Brain Response to Good and Bad Design

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Abstract. This paper is about the decision of whether good or bad design is the result of the human brain process. Our research team has used the technique of functional MRI and Electroencephalogram (EEG) to address the question of how the brain answers while subjects viewed different designs. Classifying the good or bad designs, subjects chose a mouse button to decide their perception of good or bad design and we analyzed their patterns of EEG rhythms and fMRI. The results of fMRI showed that the perceptions of different feelings of designs are associated with the frontal lobe and the occipital lobe. After analyzing the EEG by the Event-related brain potentials (ERP) method, we also found that the amplitude of ERP components in perception of bad design is greater and latency is shorter than that of good design. Therefore, the human brain responds sooner and stronger in perception of bad feeling.

Keywords: Human Behaviors, EEG, fMRI, ERP, Interaction and Interface Design, Usability Test, Brainwork, Visual Brain.

1 Introduction

With advances in computer video display technologies such as EEG, fMRI, PET, and SPECT, brain research has become a contemporary issue. Most people thought that the brain is just black box and is not an interesting area to explore, but because of developed new technologies such as EEG, PET, and fMRI, research of the brain revealed how it is structured and worked. [1]

The weight of the human brain is about 1400g and contains between 1 billion and 100 billion neuron, and is divided into the brain stem, limbic system, and cortex. The brain stem is the major route by which the forebrain sends information to and receives information from the spinal cord and peripheral nerves. The limbic system is a system of nerves in the brain involving several different areas concerned with basic emotions such as fear and anger, and basic needs such as the need to eat and to have sex. [1] The Cortex forms 90 percent of the brain, and plays a key role in memory, attention, perception, awareness, thought, language, and consciousness. Also this part of the brain is divided into four sections: the occipital lobe, the temporal lobe, the parietal lobe, and the frontal lobe. Functions, such as vision, hearing, and speech, are distributed in these selected regions. Brain research has become a contemporary issue and

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has explored diverse aspects of many different major areas such as medical science, engineering, psychology, biotechnology, linguistics, economics, music, etc. This research has provided new insight into underlying disease mechanisms and is beginning to suggest new treatment. Also using the Neuro-Lingustic Programming (NLP) method, researchers understand human behavior and cure the human mind to lead a better life. [2]

The brain controls body activities, feels the five senses, and shapes thoughts, hopes, dreams, and imaginations. In short, the brain is what makes people human. [1] Recently, there are lots of brain researches relating to linguistics and music activities. For example, a person hears two different sentences; "He takes coffee with cream" and "He takes coffee with dog" and examined their brain movements. There are certain distinctions between the two sentences. The human brain has a strong reaction when people hear the latter sentence that is not normal. Likewise, there are certain differences of brain movements when people hear natural and unnatural melodies from music. [3,4,5] It can be linked to the art and design areas, so that research can be about how the human brain acts when people do artistic activities, and how people feel when they look at artistic works or designs.

If people look at the smile of the Mona Lisa, they usually get a good feeling. On the other hand, if people look at a photo that shows a scene with a terrible car accident, they get a bad feeling. According to this fact, if our researchers can clarify and measure how the brain works when people get a good or bad feeling, we can come up with an objective evaluation of which part of design makes people get a good feeling or bad feeling. Also we can determine the main aspects of a design with good value.

We have used the technique of functional MRI and EEG to address the question of how the brain answers while subjects viewed different designs. Twenty-five subjects participated in this research and viewed fifty design images randomly. Classifying the good or bad designs, subjects chose a mouse button to decide their perception of good or bad design. We analyzed their patterns of EEG rhythms and fMRI to find the characteristics of brain activity based on good and bad designs.

2 Brain Structure and Movement

2.1 Brain Structure

As I mentioned before, the brain is divided into four sections: the occipital lobe, the temporal lobe, the parietal lobe, and the frontal lobe, and functions such as vision, hearing, and speech, are distributed in these selected regions. The occipital lobe is located in the back of the brain and plays a role in processing visual information. (Fig.1) The parietal lobe plays a role in sensory processes, particularly determining spatial sense and navigation, attention, and language. The frontal lobe has a role in controlling movement and in the planning and coordinating of behavior. The temporal lobe is involved in auditory processing and is home to the primary auditory cortex. [1].

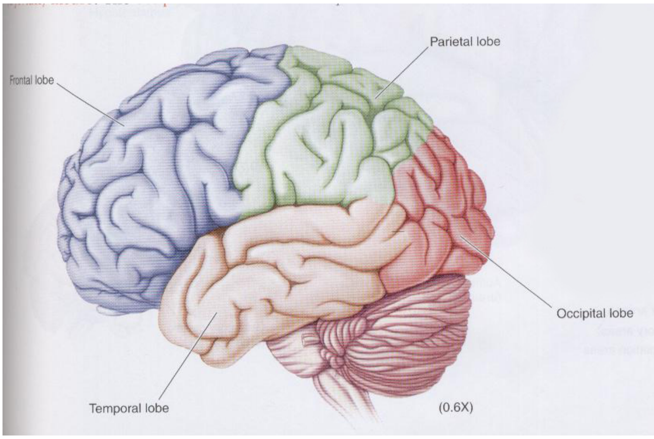


Fig. 1. Brain Classifications [1]

2.2 Brain Movement and Technology

Functional magnetic resonance imaging (fMRI). People use the MRI, which provides a high quality, three-dimension image of organs and structures inside the body to examine a body structure. But to examine the brain activity people need to use fMRI and this is most popular neuroimaging technique today. This technique compares brain activity under resting and active conditions, and it combines the high spatial resolution, which is a correlate for neuronal activity. This technique allows for more detailed maps of brain areas underlying human mental activities in health and disease. Our team has used the technique of fMRI to find out which part of brain is more activated when subjects viewed good or bad design. [1].

Electroencephalogram (EEG). Many of the recent advances in understanding the brain are due to the development of techniques that allow scientists to directly monitor neurons throughout the body. Electroencephalogram is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. In this method, electrodes placed in specific parts of the brain, which vary depending on which sensory system is being tested-make recordings that are then processed by a computer. [1].

EEG has several strong sides as a tool of exploring brain activity; for example, its time resolution is very high (on the level of a single millisecond). Other methods looking at brain activity, such as PET and fMRI have time resolution between seconds and minutes and it measures the brain's electrical activity directly. EEG can be used simultaneously with fMRI so that high-temporal-resolution data can be recorded at the same time as high-spatial-resolution data. [6].

Our team has used the technique of EEG (Electroencephalogram) to address the question of how the brain answers while subjects viewed images. Most important thing to use EEG is which part of brain we need to place electrodes to measure the brain waves. Electrode location and names are specified by the 10-20 system for most research applications. This system is an internationally recognized method to describe and apply the location of electrodes in the context of an EEG test. [6] (Fig.2).

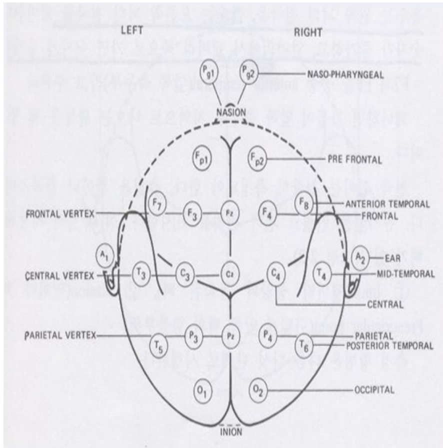


Fig. 2. Electrodes location to check the EEG (10-20 System) [8]

Event-related potential (ERP). During the experiment, we used event-related brain potentials (ERP), which is a method in checking an electroencephalogram in certain moment when subjects received the event like viewed designs.

ERP is any measured brain response that is directly the result of a thought or perception. It can be reliably measured using the EEG, a procedure that measures electrical activity of the brain through the skull and scalp. [7].

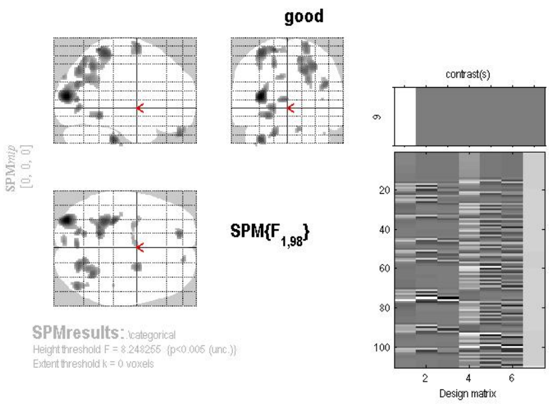
There are two important components in ERP waveform, which are P300 and N400. The N400 ERP component is described as a negative voltage deflection occurring approximately 400ms after stimulus onset, where as P300 component describes as a positive voltage deflection 300ms after stimulus onset. The presence, magnitude, topography and time of this signal are often used as metrics of cognitive function in decision making processes. While the neural substrates of this ERP still remain hazy, the reproducibility of this signal makes it a common choice for related researches. [6].

3 Brain Response to Good and Bad Design

Our team has used the technique of functional MRI and EEG to address the question of how the brain answers while subjects viewed different designs. Twenty-five subjects participated in this research and viewed fifty design images randomly. First, as I am a professional graphic designer, I subjectively chose twenty-five designs that evoked good feelings and twenty-five that evoked bad feelings. (Fig.3)

Because the author's judgment of good or bad designs was purely subjective, the individual subjects were asked to categorize each design as good or bad. As they viewed each image, they either clicked the right mouse button to classify the image as good, or the left mouse button to classify the image as bad. As they did this, we analyzed their patterns of EEG rhythms and fMRI.

Fig. 3. Design image examples for experiment



Statistics: ***p-values adjusted for search volume***

set-level *p*	set-level c	cluster-level $p_{corrected}$	cluster-level k_E	cluster-level $p_{uncorrected}$	voxel-level $p_{FWE-corr}$	voxel-level $p_{FDR-corr}$	voxel-level *F*	voxel-level $(Z_{\equiv})$	voxel-level $p_{uncorrected}$	mm mm mm
0.013	20		389		0.766	0.394	13.99	3.42	0.000	-32 -84 12
			325		0.963	0.394	11.75	3.12	0.001	-32 -38 64
					0.972	0.394	11.52	3.09	0.001	-16 -44 68
					1.000	0.394	8.89	2.69	0.004	-34 -42 48
			64		0.968	0.394	11.62	3.11	0.001	-32 -28 -36
			500		0.988	0.394	10.95	3.01	0.001	20 -70 44
					0.990	0.394	10.82	2.99	0.001	30 -54 48
					0.997	0.394	10.13	2.88	0.002	16 -64 56
			94		0.991	0.394	10.75	2.98	0.001	-24 -44 -8
			78		0.991	0.394	10.73	2.98	0.001	46 -72 28
			50		0.993	0.394	10.61	2.96	0.002	-16 52 -30
			47		0.995	0.394	10.43	2.93	0.002	-20 -70 0
			83		0.995	0.394	10.39	2.93	0.002	22 0 74
			27		0.996	0.394	10.33	2.92	0.002	-4 -72 10
			34		0.999	0.394	9.74	2.83	0.002	-16 -64 52
			14		0.999	0.394	9.63	2.81	0.003	14 56 -26
			24		0.999	0.394	9.60	2.80	0.003	-8 -88 36
			34		1.000	0.394	9.00	2.71	0.003	-26 -4 66
					1.000	0.394	8.31	2.59	0.005	-36 2 64
			17		1.000	0.394	8.89	2.69	0.004	-8 -2 68
			5		1.000	0.394	8.57	2.63	0.004	-38 -18 -44

table shows 3 local maxima more than 8.0mm apart

Height threshold: F = 8.25, p = 0.005 (1.000) {p<0.005 (unc.)}
Extent threshold: k = 0 voxels, p = 1.000 (1.000)
Expected voxels per cluster, <k> = 122.713
Expected number of clusters, <c> = 11.36
Expected false discovery rate, <= 0.39

Degrees of freedom = [1.0, 98.0]
FWHM = 18.3 18.6 19.2 mm mm mm; 9.1 9.3 9.6 {voxels};
Volume: 1680032; 210004 voxels; 240.4 resels
Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 816.46 voxels)
Page 1

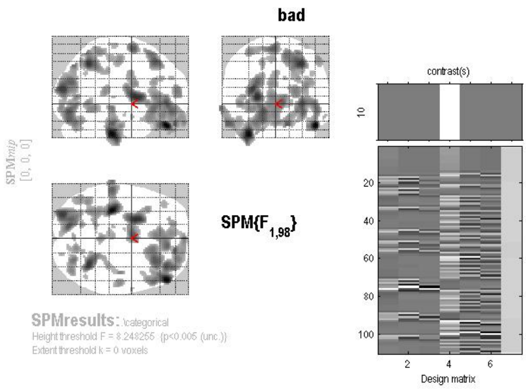
Fig. 4. The fMRI response of good design

3.1 The Results of the fMRI Based on Good and Bad Design

Our team used fMRI machine (ISOL fORTE) in the Brain Science Research Center at Korea Advanced Institute of Science and Technology (KAIST) and shooting variable is as follows: TR=3000ms, TE=35ms, Number of Slice=25, FOV=24cm, Image natrix=64x64, Slice Thickness=5mm.

The scenario of the experiment is as follows: 1. Shows “+” on a screen for 3seconds. 2. Shows good and bad design randomly for 3seconds. 3. Shows “+” on a screen for 3seconds again. We kept repeating this process to show all fifty designs. At the same time, subjects chose a mouse button to decide their perception of good or bad designs.

Fig 4 presents the part of brain that showed activity when one subject saw a good design. The top left brain image shows the midsagittal section, the right image is showing the coronal section, and the bottom image shows a horizontal section. The left part of the midsagittal is the location of the occipital lobe and the right part is the location of the frontal lobe. The top part of horizontal section is the right part of midsagittal section and bottom part is the left part of midsagittal section.



Statistics: ***p-values adjusted for search volume***

set-level		cluster-level			voxel-level					mm mm mm
p	c	$p_{corrected}$	k_E	$p_{uncorrected}$	$p_{FWE-corr}$	$p_{FDR-corr}$	F	$(Z_{\equiv})$	$p_{uncorrected}$	
0.000	38		3036		0.274	0.105	18.11	3.90	0.000	50 44 -26
					0.804	0.105	13.68	3.38	0.000	32 44 0
					0.864	0.105	13.12	3.31	0.000	14 54 -26
			1044		0.343	0.105	17.37	3.82	0.000	-34 -24 -38
					0.880	0.105	12.95	3.29	0.001	-60 -24 -24
					0.957	0.105	11.87	3.14	0.001	-70 -24 -6
			599		0.586	0.105	15.35	3.59	0.000	-24 6 8
					0.994	0.105	10.50	2.94	0.002	-36 20 0
			684		0.633	0.105	15.00	3.55	0.000	32 -54 48
					0.975	0.105	11.43	3.08	0.001	28 -56 62
					0.999	0.105	9.73	2.82	0.002	32 -30 40
			926		0.685	0.105	14.61	3.50	0.000	-30 -86 18
					0.885	0.105	12.89	3.28	0.001	-24 -78 26
					0.990	0.105	10.80	2.99	0.001	-28 -88 -6
			652		0.831	0.105	13.44	3.35	0.000	-16 -78 -10
					0.953	0.105	11.94	3.15	0.001	-20 -72 -4
					0.957	0.105	11.86	3.14	0.001	-24 -72 -22
			619		0.842	0.105	13.34	3.34	0.000	26 30 52
					0.960	0.105	11.81	3.13	0.001	14 26 58
			178		0.869	0.105	13.07	3.30	0.000	-2 2 66
					0.996	0.105	10.33	2.92	0.002	-16 -2 68

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Expected false discovery rate, <= 0.10

Degrees of freedom = [1.0, 98.0]
FWHM = 18.3 18.6 19.2 mm mm mm; 9.1 9.3 9.6 {voxels};
Volume: 1680032; 210004 voxels; 240.4 resels
Voxel size: 2.0 2.0 2.0 mm mm mm; (resel = 816.46 voxels)
Page 1

Fig. 5. The fMRI response of bad design

The bottom table of fig4 shows the coordinates of where the brain was activated. Using these coordinates we can indicate the broadmann area in the activated brain areas. After observing the broadmann area, the most activated areas were points 19,7,11,and 6. These areas are the occipital lobe, the parietal lobe, the prefrontal lobe, and the frontal lobe. The decisions to judge images either good or bad are made in the occipital lobe and the frontal lobe. The broadmann 7 area, which controls visual-motor coordination, is located in the parietal lobe, but it is close to the occipital lobe.

Fig 5 presents the part of brain that showed activity when one subject saw a bad design. When subjects judged the design as bad, their brain was activated in broadmann area 18, 19,7,11,6, and 20 and these areas are location of the occipital lobe, parietal lobe, prefrontal lobe, frontal lobe, and temporal lobe. The broadmann 20 area, which controls the high-level visual processing and recognition, is located in the temporal lobe. Similarly, The occipital lobe, frontal lobe, and parietal lobe were activated while subjects looked a bad design. We noticed that there were differences in specific activated areas, for example, the brain action when subjects had a bad feeling was much stronger than when subjects had a good feeling. Also, there was little difference in brain action between the left and right brain when the subject perceived the design as good, but left-brain action was strong when subjects perceived the design as bad.

3.2 The Results of the EEG Based on Good and Bad Design

Based on the fMRI result, our researchers decided to attach electrodes in the area of the occipital and the frontal lobe, which is Fp1, Fp2, O1, and O2 from 10-20 system, and examine the EEG in the areas. (See Fig.2.) Twenty-five subjects participated this research and the scenario of the experiment is as follows: 1.Shows “+” on a computer screen for 1minute to be a steady state of brain. 2. Shows good and bad design randomly for 3seconds. 3. Subjects choose a mouse button to decide their perception of good or bad designs. 4. Shows “+” on a computer screen for 1minute to be a steady state of brain again. We kept repeating this process to finish all fifty designs.

During the experiment, we used event-related brain potentials (ERP), to check EEG in certain moment when subjects received the different feelings. Fig6 image shows the amplitude of the occipital lobe when the subjects perceived the design as good or bad. The latency of P300 component from channel O1 and O2 when subjects had a bad feeling appeared faster than when subjects had a good feeling. Also the amplitude of the perception of bad feeling is higher than the amplitude of the perception of good feeling.

Fig 7 shows the result of difference of latency based on subjects’ perception of good or bad design. From this figure, the x-axis represents the result of the latency (G) of a bad design subtracts from the latency (B) of a bad design, and the y-axis is the subjects’ number. Most points placed in plus area which means the latency (G) of a good design is longer than the latency (B) of a bad design. Therefore, the human brain responds sooner and stronger action when subjects perceived the design as bad.

We also examined the latency of the frontal lobe when the subjects perceived the design as good or bad, and the result is similar with the occipital lobe. As I mentioned before, the human brain responds sooner to in perception of bad feeling. However, these results are the mean value of subjects, there are people responded sooner in perception of good feeling.

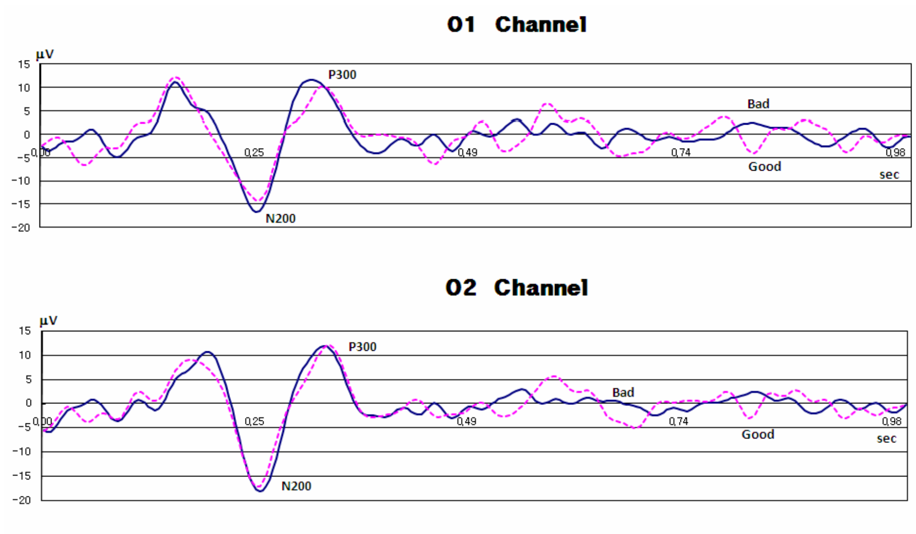

Fig. 6. Comparison of the occipital lobe characteristic

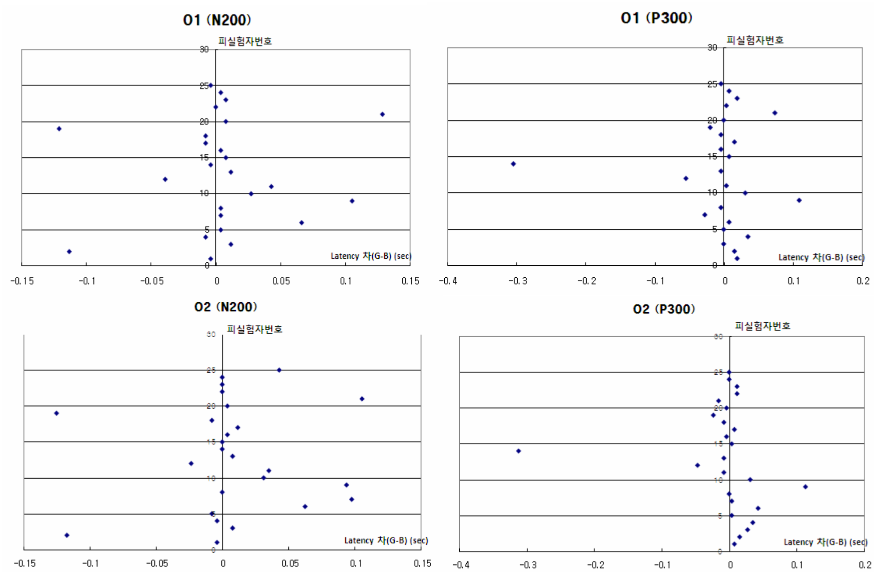

Fig. 7. Comparison of the occipital lobe latency

4 Conclusion

With advances in computer video display technologies such as EEG, fMRI, PET, and SPECT, brain research has become a contemporary issue. Based on the issue, many different major areas such as Medical Science, Engineering, Psychology, Linguistics, Biotechnology, Economics and Music explored diverse aspects of brain research. Hence, there should be lots of possibilities to study brain research relative to Art and Design.

When one makes the decision that something is good or bad his/her decision is a result of the human brain process. It is obvious that the brain works differently depending on a good feeling or a bad feeling. In other words, the brain will answer different ways when people look at good design or bad design. Although there would be a difference in determining design values, it depends on the individual. In the case of a masterpiece, most people admit its artistic value. According to this fact, if our researchers clarify how the brain works when people look at good and bad design, we come up with an objective evaluation of how people judge the design value. Based on the result, we also determine what can be the main aspects of a design with good value.

We have used the technique of functional MRI and EEG to address the question of how the brain answers while subjects viewed different designs. The results of fMRI show that the perceptions of different feeling for designs are associated with the frontal lobe and the occipital Lobe. The occipital lobe is placed in back of the brain part and has a visual cortex so controls with the organ of vision. The frontal lobe is placed in front of the brain part and takes care of complicated functions such as thinking, planning, and deciding. Based on the fMRI result, our researchers decided to attach electrodes in the area of the occipital and the frontal lobe and examine the EEG in the areas. During the experiment, we used the ERP, which is a method in checking the EEG in certain moment when subjects received the event like viewed designs. After analyzed the EEG by the ERP method, we also found that the amplitude of ERP components in perception of bad design was higher and latency was shorter than that of good design.

From all examinations, we found there is a significant distinction between an individual because of a characteristic of brain. Some people have strong action in left-brain and some are not. But in general, the human brain responds sooner and stronger to action in perception of bad feeling. Thus, we assume it can be an objective fact to determine good value of design when brain responds slower and exhibit a long latency. Considering this issue, we also can determine what aspect that makes good value of design and apply as a solution to create a better design.

In the future, the research includes not only pure design but also can be applied into the human interface design. One of the most important issues in the human interface design is a usability test to grasp a person's individual feeling and measure the emotional satisfaction. The idea of this paper will show as a great method of usability test to classifies the good or bad interface design as well as link with ease of use.

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