THE CINGULAR THEORY OF UNIFICATION: THE CINGULATE CORTEX DOES EVERYTHING

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1. Abstract

We are witnessing a growing phenomenon the likes of which has not been seen since the dawn of the industrial revolution. Since the discovery of a small strip of brain called the cingulate cortex in the early nineteenth century, research has progressed from a trickle of studies to a torrent of investigations threatening to flood the field of neuroscience completely. In these ensuing years the cingulate has been found to play a vital role in almost all human emotions and behaviors - from error prediction to pain perception, and from political persuasion to one's feeling of optimism. But with so many functions, it has been difficult to answer the simple question of "what exactly is the role of the cingulate?". Here we report, for the first time to the best of our knowledge, the "Cingular Theory of Unification" which postulates that the cingulate cortex is the alpha and omega, responsible for all of humankind's functions. We believe that this theory not only explains the available data, but also prophesizes exponential growth in cingulate research that will dominate all neuroscience research. We provide humble advice on how to avoid such an apocalyptic future.

2. Chapter

The cingulate cortex resides in a ring-like strip of brain tissue in the center fold of the neocortex surrounding the lateral ventricles. The shape of this brain region presumably inspired the German physiologists[1] that discovered it in the early 19^{th} century to name it the "cingulate" which is derived from the Latin *cingulum*, meaning a belt worn by Roman soldiers to protect their groin. But like many great discoveries, it took much time for the cingulate to grab hold of the conservative scientific community. Since the early 1900s, sporadic reports have described the neural correlates of the cingulate cortex. However, compared to flood of motor, visual, and

[1]Karl Friedrich Burdach (Vom Baue und Leben des Gehirns und Rckenmarkes. Leipzig: in der Dyck'schen Buchhandlung, 3 vols., 1819-1826) or Adolf Pansch (Die Furchen und Wlste am Grosshirn des Menschen. Zugleich eine Erluterung zu dem Hirnmodell. Berlin, 1879)

auditory papers, the cingulate reports were a mere trickle. The fault was not of the carpenters, but of the tools that they were using. The belt had to wait for the invention of functional magnetic resonance imaging (fMRI) which would emerge as the savior and restore the cingulate to its throne. In a matter of a few short years, the fundamental role of this brain area began to shift beneath the feet and groins of neuroscientists. By the early 21^{st} century the cingulate cortex had been found to be involved in loneliness (Eisenberger et al., 2004), religious experiences (Beauregard and Paquette, 2006), political leanings (Amodio et al., 2007), stimulus-reward associations (Takenouchi et al., 1999; Cardinal et al., 2003), motor planning (Shima and Tanji, 1998), error detection (Devinsky et al., 1995), pain perception (Harris et al., 2007), social exclusion (Eisenberger et al., 2004), reward expectancy (Shidara and Richmond, 2002), sleep (Rolls et al., 2003), the placebo effect (Wager et al., 2004), optimism (Sharot et al., 2007), political liberalism (Amodio et al., 2007), and work from our group on neuroprosthetic models (Marzullo et al., 2006a).

We do not believe by any means this to be a comprehensive list. Quite to the contrary, we hypothesize that the reason why so many aspects of human behavior appear to have a neural correlate in the cingulate is due to one simple fact:

The cingulate cortex is responsible for everything.

We call this the "Cingular Theory of Unification" which unifies all of the existing discoveries into one simple framework. One implication of this hypothesis is that since more and more researchers will find this brain region attractive, the amount of publications should grow unabated.

To test our theory, we retrieved the number of abstracts that referenced the words "cingulate cortex" in a popular scientific paper repository *Pubmed* (http://www.pubmed.org) and created a histogram of cingulate references by binning the number of citations by year. We then tested the curve against traditional growth functions and fit the model to the function with the strongest statistical fit. As controls, we also repeated the experiment for two historical heavyweights of brain science research: the "motor cortex" and the "auditory cortex".

Figure 1 shows the results of our analysis. There is an initial increase during the 1950s for both the auditory and motor cortices, most probably due to the advent and progress of extracellular recording and stimulation methods. Compared to these cortical areas, the cingulate is a late bloomer, only beginning to rapidly increase during the early 1990s.

But this late surge is extremely dramatic. In fact, the cingulate cortex begins to surpass the auditory cortex in the late 1980s and finally overtakes the mighty motor cortex in 2007. These trends were best modeled as exponential fits using least-squares estimation. Of the three, the cingulate cortex had the best fit (with an $R^2 = 0.97$) and also the most explosive growth. It should be emphasized that such a

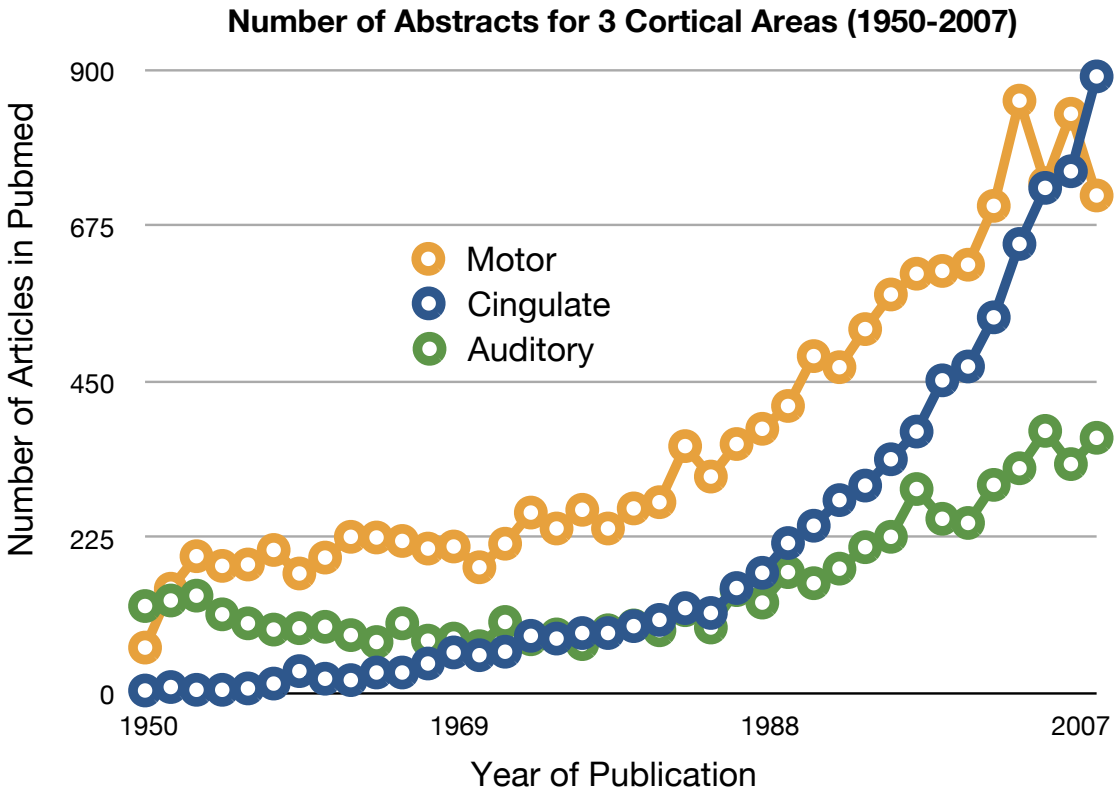

FIGURE 1. Number of Abstracts for Three Cortical Areas (1950-2007): The total number of abstracts from 1950 to 2007 which mention one of the three cortical areas are displayed. Note that in 2007, the number of abstracts that mentioned "Cingulate" finally overtook the mighty motor cortex. The R^2 values of an exponential regression fit were 0.90, 0.97, and 0.54 for the number of motor, cingulate, and auditory papers respectively.

high R^2 value is almost unheard of in the scientific community. With such a strong fit, we three sophomoric prophets can predict the future of neuroscience.

Using this model, we conservatively attempted to predict the next 20 years of research for these three fields of study. Figure 2 shows our estimates from now to the year 2027.[2] We are beginning to see an alarming trend - cingulate cortex publications

[2]We also ran the analysis on the visual cortex. In 2007, the visual cortex was still king, with 911 publications to the cingulate's 893. However, the cingulate will not be deterred. For example, in 1970, there were 343 visual cortex publications, compared to only 6 (!) cingulate cortex papers. We predict 2008 will be the year even the mightiest of mighty, the visual cortex, is finally dethroned by

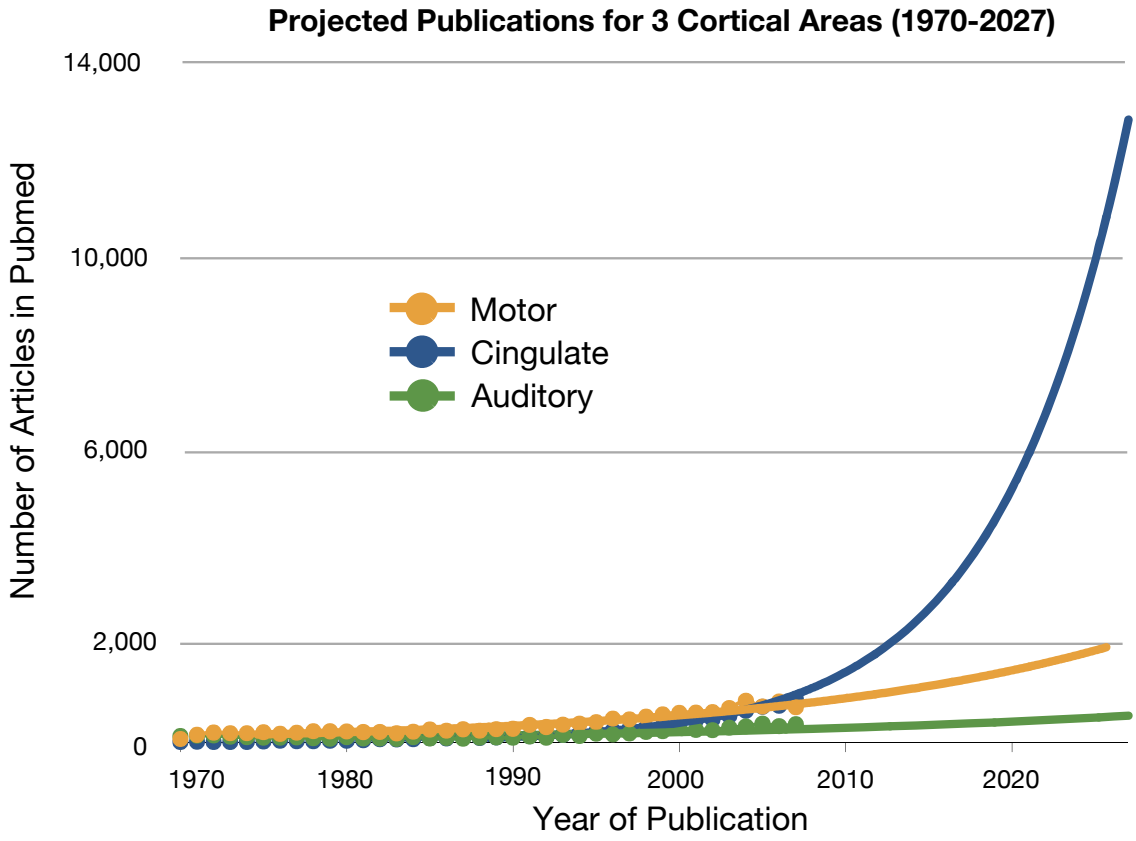

FIGURE 2. Projected Publications for Three Cortical Areas (1970-2027): Using our exponential model, we predict that the number of citations for the cingulate cortex in the year 2027 will be on the order of ∼13,500! That is a 15× increase in publications from the ∼900 in 2007, whereas the motor and auditory cortices will have a more reasonable and sustainable number of publications.

will increase by a factor of 15, whereas motor and auditory research will only increase by a factor of 1.5−3. If we extend our model to predict towards the end of the 21^{st} century, though merely a prophetical projection, the cingulate cortex will dominate $> 99\%$ of all neuroscience research. We also predict that between 2050−2100, there will be more cingulate publications than there are cells in the cingulate cortex itself.

the warlike cingulate cortex, the beowolf of our age. By 2027, the visual cortex will only increase by a mere factor of 3, compared to the cingulate's 15.

At this point, we fear that the 'Cingularity' will be reached, and the cingulate cortex will become self-aware.

This trend does not have to continue! As intelligent, sentient beings we have the power to stop our very own cingulate corticies from taking over America, and indeed, the entire world. If the cingulate decides to use its powers for for evil, future human success may be neither assumed nor assured[3]. We hereby pronounce that we should use the best of our energies and skills to determine not *what* the cingulate does, but *how* the cingulate does all it does, and indeed, what its true intentions really are.

Even though the original discoverers did not realize that the cingulate cortex was at the apex of the functional hierarchical model of the brain, they could not have chosen a more appropriate name. For, it truly lives up to a *cingulum* by tying together every human's needs, wants, hopes, desires, hates, loves, and fears.

3. Acknowledgements

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4. Appendix

We wholeheartedly encourage other scientists to investigate this trend against their pet neocortical area. Simply go to pubmed.org, search for a cortical area (*e.g.* "motor cortex"), save all output to a txt file, and run the following code in Matlab with the following function, for example: fff('/motorcortex.txt'). A histogram will then be generated for you.

```
function [ n ] = fff( input_args )
%FFF Summary of this function goes here
%   Detailed explanation goes here

file = textread( input_args ,'%s','delimiter','\n','whitespace','');
iYear = 1;
for i=1:length(file)
   i19 = findstr( file{i}, '19' );
   i20 = findstr( file{i}, '20' );

   if length(i19) > 0
       try
           year{ iYear } = file{i}(i19:i19+3);
       iYear = iYear + 1;
```

[3]Such dire predictions are in full agreement with previous work from our group examining the ability of rat brains to control the stock market (Marzullo et al., 2006b).

```
        end
    end

    if length(i20) > 0
        try
        year{ iYear } = file{i}(i20:i20+3);
        iYear = iYear + 1;
        end
    end

end


    iYear = 1;

for i = 1:length( year )

    tm = str2num(year{i} );
    if size(tm,1) > 0
        try
       y( iYear ) = tm;
       iYear = iYear + 1;
        catch
           disp('error'); disp(i);
        end
    end
end
cingulate =  y(y<2008 & y>1949);

edges = [1950:2007];
n = histc( cingulate, edges );

figure;
bar( edges, n );
size( year );
```

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