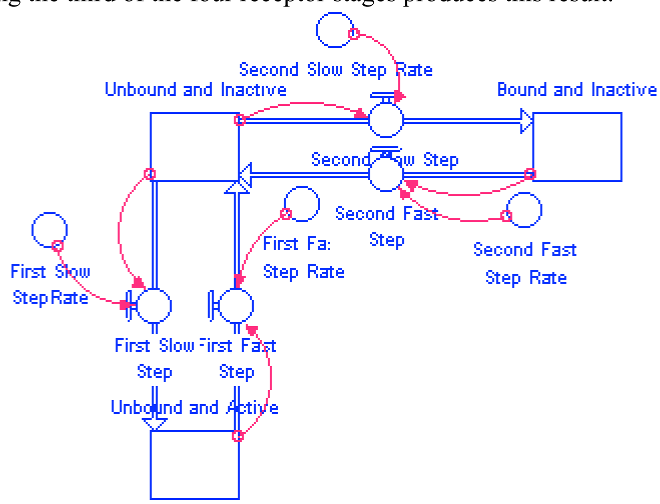
The first receptor stages to be studied were the unbound active and unbound inactive receptors. They need to be in equilibrium. Each stage requires this as it leads the way into the next receptor stage to be studied. All of the relationships are exponential, meaning that the inflow and outflow from each receptor is dependent on a percentage of the stock value at any given moment. Also, there is a slow step and a fast step for each relationship. The resulting model and graph is shown below.



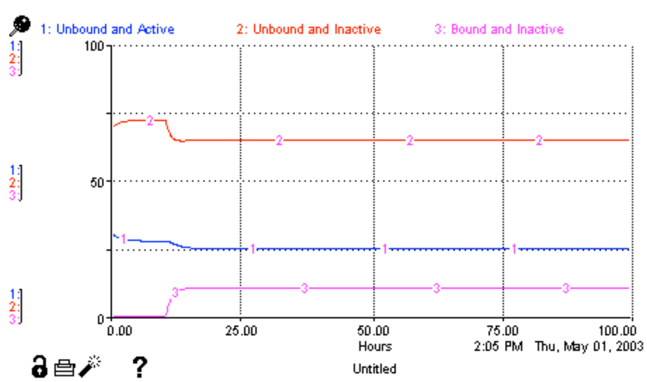


As the graph clearly shows, the two receptor stages maintain a 70 to 30 ratio, with the unbound and inactive state being the higher of the two. This ratio will prove to be important later on in the explanation. The slow step rate has a value of 0.2, while the fast step rate value is 0.46.

Connecting the third of the four receptor stages produces this result.

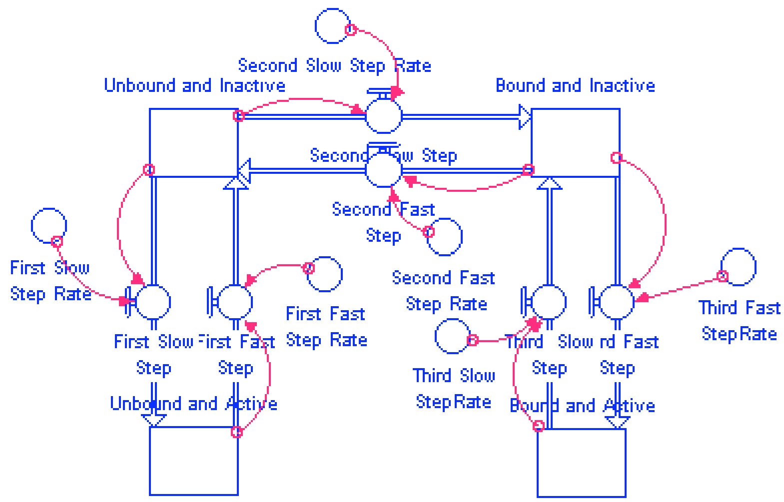


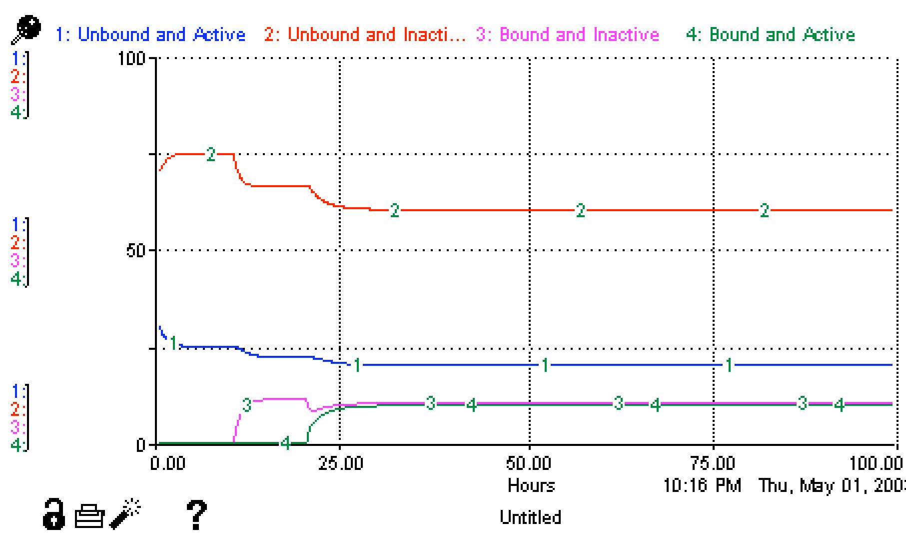
In this case, the numbers of the fast and slow step from the original two receptors are 0.52 and 0.2, respectively. These values had to change to accommodate for the added piece. The slow rate, outflow from the unbound and inactive stock is 0.14, while the fast rate, connecting to the outflow from the bound and inactive stock, is 0.88. The graph of this model will again show an equilibrium relationship, but since there can ever only be 100% of the drugs in the system, the unbound and inactive will be reduced to 65 and the unbound and active to 25 in order to accommodate for the bound and inactive receptor stage, to be about 10% of the total drug receptor state.



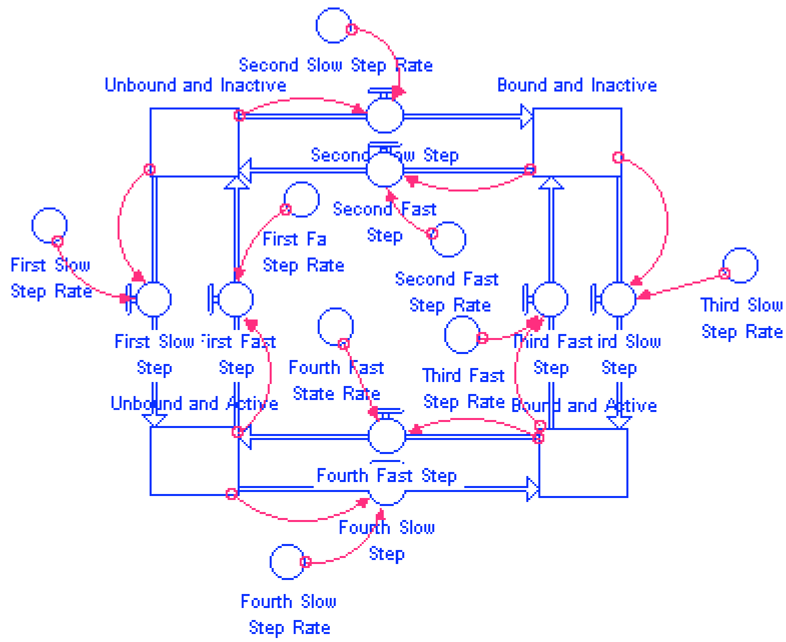
The reason the graph starts out unequal is because the step function was used to activate the third receptor stage at time t=10 hours, in order to display what the third state is doing to the model.

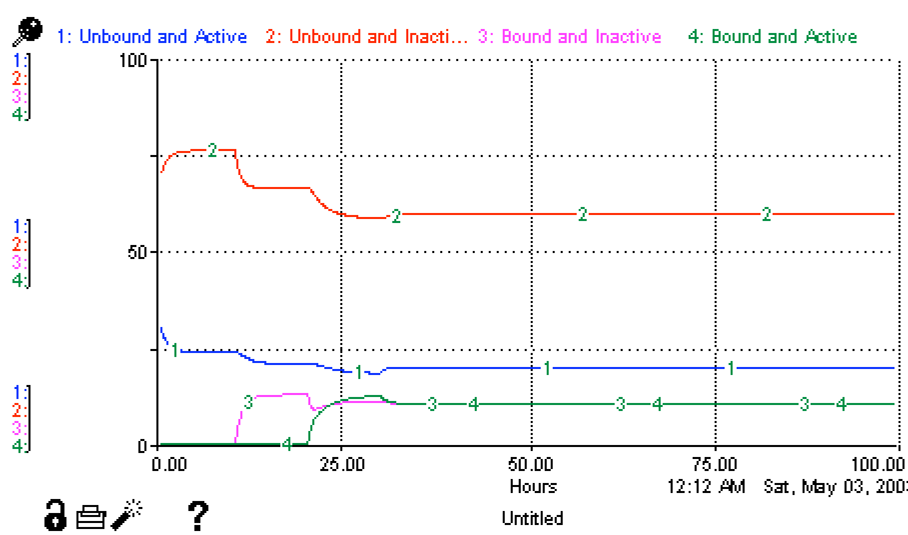
Adding the fourth receptor stage will again produce a new equilibrium, since an additional 10% of the total will now be in the bound and active receptor category, making the value of the unbound and inactive receptor change to 60 and the unbound and active to 20. The values of each component to the inflows and outflows also had to change once again. The slow and fast steps from the first two receptors become 0.25 and 0.75, respectively. The fast and slow steps that flow in and out of the bound and inactive receptor are now 0.95 and 0.10, respectively. And the new fast and slow rates flowing in and out of the bound and active receptor to the fourth receptor state are 0.85 and 0.20, respectively. The model and graph are again shown below. And the third receptor state was introduced at time 10 hours, the fourth was introduced at time 20 hours. A graph shows the effect of the new percentages on the original receptor stages, before introducing each new component state.





Connecting the four together proved to be an arduous task. Each fast and slow rate had to be varied to create an equilibrium between all four receptor stages. The ending result has the four fast rates, starting at the unbound and inactive receptor and following the arrows of the fast steps around counter-clockwise are 0.25, 0.25, 0.58, and 0.18 respectively. The slow steps in this complete model, beginning again at the unbound and inactive receptor, but following the arrows clockwise, are 0.95, 0.90, 0.80, and 0.80 respectively. The final model and graph becomes:





Feedback loops and Model Components

The time specs of this particular model are set at 100 hours. This is so the model shows over a span of about four days that the receptor stages in the brain are maintaining a constant level. The separate component states are introduced at time 10 hours and 20 hours, showing that change occurs in only a few hours.

Again though, the crucial equilibrium necessary to maintain a healthy life is achieved, even after a new receptor stage is put into action.

Each stock has six feedback loops describing its relationship with the components surrounding it. There are two for the inflow and outflow, one which relates an adjoining stock, one which describes the stock and the inflow and outflow going into one of the neighboring stocks, and two which relate the entire model. All of the loops are balancing, since all the stocks are connected to each other in the model and each is dependent on the behavior of each of the other stock, counteracting an increase or decrease in any drug receptor state.

The two major feedback loops show this relationship. One starts at one of the stocks and follows it through clockwise from a slow step to another stock to another slow step, etc until reaching the original stock again. The other critical feedback loop follows the fast steps counter clockwise in this same fashion, from one stock to a fast step flow to another stock, until reaching the original stock, where it had started.

An example of one of these crucial loops is show below. As it can be seen, all four receptor stages are connected through the fast and slow steps, which bind them together. Since this loop is balancing, each piece follows an inflow into a stock into another flow until it completes the circle, where it just begins again. This causes the model to maintain equilibrium for each stock.

Unbound and Active

Fourth Fast Step   First Fast Step

Bound and Active   Unbound and Inactive

Third Slow Rate   Second Slow Rate

Bound and Inactive

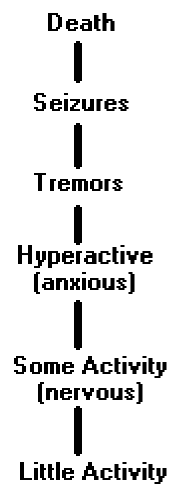
The Finished Model

Now, an explanation of how this model affects emotions. In the brain, these four receptors play important roles in the emotions and behavior of a person. As previously stated, the ratio of these four receptor stages is critical. The inactive receptors, two that occur on the top of the model, indicate how active mentally, emotionally, and physically a person is. The bottom two, or active receptor states indicate how relaxed or sedated a person is.

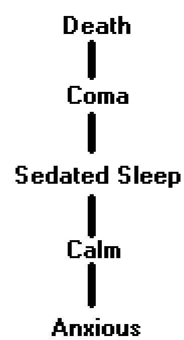
If this ratio becomes too ‘top heavy’ a person find that they are anxious a lot, cannot concentrate, and generally have a tough time falling to sleep. In this state, the heart is receiving too many of a certain type of impulse, causing it to beat faster and the muscles of the body to contract. This is a major reason why people with anxiety often find their legs shaking unconsciously or find themselves playing with inanimate objects (twiddling with pens, etc).

On the other hand, if the bottom is way out of proportion, the person finds that they have trouble staying awake, they are often too calm, and maybe even find themselves depressed.

In order to show this relationship a little more clearly, the below figures show a simplified order of the emotions a person will feel. The top-heavy emotions follow this path.



The bottom heavy emotions follow this path.



These emotional states clearly show that both of the imbalances can, at an extreme level, lead to death. Looking at the latter of the two figures, a normal person's drug levels will generally center around the calm area, moving from anxious, which is this case will mean active, to sedated sleep, which in this case will refer to a deep sleep. Throughout a day, the receptors in a person's body do not stay in perfect equilibrium, as they do in the model, but they should stay in relatively the same ratio. Certain days can hold a higher jump in emotional level either way, but the equilibrium should be maintained within twenty-four hours or so.

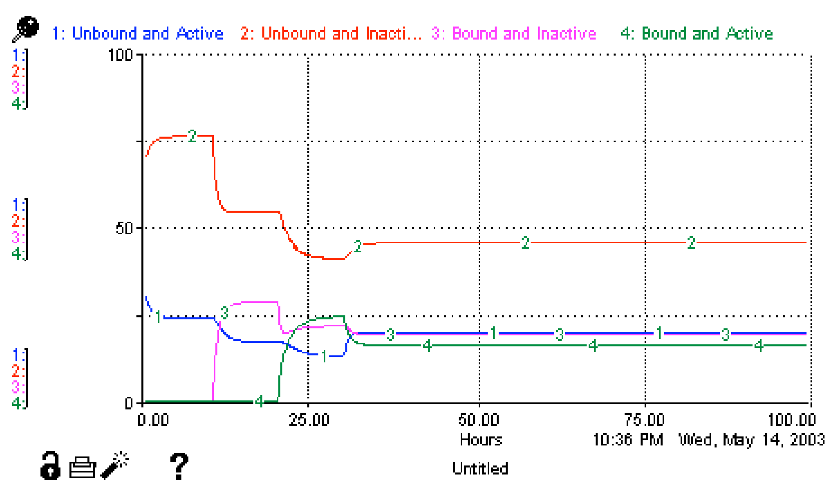
The below table shows how precisely equilibrium was reached. Again, the time is in hours, B and A represents bound and active, B and I represents bound and inactive, U and A represents unbound and active and U and I represents unbound and inactive. Remember, these numbers are percentages of the total drugs in each of the receptors and the desired ratios occur when bound and active and bound and inactive are around 10%, unbound and inactive is around 60%, and unbound and active is around 20%, for a total of 100%.

Time	B and A	B and I	U and A	U and I
.0	0.00	0.00	30.00	70.00
5.0	0.00	0.00	23.83	76.17
10.0	0.00	0.00	23.81	76.19
15.0	0.00	12.54	20.90	66.56
20.0	0.00	12.61	20.81	66.58
25.0	11.28	10.54	18.85	59.33
30.0	12.28	10.98	18.30	58.43
35.0	10.30	10.25	19.88	59.57
40.0	10.28	10.25	19.87	59.60
45.0	10.28	10.25	19.87	59.60
50.0	10.28	10.25	19.87	59.60
55.0	10.28	10.25	19.87	59.60
60.0	10.28	10.25	19.87	59.60
65.0	10.28	10.25	19.87	59.60
70.0	10.28	10.25	19.87	59.60
75.0	10.28	10.25	19.87	59.60
80.0	10.28	10.25	19.87	59.60
85.0	10.28	10.25	19.87	59.60
90.0	10.28	10.25	19.87	59.60
95.0	10.28	10.25	19.87	59.60
Final	10.28	10.25	19.87	59.60

The Extremes

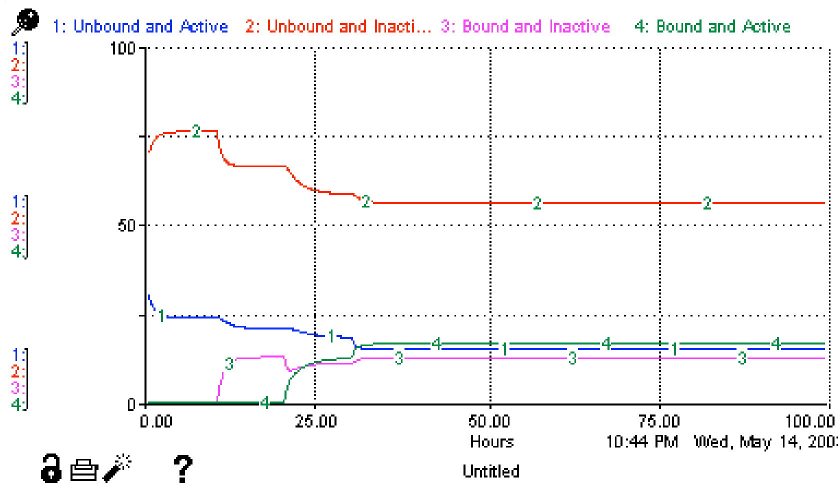
In order to show how easy it is for this equilibrium to become disrupted, the model will be tested.

This first example will show what happens if all fast and slow steps stay the same, except for the slow step leading from unbound and inactive to bound and inactive. Instead of 0.18, it will be changed to 0.50. The resulting graph is shown below.



Instead of maintaining the original ratio, the unbound and inactive stock has plummeted to only 45%. The unbound and active receptor has maintained a value of 20, but both of the bound receptors have almost doubled. This would create a bottom heavy bag of emotions for the person, leading them to feel as if they are sedated and depressed. This type of situation would call for Paxil or Prozac, both depression medicines, in order to correct this ratio imbalance.

On the opposite side of the model, if all the other fast and slow rates were kept constant, but the slow rate connecting the unbound and active receptor to the bound and active receptor is changed from 0.25 to 0.75, the graph shown below occurs.



Whereas before when the ratio from unbound and inactive to unbound and active was 70:30 and then 60:20, never being more than 3:1, now the ratio is almost 4:1. This causes a top-heavy environment in this person's brain and the may reflect someone with attention deficit. Again, drugs would be prescribed to correct this imbalance. It is important to also keep in mind that the drugs only work at 10-12 hours at a time, so the person would either have to take one a day, in order to concentrate through the school day, or two to keep this equilibrium for the entire 24 hours.

Just changing one of the pathways into or out of a stock can have dire consequences for the person. It has just been shown that it could either decrease their outlook on the world or prevent them from being able to concentrate; these are both very important factors to a successful life. If the problem is perpetuated, the figures on emotions above show that depleting either the unbound and inactive stock or unbound and active stock can lead directly to death.

Twenty years ago, there were no corrective drugs that a person could take when the natural drugs in their body weren't performing at the desired level. Prescription medicines didn't require a simple doctor's visit, prognosis, and trip to a local pharmacy. They didn't exist. At least not in such mass quantity as they do today.

Anxiety and attention deficit disorder have increasingly become more common as a result of changes in the American society. People are more hurried in their every day lives, find a great deal more required of them at a younger age, and often feel the need to simply give up. Alcoholism has become rampant. More women are not taking care of their bodies while pregnant. These factors and more have contributed to an increase in emotional diseases in this country. This paper attempts to show how the imbalances are created and provides some explanations about how to readjust the imbalance, but falls short of providing an answer to stopping the imbalances completely. The problem may be though, that there is no answer and this problem is quickly turning into something that can easily affect anyone.

What I learned

- The importance of the equilibrium maintained by drug receptors in the brain
- What the phrase "chemical imbalance" really means
- The difficulty behind creating four stocks which all connect in a square of flows, all using exponential equations
- The ratios naturally maintained inside the brain
- The fact that there are a lot of questions about the way the human brain works which have yet to be answered
- The reason some people cannot help that they are depressed or anxious or hyper and the resulting drugs that help them

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