

The Cingulate Cortex Does Everything

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Here we explain most of the mysteries concerning the brain.

We report the “Cingular Theory of Unification,” which postulates that one brain region—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.

The History and Mystery of the Cingulate Cortex

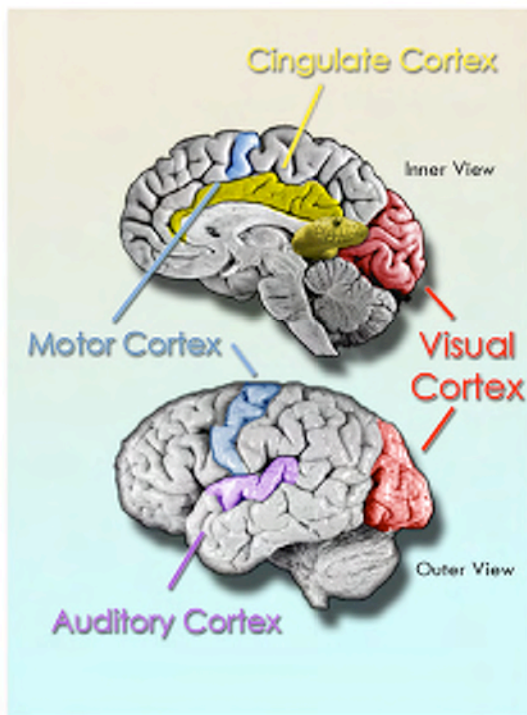
Since the discovery of the small strip of brain called the cingulate cortex in the early 19th century, research has progressed from a trickle of studies to a torrent of investigations threatening to flood the field of neuroscience completely. In these ensuing years the cingulate has been found to play 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 this simple question: what exactly is the role of the cingulate?

The Mystery and History of the Cingulate Cortex

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 physiologists¹ who discovered it to name it the “cingulate,” 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 auditory papers, the cingulate reports were a mere trickle. The fault was not of the carpenters, but of the tools that they were using.

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MRI to the Rescue

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 became widely discussed. By the early 21st 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).

The Cingulate Cortex to the Rescue

We do not believe 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.

Our Triumph, and How We Did It

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 grouping 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 the motor cortex and the

auditory cortex, two historical heavyweights of brain science research:.

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 ($R^2 = 0.97$) and also the most explosive growth. It should be emphasized that such a high R^2 value is almost unheard of in the scientific community. With such a strong fit, we three sophomore 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 will increase by a factor of 15, whereas motor and auditory research will only increase by a factor of 1.5³. If we extend our model to predict towards the end of the 21st century, though merely a prophetic projection, the cingulate cortex will dominate > 99% of all neuroscience research.

The Cingularity

We predict that between 2050 and 2100, there will be more cingulate publications than there are cells in the cingulate cortex itself. 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 cortices from

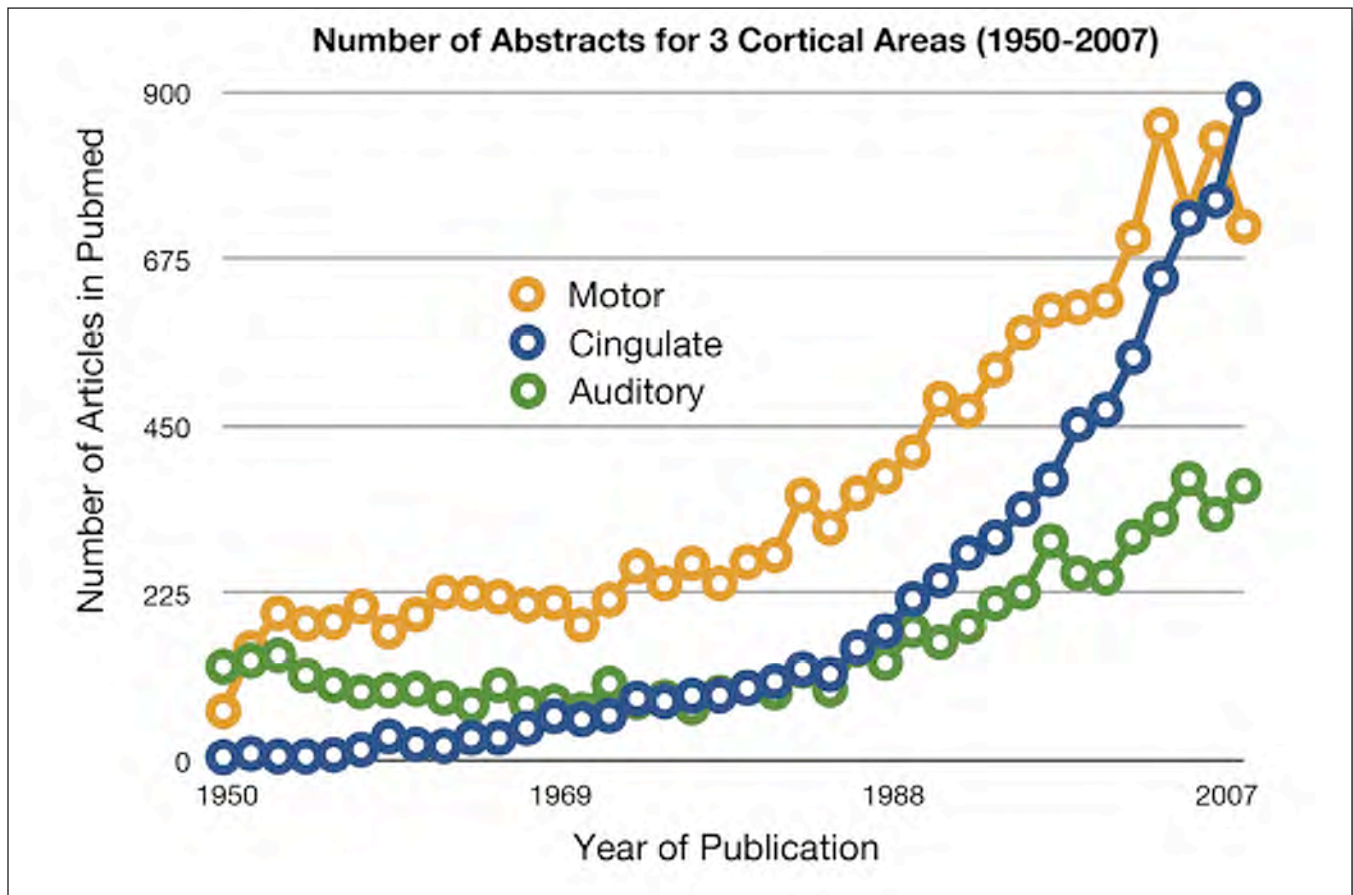


Figure 1. Number of abstracts for three cortical areas (1950-2007). The total number of abstracts from 1950 to 2007 which mention one of the three cortical areas are displayed. Note that in 2007, the number of abstracts that mentioned “Cingulate” finally overtook the mighty motor cortex. The R^2 values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

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.

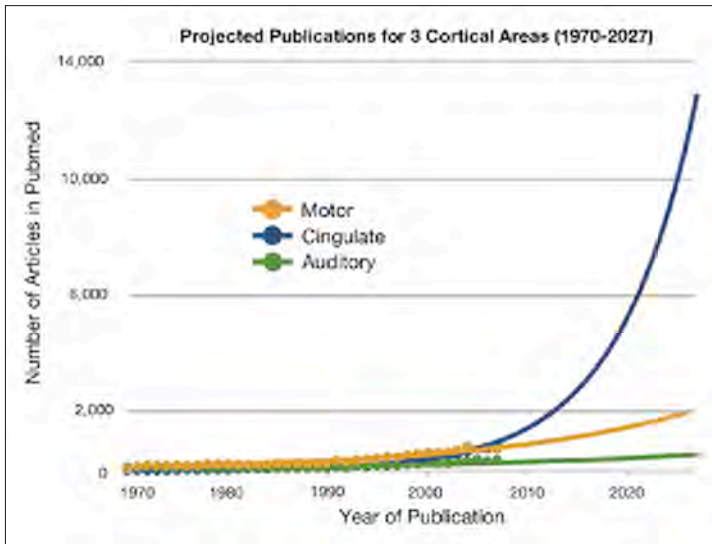


Figure 2. Projected publications for three cortical areas (1970-2027). Using our exponential model, we predict that the number of citations for the cingulate cortex in the year 2027 will be on the order of 13,500! That is a 15-fold increase in publications from the 900 in 2007, whereas the motor and auditory cortices will have a more reasonable and sustainable number of publications.

Every Day

Read something new and improbable every weekday on the Improbable Research blog, on our web site:

WWW.IMPROBABLE.COM

Acknowledgements

The authors wish to thank Dr. Régis Olry and Dr. Stanley Finger for their help in finding historical references on the discovery of the cingulate cortex, as well as Dr. Manfred Spitzer for his encouragement in publication and the translation of the original text into German. Results from this study were previously presented at the 2007 annual Society for Neuroscience meeting in San Diego, California.

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;
        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 );
```

Notes

1. Karl Friedrich Burdach (*Vom Baue und Leben des Gehirns und Rückenmarkes*. Leipzig: in der Dyck'schen Buchhandlung, 3 vols., 1819–26) or Adolf Pansch (*Die Furchen und Wülsche im Grosshirn des Menschen. Zugleich eine Erluterung zu dem Hirnmodell*. Berlin, 1879)
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 the warlike cingulate cortex, the Beowulf of our age. By 2027, the visual cortex will only increase by a mere factor of 3, compared to the cingulate's 15.
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).

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AIR Teachers' Guide

Three out of five teachers agree: curiosity is a dangerous thing, especially in students. If you are one of the other two teachers, *AIR* and *mini-AIR* can be powerful tools. Choose your favorite *hAIR*-raising article and give copies to your students. The approach is simple. The scientist thinks that he (or she, or whatever), of all people, has discovered something about how the universe behaves. So:

- Is this scientist right—and what does “right” mean, anyway?
- Can you think of even one different explanation that works as well or better?
- Did the test really, really, truly, unquestionably, completely test what the author thought he was testing?
- Is the scientist ruthlessly honest with himself about how well his idea explains everything, or could he be suffering from wishful thinking?
- Some people might say this is foolish. Should you take their word for it?
- Other people might say this is absolutely correct and important. Should you take their word for it?

Kids are naturally good scientists. Help them stay that way.