Open Science: Replication and Extension of an Electroencephalography Study of the Aversive Nature of Commission Errors

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A Thesis
Presented to
The Division of Philosophy, Religion, Psychology, and Linguistics
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Bachelor of Arts

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I want to thank a few people.

Preface

This is an example of a thesis setup to use the reed thesis document class.

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Abstract

The preface pretty much says it all.

Dedication

You can have a dedication here if you wish.

Introduction

0.1 The Neural Basis of Error Monitoring and Defensive Motivation

0.1.1 Error Monitoring

The mechanisms by which people monitor and correct for errors remain rich areas of investigation in neuroscience and psychology in general. Related to executive control, error monitoring – whatever its underlying mechanisms – consistently proves aversive (Leue et al., 2012). One prominent model of this nature of error monitoring posits its arising from anticipation of greater cognitive demand (Botvinick, 2007) and is called the integrative account. Another model, revised reinforcement sensitivity theory (or rRST), describes the aversive nature of errors as originating in anticipation of negative consequences (Corr, 2004). Much evidence from experiments manipulating task complexity point to a significant role of expectation of cognitive load (Leue et al., 2012), and similarly, experiments manipulating incentives and performance import(Weinberg et al., 2011; Bush et al., 2000) lend credence to the latter prediction. It would then seem that these models not only fail to be mutually exclusive, but other evidence supports their being simultaneously viable mechanisms (as in the allowance that error-related activity in the anterior cingulate cortex makes for both models playing a role, (Bush et al., 2000)). More specifically speaking to the role of anticipation, however, is evidence from physiological measures pointing to the role of defensive motivation, because it would be adaptive for an organism to note and correct behavior leading to errors.

0.1.2 Defensive Motivation

Particularly in the context of error monitoring, defensive motivation is thought to arise as a response to a commission error as a means of improving diligence and mitigating future errors. Evidence for this comes from a variety of experimental manipulations, including reward incentives and punishments. Additionally, insofar as defensive motivation is yoked to affective states like anxiety, more evidence for the relationship between these and error can also be found in experiments measuring and manipulating state anxiety and also measuring the more stable trait anxiety (Hajcak, 2012). Across manipulations measures of defensive motivation include skin conductance, startle response, and event-related potentials (ERPs) (Hajcak & Foti, 2008).

0.1.3 The ERN and Startle

The ERN is measured by electroencephalography (EEG), a method of measuring neural activity time-locked to specific neural events such as perception, cognition, and motor activity (i.e. ERPs). What exactly electrodes at the scalp are recording is uncertain, but is thought to be the voltage resulting from the summation of dipoles from many neurons (Luck, 2005). These dipoles are spatially proximal pairs of positive and negative electrical charges arising from postsynaptic potentials. These occur when excitatory neurotransmitters are released at apical dendrites of a pyramidal cell in the cortex, i.e. presynaptic terminals, causing positive ions to flow into the postsynaptic neuron, leaving the charge outside of the cell relatively negative. Then current flows out of the cell body and basal dendrites, creating a net positivity. The ERN is a negative-going component peaking roughly 50-100 milliseconds after a commission error (figure 1), and though it is often difficult to determine the source of an ERP component, it is usually found over the frontal-central midline (Falkenstein et al., 1991), and further data suggests the ERN originates in the anterior cingulate cortex (Bush et al., 2000). Experiments have found a positive relationship between ERN amplitude and a variety of other phenomena, including diagnosis of obsessive-compulsive disorder, diagnosis of generalized anxiety disorder, and higher ratings of anxiety irrespective of diagnoses (Weinberg et al., 2011), findings that prompt some researchers to suggest that increased ERN itself might be a predictive marker of anxiety and disorders thereof (Hajcak, 2012).

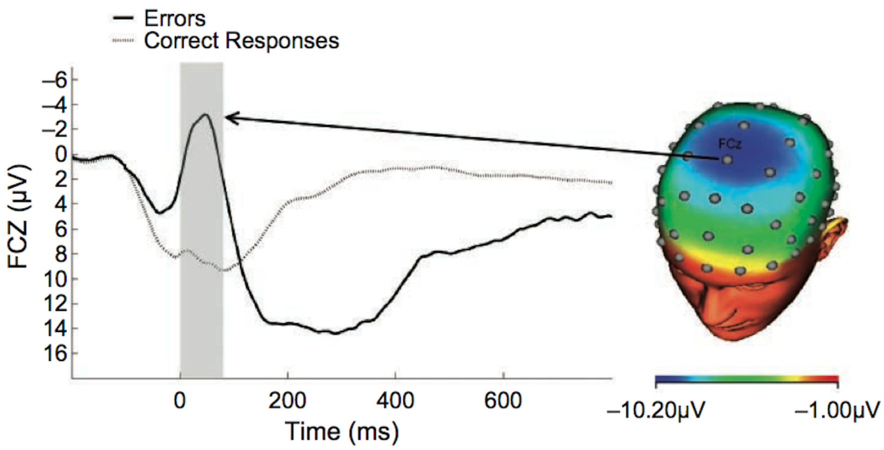

Figure 1: Mean event-related potentials time-locked to correct and erroneous responses at electrode FCz (left). This graph plots voltage over time, where the response occurs at 0 milliseconds (ms). The error-related negativity (ERN) is observed as a sharp negative deflection that peaks around 50 ms (illustrated by the gray bar) after the commission of a mistake.The voltage difference between errors and correct responses in the time window of the ERN can be plotted over the scalp (right); the ERN is maximal at the frontal-central midline of the scalp. Caption also from Figure 1 of Hajcak, 2012

0.1.4 State versus Trait Anxiety

0.2 Open Science

0.2.1 Historical Precedence

0.2.2 The Open Science Framework

0.2.3 The Reproducibility Project

Chapter 1

The Replication

1.1 Methods

1.1.1 The Task

Participants performed a flanker task in which they viewed five horizontally aligned arrows on a computer screen. On each trial, participants were to specify the direction of the central arrow with the click of a left or right mouse button. Whether the central arrow was aligned with flankers was pseudorandomly chosen and of equal frequency. Trials on which central and flanker arrows were aligned will hereafter be called compatible, while trials on which the central and flanker arrows were not aligned will hereafter be called incompatible.

Each participant first performed one practice block of 30 trials followed by eight additional blocks of 30 trials. Stimuli (i.e. the arrows) were presented for 200 ms with an intertrial interval (ITI) that varied pseudorandomly from 500 to 1000 ms. At the end of each of these blocks, participants saw on the screen one of three messages according to performance: if 75% accurate or below, they saw "Please try to be more accurate"; if above 90% they saw "Please try to respond faster"; if between these levels of accuracy, they saw "You're doing a great job."

1.1.2 Errors and EEG

While performing this task each participant was monitored for his or her electroencephalographic (EEG) and electromyographic (EMG) activity using the EasyCap electrode cap and BrainAmps Standard system (Brain Products, Gilding, Germany). Recordings were taken from 96 scalp electrodes at equidistant positions as well as from two reference electrodes placed on the left and right mastoids. Electrooculogram (EOG) from blinks and other eye movements were recorded from four facial electrodes placed approximately 1 cm: above the right eye, below the right eye, left of the left eye, and right of the right eye. All bioelectric signals were digitized on a laboratory microcomputer using Recorder software (Brain Products). Sampling was at 1000 Hz.

Offline analysis was performed using Brain Vision Analyzer software (Brain Products, Gilching, Germany). Data was referenced to the numeric mean of the mastoids and band-pass filtered with cutoffs of 0.1 and 30 Hz. EEG was segmented for each trial, beginning 200 ms before response and continuing for 800 ms. It was corrected for blinks and eye movements using ¡method here¿. The ERN was defined as the average activity in a 0- to 100-ms window following response onset on error trials, but it generally peaks approximately 50 ms following commission of an error. The ERN will also be statistically evaluated using either STATA or R, with Greenhouse-Geisser correction applied to p values associated with multiple degrees of freedom, repeated measures comparisons.

1.1.3 Startle and EMG

When presented, startle probes consisted of a 50-ms 105-dB burst of white noise with instantaneous onset 300ms after response. They were presented on 10% of all trials in the practice block. In the eight blocks following practice, they were presented on 50% of error trials, 50% of correct trials following errors, and a random 4% of other correct trials.

Startle response was measured with two electrodes placed approximately 12 mm apart under each participants left eye on the obicularis muscle. Startle response EMG data was band-pass filtered (28512 Hz; 24 dB/ octave roll-off), rectified, then low-pass filtered at 30 Hz (24 dB/ octave) and baseline-corrected. Response magnitude and latencies were quantified according to a peak in the 20- to 120-ms window after the startle probe was presented. It will be statistically evaluated using STATA or R, with Greenhouse-Geisser correction applied to p values associated with multiple degrees of freedom, repeated measures comparisons.

1.2 Results

1.3 Discussion

Chapter 2

The Extension

2.1 Methods

2.2 Results

2.3 Discussion

Chapter 3

General Discussion

Chapter 4

The Future of Open Science

Chapter 5

Tables and Graphics

5.1 Tables

The following section contains examples of tables, most of which have been commented out for brevity. (They will show up in the .tex document in red, but not at all in the .pdf). For more help in constructing a table (or anything else in this document), please see the LaTeX pages on the CUS site.

Table 5.1: A Basic Table: Correlation of Factors between Parents and Child, Showing Inheritance

Factors	Correlation between Parents & Child	Inherited
Education	-0.49	Yes
Socio-Economic Status	0.28	Slight
Income	0.08	No
Family Size	0.19	Slight
Occupational Prestige	0.21	Slight

If you want to make a table that is longer than a page, you will want to use the longtable environment. Uncomment the table below to see an example, or see our online documentation.

5.2 Figures

If your thesis has a lot of figures, LaTeX might behave better for you than that other word processor. One thing that may be annoying is the way it handles "floats" like tables and figures. LaTeX will try to find the best place to put your object based on the text around it and until you're really, truly done writing you should just leave it where it lies. There are some optional arguments to the figure and table environments to specify where you want it to appear; see the comments in the first figure.

If you need a graphic or tabular material to be part of the text, you can just put it inline. If you need it to appear in the list of figures or tables, it should be placed in the floating environment.

To get a figure from StatView, JMP, SPSS or other statistics program into a figure, you can print to pdf or save the image as a jpg or png. Precisely how you will do this depends on the program: you may need to copy-paste figures into Photoshop or other graphic program, then save in the appropriate format.

Below we have put a few examples of figures. For more help using graphics and the float environment, see our online documentation.

And this is how you add a figure with a graphic:

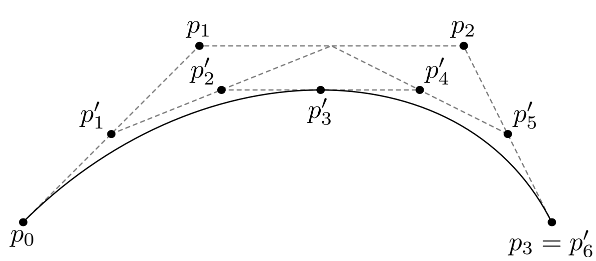

Figure 5.1: A Figure

5.3 More Figure Stuff

You can also scale and rotate figures.

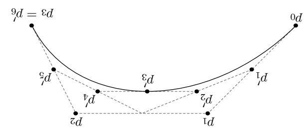

Figure 5.2: A Smaller Figure, Flipped Upside Down

5.4 Even More Figure Stuff

With some clever work you can crop a figure, which is handy if (for instance) your EPS or PDF is a little graphic on a whole sheet of paper. The viewport arguments are the lower-left and upper-right coordinates for the area you want to crop.

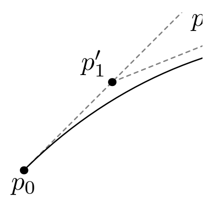

Figure 5.3: A Cropped Figure

5.4.1 Common Modifications

The following figure features the more popular changes thesis students want to their figures. This information is also on the web at `web.reed.edu/cis/help/latex/graphics.html`.

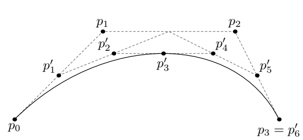

Figure 0.8: Interaction bar plot showing the degree of specialization for each flower type.

Conclusion

Here's a conclusion, demonstrating the use of all that manual incrementing and table of contents adding that has to happen if you use the starred form of the chapter command. The deal is, the chapter command in LaTeX does a lot of things: it increments the chapter counter, it resets the section counter to zero, it puts the name of the chapter into the table of contents and the running headers, and probably some other stuff.

So, if you remove all that stuff because you don't like it to say "Chapter 4: Conclusion", then you have to manually add all the things LaTeX would normally do for you. Maybe someday we'll write a new chapter macro that doesn't add "Chapter X" to the beginning of every chapter title.

4.1 More info

And here's some other random info: the first paragraph after a chapter title or section head *shouldn't be* indented, because indents are to tell the reader that you're starting a new paragraph. Since that's obvious after a chapter or section title, proper typesetting doesn't add an indent there.

Appendix A

The First Appendix

Appendix B

The Second Appendix, for Fun

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