

2017

The effects of text column width on memory for prose

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A Dissertation

entitled

The Effects of Text Column Width on Memory for Prose

by

Eric Charles Prichard

Submitted to the Graduate Faculty as partial fulfillment of the requirements for the

Doctor of Philosophy Degree in Psychology

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May 2016

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Research indicates that performing bilateral saccadic eye movements prior to encoding harms recall performance in consistent handers while bilateral saccadic eye movements performed prior to recall enhance performance in people with a strong preference for their dominant hand (consistent handers). This is sometimes explained in terms of the hemispheric encoding and retrieval asymmetry (HERA) model. The following contains a review of literature relevant to the HERA model and the relationship between handedness, eye movements, and memory. Following the review, two studies attempt to extend this research into a more applied realm by inducing eye movements via the width of the text column (with width being defined by the number of characters per line of text). In study one, participants were given a story about a fictional island. The lines of text were either ~28 characters or ~120 characters wide. Participants were also split by handedness (consistent vs. inconsistent) and gender. Participants were later given a set of 20 questions following the story. There was a handedness by text width interaction. Consistent handers who read the story with ~28 character lines performed worse than the other groups. This is consistent with theory and previous research. In study two, participants were given a fictional story about the day of a man named Joe. Text lines

were either ~28 characters or ~120 characters. Participants were later given an alternative version of the story and asked to circle any details that had changed (The two versions of the story are hereafter referred to as “version A” and “version B.” During this recognition phase, the story’s text lines were ~28 characters or ~120 characters. Story version was counterbalanced so that half of the participants read version A first and half read version B first. Text width conditions were fully crossed. Participants were also divided by gender and handedness. The measure of sensitivity was d' . The only effect was a main effect of condition. Participants who read wide columns during encoding performed best. This effect was difficult to interpret however due to several methodological limitations. Finally, both studies were discussed in terms of theoretical and practical implications. A method for following up on study two is suggested.

I would like to dedicate this work to my grandmother Margaret Prichard McCoy, who passed away during my graduate studies. I would also like to dedicate it to my nephew Caleb John Perrotte, who came into the world during my studies. The tragedy of my grandmother's passing taught me the power of family ties and Caleb's birth offered a glimpse at the first light of a new generation. Although I am just a bridge between generations, I hope the work I do as a scholar and teacher makes both those who came before and those who come after proud.

Acknowledgements

I would like to acknowledge Ryan Taipala, Rebecca Aspacher, and Kritika Singh for their assistance with data collection. I also want to thank committee members J.D. Japser, Jason Rose, Kamala Newton, and Douglas Coleman for their service. Special thanks to Steve Christman who chaired the committee and acted as my graduate advisor over the last five years. The list of UT psychology friends who have been great sources of intellectual stimulation and support is long and will necessarily be incomplete. But I will do my best. Thank you (in no particular order) Joanna, Alissa, Lindsay, Erin, Stephen P., Ray, John, Fawn, Jamie, Claudia, and Jaclynn. A special shout out goes to Michelle Roley-Roberts, Jill Brown, and Heather Wojton. They were my original three UT friends and I miss them dearly, although I am proud of what they have achieved since leaving Toledo. I need to thank my parents Pete and Michelle Prichard, my grandmother Marilyn Spiegel, and my sister and brother in law Erin and Nick Perrotte. Without their support, I don't know how I would have stayed sane during graduate school. I am still not sure I have, but I am confident that my mind is relatively more intact than it would have otherwise been because of them. Finally, I must acknowledge my dog Maci. The poor animal was forced to listen to me talk to her about statistics when I am pretty sure she would have rather been playing fetch and running around in circles.

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List of Abbreviations

ANOVA	Analysis of Variance
EEG	Electroencephalogram
EHI	Edinburgh Handedness Inventory
HAROLD	Hemispheric Asymmetry Reduction in Older Adults
HERA	Hemispheric Encoding and Retrieval Asymmetry
LSD	Least Squared Difference
PET	Positron Emissions Tomography
rTMS	Repeated Transcranial Magnetic Stimulation

List of Symbols

μ^2_pPartial Eta Squared

dCohen's d

d' d prime

F F ratio

M Mean

pp-value

SE Standard Error

SDStandard Deviation

z Z score

Chapter One

The Hemispheric Encoding and Retrieval Asymmetry Model

One of the great challenges faced by researchers in the areas of neuropsychology and neuroscience is the formulation of reasonably accurate models of how specific regions of the brain contribute to the emergence of high level processes. Even some of the most enduring models will only lead to correct predictions some of the time. For example, the Hemispheric Encoding and Retrieval Asymmetry (HERA) model (Tulving, Kapur, Craik, Moscovitch, & Houle, 1994; Habib, Nyberg, & Tulving, 2003) draws on numerous brain imaging studies and offers a relatively simple rule of thumb for the relationship between activity in the two hemispheres and various memory tasks. According to the model, there is a relative increase in the activity of the left prefrontal cortex while memories are being encoded and while semantic memories are being retrieved. There is a relative increase in right prefrontal activity during the retrieval of episodic memories. Although this pattern does not always hold (Habib, Nyberg, & Tulving, 2003), it is reliable enough to have contributed to the emergence of successful experimental paradigms which assume a right hemisphere role in episodic retrieval. However, although the experiments that follow are ultimately intended to be an extension of this behavioral research, it is still worth a brief examination of some of the controversy surrounding HERA and some of the recent research that lends support to the model before moving on to the behavioral extensions of the model.

The original formulation of the model was published by Tulving, Kapur, Craik, Moscovitch, and Houle (1994). They looked for patterns among positron emission tomography (PET) studies and found that during the encoding and retrieval of semantic

verbal materials, blood flow tended to increase in the left prefrontal cortex. During the retrieval of episodic verbal material, blood flow tended to increase in the right prefrontal cortex. Subsequent findings were mixed. The HERA model did not always seem to hold for nonverbal materials (Fletcher & Henson, 2001; Owen, 2003). Habib, Nyberg, and Tulving (2003) reviewed studies which reported supporting evidence for the HERA model and provided a more specific formulation. They proposed that if the difference between left prefrontal activity during encoding and left prefrontal activity during retrieval is greater than the difference between right cerebral blood flow at encoding and right cerebral blood flow at retrieval, then the encoding portion of the model stands up to test. Similarly, if the difference between right cerebral blood flow at retrieval and right cerebral blood flow at encoding is greater than the difference between left cerebral blood flow at retrieval and left cerebral blood flow at encoding, the retrieval part of the model has stood up to testing. In other words, they proposed that asymmetries in the relative changes in blood flow during encoding and retrieval are more important than absolute measures of brain activity.

Since then, however, there has been an assortment of findings, consistent with HERA, using methods other than PET and materials other than verbal materials. Babiloni, Vecchio, Cappa, Pasqualetti, Rossi, Miniussi, and Rossini (2006) used EEG and visuospatial stimuli and obtained the general pattern of activation predicted by HERA. Rossi, Miniussi, Pasqualetti, Babiloni, Rossini, and Cappa (2004) used repetitive transcranial magnetic stimulation (rTMS) in order to cause transient interference of processes carried out in the stimulated region of the brain. They found that rTMS of the left dorsolateral prefrontal cortex during encoding hurt retrieval in both young and old

adults, while rTMS of the right dorsolateral prefrontal cortex during retrieval hurt the performance of only young adults. Thus, using rTMS, they found a pattern that supports the predictions of HERA, but that this pattern was age dependent. This seemingly confirmed the prediction of Cabeza (2002), who predicted that age related changes to the brain would attenuate the pattern predicted by HERA. The addition was named the Hemispheric Asymmetry Reduction in Older Adults (HAROLD) model.

Most of the studies cited above used visual stimuli, but other recent studies have even found evidence that the HERA model holds when participants are asked to recall sensory information. Okamoto et al. (2011) used functional near-infrared spectroscopy to investigate lateral prefrontal cortex activity during the encoding and retrieval of information about a liquid taste stimulus, and found evidence of right hemisphere dominance during retrieval, which they concluded was consistent with HERA. Platel (2005) found evidence of the asymmetries predicted by HERA during the encoding and retrieval of auditory information.

While critics of the HERA model (Fletcher & Henson, 2001; Owen, 2003) raise valid points and even Habib et al. (2003) acknowledged that the model does not always hold, and may be more valuable for its heuristic usefulness than for being a comprehensive model of the role of hemispheric asymmetry in recall, the pattern appears frequently enough that it strongly suggests some sort of right hemisphere role in episodic recall and some sort of left hemisphere role in encoding.

This useful heuristic, general rule of thumb though it may be, actually leads to a fairly interesting hypothesis that can be tested by behavioral scientists. If recall involves increased right hemisphere activity, then one might predict that individuals with more

functional access to their right hemispheres should perform better on episodic memory tasks than individuals with less functional access. This “functional access” could be a biologically based individual difference mediated by elevated baseline activity in the right hemisphere, more efficient interhemispheric communication, or both. If researchers could discover an easily observed individual difference that acts as a marker of greater functional access to the right hemisphere, then they would be able to test this hypothesis. Furthermore, if there was a way to behaviorally induce greater functional access to the right hemisphere, then the hypothesis could be tested via a second means. A more powerful test of the hypothesis would cross the individual difference and the method of selective hemispheric activation in order to see whether they interacted. Memory differences predicted by an individual difference variable or behavioral activation alone could be explained in terms other than functional right hemispheric access. But if findings made using both experimental paradigms corroborated each other and if combining the paradigms led to an interaction, then it would be much more difficult to dispel the idea that behavioral findings support right hemisphere involvement in episodic retrieval and left hemisphere involvement in encoding.

The series of behavioral studies described above are not hypothetical. Well-developed experimental paradigms using handedness, a biologically based individual difference variable, and eye movements, a potential means of bilaterally increasing activity in the prefrontal cortices, have both yielded results predicted by HERA’s rule of thumb. Both of these literatures are reviewed below and provide the empirical foundation for the experiments conducted in this report.

Chapter Two

Handedness and Memory

Handedness has long been a variable of interest to researchers. Human handedness is quite peculiar when compared to handedness and pawedness in other mammals. For example, only about 11% of humans are left handed (McGilchrist, 2010), but this imbalance is nowhere near as great in closely related primates (Hellige, 1993). Furthermore, the relative temporal and geographic stability of the human handedness imbalance continues to defy simple explanations in terms of population genetics, despite attempts of such theories as the “fighting hypothesis” to come up with evolutionary explanations that seemingly rescue left handers from the processes of natural selection and genetic drift (Groothuis, McManus, Schaafsma, & Geuze, 2013).

Adding to the confusion, studies using direction of handedness often yield messy and difficult to interpret data (Hellige, 1993). Many of the problems researchers run into stem from the treatment of direction of handedness as *the* phenotypic manifestation of handedness. However, handedness is more complicated than the simple left/right dichotomy suggests. Early genetic models predict the existence of alleles for right handedness/left hemisphere language lateralization and genes for handedness determined by chance (Annett, 1981; McManus, 1991). A recent revision of the McManus model (McManus, Davidson, & Amour, 2013) retains the attribute of predicting chance and lateralization (called *Dextral* in the McManus models) genes, but suggests that handedness is a complex multilocus trait influenced by multiple genes. This suggests the possibility that there could be a wide degree of variability in the extent to which individuals have genetically determined right handedness or environmentally influenced

handedness. If this is the case, degree of handedness should be part of the phenotypic description of handedness. This is consistent with animal models showing that strength of paw preference is more heritable than direction of pawedness (Hellige, 1993).

The notion that degree of handedness is an important biologically based variable, not just in addition to direction, but even independently of direction, has empirical support in the neuroimaging literature. Luders et al. (2010) found that callosal thickness is negatively correlated with degree of handedness and Cherbuin et al. (2013) found that callosal thickness is negatively correlated with leftward cerebral asymmetry. In both cases, the effect sizes were small, but an important thing to remember about systems as complex as the brain is that small differences at the anatomical level may lead to large differences at the behavioral level. As such, there is at least circumstantial evidence that people who are less consistently handed may have more callosal thickness and less leftward asymmetry. Both of these traits could mediate greater interhemispheric communication and greater baseline right hemisphere activity relative to strongly lateralized individuals. These are the conditions with which *functional access to the right hemisphere* was defined earlier. Indeed, EEG evidence suggests that inconsistently handed people have higher baseline resting right hemisphere activity in the alpha band than consistently handed people (Propper, Pierce, Geisler, Christman, Bordello, 2012). Combined, these findings make degree of handedness just the sort of individual difference variable that could be used to explore the possibility of a right hemisphere role in episodic retrieval. Behavioral experiments using degree of handedness as a predictor of memory performance bear this out.

Experiment 1 of a paper published by Christman, Propper, and Dion (2004) explored whether degree of handedness would predict performance on the classic Deese-Roediger-McDermott (Roediger & McDermott, 1995) task. Using the Edinburgh Handedness Inventory (Oldfield, 1971) they separated participants into consistent and inconsistent handers by taking a median split of participants' raw scores on the inventory (hereafter referred to as the EHI)¹. Consistent left handers, however, were excluded from analyses. Compared to consistent hander, inconsistent handers recalled descriptively more correct words and were significantly less likely to falsely recall critical lures.

In the experiment above, inconsistent handers outperformed strong handers on a recall task, which is a good test of episodic memory. However, inconsistent handers did not remember significantly more correct information. By itself, it is ambiguous evidence for the HERA model. A set of follow-up studies incorporated measures of semantic memory, which is hypothesized by Tulving et al. (1994) to rely on left hemisphere mediated retrieval, and memory for daily events (Propper, Christman, & Phaneuf, 2005). In experiment one, Propper et al. presented participants 72 words and then administered either a recall test or a fragment completion test, which they argued served as a test of semantic memory. This time inconsistent handers not only had marginally fewer false alarms, but significantly more hits. In the fragment completion task, there was no handedness difference. In experiment two, participants were asked to record 10 unusual events that happened to them over the course of 6 days. One week after turning the journal in, they were given a recall test. Inconsistent handers recalled more unusual events from their own journals than consistent handers. In experiment one of a paper by

¹ For a discussion of measurement issues involved in using the EHI, refer to Appendix F.

Christman, Brown, & Propper (2006), the authors used a technique for estimating the age of onset of early childhood amnesia. In order to ensure the memories were true, they contacted the parents and guardians of as many participants as possible. Inconsistent handers had earlier childhood memories than consistent handers. These later results more strongly match the patterns predicted from the HERA model.

Further studies supported the idea that the handedness differences in memory are largely driven by inconsistent handers having better episodic memory but not necessarily better semantic memory than consistent handers. Propper and Christman (2004) conducted two studies using a recognition memory paradigm. On the whole, the performance of consistent and inconsistent handers did not statistically differ. However, participants were asked whether they “remembered” seeing a word, or “knew” they saw it. A “remember” judgment implies recalling seeing the word, and should tap into episodic memory. A “know” judgment implies a feeling of familiarity without recalling the moment the word was seen. This sort of memory is characteristic of information contained in a semantic association network. For example, one might know the Declaration of Independence was signed on July 4, 1776 without having any recollection of the exact moment they learned this information. General knowledge is semantic memory. In experiment, while there were no handedness differences in overall accuracy, inconsistent handers were more likely than consistent handers to base correct recognitions on “remember” responses. Conversely, consistent handers were more likely than inconsistent handers to base correct recognition on “know” responses. In experiment two, a similar pattern was obtained. These results map onto the idea that the right

hemisphere plays an important role in episodic retrieval and the left hemisphere plays a role in semantic retrieval.

Not only do handedness studies seem to support the HERA account, at least in its most general formulation, but also the HAROLD account. Lyle, McCabe, and Roediger (2008) administered a battery of memory tests to a sample of adults ranging in age from 30 to 90 years old. When the results from young adults were analyzed, inconsistent handers outperformed consistent in a paired associates recall task and a source memory task. However, there was no difference between consistent and inconsistent handers among older adults. It could be that the age related changes that eliminate the handedness difference bear some sort of connection to the age related change that lead to the shifts in hemispheric activation during recall described by the HAROLD account.

While most of the research cited above used list learning as a dependent variable, it is worth pointing out that two studies mentioned above looked at memory for early childhood events (Christman, Brown, & Propper, 2006) and unusual real world occurrences (Propper, Christman, & Phaneuf, 2005) respectively. This at least suggests that the predicted pattern holds for non-verbal material. The generalizability of the pattern of results gained further support when Lyle and Osborne (2011) found that inconsistent handers had superior memory for faces.

Only recently, however, has research moved in the direction of looking at memory for prose level material. Prichard (2013) found that inconsistent handers showed superior free recall when asked to remember as many details as possible about a story describing two boys skipping school. Work looking at handedness and memory for prose is still in its early stages, and is a promising avenue for future research. Since reading is a

necessary life skill in an industrialized country, any research that sheds light on the way prose is processed and remembered has potential theoretical *and* applied significance. Part of the purpose of the proposed studies is to build on what has already been done with memory for prose by incorporating bilateral saccadic eye movements, which have been shown to enhance memory and which may be a means to induce bilateral hemispheric activation (Christman & Propper, 2010).

Before moving on to eye movements, however, one potential methodological criticism of the handedness research, namely the tendency of samples to be overwhelming right handed, needs to be addressed. Even though degree of handedness is important, it does not mean that direction is necessarily unimportant and researchers cannot be sure of all of the ways in which degree and direction of handedness may interact. However, Lyle, Hanaver-Torrez, Hacklander, and Edlin (2012) collected a sample that included a sufficient number of consistent left handers to test whether degree or direction was more predictive of memory performance. At least in the case of memory, they found that degree and not direction predicts memory ability.

Chapter Three

Eye Movements and Memory

Although the present review is recounting the history of research investigating handedness and memory and eye movements and memory in a sequential manner, the two literatures largely evolved together. Studies that examine eye movements and handedness often employ the same methodologies and use the same stimulus materials, with the exception of eye movement versus control conditions being the critical independent variable as opposed to consistent versus inconsistent handedness (Christman & Propper, 2010). Although the exact relationship between eye movements and hemispheric activation is uncertain, early evidence that there was some sort of relationship provided some potentially important early insights, especially in light of recent research. Bakan and Svorad (1969) found negative relationships between the tendency to make rightward lateral eye movements and resting alpha band activity and between the tendency to make rightward lateral eye movements and hypnotic suggestibility. Why making more leftward eye movements should increase overall cerebral activation and hypnotic suggestibility is unclear. However, there is an intriguing, albeit speculative, possible answer to the second question. Ramachandran's (1995) work with patients suffering from anosognosia led him to propose that the right hemisphere plays an important role in belief updating. Could it be that leftward lateral eye movements increase right hemisphere activation, thus inducing an increased state of suggestibility? This is certainly an answerable empirical question, and it is tantalizingly suggestive of the possibility that eye movements could interact with lateral asymmetries. However, a tantalizingly suggestive question is not evidence. More direct support for the

hypothesis that eye movements can change patterns of hemispheric asymmetry was obtained by Christman and Garvey (2001) who found that bilateral saccadic eye movements reduced baseline asymmetries in chimeric face perception.

Christman, Garvey, Propper, and Phanuef (2003), still drawing upon the HERA model, set out to test whether or not changing the pattern of hemispheric asymmetry via bilateral saccadic eye movements would change memory performance. If, for example, bilateral saccadic eye movements increased right hemisphere activation or simply improved the efficiency of information exchange between the two cerebral hemispheres, then one might predict that bilateral saccadic eye movements would improve memory. In experiment one, participants were shown a list of 36 words and then asked to perform bilateral, vertical, or no eye movements. Participants then received a list of 72 words, including the original 36. Participants who performed bilateral saccadic eye movements were better able to discriminate between old and new words. This effect was driven by a tendency for participants who performed bilateral saccadic eye movements to have fewer false alarms. In their second experiment, they found that participants who performed bilateral saccadic eye movements were better able to recall unusual events from a journal kept over six days. This is the same procedure employed by Christman et al. (2005). In this case, consistently handed participants who performed bilateral saccadic eye movements performed like inconsistent handers on a memory test.

Experiment 2 of Christman et al.'s (2006) paper investigating lateral asymmetry and the offset of early childhood amnesia also used eye movements in order to manipulate the pattern of hemispheric asymmetry. Once again, people who performed eye movements looked like inconsistent handers, and recalled early childhood memories.

Studies in which eye movements help memory performance are suggestive of the possibility that eye movements enhance functional access to the right hemisphere (as earlier defined.) This also raises the question of what would happen if a group of people hypothesized to have a higher baseline of resting right hemisphere activation were to perform eye movements? Lyle, Logan, and Roediger (2008) conducted two studies in which participants were given free recall and recognition tests respectively over a list of 50 words. They also divided the participants into consistent and inconsistent handers. Only consistent handers benefited from eye movements in either experimental paradigm. That is to say, consistent handers had higher recall scores and fewer false alarms when they performed eye movements.

If inconsistent handers have higher baseline right hemisphere activation, and bilateral saccadic eye movements somehow increase either overall cortical activity, interhemispheric connectivity, or right hemisphere activation, then it makes sense that eye movements would do less to help them, if anything at all, than they do to help inconsistent handers. On the whole, then, neuroscience data, handedness data, and data looking at the effects of eye movements seem to converge on the idea that there is a right hemisphere role in episodic retrieval, that some individuals have greater baseline access to the right hemisphere, possibly mediated by a greater degree of interhemispheric communication, and that bilateral saccadic eye movements can temporarily alter the pattern of relative hemispheric activation in at least a subset of the population (consistent handers).

Although the data seem to converge on a relatively neat story, aspects of the theoretical account of the effects obtained using the Handedness-Eye Movement

Paradigm have already been challenged. Lyle and Martin (2010) conducted an experiment intended to test whether or not the eye movements improve interhemispheric connectivity. They asked participants to focus on a fixation point. Two upper case letters were presented to the upper left and right visual fields. A lower case letter was then presented to either the lower left or right visual field. Participants were asked to judge whether the lower case letter matched one of the top letters. When the lower case letter was the same as the upper case letter in the same visual field, there was a within-hemisphere match. When the lower case letter was the same as the letter in the opposite visual field, there was an across hemisphere match. Inconsistent handers were more accurate than consistent handers during across hemisphere *and* within hemisphere trials, but bilateral saccadic eye movement led to better performance during within hemisphere trials only. Theoretically, eye movements should have led to better across hemisphere performance. The authors suggested these results disconfirmed increased interhemispheric communication as the mechanism by which eye movements improve memory and proposed instead that they improve top down attentional control. This does not necessarily rule out the hypothesis that bilateral saccadic eye movements increase functional access to the right hemisphere. For one thing, an attentional control account is consistent with an account of increased right hemisphere access if one even partially accepts McGilchrist's (2010) framework, or the related earlier framework proposed by Ornstein (1997), which suggests that part of the right hemisphere's role is to be attentive to the broader context of the environment and directing the attention of the left hemisphere. Hence, increased right hemisphere activity could increase attentional control, without necessarily acting via the major commissures between the two

hemispheres. Furthermore, McGilchrist points out that the right hemisphere controls conjugate eye movements. This is an important fact for two reasons. First, it is further evidence of the importance of the right hemisphere for attentional processes. Second, it provides a simple potential explanation for why bilateral saccadic eye movements might increase right hemisphere activity without necessarily increasing communication across the corpus callosum. If conjugate eye movements are controlled by the right hemisphere, performing conjugate eye movements should activate the right hemisphere. It is also worth pointing out that other behavioral methods of activating one or both of the hemispheres lead to results which are arguably more readily explained in terms of levels of cerebral activation than in terms of attentional control. For example, Prunier (2013) presented 338 participants a list of 36 words and then asked them to squeeze a hand dynamometer in order to induce contralateral activation. Both consistent and inconsistent handers showed an inverted U-shape pattern when correct responses were taken as a function of grip strength. At lower grip strengths, consistent handers saw an increase in performance and a drop off thereafter. Inconsistent handers saw an increase in performance at higher grip strengths, which would have led to greater contralateral activation. These data suggest higher levels of baseline cerebral resting activity among consistent handers, which means that additional activations leads to peak performance and a decrement sooner for them than it does for inconsistent handers. This explanation is very similar to the cerebral activation hypothesis for the effects of eye movements, although it is possible that the increased cerebral activation associated with increased grip strength could lead to an increase in attentional control processes.

Reality is likely much more complicated than any current model explaining the effects of handedness and eye movements on memory. It will likely take years of study and the introduction of new brain imaging methodologies before researchers get a good handle on all of the anatomical and physiological substrates that underlie the above reported results. Much like HERA itself, this Handedness-Eye Movement Paradigm is a relatively general model that has had success in making experimental predictions, and which has the potential to provide heuristic usefulness to theorists interesting in delving deeper into hemispheric asymmetry and individual differences. Furthermore, there are avenues for applied research, especially as pertains to the use of eye movements to improve memory. The studies to be reported will attempt to take the research cited above in an applied direction by investigating whether the way a page is laid out can affect memory performance. HERA and the right hemisphere access accounts of the Handedness-Eye Movement Paradigm may yet rise, fall, or be revised in light of future work. Yet the potential for the empirical findings these frameworks have spawned to be useful can be realized immediately.

Chapter Four

Rationale for the Studies

The literature reviewed above has several potentially important methodological and theoretical implications. First, it suggests that the right hemisphere may play a role in the retrieval of episodic memories. Second, it suggests that handedness may serve as a marker of more baseline functional access to the right hemisphere. Third, it suggests that bilateral saccadic eye movements may temporarily alter the pattern of lateral asymmetry in the brain, and that these eye movements improve memory in a subset of the population.

The studies will serve several purposes. First, study one will extend the eye movement literature to prose processing. Prichard (2013) already found evidence that, compared to consistent handers, inconsistent handers have better recall for information read in prose passages. However, to the knowledge of the author, little work has been done looking at prose and eye movements. This is important because the act of reading prose induces rightward eye movements in most Western languages. However, Ornstein (1997) suggests that right to left languages such as Hebrew selectively activate the right hemisphere because reading requires continuous leftward eye movements. This could potentially affect how prose is processed and remembered.

Purpose two is closely related to purpose one. Since prose induces eye movements, study one will manipulate eye movements by manipulating the width of reading columns instead of making participants do eye movements prior to recall. Christman and Sabry (2009) found that manipulating the width of a passage affected its persuasiveness. When narrow, the passage was more persuasive, which is in line with

Ramachandran's (1995) theory and evidence looking at right hemisphere access and persuadability (e.g., Christman, Henning, Geers, & Propper, 2008; Jasper, Kunzler, Prichard, & Christman, 2014). It is worth exploring whether naturalistically manipulating margin width will have similar effects on memory. This manipulation will take the experiment into the realm of applied research. Newspapers often use narrow columns in order to save space. The question is, how does the way text is laid out affect our ability to remember what we read? The HERA model suggests that the left hemisphere is important for encoding. More rapid bilateral eye movements may increase functional right hemisphere access during reading, which may actually interfere with encoding. This is what Christman and Butler (2005) found when used the traditional eye movement paradigm in order to compare the effect of eye movements at encoding versus retrieval. Furthermore, the continuous rightward movements that characterize reading with wide paragraph columns may increase left hemisphere activation, potentially leading to an enhancement of encoding. What if a common page layout in newspapers and journals actually makes it more difficult for the public to remember what they are reading? Study one will be the first laboratory experiment to explore this possibility.

Study two will explore whether alternating left-right versus mostly rightward eye movements at the time of encoding or retrieval, manipulated via column width, will affect the rate of hits and false alarms during a recognition test. Once again, a prose passage will be used. Instead of looking at recall, participants will be presented the passage a second time and will have to recognize details which have been changed. This study will address the possibility that how reading material is laid out may change the likelihood a reader either correctly or incorrectly recognizes a supposed fact later. Once

again, interesting questions are raised for educators and publishers. Is it possible that something as simple as page layout makes false recognition more probable?

Third, both studies will include a measure of handedness for exploratory purposes. The intent is to investigate whether handedness interacts with column width. Finally, these studies aim to assist in the development of a brand new methodologies. Since, to the knowledge of the author, nobody has ever tried to investigate whether text induced eye movements interact with memory before, the methods reported herein are relatively new. There is a certain danger to creating new methods. Unforeseen issues, errors, and sources of noise can mask new effects. However, the reward is a novel contribution to experimental research and new avenues for researchers to explore.

Chapter Five

Study One Methods and Hypotheses

Sample

The sample consisted of 120 ($M_{age} = 19.23$; 76 Females) University of Toledo students taking Psychology 1010. They were recruited using the university's SONA System.

Materials

Edinburgh Handedness Inventory

The Edinburgh Handedness Inventory (Appendix A), frequently referred to as the EHI, is a 10 item questionnaire which lists 10 common manual tasks. Participants have five response options for each task: *always left*, *usually left*, *no preference*, *usually right*, and *always right*. For each item a score of -10 is assigned for the *always left* option, a score of -5 is assigned for the *usually left* option, a score of 0 is assigned for the *no preference* option, a score of 5 is assigned for the *usually right* option, and a score of 10 is assigned for the *always right* option. EHI raw scores can range from -100 to 100. Participants are assigned to the consistent and inconsistent handedness groups by taking the EHI's absolute scores, as opposed to the raw scores, and taking a median split of the scores. Participants who score in the lower half, suggesting less lateralization of preference, are considered inconsistently handed. Participants who score in the upper half, suggesting more lateralization of hand preference, are considered consistently handed. Because dichotomizing a variable which can be treated a continuous is a controversial practice and because it cannot be assumed a priori that a self-report questionnaire is a good measure of a behavior, an appendix with supplementary data and

a discussion of some of the issues involved in using the EHI as a categorical tool has been added in order to give the topic a more in depth treatment (Appendix F).

Spinoza Story Island and Questions

All participants read a 229 word story (Appendix B) about a fictional island called Spinoza Island. Later, at testing, participants were asked to write their responses to 20 questions (Appendix C) about the story. The questions were designed to force participants to recall details from the story.

Procedure

The participants were greeted by the experimenter and instructed to sit in one of two designated seats at either end of a long table. After obtaining signed consent, the experimenter provided the participants with instructions. The participants were told that they “may be asked some questions about the story” which was read for the study. Hence, the memory test was not a surprise.

Participants were tested one to two at a time. They were given the story face down. Half were randomly assigned the story with narrow columns and half were randomly assigned the story with wide columns. Wide columns had a width of ~120 characters and narrow columns consisted of columns of ~28 characters². All participants were given two minutes to read the story. After two minutes, they were given 10 minutes to complete the EHI and a questionnaire (Appendix G) which was used as part of another study. After the 10 minute questionnaire period, participants were given two minutes to

² According to McConkie and Rayner (1975) 12-15 characters is the maximum character length at which information useful to reading can be discerned. The 28 character columns were based on twice this number. The 120 characters were based on the number of characters that could fit across a page.

answer as many questions as they could. Participants were then debriefed by the experimenter³.

Analytic Methods

Data were analyzed using a 2(Story Margin Width: Wide vs Narrow) x 2(Handedness: Inconsistent vs Consistent) x 2 (Sex: Male vs Female) between subjects ANOVA. The dependent variable was the percentage of correctly answered questions.

Hypotheses

It was predicted that there would be an overall main effect of story column width, with participants who read wider columns answering more questions correctly. It was also predicted that there would be an overall main effect of handedness, with inconsistent handers answering more questions correctly.

There was one predicted interaction. It was predicted that there would be a handedness by story column width interaction. Since narrow story columns were predicted to interfere with encoding, only inconsistent handers who read wide story columns should have a memory advantage over consistent handers.

³ In both studies, the timing was based on several pilot sessions. The goal was to keep the experiments short enough to minimize participant boredom and to maximize efficiency, while still giving participants enough time to read through the materials.

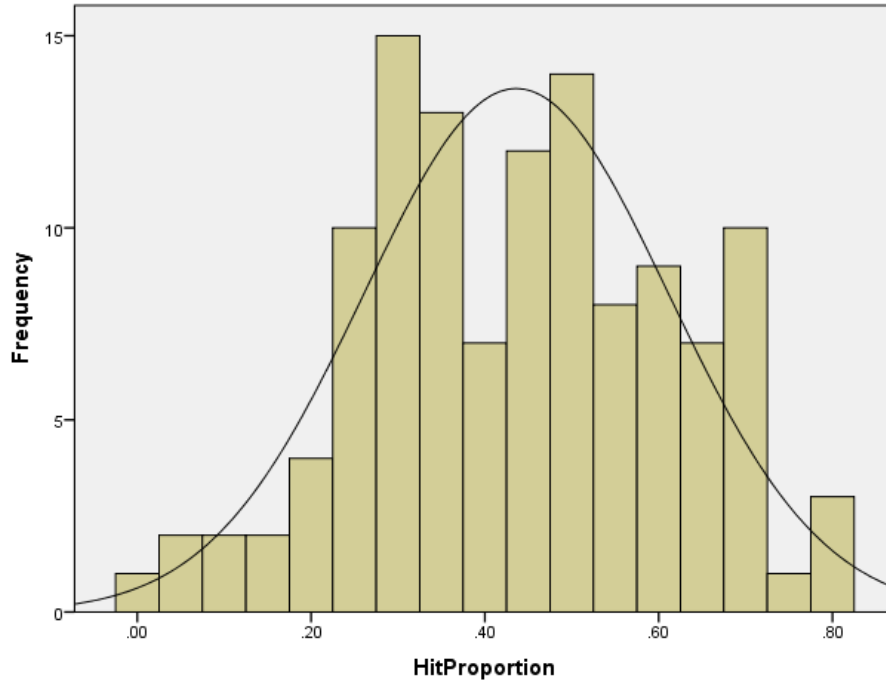
Chapter Six

Study One Analysis and Discussion

Preliminary Analyses

Prior to testing the main hypothesis, preliminary data analyses were used in order to test the dependent variable for violations of the assumptions of normality. The overall mean percentage of questions answered correctly was 43.6 ($SE = 1.6$). The Shapiro-Wilk test was used to test for violations of normality. The test failed to reject the null ($p = .116$), indicating that the distribution of the data could be roughly approximated by a normal distribution. Figure 1 provides a visual comparison of the dependent variable data and the normal curve.

Figure 1: Histogram of Proportions of Correct Responses (Hits) vs Bell Curve



The median absolute EHI score was 80. Because doing so yielded the most balanced cells, participants with a score of 80 and below were placed categorized as inconsistent handers. After crossing the handedness and condition cells, there were 31 inconsistent handers in the Narrow Condition, 29 consistent handers in the Narrow Condition, 33 inconsistent handers in the Wide Condition, and 27 consistent handers in the Wide Condition.

Main Analyses

The main analysis consisted of a 2(Condition: Wide vs Narrow) x 2 (Handedness: Consistent vs Inconsistent) x 2 (Sex: Male vs Female) analysis of variance. The data were analyzed using IBM statistics version 21.

There were no main effects. There was, however, a condition by handedness interaction, $F(1, 112) = 3.9, p = .05, \mu^2_{partial} = .034$. Table 1 shows all of the F -values. The interaction was broken down by comparing the four cells using both Tukey's HSD and the LSD (least squared differences) test. The reason for using two tests is that Tukey's HSD accounts for multiple comparisons while the LSD test is more liberal. If the tests disagree, one may still use the LSD test to get an idea of which effects are driving the interaction and which effects should be hypothesized during replication attempts. *It may also suggest that a replication may require more participants in order an appropriate level of statistical power.* None of the effects were significant when Tukey's HSD was used to make comparisons. However, the LSD test revealed a difference between consistent handers in the Narrow Condition ($M = 36.3\%, SD = 17.8\%$) and inconsistent handers in the Narrow Condition ($M = 46.4\%, SD = 17.5\%$), $p = .026$, consistent handers in the Wide Condition ($M = 46.2\%, SD = 16.4\%$), $p = .034$, and inconsistent handers in

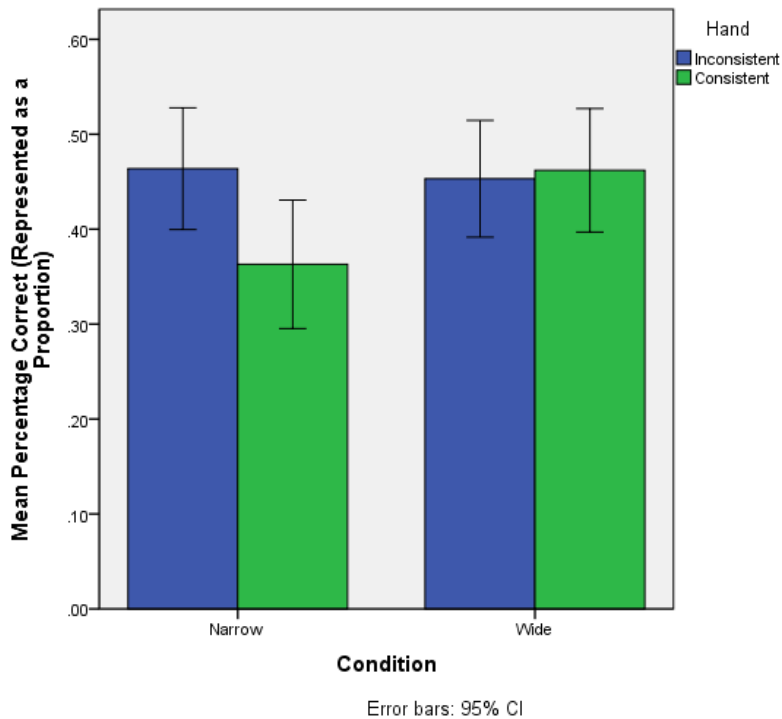
the Wide Condition ($M = 45.3\%$, $SE = 17.3\%$), $p = .043$. A graphical representation of the interaction is presented in Figure 2.

Table 1: Full ANOVA Table for Experiment One.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.251 ^a	7	.036	1.172	.324
Intercept	18.350	1	18.350	600.659	.000
Condition	.092	1	.092	3.011	.085
Hand	.064	1	.064	2.081	.152
Sex	1.006E-6	1	1.006E-6	.000	.995
Condition * Hand	.119	1	.119	3.909	.050
Condition * Sex	.016	1	.016	.521	.472
Hand * Sex	.004	1	.004	.126	.724
Condition * Hand * Sex	.032	1	.032	1.063	.305
Error	3.422	112	.031		
Total	26.488	120			
Corrected Total	3.672	119			

a. R Squared = .068 (Adjusted R Squared = .010)

Figure 2: Condition by Handedness Interaction



Discussion

The data obtained did not conform to the predictions. There was no main effect of handedness or condition. Furthermore, the condition by handedness interaction was not driven by inconsistent handers outperforming consistent handers in the wide condition. On the contrary, it was driven entirely by consistent handers in the narrow column condition performing worse than participants in the other conditions. In the brief discussion to follow, two issues should to be addressed. They will then be revisited in final chapter.

First and foremost is the question of why the results were so different from the predictions. Christman and Bulter (2005) found that eye movements prior to encoding hurt the memory of only consistent handers. Other research shows that only consistent handers benefit from rapid eye movements prior to retrieval (e.g., Lyle, Logan, &

Roediger). If this is the case, perhaps the eye movements induced by reading a narrow column hurt only consistent handers. That would explain the overall pattern of results, especially if handedness differences and the effects of eye movements are the result of increased right hemisphere activity in inconsistent handers. If right prefrontal activity increases in consistent handers during encoding, then they might be encoding information less efficiently when they are given text in a narrow column format. It is hard to explain the effect in terms of attentional control alone. One might suspect that an increase in attentional control would increase the ability of consistent handers to focus on the story. If this were the case, it would not make sense for them to remember *less* of what they read. From a theoretical perspective, this study suggest there is more to the eye movement effect than would be suggested by theories posit attentional control as the sole mechanism by which eye movements at retrieval improve memory (e.g., Lyle & Martin, 2010).

Another possibility is that we the wide columns helped the consistent handers allowing them to improve to the point that they resembled inconsistent handers. This possibility will be further explored in the discussion. In order to distinguish between the hypothesis that eye movements hurt consistent handers in the narrow column condition and the hypothesis that the wide page layout helped consistent handers in the wide columns condition, a future study would have to include a control condition with a normal 80 character layout. However, the discussion will introduce from previous data which used the normal layout in order to provide a point of comparison. This should not be taken for a proper control condition, although it may provide the a priori hypotheses for a study which includes a proper control condition.

The second question is what to make of the marginal simple effects. When a test that accounts for multiple comparisons was applied, the significant differences between consistent handlers in the Narrow Condition and the other groups disappear. Does this suggest that the effects are spurious or that a conceptual replication should be more powerful? Table 1 shows the three comparisons, their effect sizes as measured by Cohen's d , and the observed power as calculated by G*Power.

Table 2: Effect Sizes and Post Hoc Power for Paired Comparisons

Comparison	Cohen's d	Observed Power
Consistent Narrow vs Inconsistent Narrow	.57	.58
Consistent Narrow vs Consistent Wide	.58	.57
Consistent Narrow vs Inconsistent Wide	.51	.50

The effect sizes, as measured by Cohen's d , suggest medium effects. Given the cell sizes, the paired comparisons were slightly underpowered. Using G*Power, it was determined that the comparison with the weakest effect size ($d = .50$) would require cell sizes of 62 participants per cell before power reached .80. This lends support to the idea that the inconsistency between the more conservative Tukey's HSD test and the LSD test is due to a lack of statistical power. Future replications should redress this issue by increasing sample sizes or finding a means by which to implement a within subjects design.

Chapter Seven

Study Two Methods and Hypotheses

Sample

The sample consisted of 160 ($M_{age} = 18.87$; 113 Females) University of Toledo students taking Psychology 1010. They were recruited using the university's SONA System.

Materials

EHI

The Edinburgh handedness inventory was used to assess handedness. The procedure was that described in detail in Chapter 5.

Joe's Day

Participants read two versions of a story (Appendix D) about the day in life of a person named Joe. The two versions of the story, which are approximately 550 and 545 words respectively, are almost identical. However, 58 details differ from one story to the other. Half of the participants got version one at encoding and version two during the recognition test. The other half of the participants got version two at encoding and version one during the recognition test.

Procedure

Participants were tested one to two at a time. They were given the story face down. Half were assigned to read version one first and half were assigned to read version two first. Furthermore, half of the participants received a version of the story with narrow columns at encoding and half received a story with wide columns at encoding. Finally, half of participants received a version of the story with narrow columns during the test

phase, and half received a version of the story with wide columns during the test phase. In keeping with the procedure developed by Christman and Sabry (2009), wide columns consisted of columns of a width of ~120 characters and narrow columns will consist of columns of ~28 characters.

All participants were given three minutes to read the story. After three minutes, they were given 10 minutes to complete the EHI and a questionnaire (Appendix G) which was used as part of another study. After the 10 minute questionnaire period, participants were given three minutes and were told “*This is a slightly altered version of the story you read earlier in the session. Please circle any words, phrases, or details you believe have been changed.*”

Analytic Methods

First, a preliminary analysis tested for an effect of story order. Because the conditions were not assigned randomly in study two, preliminary analysis also tested for a participant order effect. Data were then data collapsed across orders and analyzed using a 2(Width at Encoding: Wide vs Narrow) x 2 (Width at Retrieval: Wide vs Narrow) x 2(Handedness: Inconsistent vs Consistent) x 2 (Sex: Male vs Female) ANOVA. The DV was d' . This is a measure of sensitivity of signal to noise and adjusts for a participants' bias towards liberally recognizing many “changes” or conservatively rejecting real changes. A liberal participant could recognize more real changes than a conservative participant, and yet also “recognize” so many false alarms that they actually have a lower hit to false alarm ratio. Hence, the number of correctly recognized items by itself is a poor measure of recall.

In order to calculate an estimate of d' one can use the following formula:

1. $d' = z(\text{Hit rate}) - z(\text{False alarm rate})$

In other words, z scores are calculated for each participants hit rate and false alarm rate. The false alarm rate is then subtracted from the hit rate, yielding an index of sensitivity to signal among noise. The higher d' is, the better a participant is at distinguishing between true memories and false alarms.

Hypotheses

There was no predicted main effect of order. There was a predicted main effect of condition. It was thought that participants asked to read wider margin answering would higher d' values than participants in conditions with narrow encoding. It was also predicted that participants who had to recognize details from the narrow passages would obtain higher d' values than participants who had to recognize details from wide passages. This is because eye movements should enhance retrieval. By this logic, the highest scoring condition would be the condition with wide encoding and narrow retrieval, while the lowest performing condition would be the condition with narrow encoding and wide retrieval. It was further predicted that there would be an effect of handedness, with inconsistent handers having higher d' values.

There was a predicted condition by handedness interaction. Since narrow story columns were predicted to interfere with encoding, only inconsistent handers assigned to conditions in which they read wide story columns at encoding were predicted to have a memory advantage over consistent handers. Since the literature suggests only consistent handers who read a wide margin version of the story at encoding will benefit from eye movements at retrieval (Lyle, Logan, & Roediger, 2008), it was also predicted that

consistent handers will be the ones who improve when the story has narrow columns at the time of testing.

Chapter Eight

Study Two Analysis and Discussion

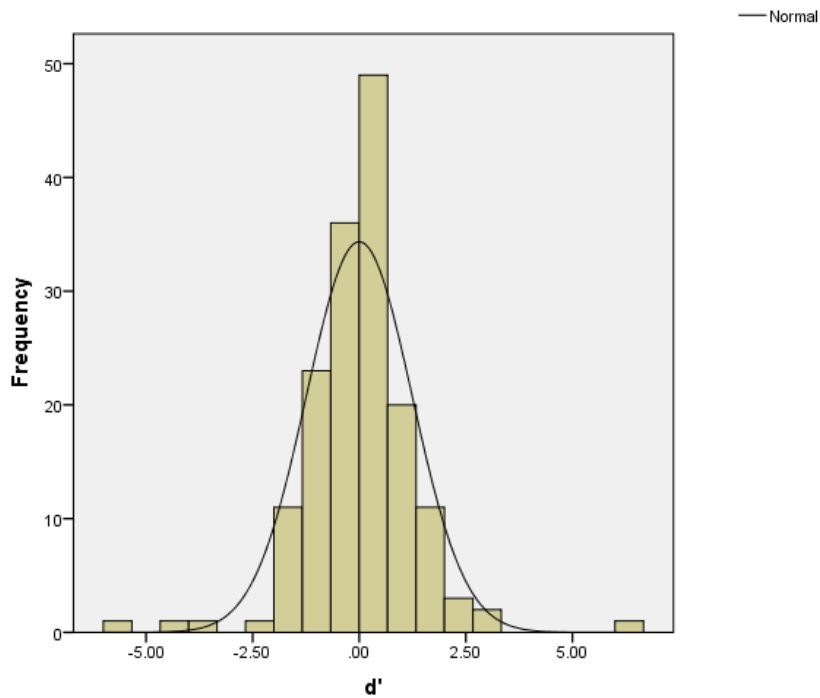
Preliminary Analyses

Study two required a slightly more involved preliminary analysis. First, in order to calculate d' , a false alarm rate needed to be calculated. The hit rate was taken by dividing the raw number of correct responses over 58. A list of potential false alarms had to be determined. Prior to any analysis, the experimenter had to look at what participants circled. When participants circled a detail that was present in the original story, but failed to circle a detail that changed, this was counted as a false alarm. In several cases, judgments had to be made about whether a participant made a false alarm. If a new detail was circled as part of an entire sentence in which a detail was changed, it was counted as a hit. In several cases, participants circled entire paragraphs. When this happened, all hits and false alarms were counted. After scoring, the experimenter came up with 38 false alarms that had been seen in one form or another (Appendix E). False alarms were then taken out of 38.

The next step was to assign a false alarm rate to all participants with 0 false alarms. This was necessary because d' cannot be estimated if the FA is 0. This is corrected by assigning a false alarm rate $1/(2N)$, where N is the number of potential false alarms, to each participant with a false alarm rate of 0. In other words, participants with no false alarms are given 1/2 of a false alarm. In this case, participants were assigned a false alarm rate of 1/76 or .013. Next, z scores for hits and false alarms were obtained using SPSS version 20. Finally, d' for each participant was calculated by subtracting the z score of the false alarm rate from the z score of the hit rate.

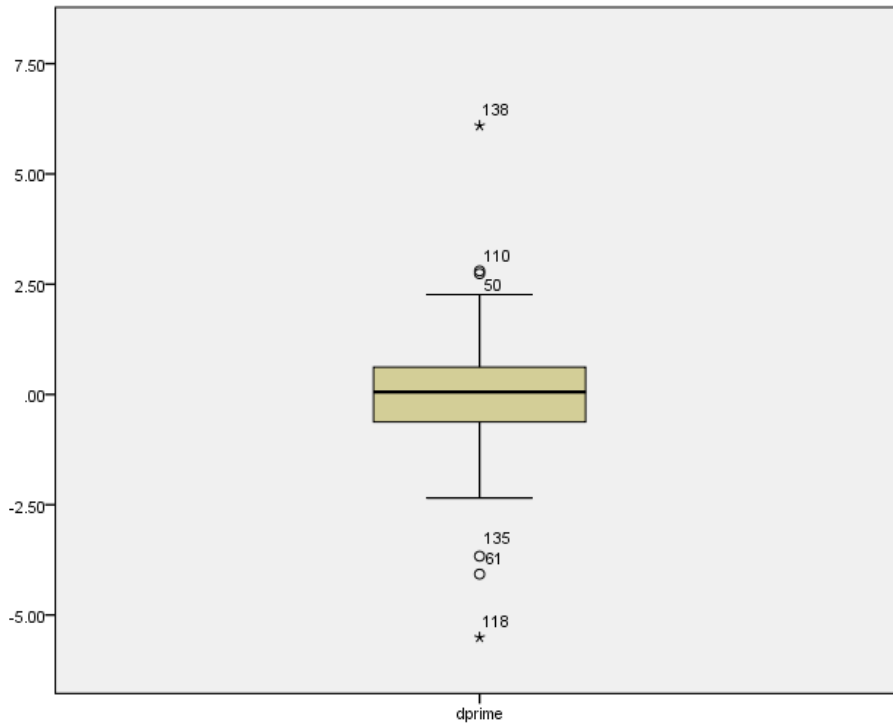
Once the d' scores were calculated, the data were tested for normality. The Shapiro-Wilk test was significant, suggesting that the data violated assumptions of normality, $p < .01$. The next step was a visual comparison of the distribution to the normal curve, as shown below.

Figure 3: Histogram of d' Scores vs Bell Curve



As can be seen from the graph, the data are roughly bell shaped, but there seemed to be several outliers. For this reason, a second visual scan of the data was performed. This time, the experimenter looked at a Tukey box plot in which outliers are marked. The chart is reproduced below.

Figure 4: Tukey Box Plot of d' Scores.

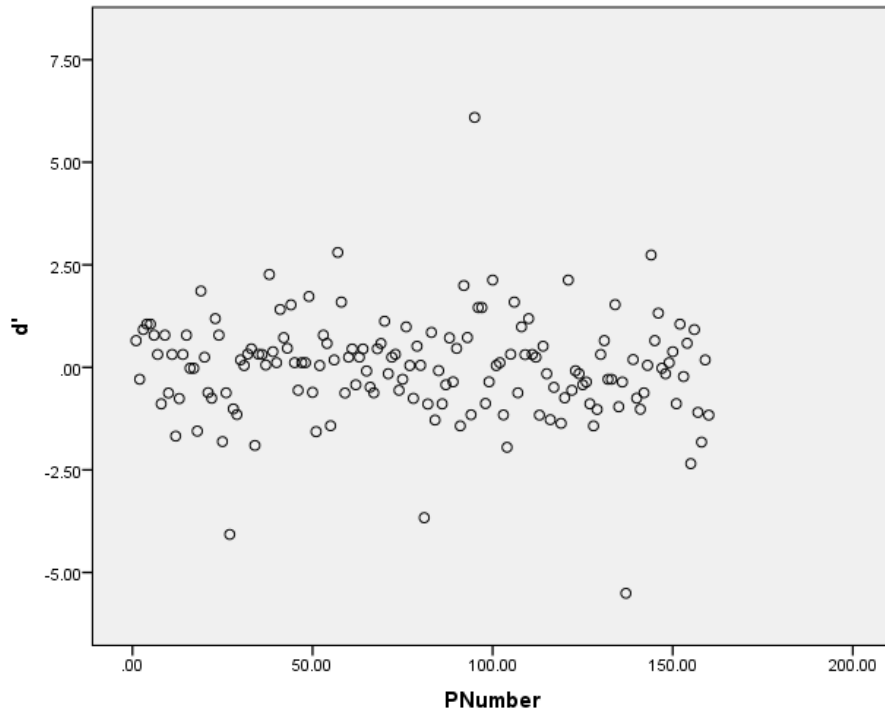


Scores with circles represent participants whose scores are 1.5 IQR (the interquartile range) above or below the median. Numbers with asterisks represent participants with scores 3 IQR above or below the median. The outliers were determined to be the likely source of non-normality. The decision was made to refrain from any transformations of the data. The analyses reported below were run a second time with the outliers removed, however the pattern of results was the same. As such, only the analyses including the outliers are reported below.

Next, the possibility of a monotonic change in performance due to something other than condition was explored. The conditions were run in a preset order instead of being randomly assigned. This can act as a confound because the way the experimenter runs the study may subtly change with practice and because participants may be different at the end of a data collection period, such as a semester, than they are at the beginning.

In order to test for the possibility of a confound, Spearman's rho was used to correlate participant number and d' . Participant number can be considered an ordinal measure of when a participant showed up. Spearman's rho is non-parametric, which means it can be used to find a correlation between an ordinal and continuous variable. It is also designed to detect monotonic relationships. A monotonic relationship is a relationship in which a variable changes as a function of another variable in one direction. All linear relationships are monotonic, but not all monotonic relationships are linear. Spearman's rho has the advantage of being more powerful than Pearson's r in some cases where a relationship is monotonic, but non-linear. If participant number correlated with d' , in a monotonic fashion, then it would have been impossible to distinguish condition effects from the effects of either the experimenter or the participants changing over time. This was not the case as $\rho = -.128, p = .110$. It is also wise practice to do a visual scan of the data to make sure that there is no evident relationship that is being obscured by outliers. A scatterplot showing d' over participant number has been copied below.

Figure 5: d' Over Participant Number



From the graph and the statistical test, it is difficult to see any monotonic pattern as a function of when participants showed up.

Next, an independent samples t -test was conducted in order to determine whether there was evidence of an order effect. No effect of order was obtained, $t(158) = .038, p = .97$.

The median absolute EHI score was 85. Because doing so yielded the most balanced cells, participants with a score of 80 and below were placed categorized as inconsistent handers..

Main Analyses

The main analysis consisted of a 2(Width at Encoding: Wide vs Narrow) x 2 (Width at Retrieval: Wide vs Narrow) x 2(Handedness: Inconsistent vs Consistent) x 2

(Sex: Male vs Female) ANOVA. The DV was d . Data were analyzed using SPSS version 21.

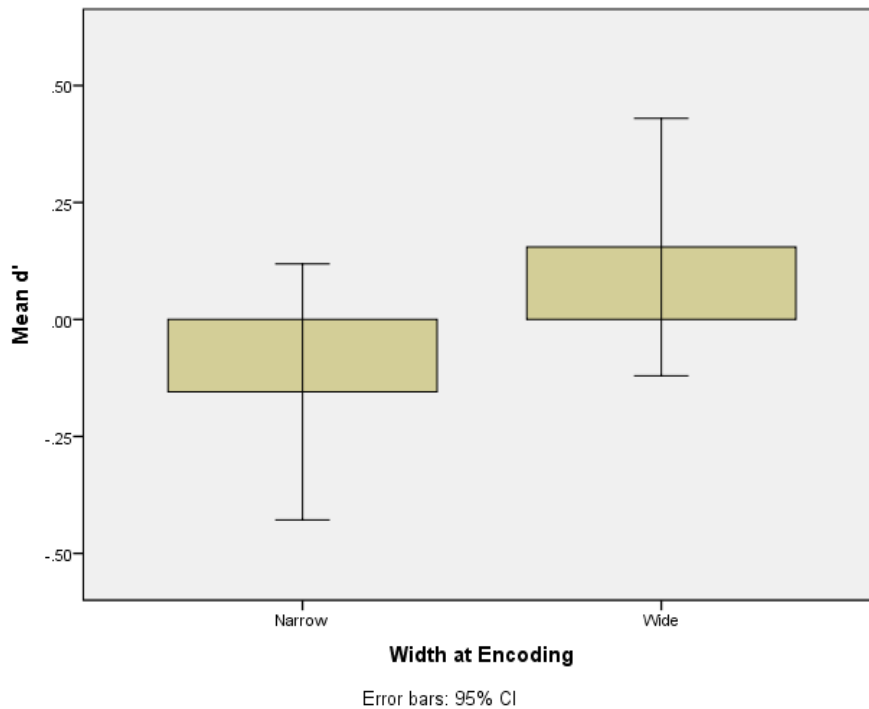
There was a main effect of width at encoding, $F(1, 144) = 3.87, p = .051, \mu^2_{partial} = .026$. There were no other significant effects or interactions. The full ANOVA table is presented below (Figure X), as is a graph comparing the d 'scores of participants in the wide and narrow encoding conditions. The effect is driven by participants in the wide encoding condition ($M = .1548, SD = 1.24$) performing better than participants in the narrow encoding condition ($M = -.1548, 1.23$), $d = .25$.

Table 3: Full ANOVA Table for Experiment 2.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	25.460 ^a	15	1.697	1.118	.345	.104
Intercept	.600	1	.600	.395	.531	.003
WidthEncoding	5.879	1	5.879	3.874	.051	.026
WidthRetrieval	2.988	1	2.988	1.969	.163	.013
Hand	.599	1	.599	.395	.531	.003
Sex	.000	1	.000	.000	.991	.000
WidthEncoding * WidthRetrieval	.620	1	.620	.408	.524	.003
WidthEncoding * Hand	.009	1	.009	.006	.938	.000
WidthEncoding * Sex	3.295	1	3.295	2.171	.143	.015
WidthRetrieval * Hand	.004	1	.004	.002	.961	.000
WidthRetrieval * Sex	4.991	1	4.991	3.289	.072	.022
Hand * Sex	3.114	1	3.114	2.052	.154	.014
WidthEncoding * WidthRetrieval * Hand	1.302	1	1.302	.858	.356	.006
WidthEncoding * WidthRetrieval * Sex	.328	1	.328	.216	.643	.002
WidthEncoding * Hand * Sex	.166	1	.166	.110	.741	.001
WidthRetrieval * Hand * Sex	2.619	1	2.619	1.726	.191	.012
WidthEncoding * WidthRetrieval * Hand * Sex	1.782	1	1.782	1.174	.280	.008
Error	218.527	144	1.518			
Total	243.987	160				
Corrected Total	243.987	159				

a. R Squared = .104 (Adjusted R Squared = .011)

Figure 6: Mean d' by Width of Columns at Encoding



Discussion

Study 2 presented more interpretational challenges than study one. There were no handedness effects whatsoever. The handedness effects did not even trend towards significance. There was a main effect of width at encoding, but it this effect should be interpreted carefully given the small effect size and wide variability within the conditions.

It is not necessarily surprising that there were no effects of handedness. Reviews of the literature using handedness as a predictor of memory performance typically find differences in recall but not recognition (See Christman & Propper, 2010; Prichard, Propper, & Christman, 2013 for reviews). The bigger issue seems to be the relative noisiness of the condition effects. Previous work shows that eye movements at retrieval improve sensitivity as measured by d' in list learning paradigms (Christman, Garvey, Propper, & Phaneuf, 2003; Lyle, Logan, & Roediger, 2008), although the effects obtained

by Lyle et al. (2008) represent one of the cases where recognition effects were handedness dependent.

One potential source of noise was the scoring method. False alarms were not decided upon ahead of time, but were determined on the basis of how the participants responded and the judgments of the experimenter. Furthermore, participants occasionally circled several sentences or entire paragraphs at a time. This forced the experimenter to make judgments, which may have contributed noise. Finally, the effects of backtracking may be more problematic in a paradigm which requires one to circle a correct response.

In the next section, some of the methodological issues discussed here will be revisited. A new method of scoring and slightly revised materials will be proposed. While the potential theoretical implications and practical implications of the study will be tentatively discussed, the main focus will be on attempting to replicate and strengthen the main effect. Thus, the primary contribution of study two may be in invention of a refined paradigm for studying recognition memory using prose materials.

Chapter Nine

General Discussion

The two studies reported herein attempted to extend a literature showing an association between memory and bilateral saccadic eye movements with memory (e.g., Christman, Brown, & Propper, 2006; Christman, Garvey, Propper, and Phanuef, 2003; Lylr, Logan, & Roediger, 2008; Lyle & Martin, 2010) to paradigms which use prose level materials. In the pages to follow, three main topics will be discussed. First, there will be a discussion of the potential theoretical implications of the two studies. The theoretical implications of study two are somewhat less clear due to methodological and statistical limitations. The second section of the discussion will cover these limitations and propose methodological changes for future replications. The final section of the discussion will focus on application. The results from study one suggest that this dissertation may be of interest to the area of applied cognition. It represents the first evidence that a proportion of the population *may* be at a disadvantage when trying to encode information laid out in a columnar format. However, results should be replicated before strong conclusions are drawn.

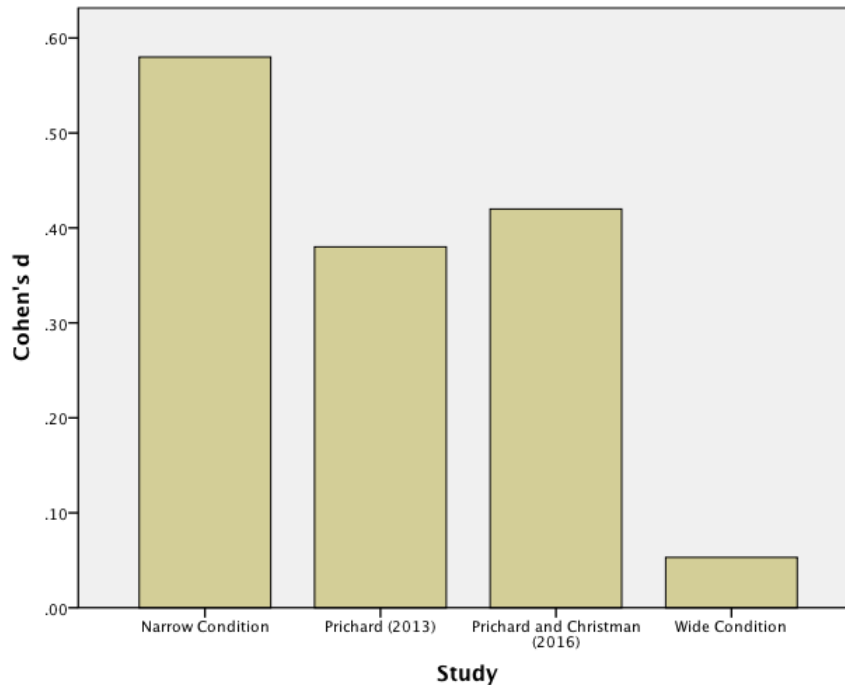
Theoretical Implications

The main theoretical implication of study one is that it may provide support for the idea that the HERA model at least partially accounts for the effects of eye movements on the memory of consistent handers. While Lyle and Martin's (2010) theory that saccadic eye movements prior to recall enhance top down attentional control mechanisms has gained additional experimental support in recent years (Lyle & Edlin, 2014), it is difficult to explain the effects of eye movements *during* encoding to attentional control

alone. Christman and Butler (2005) found eye movements harmed the performance of consistent handers prior to encoding, while the current study was the first to induce eye movements during encoding by manipulating the layout of the to be remembered materials. As the stimulus materials were prose passages, one might hypothesize that an increase in top down attentional control should enhance the ability of readers to attend to the story. This is especially important given that the experimenter told participants that their memories would be tested.

Alternatively, the effect may have nothing to do with eye movements inhibiting encoding. Prichard (2013) found that inconsistent handers remembered more information from prose passages. A recent unpublished report by Prichard and Christman (2016) reports a second study using prose passages in which inconsistent handers out performed consistent handers. One could plausibly argue that there is nothing unusual about the narrow column condition. Perhaps the correct interpretation is not that eye movements harmed the memory of consistent handers, but that consistent rightward movements across the page enhanced memory in consistent handers. The only way to settle this question is to run a replication study in which a third condition with formatting similar to that of a standard page (~80 characters) is used. The author reanalyzed the simple effects from Prichard (2013) and Prichard and Christman (2016). The sizes of the effects were somewhat smaller than the simple effect obtained in the narrow column condition from Study 1 [See Figure 7].

Figure 7: Cohen's *d* Across Studies of Handedness and Memory for Prose



While comparing the effect size is not the same thing as having a proper control condition, it does allow for the formulation of future hypotheses. If the handedness effect were to be of roughly the same size in the narrow column condition and the control condition, then the findings would suggest that wide columns help consistent handers. Conversely, if the handedness effect were to be of roughly the same size in wide column condition and the control condition, then the findings would suggest that narrow columns harm consistent handers. If, as the graph suggests, the effect decreases in size with the width of the columns, it would leave open the possibility that multiple mechanisms could be at play. Any of these findings, however, would provide support to the hypothesis that page layout differentially affects the memory of people with different patterns of cerebral organization.

The theoretical contributions of study two are more tenuous. There was one main effect. Participants who read wide columns at encoding scored higher on a test of recognition memory. This is partially consistent with both the idea that reading wide columns enhanced the memory of consistent handers and the hypothesis that right word eye movements enhance left hemisphere retrieval. Unfortunately, potential consistency with a theoretical model is hardly a critical test of a model and the results obtained in Experiment 2 are consistent with numerous other explanations besides. Two of the most serious challenges to a HERA based explanation are the effects of backtracking on memory and the possibility of a spurious statistical result.

Weger and Inhoff (2006) looked at the relationship between backward regressions during reading and inhibition of return build up. Inhibition of return is the latency between a saccadic eye movement towards a distractor and the return of attention to the initial fixation point. The experimenters used individual differences in the rate at which inhibition builds up and the type of backwards eye movements preferred during sentence reading. Participants who built up inhibition of return more readily made larger backwards regressions during reading. Larger backwards regressions were also associated with unexpected and lexically ambiguous information. This suggests that there is an individual difference in the type and size of backwards eye movements people make during reading. A recognition task in which one must search for details likely entails a more complex visual search procedure than simply reading, reading in columns may result in more regressions as sentences and phrases are broken up more frequently, and there is an unaccounted for individual difference in the types of backwards eye movements performed during reading. It is possible that all of these effects are

interacting. These effects could be adding to the noise in the results. The next section will discuss potential solutions to these difficulties.

The other potential explanation is that a spurious result was obtained. The scoring method was somewhat difficult as false alarms had to be determined after the study was completed and the scorer had to make judgments about when to consider a response a false alarm, a hit, or both. In the next section, a new scoring method designed to eliminate experimenter subjectivity entirely is proposed.

Methodological Considerations

The issue of replicability in psychological science has become a hot topic. A large scale attempt to replicate effects published in top tier psychology journals has recently yielded mixed results at best (Open Collaboration, 2015). However interesting or novel, the only theoretical significance of an unreproducible result may be its role in leading theorists terribly astray for a time. It is more important than ever to determine what would be required to reproduce and extend a result and to treat a single study as a just one test among the many required to estimate the size and direction of an effect. For this reason, this chapter includes a brief consideration to key methodological limitations within each study.

The largest barrier to replication in study one seems to be statistical power. The simple effects were only significant when the post hoc test used did not account for multiple corrections. According to the post hoc power tests, a replication should use about twice the number of participants used in the original study. A similar increase in sample size will likely assist in any attempt to clarify or replicate results in study two. Another option is designing materials that could allow for a mixed methods design. One

could create a second story with questions. Everyone would get both stories. Counterbalancing could be used in order to ensure that each story appears first and second as well as wide and narrow an equal number of times. This may slightly reduce the number of participants needed for a replication. An absolute must for any future replication of study one is the inclusion of a control condition in which participants receive a passage with standard columns of ~80 characters in width. If the pattern obtained in study one is replicated, the control condition will be crucial for beginning to determine the underlying mechanism.

The methodological issues involved in study two are somewhat more serious. First, it is proposed that any conceptual replication of study two change the scoring method. It is here proposed that every sentence have a single real change and predetermined critical lure. In this way, the number of critical lures and false alarms will be equal. Next, it is proposed that during the test phase, both the true change and critical lure be bolded. The instructions would make clear that in each sentence one changed detail and one unchanged detail has been bolded. Participants will be told to circle the detail which they believed to be changed. An example of how such materials might look has been provided as Appendix H. In this case, a version of the Spinoza Island story has been altered, although the story from study two could be used as well. For the purposes of the Appendix, the critical lure has been bolded and italicized while the true change has just been bolded. However, during the test phase the participants would see two bolded words and be instructed to circle just one of these words.

The trickier question is that of backwards regression while reading. Bolding the two options would make the test phase somewhat less of a visual search task. However, it

would not account for individual differences in inhibition of return and backtracking strategies. While this seems like a potentially less serious issue for study one, as there was a handedness effect, there was no handedness difference in study two. It is here proposed that the visual search like nature of the recognition task makes it more susceptible to effects related to backwards regression and that a future study may benefit by controlling for this. One strategy is to measure inhibition of return and use it as a covariate. A second strategy would be to present materials on a computer screen and using eye tracking equipment to follow the eye movements of participants. There is particular appeal in looking at inhibition of return. As it is an individual difference that has been unstudied in the context of handedness, it is unknown whether these variables might be related or even interact. Perhaps the lack of a control for an important individual differences masked handedness effects in Study 2.

Practical Implications

From an applied cognition perspective, the results of study one are of potentially great significance. This of course assumes that the results are replicated and that the inclusion of a proper control condition provides some clues as to the mechanisms underlying the interaction of handedness and text column width. Although study two is more equivocal, future results may reveal that this is true of study two as well. Study one provides substantive evidence that a biologically based individual difference may be associated with more difficulty encoding information from written material, but that a simple change in format could eliminate this difference.

The next steps should focus on taking these findings squarely into the realm of applied cognitive psychology. After conceptual replication, it will be crucial to use more

naturalistic materials. Magazines and newspaper often use skinny paragraphs as a space saving measure. Cell phone screens also provide information in a narrower format. Other questions which should be asked are:

- 1) Do people have compensatory strategies when they read from narrow columns and how widespread are these strategies?
- 2) What is the temporal course of the effect? Inconsistent handers and consistent handers who read the wide margined materials had better memories 10 minutes after stimulus presentation. Does this hold after a day? Does it hold after a week?
- 3) What are effects on comprehension? Do consistent handers who read information from a narrow format make more errors about the meaning of what they read? Would they be more likely to endorse false statements about the materials? Are there times when the detriments in comprehension could be serious enough to warrant a change in format?

The questions generated from study one alone could lead to the creation of a multistep research program. Should revisions of study two yield results, especially should individual differences in inhibition of return end up being an important variable, then the potential list of questions for applied cognitive scientists would grow exponentially.

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Appendix A

Handedness Inventory

Please indicate your preference in the use of hands for each of the following activities or objects by placing a check in the appropriate column.

	Always Left	Usually Left	No Pref- erence	Usually Right	Always Right
Writing					
Drawing					
Spoon					
Open Jars					
Toothbrush					
Throwing					
Comb Hair					
Scissors					
Knife					
Striking a Match					

Is your mother left-handed? _____

Is your father left-handed? _____

Do you have any brothers or sisters who are left-handed? _____

Are you male or female? _____

M F

What is your age in years? _____

Appendix B

Spinoza Island

Spinoza Island is located 80 miles off the coast of Florida. It was settled by the Dutch in 1700. At that time, it was primarily a center of trade and exploration. Today, its main industries are fishing and tourism. About 2500 people live on the island, but more than 10,000 people visit every year. Most visitors arrive by boat, the busiest month being February. New Hague, the island's only town, offers many pleasing and relaxing activities. Its lovely beaches are covered in sand that is particularly good for glassmaking. Because of this, the island is home to the world's most visited museum dedicated to lens makers. The wealthy stay at the Baruch Plaza, which is the island's most luxurious hotel. However, the town also features a dozen other lovely inns. Bicycling is the most common form of transportation and bike tours are very popular. When hungry, visitors have the option of 20 four and five star restaurants to choose from. On Wednesday evenings, one can enjoy live Caribbean music at the Amsterdam Cafe. Those who come in May discover the world's largest annual conference on Pantheism and visitors who happen to be around on November 24th are invited to join in on the island's Independence Day celebrations. So peaceful is the island, that it was allegedly a favorite secret vacation spot for the scientist Albert Einstein. Think about that!

Appendix C

Study One Questions

About how many people visit the island every year?

Spinoza Island was allegedly a favorite secret vacation spot for what scientist?

How many people live on the island?

In addition to its most luxurious hotel, how many inns does the island have?

Spinoza Island is home to the largest annual conference on what?

How do most visitors arrive to Spinoza Island?

What is the busiest month?

How many four and five star restaurants does Spinoza island have?

When was Spinoza Island settled?

Spinoza Island is located 80 miles from what state?

Who settled Spinoza Island?

Where can one enjoy live Caribbean music on Wednesdays?

What is the name of Spinoza Island's most luxurious hotel?

What is the most common form of transportation on Spinoza island?

Spinoza Island has the world's most visited museum dedicated to what?

What is the name of the island's only town?

When is the island's Independence Day?

Spinoza Island's sand is particularly good for making what?

What are Spinoza Island's main industries today?

When it was settled, Spinoza Island was primarily a center of what?

Appendix D

Study Two Story

One day, Joe woke up at **7/8** am. He made himself a bagel with **cheese/butter** and read the morning newspaper, in which he read about the hometown **baseball/football** team's **15-12 victory over/loss to** the **Ridgeville/Crestville** Wombats. After eating, he got in his **car/truck** and headed down the **expressway/freeway** to his job at **G&B/G&E** Exterminators. When he arrived, he learned that his boss was home sick with a bad **chest/head** cold, so Joe unexpectedly got the day off. He decided to spend some time at the local **library/bookstore**, where he **read/bought** a book on **Arctic/Antarctic** exploration. He then went to a **restaurant/diner** for lunch, where he had a **ham/turkey** and cheese sandwich.

After he finished eating and was **walking out/leaving**, he noticed a thrift shop **next door/across the street**. Always on the lookout for interesting **bargains/deals**, he decided to walk in and **browse/look around** for a while. Although he was **extremely/mildly** tempted by **an antique/a new jacket/coat** with red and **yellow/gold** trim, he decided to save the **cash/money** and walked back out. At this point, he noticed a traffic cop standing near his vehicle writing out a ticket. “Oh, that’s **grand/great**; just what I need.” He approached the cop, hoping to try to talk them out of it. The cop looked up, **gestured/pointed** to a **silver/gray** vehicle parked in front of his, and asked “Is this vehicle yours?” Joe **happily/nervously** said “No” and quickly got into his own vehicle before the cop noticed that his meter was also **expired/out of time**.

Since Joe had the rest of the **day/afternoon** off, he decided to **run some errands/have some fun**. First, he stopped by the local hardware store to check out the

new line of power **saws/drills**. Next, he **drove/walked** over to the local shopping **center/mall**, where he spent some time enjoying the **window shopping/people watching**. Then Joe decided to head off to the city **park/zoo**, where he amused himself by watching the **ducks/geese** frolic in a pond. Finally, he headed over to the sport supplies store, where he bought some golf **balls/tees** and a new baseball **cap/glove**.

Afterwards, on his way home, Joe stopped by the **grocery store/supermarket** to pick up some **apples/apple juice**, a **gallon/quart** of milk, and a loaf of bread. After parking his car **in the garage/on the driveway**, he went inside, put the **food/groceries** away and turned on the **TV/radio**. After a few minutes of the news and weather, he turned it off and went back outside to work in his **garden/yard**. He pruned his **elm/oak** tree, fertilized his **begonias/petunias**, and **trimmed/watered** the grass along the **sidewalk/driveway**. Suddenly, he remembered he had a dinner date with some **acquaintances/co-workers**, so he went back inside to **freshen/clean** up. Realizing that he still had some time to **spare/kill**, he decided to stop by the video store on his way to dinner to **return/rent** a movie.

He arrived at the restaurant, somewhat surprised that he was about ten minutes **early/late**. The dinner was wonderful, and he and his friends **talked/chatted** for a long time afterwards. They talked mostly about the **upcoming/recent** elections and about the Wombats' chances to win their league **this/next** year. Eventually, it was time to go, and Joe said **good-bye/farewell** to his friends.

When he finally **returned/got back** home, he was too tired to do **anything/much** else, so he ended up going straight to **sleep/bed**.

Appendix E

Study Two False Alarms

One day, Joe woke up[1] at **7/8** am. He made himself a *bagel*[2] with **cheese/butter** and *read the morning newspaper*[3], in which he read about the *hometown*[4] **baseball/football** team's *15-12*[5] **victory over/loss to** the **Ridgeville/Crestville Wombats**[6]. After eating, he got in his **car/truck** and headed down the **expressway/freeway** to his job at **G&B/G&E Exterminators**[7]. When he arrived, *he learned that his boss was home sick*[8] with a bad **chest/head** cold, so Joe *unexpectedly got the day off*[9]. He decided to spend some time at the local **library/bookstore**, where he **read/bought** a book on **Arctic/Antarctic** exploration. He then went to a **restaurant/diner** for *lunch*[10], where he had a **ham/turkey** and *cheese*[11] sandwich.

After he finished eating and was **walking out/leaving**, *he noticed a thrift shop*[12] **next door/across the street**. Always on the lookout for *interesting*[13] **bargains/deals**, he decided to walk in and **browse/look around** for a while. Although he was **extremely/mildly** tempted by **an antique/a new jacket/coat** with *red*[14] and **yellow/gold** trim, he decided to save the **cash/money** and walked back out. *At this point, he noticed a traffic cop standing near his vehicle writing out a ticket*[15]. “Oh, that’s **grand/great**; just what I need.” *He approached the cop, hoping to try to talk them out of it*[16]. The cop looked up, **gestured/pointed** to a **silver/gray** vehicle parked in front of his, and *asked “Is this vehicle yours?”*[17] Joe **happily/nervously** said “*No*”[18] and quickly got into his own vehicle before the cop noticed that his meter was also **expired/out of time**.

Since Joe had the rest of the **day/afternoon** off, he decided to **run some errands/have some fun**. First, he stopped by the *local hardware store*[18] to check out the new line of power **saws/drills**. Next, he **drove/walked** over to the local shopping **center/mall**, where he spent some time enjoying the **window shopping/people watching**. Then Joe decided to head off to the city **park/zoo**, where *he amused himself*[20] by watching the **ducks/geese** frolic in a *pond*[21]. Finally, he headed over to the *sport supplies store*[22], where he bought some golf **balls/tees** and a new baseball **cap/glove**.

Afterwards, on his way home, Joe stopped by the **grocery store/supermarket** to pick up some **apples/apple juice**, a **gallon/quart** of milk, *and a loaf of bread*[23]. After *parking*[24] his car **in the garage/on the driveway**, he went inside, put the **food/groceries** away and turned on the **TV/radio**. After *a few minutes*[25] of the *news*[26] and *weather*[27], he turned it off and went back outside to work in his **garden/yard**. He *pruned*[28] his **elm/oak** tree, *fertilized*[29] his **begonias/petunias**, and **trimmed/watered** the *grass*[30] along the **sidewalk/driveway**. Suddenly, *he remembered he had a dinner date*[31] with some **acquaintances/co-workers**, so he went back inside to **freshen/clean** up. Realizing that he still had some time to **spare/kill**, he decided to stop by the *video store*[32] on his way to dinner to **return/rent** a movie. He arrived at the *restaurant, somewhat surprised*[33] that he was about *ten minutes*[34] **early/late**. The *dinner* was *wonderful*[35], and he and his friends **talked/chatted** for a *long time afterwards*[36]. They talked mostly about the **upcoming/recent elections**[37] and about the *Wombats'*[38] chances to win their league **this/next** year. Eventually, it was time to go, and Joe said **good-bye/farewell** to his friends.

When he finally **returned/got back** home, he was too tired to do **anything/much** else, so he ended up going straight to **sleep/bed**.

Appendix F

What Does the EHI Measure?

The research presented in this dissertation assumes that the Edinburgh Handedness Inventory really measures handedness and that it is a tool which can successfully dichotomize people into two meaningful categories on the basis of the consistency of hand use. The use of the EHI in this manner has been empirically fruitful (Prichard, Propper, & Christman, 2013). However, with recognition that handedness is more complex than a simple left-right dichotomy has come renewed debate about how handedness should be measured and how handedness groups should be classified (e.g., Tran, Stieger, & Voracek, 2014; Fagard, Chapelain, & Bonnet, 2015). Most notably, it has been suggested that questionnaires associating handedness and other cognitive variables such as magical ideation are actually just measuring a response bias and not handedness per se (Grimshaw, Yelle, Schoger, & Bright, 2008). The author of this dissertation became somewhat interested in the question of what the EHI is measuring several years ago. He did a set of analyses exploring the question. The first is a published factor analysis paper which showed that the greater variability of hand use among inconsistent handers resulted in a more complex factor structure for scores on a common variant of the EHI (Christman, Prichard, & Corser, 2015). The significance of this is that the authors expected this finding on the basis of genetic models, which suggest a combination of genetic and environmental factors shape hand preference in inconsistent handers. The second study, not yet submitted as of the writing of this dissertation, used the same large data set. The purpose of the second study was twofold. The first purpose was to use a discriminant function analysis in order to determine whether the EHI could

be used to calculate weighted linear functions that satisfactorily distinguish between consistent and inconsistent handers. The second was to investigate which items most strongly predict degree of handedness and which items most strongly predict direction of handedness. The hope was that this study would provide further empirical evidence that using the median split EHI as a classification tool is a justifiable practice and that the items which distinguish consistency of handedness are different from the items which distinguish direction. It was thought that direction of handedness would be most strongly predicted by strength of preference for the writing hand, while consistency of handedness would be most strongly predicted by tasks that required less fine grained motor dexterity. Such a finding would call into question the idea that consistency of handedness as measured by the EHI, or at least the version presently used by the Toledo research group, is simply a response bias. While it doesn't rule out such a possibility, such results would be more readily predicted from the assumption that the EHI has at least some validity as pertains to measuring behavioral hand preference. The study is presented below.

Method

DFA

A discriminant function weights items in a questionnaire in order to predict group membership. This allows one to see which items play the biggest role in classifying cases into categories. The discriminant function can also be used to calculate a re-weighted questionnaire score for each participant. These scores can be graphed via a histogram and one can look at the properties of each group's distribution. Two DFA's were conducted. The first analysis classified 1041 university students, who were defined as left and right handers on the basis of their EHI scores. The second classified the same participants into

inconsistent and consistent handers on the basis of a media split of their absolute scores on the EHI.

EHI

The version of the EHI used was a questionnaire which listed 10 common items/tasks: writing, drawing, using a spoon, opening jars, using a toothbrush, throwing, using a comb, using scissors, using a knife, and striking a match. Response options were always use left, usually use left, no preference, usually use right, and always use right. For each items, possible scores ranged from -10(always left) to +10(always right.) Total scores ranged from -100 to +100.

Results

Left vs Right.

Of the sample, only 86 people (8.26%) were left handed. The discriminant function used to classify left and right handers was significant, Wilk's Lambda = .14, $p < .001$. About 86% of the variance in direction of handedness was accounted for by the discriminant function. The function correctly classified 98.8% of cases. The standardized canonical discriminant function coefficients in the table below are weighting values, similar to beta weights in regression. The greatest weight is given to writing and drawing. Jars, toothbrush, comb, and knife have very little weight when the function is used to classify participants by direction of handedness. Graphs reveal that scores on the re-weighted linear composites are very skewed for both groups.

Table 4: Standardized Canonical Discriminant Function Coefficients for Left vs Right

Write	.545
Draw	.253
Spoon	.139
Jars	-.094
Toothbrush	.030
Throwing	.232
Comb	.044
Scissors	.191
Knife	.011
Match	.153

Figure Eight: Left vs Right Function – Left Handers

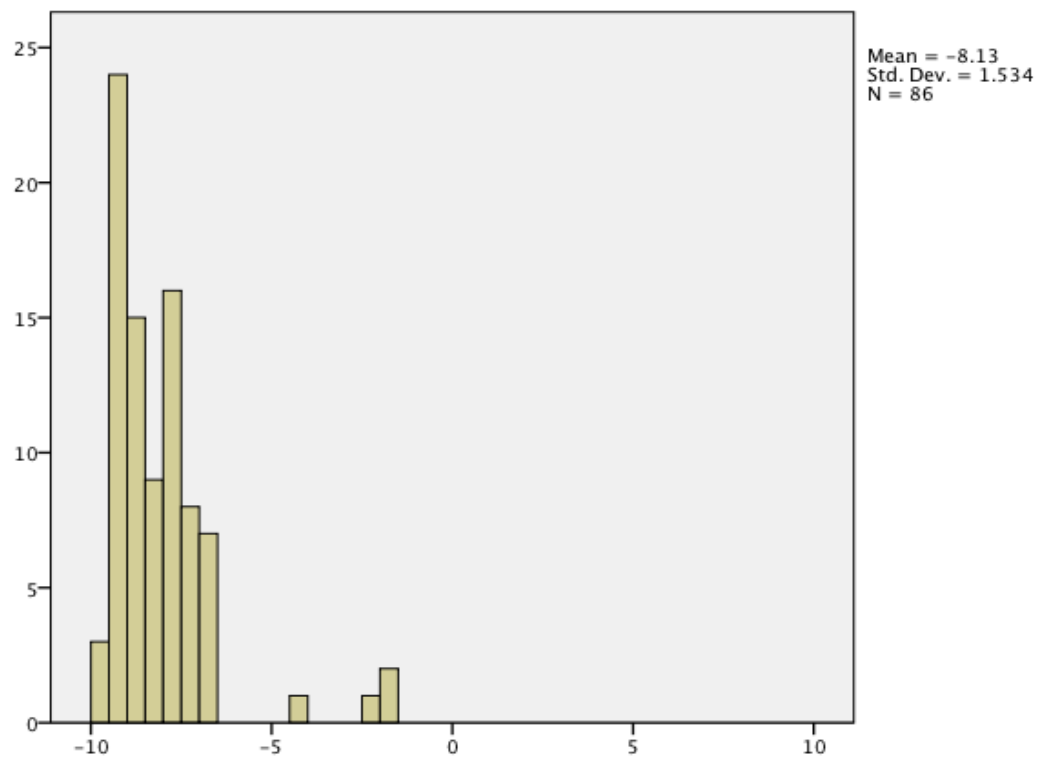
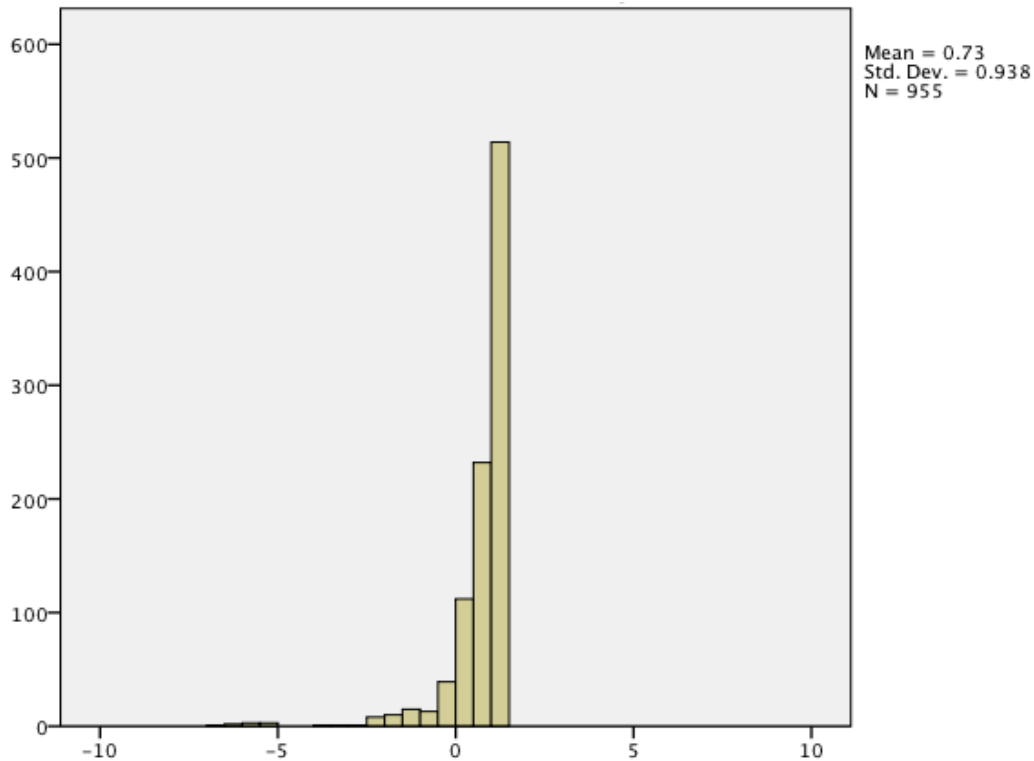


Figure Nine: Left vs Right Function – Right Handers



Consistent vs Inconsistent

Of the sample, 559 (53.7%) were inconsistently handed. The discriminant function used to classify inconsistent handers was significant, Wilk's Lambda = .58, $p < .001$. About 42% of the variance in degree of handedness was accounted for by the function. The function correctly classified 84% of cases. The standardized canonical discriminant function coefficients (table 2) were slightly more complicated than those yielded by the function classifying participants by direction of handedness. Jars and comb, two items which had very little weight in the function that classified direction of handedness, had the largest positive weights when classifying consistency of handedness. Writing had a large negative weight, suggesting that responses for writing were negatively correlated with the discriminant function. When the re-weighted linear

composites were graphed for each group, consistent handers showed a left skew.

However, the scores of inconsistent handers were almost normally distributed.

Table 5: Standardized Canonical Discriminant Function Coefficients for Consistent vs Inconsistent

Write	-.578
Draw	-.158
Spoon	.339
Jars	.643
Toothbrush	.316
Throwing	-.319
Comb	.531
Scissors	-.007
Knife	.294
Match	.024

Figure Ten: Consistent vs Inconsistent Function – Consistent Handers

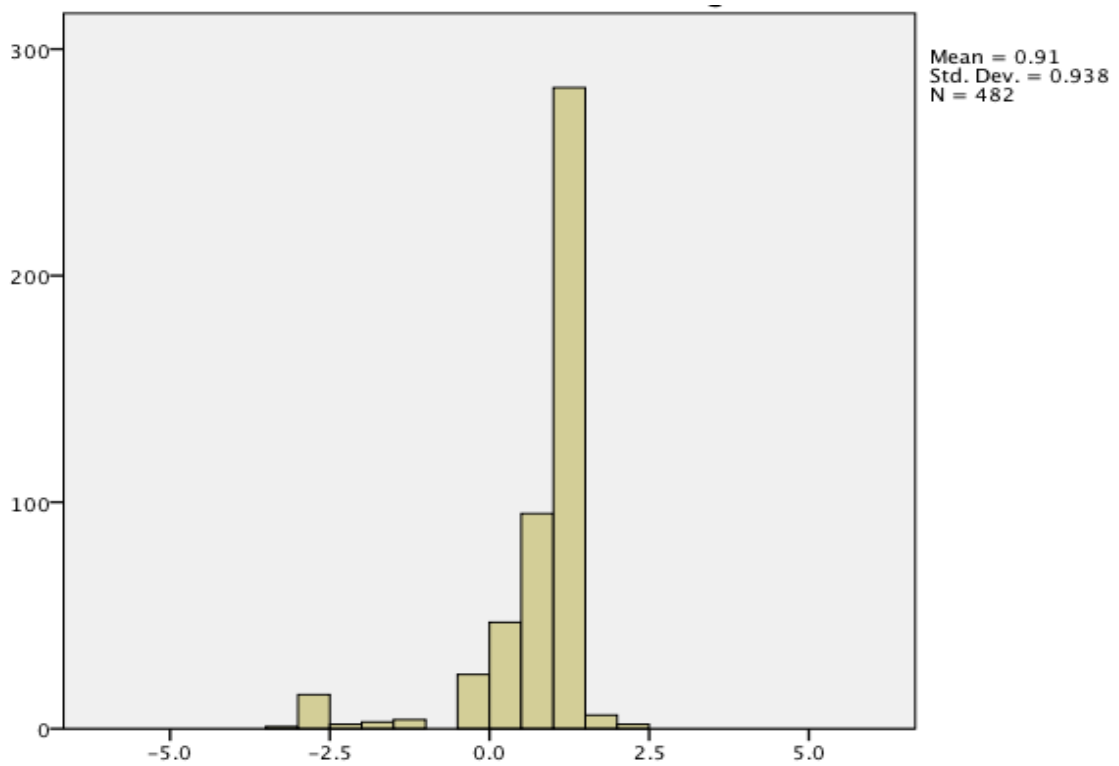
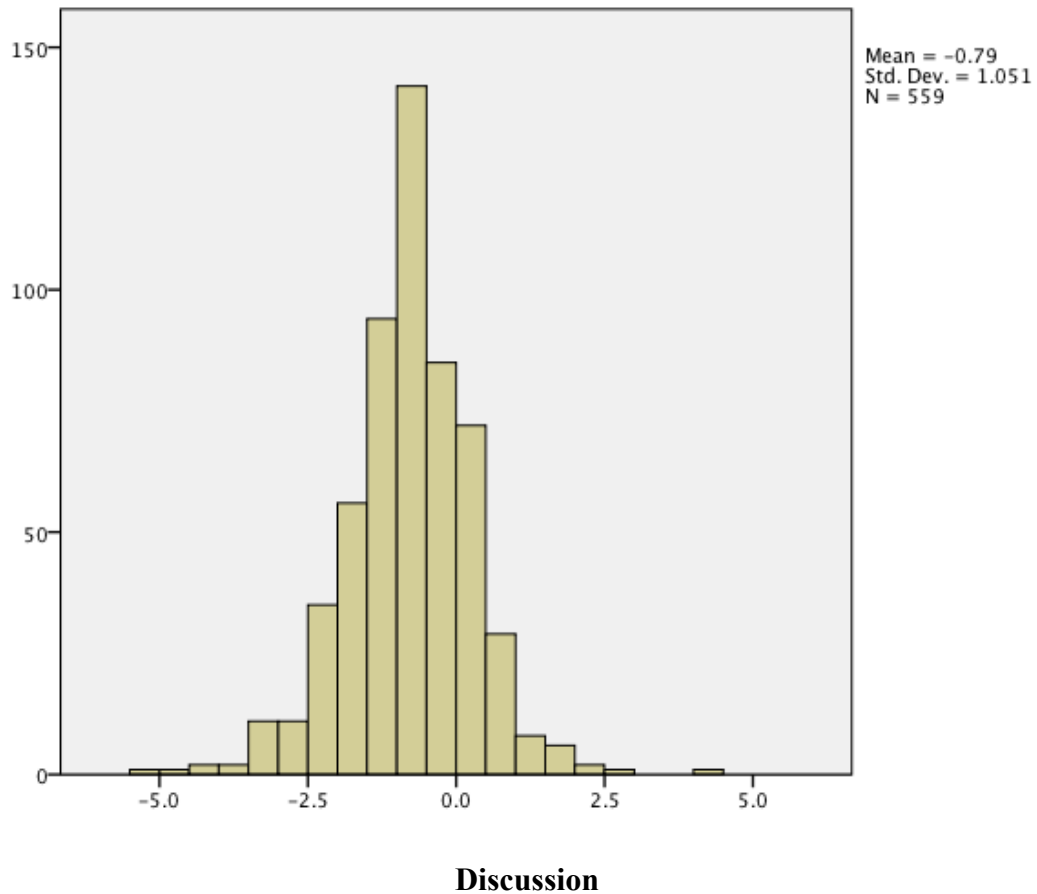


Figure Eleven: Consistent vs Inconsistent Function – Inconsistent Handers



Discussion

When measuring handedness with the EHI, different items distinguish inconsistent handers from consistent handers than distinguish left and right handers. When looking at direction, writing is a powerful predictor and opening jars and combing one's hair are very weak predictors. However, these same items have the strongest positive relationship with a function that was used to classify consistent and inconsistent handers. Interestingly, this is line with the prediction that less fine grained motor tasks would be predictive of consistency of handedness. Opening jars is a bimanual task in which one can stabilize the jar with the dominant hand and twist the lid with the non-dominant hand, stabilize the jar with the non-dominant hand and twist the lid with the dominant hand, hold the lid with the dominant hand and twist the jar with the non-

dominant hand, or hold the lid the non-dominant and twist the jar with the dominant hand. Combing is a task in which switching hands offers an easier way to comb the entire head so long as one is sufficiently comfortable with their non-dominant hand. These gross motor tasks are of quite a different nature from the fine motor pegboard task used by Grimshaw et al. (2008) as their behavioral measure of handedness.

Furthermore, the discriminant function that classifies participants by degree of handedness yields a near normal distribution for inconsistent handers, but not for consistent handers. This is the real story of the analysis. Handedness questionnaires almost always have a characteristic j-shaped distribution. Not only is the Gaussian extremely rare when looking at questionnaires measuring handedness, but this finding (which had not been predicted a priori) would be exactly what one would expect if inconsistent handers have a major chance component to their handedness and if the tasks most influenced by chance or environmental factors were given the greatest weight in the measurement of handedness. This study provides evidence that consistent and inconsistent handers are meaningfully different and the pattern of data is more in line with the assumption that the EHI variant used measures at least something of true behavioral hand preference and not simply response bias.

Appendix G

Distractor Task for Studies One and Two

Some Information about Adrenal Fatigue

Adrenal fatigue is a collection of signs and symptoms, known as a syndrome, that results when the adrenal glands function below the necessary level. Most commonly associated with intense or prolonged stress, it can also arise during or after acute or chronic infections, especially respiratory infections such as influenza, bronchitis, or pneumonia. As the name suggests, its main symptom is persistent fatigue that is not relieved by sleep but it is not a readily identifiable entity like measles or a growth on the end of your finger. You may look and act relatively normal with adrenal fatigue and may not have any obvious signs of physical illness, yet you live with a general sense of unwellness, tiredness or "gray" feelings. People experiencing adrenal fatigue often have to use coffee, colas, and other stimulants to get going in the morning and to prop themselves up during the day.

This syndrome has been known by many other names throughout the past century, such as non-Addison's hypoadrenia, sub-clinical hypoadrenia, neurasthenia, adrenal neurasthenia, adrenal apathy and adrenal fatigue. Although it affects millions of people in the U.S. and around the world, conventional medicine is only starting to recognize it as a distinct syndrome.

Adrenal fatigue can interfere with your life. In the more serious cases, the activity of the adrenal glands is so diminished that you may have difficulty getting out of bed for more than a few hours per day. With each increment of reduction in adrenal function, every organ and system in your body is more profoundly affected. Changes occur in your carbohydrate, protein and fat metabolism, fluid and electrolyte balance, heart and cardiovascular system, and even sex drive. Many other alterations take place at the biochemical and cellular levels in response to and to compensate for the decrease in adrenal hormones that occurs with adrenal fatigue. Your body does its best to make up for under-functioning adrenal glands, but it does so at a price. (From www.adrenalfatigue.org)

Circle the responses that best match the strength of your own feelings. Remember, there are no wrong answers. We just want your opinion.

Given what you now know, how good of an idea do you feel it is that the University of Toledo invest \$1,000,000 in research on Estriderol, a drug designed to increase adrenal gland activity?

1

2

3

4

5

6

A very
good idea

A very
bad idea

The University is considering putting information about Estriderol on our Alumni website in order to get broad feedback from the Toledo family. As part of the site, we're considering linking several short news and magazine articles about the drug. Place an "X" next to titles of the articles you would most prefer to read to get more information about Estriderol. You may place an "X" next to as many titles as you wish

Adrenal Fatigue Remedy: More Gimmick than Science _____

Defenders of Estriderol Won't Acknowledge Failures _____

Drug Trials for Estriderol Less Promising Than Advertised

Estriderol: Big Promises, But No Results _____

Estriderol Well Worth Expense According to Earliest Drug Trials _____

Adrenal Fatigue: Treatments Past, Present, Future _____

New Adrenal Fatigue Drug Being Developed by Pfizer _____

What is Estriderol: The Chemistry of Targeting the Adrenal Gland _____

Breakthrough on New Adrenal Fatigue Drug _____

Naysayers Aside, Estriderol Is Poised For Success _____

Estriderol to Start Clinical Trials in May _____

Estriderol: New Hope for Sufferers of Adrenal Fatigue _____

The Pharmaceutical Industry's Attempt to Turn a Flop into Profit. _____

Meet the German Chemists behind Estriderol _____

Estriderol is Big Pharma's Great Wild Goose Chase _____

Life with Adrenal Fatigue: Will Estriderol Be My Answer? _____

When Estriderol Hits Market, Adrenal Fatigue Will Be History _____

Estriderol May Have Benefits Beyond Treatment of Adrenal Fatigue

Next, we would like you to briefly read the abstract below of the most recent study published on Estriderol's efficacy. An abstract is a one paragraph summary of a scientific report that makes its most important findings accessible. It is important to us that you have an idea of where the development of the drug is.

We administered Estriderol to a sample of 538 sufferers of adrenal fatigue syndrome (AFS). They ranged in age from 18-67, and the sample was 53 percent male. Of the sample, 50 percent saw *no significant* reduction in AFS symptoms over the course of the 6 week trial. In our opinion, this does not represent a substantial reduction in symptoms. Furthermore, of the volunteers in the sample, a few people reported side effects. Among those who did report abnormalities, suspected side effects included diarrhea, headache, nausea, insomnia, and serious allergic reaction. We do not recommend further research on the drug.

**Circle the responses that most best matches the strength of your own feelings.
Remember, there are no wrong answers. We just want your opinion.**

How weak or strong were the data from the study above?

1 2 3 4 5 6

Very
weak

Very
strong

All in all, how persuasive do you find the summary of the research above?

1 2 3 4 5 6

Very
unpersuasive

Very
persuasive

Given what you now know, how good of an idea do you feel it is that the University of Toledo should invest \$1,000,000 in research on Estriderol, a drug designed to increase adrenal gland activity?

1 2 3 4 5 6

A very
good idea

A very
bad idea

Debriefing

The preceding survey was not actually a survey about the drug Estriderol. The University is NOT considering making a \$1,000,000 investment in the drug Estriderol. Estriderol is fictitious and it is generally agreed among the medical community that adrenal fatigue syndrome is not a real illness. We engaged in a bit of deception in order to test something called confirmation bias.

Psychological research shows that once people form an opinion, even if they have no emotional or personal stake in that opinion, they are more likely to choose to look at information that conforms to that opinion and that they find arguments that agree with their conclusions more convincing.

Our goal was to see whether this happened in the context of choosing how the university should spend its money, an important issue as research institutions around the country face tough choices about what kind of research to support. We would appreciate if you not tell your classmates about what was in the study so we can get at their true perceptions. Studying confirmation bias requires that the information presented remain believable.

Please initial below to signify that you have read the debriefing statement, that you understand Estriderol is not a real drug, adrenal fatigue is not a real disease, that the actual purpose of the experiment is to study confirmation bias, and that we can trust you to keep the true purpose of the research a secret until all data have been collected.

Initials

Appendix H

Proposed Method for Replicating Study Two

Spinoza Island is located **80** miles off the coast of **Florida/California**. It was settled by the **Dutch** in **1700/1800**. At that time, it was primarily a center of **trade/shipbuilding** and **exploration**. Today, its main industries are **fishing/manufacturing** and **tourism**. About **2500/5200** people live on the island, but more than **10,000** people visit every year. Most visitors arrive by **boat**, the busiest month being **February/December**. **New Hague/New Denmark**, the island's **only** town, offers many pleasing and relaxing activities. Its lovely **beaches/deserts** are covered in sand that is particularly good for **glassmaking**. Because of this, the island is home to the world's **most** visited museum dedicated to **lens/window** makers. The wealthy stay at the **Baruch** Plaza, which is the island's most **luxurious/famous** hotel. However, the **town/waterfront** also features **a dozen** other lovely inns. **Bicycling/go-karting** is the most common form of transportation, but **hiking** tours are very popular. When hungry, visitors have the option of **20** four and five star **restaurants/eateries** to choose from. On **Wednesday** evenings, one can enjoy live **Caribbean/Polynesian** music at the Amsterdam Cafe. Those who come in May discover the world's largest annual conference on **Pantheism** and visitors who happen to be around on November 24th are invited to join in on the island's **Independence/Boxing** Day celebrations. So **peaceful/stimulating** is the island, that it was allegedly a favorite secret vacation spot for the scientist **Albert Einstein**. Think about that!

