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## GENERAL INFORMATION

- **Fall 2011 Editorial Board, Advising, and Staff**
  
  *Indiana Undergraduate Journal of Cognitive Science*

- **Submission Instructions**
EDITOR’S NOTE

I’m tempted to say, “The sixth volume of the Indiana Undergraduate Journal of Cognitive Science is hot off the presses!” Of course, it wouldn’t be very accurate. Since its inception, IUJCS has been an online publication. There are many reasons for this, but we are propelled by one in particular: accessibility.

In any field or discipline, undergraduate students rarely have full access to the power and resources necessary to effectively conduct and publish independent research and writing. Nonetheless, in the field of cognitive science, scores of bright undergraduates are working on brilliant, innovative research every day. Many students are the principal investigators behind this research. We believe that they deserve due recognition for their work. The Indiana Undergraduate Journal of Cognitive Science is one way of empowering, motivating, and recognizing these students.

Cognitive science draws from many schools and disciplines, and students from a range of variegated programs, departments, and universities around the globe can contribute to our understanding of the mind. For these reasons, this journal is open to submissions from any undergraduate in any university in the world. It has no limit to the number of submissions it will accept, nor to the length or scope of those submissions. The fact that it is an online publication helps facilitate these principles.

Our only qualifications are that submissions are of sufficient quality, accuracy, originality, and scientific soundness. I’m confident that you’ll find these attributes in the five articles included in this volume.

Saba Chowdhry, of Case Western Reserve University in Cleveland, Ohio, constructs a critique of Jean Mandler’s theory of perceptual analysis. She creatively argues that Mandler’s theory, which heavily favors visual input as a primary source of concept formation in cognitive development, overlooks the fact that blind individuals have comparable cognitive development to sighted individuals.

Alicia J. Johnson, Sook-Lei Liew, and Lisa Aziz-Zadeh, of the University of Southern California in Los Angeles, California, offer a novel analysis of an underreported mental condition known as body integrity identity disorder. Individuals afflicted by this condition often desire paralysis or amputation of healthy limbs as a means of conforming their bodies to their mental understanding of themselves.

Scott Munro of York University in Toronto, Ontario, marries philosophical and neuroscientific theories of consciousness in his article in this volume. Munro argues that only an interdisciplinary approach to the problem of understanding consciousness can ever hope to be successful.

Leslie Rith-Najarian of Harvard University in Cambridge, Massachusetts, presents research assessing the ways in which performance success at a task affects the way individuals perceive the stress of the task post-performance, irrespective of how the stress of the task is appraised prior to performance.

Jessica Wise, along with her advisors Dr. Yuliya Yoncheva and Dr. Bruce D. McCandliss of Vanderbilt University in Nashville, Tennessee, investigated how individual differences in readers' preferences influence new learning. Their research shows that many readers have preferences for certain reading strategies, and differences in these preferences predict subsequent patterns of strengths and weaknesses as these readers attempt to learn to read a new writing system.

I trust you will enjoy the submissions to this volume of the journal as much as I have. Happy reading!

Ronak Shah
Executive Editor of the Indiana Undergraduate Journal of Cognitive Science
CRITIQUE OF MANDLER’S THEORY OF PERCEPTUAL ANALYSIS

Saba Chowdhry

Department of Cognitive Science
Department of Psychological Sciences
Case Western Reserve University

In recent years, cognitive development has become a topic of mass popularity within the field of academia. Among the various developmental benchmarks, one that has eluded many is concept formation. Possibly the oldest and most famous theory regarding concept formation originates from psychology – Piaget’s theory of sensorimotor development. Jean Mandler has proposed an alternative explanation to this phenomenon. Unlike Piaget, Mandler has clearly outlined the steps that transform perceptual information into concepts. After extensive reading, I was convinced that she postulated a more probable and convincing theory. After closer inspection, however, I have located a major shortcoming in Mandler’s explanation – her theory does not seem to account for blind infants (Keil, 2008; Zlatev, 2007). Due to the plethora of people worldwide who suffer from visual impairment, there must be an explanation for concept formation that includes this sample of individuals as well. Since Mandler’s theory does not, this limitation may discredit her perspective altogether. In this paper, I intend to critique Mandler’s theory of perceptual analysis by exploring its main tenet: the importance of visual perception for cognitive development (Mandler, 1992; Zlatev, 2007). By providing examples of other ways in which these two are intertwined, we can conclude that Mandler has the right idea. If vision truly affects cognition, however, does this mean that a lack of vision interrupts proper cognitive development? If so, how do blind individuals form concepts? In this paper, I plan to address these questions. Before I begin, it is imperative to first review the key components of Mandler’s theory of perceptual analysis.

In her various articles, Mandler has suggested that perceptual analysis is the mechanism through which concepts are first formed (Mandler, 1992; Evans, 2010). According to Mandler, infants attend closely to a perceptual array presented to them by their senses. In doing so, a new kind of information is abstracted. Now the once perceptual information has been recoded into a non-perceptual form that represents meaning. This conceptual primitive is called an image schema, in which “spatial structure is mapped into conceptual structure.” (Mandler, 1992, p. 591). These conceptual primitives later form the foundation of the human conceptual system. The basis of this entire process begins at the process of perceptual analysis. According to Mandler, infants are able to engage in perceptual analysis from the time of birth – thus, it is an innate ability. However, in order to carry out this process, the infant must receive spatial information from his senses. She argues that the spatial information most crucial to concept formation comes from the visual system (Zlatev, 2007). Mandler was certainly not the first to assume that cognitive development is dependent on visual input (Hupp, 2003). It seems interesting that her theory, along with many others, is based on this assumption. In order to consider Mandler’s theory credible, we must be able to show that the two are, in fact, intertwined.

Support for the idea that vision affects cognitive development comes from many sources. For instance, Sternberg argued that cognitive mechanisms are sight-dependent (Hupp, 2003). Going back to the time of Descartes, he believed that, “although vision is influenced by one’s cognitions, a coding of the physical properties of an image must mechanically move through the optic nerve and thusly represent a picture to the nervous system” (Hupp, 2003, p. 7). For example, thoughts may be able to influence the perception of an apple, but one must first see the apple for a mental picture to exist before any kind of cognitive work can further take place. The idea that vision precedes thought was further supported by Pylyshyn
in later years (Hupp, 2003). He reported that visual perception may lead to changes in the way in which we mentally represent the observed world.

There have also been evidentiary findings that demonstrate the interrelatedness of vision and cognition. For example, by modulating cortical cells located in the posterior parietal cortex, Pylyshyn was able to illustrate the function of an “extra-visual effect” (Hupp, 2003). Signals in both the visual and motor cortexes jointly activate these cortical cells. Activation in the motor cortex does not necessarily suggest movement; as in this case, simply thinking about a plan of action can also stimulate this area. Thus, the cortical cells studied were activated by both vision and thought – this study provides convincing evidence that the systems work together. Other researchers, namely Milner and Goodale, termed this phenomenon: “vision for action” (Hupp, 2003). This concept of “vision for action” was further illustrated by Kosslyn (Hupp, 2003). By using both positron emission tomography (PET) and functional magnetic resonance imaging (fMRI), he showed that cognitive activity was coupled with general activation in the visual system.

Even further evidence can be seen based on individuals who suffer from some degree of neural trauma, rendering them unable to perform normal cognitive functioning. For example, in the case of visual agnosia, the individual is able to perceive an object (as there is nothing wrong with his retinal cells), but cannot identify it (Hupp, 2003). Clearly, wiring has been severed between neural areas of perception and those of recognition.

This type of visual agnosia, anomia, is clearly demonstrable by PET, MRI, and neuropsychological testing that implicates a disconnection of sensory impulses and cognitive evaluations between Wernicke’s area in the temporal lobe and the visual cortex, located in the occipital lobe (Hupp, 2003, p. 8).

Given these findings, scholars of cognitive science have come to accept the relationship between vision and cognition (Hupp, 2003). Mandler was correct to believe that visual perception and cognitive development are linked. Considering the studies just explored, her theory of perceptual analysis – visual perception leads to conceptual primitives – seems plausible. However, we have yet to address the conundrum of concept formation for blind individuals, in the context of perceptual analysis. If visual input is necessary for conceptual output, then we should expect to find that individuals without vision would not be able to form complete concepts. If Mandler’s theory is accurate, the blind should display delayed cognitive development.

Cognitive theorists have proposed that blind individuals “may have developed different cognitive pathways to acquire, process, and accommodate sensory information” (Hupp, 2003, p. i). In other words, those who are blind may “think differently” in comparison to sighted individuals. According to Siegler’s rule-assessment approach to cognitive development, any kind of obstacle presented to the encoding of novel stimuli may hinder the developmental process (Hupp, 2003). Obviously the loss of vision can be included as an example of a sensory impairment that ultimately interferes with the encoding process. Thus, in line with this approach, those who are blind should have mental capabilities that are far different from those with normal vision. However, current studies regarding the mental capacities of the blind and sighted do not, in fact, support this conclusion (Hupp, 2003).

Before we explore the studies described below, it is important to first consider the problem with using a “blind-versus-sighted comparison” (Orlansky, 1988). According to Warren, we must not assume that any set of common measures applied to a group of blind individuals and a group of sighted individuals will result in truly equal measurements (Orlansky, 1988). Since there is no test that is completely equal for both groups, we can only consider the available data, keeping in mind that there may be a slight margin of error.

In 1968, Tillman and Bashaw conducted a study in which both blind and sighted children completed the Wechsler Intelligence Scale for Children (WISC), which generates an IQ score representative of the child’s general intellectual ability (Begum, 2003). Tillman and Bashaw were interested in the verbal IQ in regard to subtest scores. Their findings indicate equal mean verbal IQ, but different patterns of high and low scores on the subtests (Begum, 2003). Thus, intellectual ability between these two groups is somewhat comparable, with differences in specific areas of strength and weakness.

In 1989, Ittyerah and Samarapungavan compared the performance ability of three groups of children – (1) congenitally blind, (2) sighted chil-
dren who were blindfolded, and (3) sighted children with no blindfold (Begum, 2003). They all completed the same set of tasks that have been used repeatedly to indicate level of development. “Results indicated that cognitive development in the blind is not identical to that in sighted groups. Moreover, the differences in performance between groups are content or task-specific and do not take the form of a global deficit across all developmental tasks” (Begum, 2003, p. 60). In a way, these findings mirror those found in Tillman and Bashaw’s study. In the previous study, differences in overall IQ mean were negligible. In this study, Ittyerah and Samarapungavan found no overwhelming disparity in global intellectual ability. In both, however, there were variations in performance on particular subtests, and specific tasks. This can be explained by the fact that blind children and those with normal vision “think differently”; thus, certain areas will prove to be stronger, while others remain weaker.

Just four years earlier, in 1985, Singh conducted a study that found the same results as the previous two. Unlike the others, however, the participants were adults. They completed a revised version of the Wechsler Adult Intelligence Scale (WAIS), called the WAIS-R (Begum, 2003). Their overall scores were compared, in addition to their performance on specific verbal subtests. Results show that scores “did not differ significantly” between those who were visually impaired and those with normal vision (Begum, 2003).

Tobin and Gottesman considered the literature available on this subject (Begum, 2003). As indicated by the three studies discussed earlier, differences in cognitive functioning between blind individuals and sighted individuals are minimal and trivial. “There can be little doubt that developmentally, and in every other way, such [blind] children have more things in common with their sighted peers than things that separate them” (Begum, 2003, p. 56).

This conclusion poses a serious threat to the credibility of Mandler’s theory. Blind individuals are certainly able to form concepts, as suggested by their comparable levels of cognitive functioning; moreover, they are able to do so without visual perception. Thus, it appears that Mandler’s focus on visual perception, in the context of perceptual analysis, falls short. So how do blind individuals form concepts? Results from a number of studies suggest that other sensory systems may become highly sensitive for blind individuals. With additional information from the other senses, their bodies may somewhat counterbalance the lack of vision (Hupp, 2003; Orlansky, 1988).

The child’s remaining senses – primarily hearing and touch – may develop into useful avenues of sensory input but can never fully compensate for the loss of vision, nor can they usually provide information that is as exact, complete, spontaneous, and continuous as that normally gained by children who are constantly able to see their environment (Orlansky, 1988, p. 98).

According to Marzi, blind individuals often behave differently to sensory input than sighted individuals (Hupp, 2003). A beautiful example of this was illustrated by Morgan:

Morgan then described how a sample of blind individuals was able to form a three-dimensional cognitive map based on auditory information. These individuals used this cognitive map to assist them in moving about, or orienting, to the physical world. Morgan concluded that blind individuals would often compensate for their lack of vision with over-developed abilities in other sensory functions (Hupp, 2003, p. 9).

As this example shows, blind individuals were easily able to attain spatial information from auditory stimuli alone. This clearly goes against Mandler’s preference for visual perception as the preceding element in concept formation.

In addition to auditory information, blind individuals seem to also rely on tactile stimuli. In fact, many researchers have used haptics to measure intelligence in the blind (Hupp, 2003). Worochel conducted a study that attempted to assess the perception of tactile form in blind individuals (Begum, 2003). There were three measures: reproduction, verbal description, and recognition. The findings indicate that sighted individuals were better at reproduction and verbal report, but the blind do just as well in the recognition of tactile form (Begum, 2003). These conclusions mirror the findings discussed earlier. We found that blind individuals and sighted individuals tend to differ in performance on subtests; this, in turn, indicated that the blind have certain strengths and weaknesses. Perhaps these data apply as well – blind individuals perform better on tactile recognition, and worse on reproduction and verbal description. Regardless, the idea that
blind individuals are able to gain spatial knowledge through their other senses directly opposes Mandler’s theory.

Let us, for a minute, accept the idea that spatial knowledge can be acquired by the other senses. Using the premise of Mandler’s theory, this information must then be recoded into a non-perceptual form that represents meaning. If blind individuals are receiving spatial information from other sensory inputs and are able to form concepts, it must hold that their concepts are formed from image schemas based on non-visual perceptual information. This reasoning would only work given that we follow the process in Mandler’s explanation of concept formation. At this point, however, we have exposed a rather large shortcoming in her theory. Thus, it does not make sense to apply her notion of image schemas.

As I mentioned at the beginning of this paper, Mandler’s theory is highly appealing since it so clearly offers an explanation for the relationship between spatial information and conceptual formation. Since Mandler first proposed her theory of perceptual analysis, she has dramatically impacted the way in which other members in the field of cognitive science view infant cognition (Keil, 2008). I applaud Mandler’s efforts, but we cannot overlook the fact that her reasoning does not seem to account for blind individuals. A credible theory would include all kinds of people, especially a subpopulation that is constantly growing. Currently, there are over ten million people in the United States alone who suffer from “significant impairment of vision which cannot be further improved by corrective lenses” (Hupp, 2003, p. 1). If we deem Mandler’s theory accurate, how would we explain cognitive development (including concept formation) for these people?

I believe the information from this paper discredits Mandler’s current theory. By showing that cognitive development in blind individuals is comparable to that of sighted individuals, we can disregard the main tenet in Mandler’s theory of perceptual analysis: visual perception leads to concept formation. Without this basis, the entire theory crumbles.

REFERENCES


DEMOGRAPHICS, LEARNING AND IMITATION, AND BODY SCHEMA IN BODY INTEGRITY IDENTITY DISORDER

Alicia J. Johnson, Sook-Lei Liew, and Lisa Aziz-Zadeh

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Division of Occupational Science and Occupational Therapy
University of Southern California

ABSTRACT

Body Integrity Identity Disorder (BIID) is a condition in which people generally desire amputation of healthy limbs but can also desire paralysis, blindness, or other disabilities. The current study explored the demographics and experiences of individuals with this condition with specific attention to perceived physical differences of the affected limbs. Participants were recruited from three BIID-focused Internet forums to participate in two online surveys. There were 97 unique participants total, the largest sample size of individuals with BIID to date. It was found that individuals with BIID differ from the normal population in handedness and sexual orientation. Participants who reported differences in sensation in the affected limb(s) were also significantly more likely to report difficulty in learning/imitation, difference of feeling during use, and difference in performance of the affected limb(s). Furthermore it was found that individuals who achieved amputation almost always experienced phantom limbs and that many participants choose to use prosthetics post-amputation. These results shed light on the many facets of BIID and the perception of self and body schema. Future studies using neuroimaging may be able to better understand the neural bases of BIID.

KEYWORDS
Body Integrity Identity Disorder, superior parietal lobule, forward model, inverse model, apotemnophilia

INTRODUCTION

People with Body Integrity Identity Disorder (BIID) are characterized by a powerful desire to remove one or more healthy limbs. While they do not have co-morbid mental illnesses that may alter their perceptions and they understand that the limb(s) in question are healthy and function normally, they feel that the limbs are superfluous and unnecessary (First, 2005). Many fantasize about having the limbs removed, often going to great lengths to induce permanent damage to the limbs to necessitate amputations by medical professionals (Bayne & Levy, 2005; First, 2005). They believe that the amputations will give them a sense of being “whole,” restoring their “true identity” (First, 2005).

Many studies in the past have focused on the psychology of the disorder, often grouping together individuals with BIID and those with apotemnophilia, or “amputee love,” in which people are sexually attracted to amputees or to the idea of being an amputee (Money, Jobaris, & Furth, 1977). While there often is a sexual aspect to the desire for amputations, the primary reason people with BIID report wanting amputations is to feel complete (First, 2005).

Recent studies have shown that there are biological differences between people with BIID and people who do not desire amputations. For instance, individuals with BIID have very specific, virtually unchanging lines where they would like the limb to be removed. One study has shown that above and below this line, there is a difference in skin conductance response (SCR), with the areas above the line of desired amputation having a significantly higher SCR than areas above the line or on the limbs that do not feel superfluous (Ramachandran & McGeoch, 2007). This means there is increased autonomic arousal in the affect-
ed limbs, indicating that there are unperceived physical differences between the affected and unaffected limbs. In one magnetoencephalography (MEG) study, there was an absence of activity in the right superior parietal lobule (SPL) when the affected limb was touched (McGeoch et al., 2009). Thus, one hypothesis behind BIID is that there is a mismatch between the genetically determined body map and the physical body, and this discrepancy is evident when examining SPL activation (Ramachandran & McGeoch, 2007).

The right SPL is active in proprioception as well as in tasks that require imitation or observation with the intent to perform an action (Buccino et al., 2004). Another study has shown that when a subject with congenital aplasia who has phantom sensations is asked to rotate the non-existent limbs, there is activation in the superior parietal cortex as well as the intraparietal sulcus and inferior parietal lobule (Brugger et al., 2000). People with congenital phantom limbs syndrome, to some degree, have the opposite issue as those with BIID – they have sensations from limbs that have never been part of their physical body while people with BIID, though they have the physical experience of having the present, functional limbs, do not feel that the limbs belong to the body. Thus, the SPL may be a key affected area common to both disorders, and it is possible that individuals with BIID have difficulty with learning and imitating movements with their affected limbs. Previous studies have not examined BIID’s effect on learning and imitation, leading us to formulate our questions to learn more about these particular aspects.

As there are a limited number of studies regarding this population, the current study aimed to learn more about the demographics and experiences of individuals with BIID as well as perceived physical differences in imitation, execution, and sensation of the affected body parts.

**METHODS**

**Participants**

Ninety-seven participants completed online surveys that were posted on 3 BIID-focused Internet forums. Forty individuals responded to both of two surveys, while 25 responded only to the first (for a total of 65 responses to Survey 1), and 32 responded solely to the second (for a total of 72 responses to Survey 2). Written informed consent was obtained from all participants before inclusion in the study, and if consent was not given, the participants were asked to exit the survey. This study was approved by the University of Southern California Institutional Review Board and was performed in accordance with the 1964 Declaration of Helsinki.

**Surveys**

**Survey 1.** The first survey was launched in November 2009 and closed in January 2010. Its first section inquired about the beginning of the desire (see Appendix 1 for a complete list of survey questions). The next section asked about the intensity of the desire and its fluctuation. Participants were then asked about sensation and use of the undesired limb(s). The final section asked about whether or not the participants had received treatment for BIID and if it had been successful, as well as about treatment of other psychological, neurological, or physical disorders or diseases. Subjects were also asked to submit any final comments as well as provide their email address if they were interested in being recruited for further studies. Out of 118 survey responses, 22 were unfinished, 6 were duplicates from participants who took the survey twice, and 25 were from one individual answering differently each time as determined by IP address tracking in the survey program. Removing those responses, we were left with 65 valid survey responses to analyze.

**Survey 2.** After reviewing the initial survey responses as well as the feedback from participants and forum posts, a second survey was created to follow-up with questions generated from responses to the first survey. The survey link was once again posted on the BIID-focused forums. The link was also sent to those participants who provided their email addresses in the first survey. The first section focused on demographics, including a question differentiating between BIID focused on amputation, paralysis, or the desire for other disorders. The following section inquired about whether or not individuals who desired amputations had obtained the amputations and their experiences thereafter. The next section asked the same of individuals who desired something other than amputation. An additional question asked whether or not there was a sexual
component to the participant’s BIID experience. The responses to the second survey were then matched with the responses to the first survey. The second survey had 88 total responses, 11 of which were unfinished, two were from one individual with completely different answers, and three were duplicate responses, resulting in 72 valid responses. As mentioned previously, forty participants from the first survey also responded to the second, and their responses to questions asked on both surveys remained the same.

RESULTS

Demographics and BIID characteristics

The demographic questions were part of the second survey, thus for these questions, there were 72 respondents. The average age was 46 years (SD = ±16.11 years). Thirteen were under 30 years old, twenty-nine were between 30 and 50, and thirty were 50 years of age or older. Ninety percent (n = 65) of participants were Caucasian only, with 4 additional participants who identified themselves as Caucasian and another ethnicity (2 Native American, 1 Pacific Islander, and 1 Hispanic). There was also one Hispanic, one Native American, and one participant chose not to state ethnicity. Eighty-four percent (n = 61) of respondents were male, 11% (n = 8) were female, and 4% (n = 3) listed themselves as other – intersex, transgendered (male to female), and “neutrois,” which the participant defined as “neither male nor female, as opposed to a mix of both.” Sixty percent (n = 43) of participants were heterosexual, 25% homosexual (n = 18), and 8% bisexual (n = 6). Six percent (n = 4) of participants listed themselves as “other” – two participants identified themselves “asexual,” one “autosexual,” and one participant responded that he was “too much into BIID etc.” One participant preferred not to state sexual orientation (see Table 1). Twenty-seven percent (n = 19) of respondents were single, 28% (n = 20) were in a long-term relationship, 32% (n = 23) were married, 10% (n = 7) were divorced, one was widowed, one was in the process of getting a divorce, and one was in a civil partnership.

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>#</th>
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<tbody>
<tr>
<td>Caucasian</td>
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<td>90%</td>
</tr>
<tr>
<td>Caucasian and Native American</td>
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<td>3%</td>
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<tr>
<td>Caucasian and Pacific Islander</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Caucasian and Hispanic</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>1</td>
<td>1%</td>
</tr>
<tr>
<td>Native American</td>
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<td>1%</td>
</tr>
<tr>
<td>Chose not to state</td>
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<td>1%</td>
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<table>
<thead>
<tr>
<th>Gender</th>
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<tr>
<td>Male</td>
<td>61</td>
<td>84%</td>
</tr>
<tr>
<td>Female</td>
<td>8</td>
<td>11%</td>
</tr>
<tr>
<td>Other</td>
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<td>4%</td>
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<table>
<thead>
<tr>
<th>Sexuality</th>
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</thead>
<tbody>
<tr>
<td>Heterosexual</td>
<td>43</td>
<td>60%</td>
</tr>
<tr>
<td>Homosexual</td>
<td>18</td>
<td>25%</td>
</tr>
<tr>
<td>Bisexual</td>
<td>6</td>
<td>8%</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>6%</td>
</tr>
</tbody>
</table>

Both surveys asked about handedness, resulting in 97 responses (40 respondents who answered both surveys, 25 who responded solely to Survey 1, and 32 who responded solely to Survey 2). Results were consistent between both surveys. Seventy-eight percent (n = 76) were right-handed, 13% (n = 13) were left-handed, and 8% (n = 8) reported themselves as ambidextrous.

Both surveys asked about BIID characteristics, so all 97 participants responded, and results were again consistent across both surveys. Eighty-six percent (n = 83) of the respondents desired amputation, 10% (n = 10) desired paralysis, 2 individuals desired blindness, one person wanted a broken leg with a full leg cast, and another person wanted to be disabled, needing to wear a left brace. Of all participants who desired amputation, 42% (n = 35) want left-sided amputations, 30% (n = 25) want bilateral amputations, and 28% (n = 23) want right-sided amputations. Eighty-one percent (n = 67) desired the amputation of one or both legs, 10% (n = 8) desired arm amputation, and 10% (n = 8) wanted a combination of leg and arm amputations (see Table 2).

<table>
<thead>
<tr>
<th>Desired Sites of Amputation</th>
<th>#</th>
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<tbody>
<tr>
<td>Left-sided</td>
<td>35</td>
<td>42%</td>
</tr>
<tr>
<td>Right-sided</td>
<td>23</td>
<td>28%</td>
</tr>
<tr>
<td>Bilateral</td>
<td>25</td>
<td>30%</td>
</tr>
<tr>
<td>Leg(s)</td>
<td>67</td>
<td>81%</td>
</tr>
<tr>
<td>Arm(s)</td>
<td>8</td>
<td>10%</td>
</tr>
<tr>
<td>Leg(s) and Arm(s)</td>
<td>8</td>
<td>10%</td>
</tr>
</tbody>
</table>
Learning and Imitation

The questions regarding learning and imitation were on the first survey, which had 65 participants. Participants were asked if there is a difference in sensation between the undesired limb(s) and the unaffected limbs. Of the 65 individuals who responded to the first survey, 11% (n = 7) reported more sensitivity to pain on the undesired limb(s), 15% (n = 10) reported more sensitivity to touch, 14% (n = 9) reported less sensitivity to touch, and 9% (n = 6) reported more sensitivity to temperature. Eight subjects reported multiple differences in sensation. In total, 38% of the participants (n = 25) reported some difference in sensation (see Table 3).

<table>
<thead>
<tr>
<th></th>
<th>#</th>
<th>%</th>
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<td>More pain</td>
<td>7</td>
<td>11%</td>
</tr>
<tr>
<td>Less pain</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>More sensitivity to touch</td>
<td>10</td>
<td>15%</td>
</tr>
<tr>
<td>Less sensitivity to touch</td>
<td>9</td>
<td>14%</td>
</tr>
<tr>
<td>More sensitivity to temperature</td>
<td>6</td>
<td>9%</td>
</tr>
<tr>
<td>Less sensitivity to temperature</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td><strong>Total participants reporting a difference in sensation</strong></td>
<td><strong>25</strong></td>
<td><strong>38%</strong></td>
</tr>
</tbody>
</table>

Fifteen percent (n = 10) of respondents said that it is more difficult to learn new actions or imitate unfamiliar movements using the undesired limbs. Seventy-nine percent (n = 51) of the participants said it was not more difficult, and 6% (n = 4) chose not to respond to this question. While three respondents said that the limb was more awkward or clumsy, four individuals stated that it is not a physical difficulty but that they simply are not interested in using the limbs.

When asked if it felt different to use the undesired body part(s), 42% (n = 27) of the 65 subjects reported that it does while 55% (n = 36) said that it does not and 3% (n = 2) chose not to respond to this question. In describing how it feels different, the answers generally referred to non-physical feelings – feelings of awkwardness, wrongness, distance, or unease. Two individuals mentioned that they could sense a stump when using or touching the limb. In general, the difference is in the feeling that the limb simply does not belong.

When asked if there is a difference in performance of the limbs, 19% of respondents (n = 12) said yes, 72% (n = 47) said no, and 9% (n = 6) preferred not to answer. Participants who said yes said they were clumsier, had less control, or were not coordinated. One individual said that he did not want to use it properly.

Participants who reported a difference in sensation were significantly more likely to report difficulty in learning/imitation ($\chi^2 = 14.06; df = 2; p < .001$), a difference in performance of the affected limb(s) ($\chi^2 = 9.42; df = 2; p < .01$), and that it feels different to use the affected limb(s) ($\chi^2 = 9.40; df = 2; p < .01$).

BIID Post-Amputation

The second survey contained questions regarding phantom limb experiences and prosthetic use, and there were 72 respondents for these questions. Eleven of the 72 respondents have had amputations, obtaining them through self-amputation, by going to a foreign country, or by injuring the limb and necessitating amputation. Of these, 10 have experienced phantom limb sensations, including the 5 participants who have completely achieved their desired state. This is consistent with previous findings that 90-98% of people experience phantom sensations after the loss of a limb (Ramachandran & Hirstein, 1998). The one who has not experienced any at all had amputated three toes, not a limb.

When asked what devices they use post-amputation, 4 of the 11 said that they do not use anything. Notably, all four of these individuals amputated fingers or toes only (two of those participants amputated fingers, and two amputated toes). All of the participants who had limb amputations use various devices. When asked to list what they use, all 7 listed prosthetics. In addition, four of them listed some form of crutches, and two of them use a wheelchair. When the participants who have not had their desired amputations were asked what devices they would use, prosthetics were listed 31 times, crutches 24 times, wheelchairs 18 times, canes 2 times, and a skateboard once (see Table 4).
Table 4: Devices Respondents Currently Use or Would Use Post-Amputation

<table>
<thead>
<tr>
<th>Devices participants use/would use</th>
<th># of people</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosthetics</td>
<td>38</td>
<td>66%</td>
</tr>
<tr>
<td>Crutches</td>
<td>28</td>
<td>48%</td>
</tr>
<tr>
<td>Wheelchair</td>
<td>20</td>
<td>34%</td>
</tr>
<tr>
<td>Cane</td>
<td>2</td>
<td>3%</td>
</tr>
<tr>
<td>Skateboard</td>
<td>1</td>
<td>2%</td>
</tr>
<tr>
<td><strong>Total participants that use or would use a device</strong></td>
<td><strong>51</strong></td>
<td><strong>88%</strong></td>
</tr>
</tbody>
</table>

The age of the participants was also similar – 46 years in our study, and 48.6 years in the earlier study (First, 2005). This is particularly interesting considering the desire generally starts during childhood. One might expect young people to be more proficient with technology and thus more likely to seek out or create forums like these and consequently be part of our subject pool. It is unclear whether these demographics, with a high percentage of males and homosexual participants with an average age in their 40s, reflect the characteristics of individuals with BIID or if it is simply a reflection of the people who use these online forums. Further research should be done to determine the reasons for these differences.

Eighty-one percent of participants wanted only leg amputations, 10% wanted only arm amputations, and 10% wanted a combination of arm and leg amputations, results once again comparable to those of First’s study (2005). We also found similar results regarding laterality, with 42% of our participants desiring a left side amputation, 28% a right side amputation, and 30% bilateral amputations. The current study also found that 22% of our participants were left-handed, which is more than double the average observed in the general population (10%; McManus, 2009). Previous work suggests there are differences in the right side of the brain among people with BIID, and these results add to that conclusion (McGeoch, 2009).

DISCUSSION

Demographics and BIID characteristics

A prior interview study with a smaller sample size (N = 52; First, 2005) found a high proportion of males and homosexuals in their BIID group, leading us to ask the same questions to see if we obtained similar results. Ninety percent of our participants were Caucasian, with 96% being fully or partially Caucasian, similar to First’s study in which all but two participants (96%) were Caucasian. Eighty-five percent of our participants were male, again comparable to the First study (2005). Out of our participants, 25% were homosexual (28% of males and 13% of females) and 8% bisexual (7% of males and 67% of people who reported “other” as their gender). The latter percentages are in contrast to the general population, where it is estimated that 2.8% of males and 1.4% of females identify themselves as homosexual or bisexual (Laumann, Gagnon, Michael, & Michaels, 1994). They are, however, similar to the results of First’s study (2005).
Physical Learning and Imitation

Only 15% of individuals noted a difference in learning or imitation using the affected limbs. This could be due in part to the nature of the question itself, “Is it more difficult to learn new actions or imitate new movements using your undesired limb(s) than your unaffected limbs? (For instance, would it be harder to learn to play guitar using an undesired hand?)” Since most respondents were right-handed (including all of the participants who affirmed a difference in learning or imitation) and many wanted a left limb removed, difficulty in learning could be attributed to the fact that it is difficult to learn to do tasks with the non-dominant limb in general (for example, left-handed people would likely use a left-handed guitar). Participants also said that they avoid using the affected limbs, so it could be that by not using them, they are less aware of issues with learning or performance.

As discussed previously, one study has shown that when unaffected limbs or the limbs of people without BIID were touched, there was activation in the right SPL, but this activation was not seen when the affected limbs of individuals with BIID were touched (McGeoch et al., 2009). Further research might test how SPL activation is modulated during learning or imitation with the affected limbs, especially as the SPL is known to be involved in action observation and imitation (Buccino et al., 2004). Comparing SPL activation between BIID participants and controls during a learning and imitation task could help define the SPL’s role in those processes.

We found that respondents who reported one difference with the limb (sensation, difficulty with learning/imitation, etc.) were likely to report multiple differences. This suggests that some individuals with BIID tend to perceive their limb as physically different from their other limbs as well as psychologically frustrating or distracting, while others note that they simply do not want the limb(s) to be there.

BIID Post-Amputation

There was an overwhelming presence of phantom limbs post-amputation, with ten of the eleven participants who have obtained amputations reporting phantom limb sensations. This result is consistent with the findings that 90-98% of individuals in the general population have phantom limb sensations post-amputation; Ramachandran & Hirstein, 1998) and the large percentage of participants who would use prosthetics after an amputation raise interesting questions about an individual with BIID’s body schema. A current hypothesis proposes that a mismatch between the genetically-determined body map and the physical body leads to BIID, and that this discrepancy is evident by the lack of activation in the right SPL when the affected limbs are touched (Ramachandran & McGeoch, 2007). The right parietal lobe is also thought to play a role in phantom limbs as well as with body schema overall. We would expect, then, that if individuals with BIID do not incorporate the affected limbs into their body schema, that, once the limb was removed, there would be no phantom sensation or desire to replace the limb with a realistic prosthetic device. However, the current study found that people with BIID do have phantom limbs and use realistic prosthetic devices despite the fact that there are other ways they could remain mobile (e.g., using a wheelchair or crutches).

An alternative hypothesis is that individuals with BIID may have a discrepancy between the commands from the motor cortex to the parietal lobe and from the sensory feedback to the same regions in the parietal lobe. A copy of the motor command from motor regions (often called “the forward model” or “corollary discharge”) is sent to parietal regions. Similarly, sensory feedback on the executed motor plan is also sent to the parietal regions (the “inverse model”) (Miall & Wolpert, 1996; Wolpert, Goodbody, & Husain, 1998; Wolpert & Ghahramani, 2000). Evidence suggests that the integration of these models occurs in the superior parietal lobe and is responsible for creating an estimate of the body’s current state which may be important for error monitoring of motor action, the feeling of self, and agency (Wolpert et al., 1998). Furthermore, it has been suggested that many motor control and awareness disorders such as optic ataxia, anarchic hand sign, delusions of control in schizophrenia, and phantom limbs, can be explained as a consequence of abnormalities in the forward and inverse models (Blakemore, Wolpert, & Frith, 2002). Since the SPL is less active in individuals with BIID, it is possible that the feeling that their limbs should not be there stems from a mismatch between forward and inverse models, crucial in producing a bodily sense of self.
CONCLUSION

This study examined several facets of Body Integrity Identity Disorder with the largest sample size of BIID participants to date. While a minority reported differences in learning and imitation, we found that those who did tended to report other physical differences as well. We also found that individuals with BIID generally have phantom limbs post-operation and use prosthetics, and we suggest that this is due to a discrepancy between the forward and inverse models. Our study is consistent with a previous study on BIID, but, in addition to using a larger sample group, also focused more on perceived physical differences than the previous study.

These results reveal areas that should be studied further. Future studies should focus on determining whether there is a difference between participants with BIID and a control group when it comes to learning and imitating new movements, both in terms of performance and of neural activity. Since some participants reported multiple physical differences while others tended not to, future studies could examine differences between these groups. Work should also be done to explore the phantom experiences and neural activity of individuals with BIID post-amputation. Neuroimaging studies could be used to see if there is a difference between people with BIID who desire amputation versus paralysis or some other physical difference. More in-depth interviews would result in qualitative data about experiences with BIID and phantom limbs, allowing researchers to better understand the disorder and develop new studies. By looking deeper into Body Integrity Identity Disorder, we will be able to better understand the psychological and neural processes associated with the self, body representations, and agency, as well as develop a greater understanding of individuals who suffer from the depression, frustration, and “constant consuming agony” described by individuals with BIID.

ACKNOWLEDGEMENTS

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REFERENCES


APPENDIX

Survey 1

What limb(s) do you want removed and where? (Check all that apply.)

- Left arm above elbow, Left arm below elbow, Left leg above knee, Left leg below knee, Right arm above elbow, Right arm below elbow, Right leg above knee, Right leg below knee [Note: an “Other” category was added to the second survey to clarify responses.]

At what age did you start feeling this desire?

What memories/associations do you have involving the beginning of this desire?

Has the line where you desire an amputation changed over time?

- Yes, No, I prefer not to answer

If the line has changed, how often has it changed, and when was the last time it changed? Also, where did it shift and under what context(s)?

On average, how much does your desire for amputation interfere with your daily life (1 = does not interfere at all, 10 = interferes to the point that I cannot focus on anything else)?

Does the intensity fluctuate?

- Yes, No, I prefer not to answer

If so, when (while working, early in the morning, while using the limb, etc.), how much, and what situations make it fluctuate the most?

Is there a difference in sensation between the undesirable limb(s) and others? (Check all that apply.)

- More pain, Less pain, More sensitivity to touch, Less sensitivity to touch, More sensitivity to temperature, Less sensitivity to temperature, Other

Does it feel different to use the undesirable body part(s) (less comfortable, more awkward, heavier, etc.)?

- Yes, No, I prefer not to answer

If so, please describe the difference.

Which is your dominant hand?

- Right, Left, Ambidextrous

Is it more difficult to learn new actions or imitate new movements using your undesired limb(s) than your unaffected limbs? (For instance, would it be harder to learn to play guitar using an undesired hand?)

- Yes, No, I prefer not to answer

If so, please explain.

Is there a difference in performance of the limb(s) you want removed (more/less success when using it, for example)?

- Yes, No, I prefer not to answer

If so, please explain.

Can you describe (in as much detail as possible) a situation in your daily life in which the undesired body part is especially intrusive?

Have you been treated for BIID before?

- Yes, No, I prefer not to answer

If you have been treated for BIID, what did the treatment consist of (how long did it last, what did it involve, are you currently receiving treatment)?

If you have been treated for BIID, did you have any success in lessening the desire for amputation?

- Yes, No, I have not been treated for BIID, I prefer not to answer

If you have been treated for BIID, did you have any success in managing the intrusiveness of this desire on everyday life?

- Yes, No, I have not been treated for BIID, I prefer not to answer

Do you have any of the following? (Check all that apply.)

- Anorexia, Bulimia, Gender Identity Disorder, Phantom body parts (feeling like you have a body part that is not actually there), Desire to be deaf, Desire to be blind, Desire to be paralyzed, Other
Have you been treated for any of those conditions?
   Yes, No, I prefer not to answer
If so, which, and what did the treatment consist of (how long did it last, what did it involve, are you currently receiving treatment)?
Have you been treated for any other psychological or neurological disorders?
   Yes, No, I prefer not to answer
If so, please list them.
Have you been treated for any other physical problems to the limb (arthritis, chronic pain, numbness, etc.)?
   Yes, No, I prefer not to answer
If so, what problems? Does it affect only the unaffected limb or other limbs as well?
Would you be willing to be contacted for further research? If so, please provide your email address.
   Your email address will be kept strictly confidential and be used solely in relation to this study.
   Yes, No
Where do you live (city, state)?
Would you be willing to travel to Los Angeles to participate in a study?
   Yes, No
What would you like to see researched in regards to BIID?
Do you have any comments or feedback you’d like to add?

Survey 2
How old are you?
What is your ethnicity? Please check all that apply.
   Options: Caucasian, Hispanic, Black, Asian, Native American, Pacific Islander, Other, Prefer not to answer
What is your gender?
   Options: Male, Female, Other, Prefer not to answer
What is your sexual orientation?
   Options: Heterosexual, Homosexual, Bisexual, Other, Prefer not to answer
What is your relationship status?
   Single, In a long-term relationship, Divorced, Widowed, Other, Prefer not to answer
Which is your dominant hand?
   Right, Left, Ambidextrous
What type of BIID do you have?
   Desire for amputation, Desire for paralysis, Other
If you desire amputation, what limb(s) do you want removed and where? (Check all that apply.)
   Left arm above elbow, Left arm below elbow, Left leg above knee, Left leg below knee, Right arm above elbow, Right arm below elbow, Right leg above knee, Right leg below knee, Not applicable, Other
If you desire amputation, has the line(s) where you want amputation(s) changed with age?
   Yes, No, Other, Not Applicable
If so, how (became clearer, shifted up/down or left/right, etc.) and at what age?
If you desire amputation, have you successfully obtained an amputation?
   Yes – I have obtained amputation of the limb(s) I did not want, Yes – but I still desire one or more amputations, No, Other, I do not desire amputation
If you have successfully obtained an amputation, what were the circumstances under which you obtained it (self-amputation, in a hospital, in a foreign country, etc.)?
If you have successfully obtained an amputation, has the desire gone away?
   Note: If you have always desired an amputation at multiple locations, but have not received amputations at all of those locations, please choose “Yes” if you are satisfied with the results of the ampu-
If you have successfully obtained an amputation, has it changed your perception of yourself? If so, how? For example, how did you see yourself beforehand, and how do you see yourself now? Do you feel more positively about yourself?

Please also indicate whether you use a prosthetic limb now.

If you have successfully obtained an amputation, have you experienced any phantom limb sensations (feeling like your limb is still there)?

Yes, No, Other, Not applicable

If you have not obtained an amputation, have you experienced any phantom body part sensations? If so, where?

Yes, No, Other, Not applicable

If you have successfully obtained an amputation, what devices, if any, do you use (wheelchair, crutches, prosthesis, etc.)?

If you have not successfully obtained an amputation, what devices, if any would you want to use post-amputation (wheelchair, crutches, prosthesis, etc.)?

If you desire something other than amputation, have you successfully achieved your desired state?

Yes – completely, Yes – partially, No, Other, I do not desire something other than amputation

If you have successfully achieved your desired state (non-amputation), what were the circumstances under which you obtained it (self-inflicted, in a hospital, in a foreign country, etc.)?

If you have successfully achieved your desired state (non-amputation), has the desire gone away?

Yes, No, Other, I do not desire something other than amputation

If so, please describe the change.

Is there a sexual component to your BIID?

Yes, No, Other, Prefer not to answer

If so, please explain.

Would you be willing to be contacted for further research? If so, please provide your email address.

Your email address will be kept strictly confidential and be used solely in relation to this study.

Yes, No

Do you have any other questions/comments?
CONSCIOUSNESS?
PHILOSOPHICAL AND NEUROSCIENTIFIC EXPLORATIONS

Scott Munro
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ABSTRACT
Can potential philosophical errors elucidate errant theories of consciousness in neuroscience? We briefly evaluate some philosophical issues on the basis of their conclusions and their apparent application to empirical research. One, Dennett’s concept of the Cartesian Theatre, is shown to represent inaccurate thinking. Moving forward on the premise that Cartesian Theatre type theories are theoretically flawed, three current theories of consciousness are evaluated based on their perceived equivalence to the Cartesian Theatre metaphor. Of the three Victor Lamme’s theory of recurrent processing and Giulio Tononi’s information integration theory are shown to not rely on the Cartesian Theatre metaphor. While Bernard Baars’ Global Workspace theory is established as clearly identifying with the metaphor. We propose that theories which are theoretically based on concepts demonstrated to be incorrect in other disciplines should themselves be suspect of also being flawed.

INTRODUCTION
"A rare experience of a moment at daybreak, when something in nature seems to reveal all consciousness, cannot be explained at noon. Yet it is part of the day's unity."
~Charles Ives

What is consciousness? It is one of those questions whose answer is like a Necker cube; we switch from confidently knowing an answer to complete confusion. Nothing is more open to us yet at the same time so closed off. People from different background give wildly different answers. Ask a philosopher and expect lengthy explanations of Qualia and inverted spectrums. Ask a psychologist and expect terms like attention and perception. Ask a neuroscientist and, well you get the picture. After all this asking we are no closer to (and sometimes further from) an answer. None of this does anything to change the situation, more understanding is needed. If not for the mystery alone, than for the immense impact it would have on the scientific community. I hold that the answer will emerge from across many disciplines, not just one or two. We will briefly outline some modern theories of consciousness, from two different disciplines and see what clarity can be attained towards this age old question. What is consciousness?

The Road Map
How are we going to tackle this question? You will have to agree that it is best to start at the beginning. Philosophy? Exactly. We will discuss some of the issues which philosophers have been addressing for decades. Anything salient, conclusive, or helpful will then be used as a metric for theories from neuroscience. We will establish that most of what philosophers talk about cannot be easily applied to neuroscience and will be left behind save for one concept, the Cartesian Theatre (CT). CT will be shown to apply to both disciplines. We will focus on three theories of consciousness, the Global Workspace Theory (GWT) (Baars, 2007), the Information Integration Theory (IIT) (Tononi, 2004), and Victor Lamme’s theory of Recurrent Processing (RP) (Lamme, 2010). This will show that where consciousness is concerned interdisciplinary, study is beneficial.

THE PHILOSOPHY OF CONSCIOUSNESS
"When I study philosophical works I feel I am swallowing something which I don't have in my mouth".
~Albert Einstein

We claim that whatever consciousness is eventually found to be it will at minimum be a physical process of some kind in the central nervous sys-
tem. A different and somewhat opposite view is
dualism. Dualism comes in a few flavors, only a
couple of which apply to this area, property and
substance dualism. Substance dualists like Descartes,
hold that the mind and consciousness are
not part of the physical body but reside in another
substance that is different and separate (Descartes, 1984).
Property dualists like Chalmers
are of the belief that there is only one substance, a
physical one, with different categories of properties, physical and mental (Chalmers, 1996).

The first Philosophical issues discussed will
concern the above-mentioned distinctions. We
will then move on to consider different kinds of
consciousness, access consciousness and phenomen-al consciousness. We will finish the philos-
ophical discussion with the concept of the CT, which
will be deemed applicable to neuroscience.

The Explanatory Gap

Is something left out if one were to explain
some aspect of consciousness in fully physical
terms? There are many philosophers who would
say the answer to this question is yes.

For no matter how deeply we probe into the
physical structure of neurons and the chemical
transactions which occur when they fire, no
matter how much objective information we
come to acquire, we still seem to be left with
something that we cannot explain, namely,
why and how such-and-such objective, physi-
cal changes, whatever they might be, generate
so-and-so subjective feeling, or any subjective
feeling at all. (Levine, 1983)

This problem has also been called ‘The Hard Prob-
lem’ of consciousness most notably by Chalmers.

Often, such work addresses what might be
called the “easy” problems of consciousness:
How does the brain process environment
stimulation? How does it integrate informa-
tion? How do we produce reports on in-
ternal states? These are important questions,
but to answer them is not to solve the hard
problem: Why is all this processing accompa-
nied by an experience of inner life? (Chalmers,
1996)

The claim here is even if we were able to explain
fully the processes in the brain that underlie con-
scious states we would still not be explaining the
subjective experience that accompanies those
states so there must be more than just the physical
substrate at work where consciousness is con-
cerned. This lack of explanation is referred to as
‘the explanatory gap’.

It is important to note both the above quotes
are demanding answers to “how” and “why” ques-
tions in order to concede explanation. These are
different and separate lines of questioning. The
“how” questions can be seen as strictly causal and
are common in all of the hard sciences: How does
DNA form RNA? How do green plants generate
oxygen? “Why” questions in some aspects can
also be dealt with as causal questions in the same
way: Why do objects fall towards the Earth?
Why does a beach ball float and a marble sink?
The “how” parts of this above-mentioned line of
questioning, I agree are valid and important. How
the brain manages to pull off what seems like a
miracle is exactly what scientists should be asking
about consciousness. The problem is with the
“why” questioning, namely why this processing is
accompanied by subjective experience. Would we
even have something called the explanatory gap if
what these philosophers had in mind was a “why”
such as: Why do Zebras have stripes? No. If this
were the case, there would be just as many ex-
planatory gaps as there were metaphysical “why”
questions. Science would be stuck in the explana-
tyory gap for Zebras because the answer to this
type of “why” question regarding a Zebra’s stripes
does not appear to be contained in the genetic
code that expresses them, the answer is in the
evolutionary history of the Zebra.

In the case of Zebras and many other “why”
questions an answer like this is acceptable; why
not for consciousness? It appears the “why” as-
pect of the explanatory gap which is of interest to
philosophers in these cases is more likened to:
Why is there something instead of nothing? And
why does gravity exist? The appeal of questions
like this is undeniable; however the physical theo-
ries of the universe are not rejected because ques-
tions like these still exist. This is what proponents
of the Explanatory Gap argument would have you
do. Throw out physicalist explanations due to
their inability to answer “why”. Whether a physi-
cal explanation does or does not explain why is
secondary, at least in this case, to the “how” ques-
tion. Seeing as the “how” questions have yet to be
answered this is a debate left for philosophers.
Access and Phenomenal Consciousness

According to some philosophers conscious states come in two different kinds, access and phenomenal. Access (A) consciousness is defined by Block as follows, “A perceptual state is access-conscious roughly speaking if its content—what is represented by the perceptual state—is processed via that information processing function, that is, if its content gets to the Executive system, whereby it can be used to control reasoning and behavior” (Block, 1995). Phenomenal (P) consciousness is the 1st person subjective experience or ‘what it is like’ to be in a state. Block contrasts the two states:

The paradigm P-conscious states are sensation, whereas the paradigm A-conscious states are “propositional attitudes” states like thoughts, beliefs and desires, states with representational content expressed by “that” clauses (Block, 1995).

Some philosophers agree that this distinction exists and can be found in the brain (Block, 2005), while others disagree with the distinction completely (Dennett D. C., 1995).

To be applicable to empirical studies this distinction needs to be well defined and explicit, as we are about to show this is not the case. It would seem to be that if these two kinds of consciousness are indeed separate and different as claimed by Block it should be possible to find examples of A without P and P without A. It is not a problem to bring to mind examples of P without A (driving on autopilot, noticing the sound of a ticking clock); it is slightly more difficult to find the opposite. Block makes the following attempt at an example:

If there could be a full-fledged phenomenal zombie, say a robot computationally identical to a person, but whose silicon brain did not support P-consciousness, that would do the trick. I think such cases conceptually possible, but this is very controversial, and I am trying to avoid controversy. (Block, 1995)

Controversy aside, this example presupposes the distinction between A and P in that someone would have had to program for one and not the other. So even without controversial conceivability arguments, this example does not provide any evidence of A without P. It only provides evidence that it is conceivable someone who understood the distinction could make a robot that had A and not P. Block then puts forward a less controversial case.

But there is a less controversial kind of case, a very limited sort of partial zombie. Consider the blindsight patient who “guesses” that there is an ‘X’ rather than an ‘O’ in his blind field. Taking his word for it, I am assuming that he has no P-Consciousness of the ‘X’. (Block, 1995)

Having Block assume that there is no P, is not the same as there being no P. It might be the case that a patient has no recollection, or indeed no access to the sight, of what is in the blind field. However, it was seen enough to prime the subject to guess correctly. I hold that this seeing has some sort of experience. There are many different interpretations of what may actually be happening during blindsight, none of which are conclusive (Weiskrantz, 1986; Cowey & Stoerig, 1991). Therefore this example cannot show us definitively A without P. Block then goes on to explain what he calls “super blindsight”. An individual is super blind-sighted when she or he is able to constantly internalize these guesses about what is in her visual field so as to act like she has vision. Block claims that since there is nothing it is like to experience what is in the blind field and that this information can be accessed then this shows A without P. I still disagree, Block’s assumption of no P is based on reports by the subject only, and I (and as you will see Lamme) hold that not being reportable does not mean nonexistent. These last two cases could be explained just as well with the argument that there was no A-consciousness of the P-consciousness that did indeed exist.¹

The transitive content, the information they may contain, or what these states are about may

¹ The reference is lost now, however I encountered one study where subjects were put into a driving simulator and were allowed to repeat driving tasks until there were entering zone like states. No matter how zoned out the subjects were if they were interrupted they could report instantly the phenomenology of their last few minutes, however when asked at the end subjects on the same experiment reported gaps, just like people driving familiar routes. This would seem to indicate that P exists all along but the memory or the ability to access if does not remain.
indeed fall under a distinction that is similar to what Block calls A, but that seems secondary to there being an experience. The concept of A is confusing and sounds a lot like a theory of what the experiences are about and not of the experiences themselves. With the distinction between A and P not very clear nor agreed upon, it cannot act as a starting point for the evaluation of a Neuroscientific theory. Looking at the brain empirically for something that is undefined would be like looking for a possibly large, sometimes green, almost always sideways, and arguably smooth bike-like thing in a junk yard.

The Cartesian Theatre

Having eliminated some philosophical concepts concerning consciousness as not applicable (at least at this point) to the evaluation of neuroscientific theories of consciousness, what are we left with? In his 1991 book *Consciousness Explained* Dan Dennett claims that although for the most part Cartesian Dualism (substance dualism from above) is a thing of the past, there are vestigial thought processes that affect the current theories of today’s philosophers. He called this type of thinking Cartesian Materialism.

Cartesian materialism is the view that there is a crucial finish line or boundary somewhere in the brain, marking a place where the order of arrival equals the order of “presentation” in the experience because what happens there is what you are conscious of. Perhaps no one today explicitly endorses Cartesian materialism. Many theorists would insist that they have explicitly rejected such an obviously bad idea. But as we shall see, the persuasive imagery of the CT keeps coming back to haunt us – laypeople and scientists alike – even after its ghostly dualism has been denounced and exorcised. (Dennett D. C., 1991)

What does this mean, why is it wrong to think this way, and why is it important to our current line of questioning? We will arrive at an understanding of what exactly Dennett is talking about, then work out why Cartesian Materialism is flawed, and finally carry this problem over to the neuroscience of consciousness.

Why is this a Cartesian concept? In the *Meditations* Descartes claims that the pineal gland in the brain is the spot where our material body communicated with our immaterial soul (Descartes, 1984). It was the finish line or point where it all comes together according to Descartes. Dennett claims that even though the idea of the pineal gland being the seat of our soul has been discarded we still cling to the viewpoint of there being a point or finish line for data to collect at to become conscious. Dennett thus credits the thinking behind this concept to Cartesian origins².

Why does Dennett use the word theatre in naming this concept? If it were the case that there is a finish line or point where it all comes together, then this implies that there is some process watching for or sensing this point. The audience in a theatre is the finish line for the movie; the movie is not watched until it is displayed to the audience. This thinking assumes that something has not become an item of consciousness until it is displayed to consciousness. It also implies that the audience is there waiting for something to happen. The movie being watched has two elements, audience and the movie. Both are necessary and neither is sufficient. The metaphor implies the same thing about consciousness. Consciousness happens when two processes come together, on their own they do not produce consciousness.

Why is the Cartesian Theatre considered a fallacy? After all, this metaphor actually explains many peoples’ conceptions about what consciousness is and how it must work. Information is received via our senses, and travels along through the brain being processed until it reaches consciousness. To understand why this cannot be the way consciousness functions we need to consider a few examples.

First of all, if we assume that consciousness requires some sort of observer in the brain to be “watching” what is conscious, then what is watching the observer? This is sometimes referred to as assuming a homunculus in the brain. This logically leads us to an infinite regress due to there always being the question of what is doing the observing inside observer. This critique itself is enough for many philosophers to reject all CT thinking. We will, however, explore two more concrete empirical examples, seeing as we would

² It should be noted that having this being called a Cartesian concept does not imply it is a type of dualism, or that is theory of Descartes. Cartesian is there to indicate where the thinking came from. An English terrier not from England is still an English terrier.
be hard pressed to find a neuroscientist who thinks we have a little man actually sitting in our heads watching what is conscious.

Watching television is also proof that this way of thinking is not accurate. We all know from elementary school science that sound and light travel at much different rates. This implies that when we watch our favorite television programs the audio and visual information is reaching our respective sense organs at different time, with the light hitting our eyes long before the sound hits our ears. If CT thinking were the way consciousness worked television watching would never have synced audio and video, the picture would always be ahead of the audio. This would be due to the visual information hitting the eyes first for any given instant of the program. Even if one wanted to claim that visual information takes longer to process than auditory information this still only means that there would be one ideal distance that allows for auditory and visual data to be processed to completion simultaneously. This in practice does not seem to be the case, it matters not how far or how close (to a degree) you sit relative to your television set, audio and video are experienced in sync.

A more empirical example comes from the experiments about the phi phenomenon or apparent motion (Folk, Remington, & Wright, 1994) (Wertheimer, 1912). The phi phenomenon is what psychologists call the illusion of motion from stationary images. We all perceive motion when we see movies or television programs. Yet these things are made up of 24 or 30 still pictures per second. When we watch a light move around a billboard, it is not actually moving; it is just that the stationary lights being lit up at the correct timing to create this illusion. The experiments that demonstrate this are usually set up so that two individual light bulbs are stationed at a specific angular separation and flashed in succession. If the lights are the correct distance from each other and the delay timing is correct a human will actually perceive motion. The light is perceived to have moved from the first position to the second and to have been in every point in between. This is of course an illusion the light did not in fact move and are never at any locations other than the two they started in. This experiment is interesting as it is but not very problematic for the CT.

A more interesting and problematic experiment is the color phi experiments. These experiments are exactly the same as those described above, with one crucial difference. The two lights are now different colors. What is perceived this time is a light that again moves from the first position to the second but changes colors halfway, which means we perceive the second color before we see it. How is it possible to perceive a color before we see it? Original critiques of these findings claimed that it was a matter of conditioning. Once the subject had run through enough trials, he or she grew to expect the change and thus began perceiving it. This was found not to be the case, the experiments were run with random color changes and random light positions and the illusion happened from the very beginning. What might be happening here?

This can be explained one of two ways in a CT type of theory.

1. Information is spooled for a short time to be edited before it is presented to consciousness. This would be something like the delay that is used in live television broadcasts so censors can deal with profanity. This means the actual experience itself was of something that is not accurate (motion and color change), and we remember accurately the incorrect experience.

2. We do not experience motion, however once the second light is seen some sort of memory censorship is performed and all subsequent memories of the event are of a moving light that changes color. This means we have an accurate experience with inaccurate memory of it.

So the question for a CT theory becomes “in these cases is your memory playing tricks on you, or are just your eyes playing tricks on you?” (Dennett D. C., 1991) As shown in Figure 1 these two explanations are not instances of faulty memory or perception but a case of an arbitrary placement of a
finish line, both temporally and spatially, for becoming conscious. This finish line denotes a point at which all that happens before is unconscious and all after is unconscious. Choosing an arbitrary location for a finish line obviously does not explain what is going on in this situation.

When we consider the infinite regress of a homunculus, the in-sync audio of our television experiences, and the low or non-existent explanatory power of CT thinking it is clear that this type of thinking is flawed as a model for consciousness. It is unique relative to the other aspects examined, in that it can be clearly shown to be inaccurate and is easily identifiable. This allows it to be a great candidate for evaluating theories from other disciplines; if they clearly show signs of being CT-type theories then maybe they need to be reconsidered as a valid theory.

**THE NEUROSCIENCE OF CONSCIOUSNESS**

“When it comes to exploring the mind in the framework of cognitive neuroscience, the maximal yield of data comes from integrating what a person experiences - the first person - with what the measurements show - the third person”

~Daniel Goleman

Now that we have isolated problematic concepts from philosophy that could be identified in a neuroscience theory, let’s inspect some examples. If a theory is found to fall into the CT fallacy this possibly could be grounds for re-evaluating said theory on the basis of CT thinking being rejected by philosophers. Before we do that it will be helpful to slightly redefine what the CT is. It will also be helpful to clarify my understanding of CT type theories.

a. Any theory that requires a separate process to be added to an ongoing process in order for it to be conscious will be considered a CT theory.

This is something important that is similar to the rest of the CT thinking. In the original conception of the CT, data had to go somewhere or cross some line in order to enter or become conscious, so essentially consciousness was going on and the data had to be added to that process. I am adding that if a theory states something needs to be added to a process to make it conscious (this would amount to adding consciousness to a process) it amounts to the same thing as having a finish line. For example if process A is ongoing in the brain and the brain needs to add something to it in order for it to become conscious, this would also be considered a CT theory. This amendment essentially groups central executive kinds of theories into the CT. The wording itself does not fall within the theatre metaphor, but the concept does.

Three theories have been isolated and will be explained: Information Integration Theory (Tononi, 2007), Lamme’s Theory of RP (Lamme, 2010), and Global Workspace Theory (Baars, 2005).
Once explained, I will indicate how each theory is or is not a CT theory with IIT and RP being non-CT models and GWT showing support for the metaphor. GWT is unique in that some, including Dennett, claim that it is not a CT model. I will show why I claim it is, and isolate the confusion.

**Information Integration Theory**

The Information Integration Theory of consciousness is based on information theory, specifically on Kullback-Leibler divergence or relative entropy (Kullback & Leibler, 1951). The theory states that the phenomenal aspect of consciousness occurs when the information integration of a given process within a complex is greater than 0. Tononi makes great use of thought experiments to demonstrate his point without the need for complex math. I will outline the basics of the theory and argue that it does not fall into the CT fallacy.

What is information and what does it mean for it to be integrated? “Information is classically defined as reduction of uncertainty among a number of alternative outcomes when one of them occurs.” (Tononi, 2004) Imagine a photodiode, which is able to signal when it senses light past a certain threshold. This diode is capable of being in one of two states, either 'Light' or 'No Light'. Assuming the probability of there being light in the room is equal to the probability of there being no light, this diode generates 1 bit of information when it assumes a state based on the calculation of entropy \( \log_2(2) = 1 \) bits. Alternatively, rolling a die, which has one of six possible outcomes, will generate \( \log_2(6) = 2.59 \) bits of information. Information is generated based on how much the uncertainty is reduced when an outcome occurs. The uncertainty associated with six outcomes is obviously greater than with two.

As the number of possible outcomes increases, the information generated when an outcome does occur also increases. If you were in the same room as the photodiode, you too could report 'Light' or 'No Light'; however you would be conscious, and the photodiode is not. What is the difference? The difference is that when the light turns on and you perceive the visual stimuli of the room, you are seeing that set of stimuli and not any of the countless possible visual scenes that you are capable of seeing. Instead of seeing one out of two possible scenes like the diode, you are seeing one out of infinite possible visual stimuli. You generate more information.

Information cannot be the only important element for consciousness according to this theory. If we were to measure the information in a 1 megapixel digital camera, which is essentially an array of photodiodes, we would find an amazingly high amount of information. If the array was of the kinds of diodes mentioned above (on or off only) this would amount to \( 2^{1,000,000} \) possible outcomes which amounts to 1,000,000 bits of information. The camera, as far as we know, is not conscious so the amount of information cannot be the only factor. What is the difference between you and the camera? The camera has no integration of the information, which means that there are no causal links between the constituents of the chip. No diode on the chip of the camera can affect the state of any of the other. In fact you could cut the chip up so that it was one million individual photodiodes and not change the performance. For you, this is not a possibility; neurons in your brain are causally connected to other neurons. Cutting some out definitely changes the way the entire system works. This is precisely what consciousness requires: a high amount of information that is highly integrated.

To demonstrate some of the explanatory value in this system I will outline two examples where this theory explains the presence and absence of consciousness. Tononi points out two interesting questions concerning consciousness that his theory can help explain.

1. During slow wave sleep, there are large amounts of activity in the cortex but there does not seem to be consciousness
2. The cerebellum has more neurons than the cortex but it seems to play no role in consciousness. In fact, it can be removed completely and consciousness is almost unaffected.

IIT very simply explains these two issues. Regarding slow wave sleep the activity that is seen in the cortex has a distinctive “all-or-nothing” pattern. The cortex alternates between one of two states (high or low) (Hobson, 2000; Steriade, 1997).

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4 Please note that these are very simplistic calculations based on equal probabilities of the outcomes. If the outcomes did not have equal probability, as in a loaded die, these calculations are much more complex.
This is very similar to the photodiode mentioned above. With there being only two possible outcomes the information generated when a state occurs is very low. The cerebellum, although very dense in neurons, is wired in such a way that there are little or no interactions between the many areas (Bower, 2002). Most of the neurons in the cerebellum connect to other regions in the brain; therefore integration is low while information is very high due to the extreme number of neurons. These are simplified accounts but they do display the explanatory power of the theory.

We have a basic understanding of this theory, and it has been shown to have at least some explanatory value. We need to now consider if it or is not a CT type of theory. It should be clear that this theory definitely is not of the CT type. There is nothing that monitors what is happening in the brain that determines what is or enters consciousness. A process is or is not conscious based totally on the character of the process itself, with nothing added and nowhere it needs to go. It is this aspect that allows it to explain the two curiosities that I pointed out without positing a location that equals consciousness. The slow wave sleep example is of a location that is part of consciousness (cortex) that is still very much active but not conscious. Metaphorically it would be very difficult to express any of the complex mathematics in a way that actually fits the theatre metaphor. All of these things point to a theory that is not CT.

Recurrent Processing Theory

Victor Lamme has a different theory of consciousness based on the type and location of processing. According to the theory, which I will call the Recurrent Processing theory, consciousness happens when the incoming sense data evokes Recurrent Processing (RP). RP is defined as follows: “horizontal connections start to connect distant cells within the area, and feedback connections start sending information from higher level areas back to lower levels” (Lamme, 2010). This theory is not as all-encompassing as the IIT. In this paper, Lamme is only attempting to discover if iconic memory has phenomenal content or not. I will outline his theory, show some of its explanatory value and then indicate how it is not a CT type of theory.

Lamme is attempting to determine whether iconic memory, the very detailed highly unstable visual representations that humans experience, contain phenomenal content. He is asking if there is something it is like to have iconic memory. To answer this he establishes four stages of visual processing, assigns some as obviously conscious and others as unconscious, and then proceeds to work out which if any of the other stages are conscious by seeking correlations between the stages. He concludes that for phenomenal experience to happen you need RP. I will outline the four stages and show why Lamme concludes as he does that RP is needed for phenomenal experience. First we define a fundamental term he uses in outlining these stages: the Fast Feedforward Sweep (FFS):

...each time we lay our eyes on a scene ... cortical visual processing goes through a succession of stages. First, information flows from visual to motor areas in what is called the fast Feedforward sweep (FFS). Within 100 to 120 ms ... activity spreads from V1 to the extrastriate and dorsal and ventral stream areas, all the way up to motor cortex, and prefrontal regions (Lamme, 2010)

The four stages as outlined by Lamme are:

**Stage 1** – Superficial processing during the FFS. Unattended and masked words.

**Stage 2** – Deep processing during the FFS. Attended yet masked stimuli (invisible stimuli). These stimuli do travel through the entire hierarchy and may influence behaviour as in unconscious priming.

**Stage 3** – Superficial RP. Neglected stimuli, change blindness, attentional blink.

**Stage 4** – Deep or widespread RP. A stimulus has been given sufficient time to engage in RP and is attended. Attended reportable stimuli.

According to Lamme’s conclusion, stages 1 and 2 are absolutely unconscious, and stage 4 is conscious. Stage 3 (which is Iconic memory according to Lamme) needs to be established as conscious or not. Lamme looks at correlations between the stages and determines that RP is what gives a stage its phenomenal content. This leads Lamme to a very non-intuitive conclusion.

In other words, it is perfectly understandable why we have reportable conscious visual sensations in Stage 4 (Fronto-parietal activation), or cognitive access to visual information. There are however no reasons whatsoever to assume that taking away the modules that en-
able access and report (Stage 3) also takes away the visual Phenomenality (Lamme, 2010).

This means that based on this theory we do indeed have phenomenal experiences during iconic memory; we just do not have access to them. Another feature of this theory is that it makes attention orthogonal with consciousness, this amounts very closely to separating A and P consciousness were one to accept the distinction.

It is very clear this theory does not entail any kind of location in the brain in order for something to be conscious. It does claim that things like reportability and awareness do arise from a specific location, but RP is not something added to the information to make it conscious. It is something that is happening to the information already. It should be noted that this theory is highly contested, and there is much disagreement about the actual role of RP. These discussions and critiques do not have anything to do with the theory itself being a CT theory, which it is not.

**Global Workspace Theory**

Global Workspace Theory (GWT) is the most widely accepted theory of the three mentioned in this paper. It also appears to me to be the most clear-cut example of a CT type theory of the three reviewed here. I will briefly outline what GWT is, and then produce quotes that indicate, at least in conception, that it is a CT theory. I will then briefly outline how a few theorists claim that GWT is not a CT theory and attempt to reveal them as mistaken. GWT is described as the following:

> The mobilization of any information into consciousness should be characterized by the simultaneous, coherent activation of multiple distant areas to form a single, brain-scale workspace. Areas rich in workspace neurons should be seen as ‘active’ with brain-imaging methods whenever subjects perform a task which is feasible only in a conscious state, such as one requiring a novel combination of mental operations (Dehaene & Naccache, 2001).

The theory has been adopted by neuroscientists performing imaging studies using contrastive analysis (Baars, 2007). Contrastive analysis is a method of inspecting images of the brain while it is involved in stereotypically conscious and unconscious things (masked vs. seen, attended vs. unattended, etc.), and contrasting the results. Typical results indicate a much more widespread activation for instances of conscious processing. This is taken to suggest something becomes conscious when it is able to engage a widespread enough network in the brain. The literature is vast and there is very little agreement about just how widespread or whether the network must necessarily involve specific areas of the brain. Regardless, what is held is that the content becomes conscious when it is widespread enough.

In all the papers that address consciousness this way, what is dealt with was a cognitive aspect of consciousness (awareness, attention, etc.) and nothing phenomenal. Many of the theorists claimed to be talking about phenomenal experiences but then went on to explain only cognitive aspects of consciousness (Baars, 2007; Dehaene & Naccache, 2001; Raffone & Pantani, 2010).

Is this a CT theory? Yes. Some of its strongest advocates use theatre metaphors when explaining the theory:

> GW theory may be thought of as a theatre of mental functioning. Consciousness in this metaphor resembles a bright spot on the stage of immediate memory, directed there by a spotlight of attention under executive guidance. Only the bright spot is conscious, while the rest of the theatre is dark and unconscious (Baars, 2005).

Even in the above quote from Dehaene he claims that information goes “into consciousness”. These are all clear indications the thinking behind this theory is indeed CT. Even in practice, the researchers are looking for what must happen to the information in order for it to become conscious.

It is strange that some advocates like Baars, Shanahan, and even Dennett himself make claims and arguments against GWT being CT.

> But GWT does not claim that information has to go “somewhere” for the conscious condition to arise. On the contrary, the very essence of the theory is its claim that, to give rise to the conscious condition, information has to go everywhere (Shanahan, 2010).

Those who wonder whether GWT is equivalent to a Cartesian theatre should therefore read Dennett (2001). The Cartesian reduction in-
volves a point center “where it all comes together”, named after Descartes, who proposed that such a point center exists in the pineal gland. But of course there are no such point centers in global workspace models (Baars, 2007).

The key point...is that it is the specialist demons’ accessibility to each other (and not to some imagined higher Executive or central Ego) that could in principle explain the dramatic increase in cognitive competence... This idea was also central to what I called the Multiple Drafts Model (Dennett, 1991), which was offered as an alternative to the traditional, and still popular, Cartesian Theatre Model. (Dennett D. C., 2001)

Susan Schneider points out this very same issue. In her paper she attempts and fails to integrate GWT and Dennett’s Multiple Drafts Model. At least 3 points of contention are shown to exist. The first one I have already pointed out, that being the heavy use of theatre metaphors by advocates of the GWT. Her second has to do with a specific aspect of Multiple Drafts, that of “probing”, which does not exist in GWT. The third and most powerful is the claim that GWT is built upon the Fodor’s notion of a central system.

Dahaene and Changeux’s claim that the GW view builds upon Fodor’s notion of a central system is particularly noteworthy, for it emphasizes that the GWT has an element of centralization that Dennett has disavowed in the context of his Multiple Drafts Model (Schneider, 2007)

What could be the source of these misunderstandings, most notably Dennett’s? The Shanahan quote clearly shows that he is misunderstanding that everywhere is still somewhere and having the information needing to go anywhere in order to become conscious is a property of CT models. It may be the case that Baars as well misunderstands exactly what the CT metaphor is designed to indicate. He appears to be taking it too literally. His theory does indeed include a place where it all comes together, the global workspace network, but he seems to be of the mind that because the place is not an actual point it should not be included as a CT model. The point Dennett was making in his original criticism of the CT metaphor is that this thinking is hidden behind the scenes of even the most modern theories. These apparent misunderstandings only strengthen his point. This thinking is still present and could be counterproductive.

Dennett’s claim is a bit more troubling. We have to assume the he understands his own metaphor so we cannot chalk it up to that. Upon further inspection, in the section the quote is from, when Dennett says “this idea was also central”, he is not referring to the idea of GWT, but to the idea that cognitive functions increase when regions have access to each other. He is not endorsing the entire theory; he is merely endorsing this element of the theory as a good model of cognition.

GWT does appear to be a great candidate for a modern CT theory. If Dennett’s arguments are as strong as I claim they are researchers should be careful of following a theory which appears to be based on a faulty picture of consciousness.

**Final Thoughts**

Theories such as IIT hold, in my opinion, the most promise for someday explaining the subjective nature of consciousness as well as allowing us to isolate consciousness in creatures that lack reポートability. GWT as I understand it would not serve well in doing this. Consider the enteric nervous system which resides in our digestive system. It has many similarities to the central nervous system, uses the same types of cells and neurotransmitters. It displays learning and plasticity (von Boyen, Reinschagen, Steinkamp, Adler, & Kirsch, 2002). It also has periods of widespread activation. GWT would seem to conclude that this widespread activation should be conscious. IIT on the other hand has a way of looking at how the enteric system is wired and how it fires to determine that it is not conscious. There is much to be learned by inspecting things like the enteric system through the lens of theories like IIT.

Many philosophers have accused the CT of being a straw man; they claim that the CT has never been an issue. I have shown, at least, that this kind of thinking is still currently present within neuroscience, and is something that should be addressed. Although it is not as obvious (if at all) from this paper that the non-CT theories are correct, we have seen that philosophy has and hopefully will continue to aid any discipline which is studying consciousness.
BIBLIOGRAPHY


THE ROLE OF PERFORMANCE IN THE
STRESS RE-APPRAISAL PROCESS

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ABSTRACT

Chronic stress, physiological and psychological, has been strongly associated with the onset of psychopathology, highlighting the importance of research investigating the experiences of stress. A current model of the stress process includes stress appraisal, stress reactivity, and performance in stressful situations. Past research has treated performance as a dependent variable in this model, but the research in this paper investigates the potential causal relationship of performance on stress re-appraisal. The relationship of performance with pre-task stress appraisal was compared to the relationship of performance with post-task stress appraisal. Participants filled out questionnaires pre-task and post-task, and gave a 5 minute speech in between when the Trier Social Stress Test was conducted. It was found that pre-task stress appraisal was not significantly correlated with performance, but performance did have a moderate negative correlation with post-task stress appraisal. Furthermore performance was associated with change in stress appraisal, and its inclusion in a linear equation predicted stress re-appraisal better than did pre-task stress appraisal alone. Considerations of the implications of performance interfering with the stress appraisal process are made accordingly.

INTRODUCTION

The negative effects of stress have been researched for over fifty years (e.g. Board, Persky, & Hamburg, 1956), and yet there is still much we do not understand. Stress is an important issue in psychology, as it has numerous negative consequences for individuals’ mental and physical health. Stress is associated with onset of psychopathology, as highlighted by the prevailing diathesis-stress etiology models of many mental disorders (e.g. Hooley & Gotlib, 2000). Chronic stress also negatively affects the physical functioning of the body, increasing risk for hypertension, diabetes, susceptibility to disease, neuronal atrophy, and more (McEwen, 1998). Understanding the causes of differences in stress reactivity, stress appraisal, and factors that influence their relationship, can improve our capacity to help individuals exposed to stress.

The following research study is a preliminary data analysis on some of the questions to be investigated more fully in a senior thesis. The data was collected with more rudimentary scoring and coding measures than will be used in the final senior thesis. The thesis will investigate differences in stress reactivity, stress appraisal, psychopathology, performance ability, other related factors, and their relationships to each other. For the purposes of this paper, the focus is on the relationship between stress appraisal and performance ability in a stressful situation, and how performance might be causal in changes in stress appraisal pre- to post-task.

LITERATURE REVIEW

Stress appraisal. Evidence suggests that appraisal-related processes are central in shaping how individuals react to encounters, emotionally and physiologically (Lazarus & Folkman, 1984). Appraisals allow people to evaluate an event as good or bad and determine potential implications; stress appraisal refers to an individual’s perception of whether an event will be or was stressful (negative) or not (Schneider, 2008). Stressful ap-
apraisals can take two primary forms: threat and challenge (Lazarus & Folkman). Individuals making challenge stress appraisals perceive that they have the necessary resources to meet the demands of the event. Individuals making threat stress appraisals perceive the demands of the event to outweigh the resources they believe they have to cope with the event. Individuals also make stress re-appraisals later, when event details can be included and elaborated, to judge how stressful they experienced the situation to be (Schneider). Many factors influence how individuals make these appraisals.

**Stress appraisal and performance.** Performance ability could be one of the factors that influences stress appraisal of the situation, and in reverse, appraisal of the situation may influence performance. Norlander, Bood, and Archer (2002) found that adults who performed better on a Stroop task reported lower stress following the task than those who performed more poorly. Tomaka, Blascovich, Kelsey, and Leitten (1993) found that undergraduates who perceived less threat in a stressful situation exhibited greater actual performance on a mental arithmetic task. Their actual performance correlated to their perception of how well they performed upon re-appraisal. The degree to which participants believed that they performed well was then negatively associated with re-appraising the situation as stressful, highlighting the psychological interaction between these two factors. This suggests that pre-situation stress appraisal is related to actual performance, and individuals are aware of how they performed, influencing post-situation stress re-appraisal. (This stress processes model stands as seen in Figure 1.)

![Figure 1](image1.png)

**Figure 1.** This diagram is a fuller version of the stress response processes model, taken from the prospectus for my senior thesis. For the purposes of this essay, the physiological reactivity component can be ignored. Much of the current research outlines the variables with this directionality: Initial stress appraisal occurs, which influences physiological activity, which influences performance, which influences stress re-appraisal.

**A new model proposal.** Performance ability plays an unclear role in stress re-appraisal post-task. Individuals with a threat appraisal are expected to perform relatively worse, and then report the situations as relatively more stressful post-task. The past research has treated performance as a dependent variable in this model. However, Tomaka et al. (1993) found that in some of the tasks, threat/challenge pre-task appraisals did not significantly correlate to performance, although both performance and threat/challenge appraisals correlated to stress re-appraisal post-task. This could suggest that performance is not only reliant on situational appraisal, but can be an independent trait of an individual, as some people are simply better performers. Individuals’ performance ability could have an interactional effect on the re-appraisal process, accounting for variation of stress re-appraisal within threat/challenge appraisal types. Therefore, performance ability may be more independent from pre-task stress appraisal, and comparatively more strongly correlated with re-appraisal of situation. (Figures 2 & 3)
This model treats performance as more of an independent variable, which may be partially influenced by appraisal, but ultimately has a separate effect on stress re-appraisal. Stress re-appraisal is then a function of both these variables. A stronger relationship is expected between performance and re-appraisal then between performance and initial appraisal.

This demonstrates how this interaction might occur within the maladaptive stress response group. Individuals’ performance ability could have an interactional effect on the re-appraisal process, accounting for variation of stress re-appraisal within threat/challenge appraisal types. Again this diagram is taken from a fuller model in the senior thesis prospectus.

**Hypotheses.** Pre-task stress appraisal is expected to positively correlate with post-task stress appraisal. Pre-task stress appraisal is expected to have a weak negative or insignificant correlation with performance score. Performance score is expected to have a negative correlation with post-task stress appraisal. Change in appraisal pre- to post-task is expected to be negatively correlated to performance score. Pre-task stress appraisal and performance score together is expected to predict post-task stress appraisal better than pre-task stress appraisal alone.

**METHODS**

**Performance measure.** Performance was operationalized by an averaged score from two coders (one male and one female undergraduate) who watched the videos of participants’ speeches. Inter-rater correlation of performance scores was $r = .877$ with $p < .001$, a significantly high level of agreement. Scores were out of 36, calculated from 4 items rating body language, speech flow, energy of speech, and eye contact on a 1-9 Likert scale. (Appendix A).
Stress appraisal measure. Subjects filled out the same task questionnaire pre- and post-task. Each score was out of 21, calculated from 3 items rating how much participants viewed the speech as stressful, a threat, and a positive challenge on a 1-7 Likert scale. (Appendix B and C).

Procedure. We have run 66 subjects between the ages 13-17. After subjects filled out questionnaires and had their stress physiology measured, the Trier Social Stress Test (Kirschbaum, Pirke, & Hellhammer, 1993) was implemented. The experimenter explained that the subject had to give a speech in front of two professionally trained evaluators who would judge their performance. These two evaluators were in fact confederates instructed to provide only neutral or negative feedback. Subjects were first given 5 minutes alone to prepare for the speech and fill out pre-task questionnaire. The two evaluators then returned to the room and took notes while delivering intimidating facial and body feedback during the speech task, which was video recorded. Post-task affect questionnaire was given and stress physiology measured again. Afterwards subjects were debriefed to reduce possible distress caused from the study.

RESULTS

Twenty-nine subjects were selected for this data analysis, based on usability of videos and completion of questionnaires. Subjects’ pre-task stress appraisal scores ranged from 4 to 17, with a mean of 9.69 (sd = 3.69). Subjects’ post-task stress appraisal scores ranged from 3 to 21, with a mean of 12.07 (sd = 4.63). Performance scores ranged from 10.75 to 29.00, with a mean of 20.07 (sd = 4.99). Pre-task stress appraisal had a correlation of $r = .62$ ($p < .00$) with post-task stress appraisal. Pre-task stress appraisal had a correlation of $r = .02$ ($p = .90$) with performance. Performance had a correlation of $r = -.41$ ($p = .03$) with post-task stress appraisal. Changes in stress appraisal were calculated into delta scores by subtracting pre-task stress appraisal from post-task stress appraisal. Performance had a correlation of $r = -.57$ ($p = .001$) with change in stress appraisal. (Figure 4.) Linear equation for pre-task appraisal predicting post-task appraisal is $4.6 + .77x = y$, with $R^2 = .38$. Linear equation for pre-task appraisal ($x$) and performance ($z$) predicting post-task appraisal ($y$) is $12.37 + .78x - .39z = y$, with $R^2 = .56$.

Figure 4. On the x-axis is performance score and on the y-axis is change in stress appraisal from pre-tak to post-task. The negative correlation between these two variables is moderately strong $r = -.57$ ($p = .001$) with change in stress appraisal. Higher performance scores are associated with a reduction in participant-reported stress appraisal, whereas lower performance scores are accompanied by an increase in participant-report stress appraisal.
DISCUSSION

These results were in line with the hypotheses, and generally support the notion that stress re-appraisal is a factor of both initial stress appraisal and performance. The strong positive relationship between pre-task stress appraisal and post-task stress appraisal suggests that pre-task appraisal is influential. However, performance was not correlated to pre-task stress appraisal, suggesting that stress appraisal does not necessarily predict performance, and performance should perhaps be considered more of an independent variable in this model. The negative relationship between performance and post-task stress appraisal suggests that those who perform better judge the task as less stressful afterwards. The negative relationship between performance and change in stress appraisal suggests that those who perform better had a reduction in stress appraisal, while those that performed poorly had an increase in stress appraisal. So regardless of initial stress appraisal, performance could be a factor responsible for changes in stress appraisal. Lastly, the linear equation with both pre-task stress appraisal and performance had a stronger line of best fit ($R^2 = .56$) than did the equation with only pre-task stress appraisal ($R^2 = .38$). This suggests that stress re-appraisal process is influenced by both pre-task stress appraisal and performance. This could be considered in future studies using a model of stress appraisal.

In addition to expanding our understanding of the stress appraisal process, the results of this study bring into question our ability to accurately appraise our own stress. An individual may show initial threat stress appraisal, and perhaps experience stress while performing, but they could still perform well due to independent performance ability. The result might be that they reappraise the experience as less stressful, but this is not reflective of the stress they actually underwent. This presents potential problems for physical health, mental health, and therapy. Being unaware of maladaptive stress reactivity could lead high-performing individuals to continue to put themselves in stressful situations, unknowingly exposing their body to stress damage. They may not remember the events as stressful, but their body still undergoes the stress. One limitation of this study is that stress reactivity was not an included measure, and its inclusion could further clarify the relationship between stress appraisal and performance. Regardless, if stress re-appraisal is partially based on performance, then perhaps individuals who perform well naturally may misinterpret stressful situations as facilitating, and neglect to avoid these situations. Then their ability to perform well may come at the expense of more psychopathology. In a therapeutic setting, patients may be less willing to make necessary life changes, as they do not interpret their stressful situations as unhealthy. More research on stress will help us learn how individuals can understand their stress in the healthiest way.

REFERENCES


**APPENDICES**

Appendix A: Coding of Speech Performance Score Items

1. **Body Language**
   Awkward 1 2 3 4 5 6 7 8 9 Flowed naturally

2. *Continuity of Speech*
   Few pauses 1 2 3 4 5 6 7 8 9 Many pauses

3. **Energy Speed of Speech**
   Dragging 1 2 3 4 5 6 7 8 9 Upbeat/engaging

4. **Amount of Eye Contact**
   Never 1 2 3 4 5 6 7 8 9 Always

*Indicates a reverse scored item

Appendix B: Pre-task Questionnaire

1. The upcoming speech task will be stressful to complete.
   1 2 3 4 5 6 7

2. The upcoming speech task is a threat.
   1 2 3 4 5 6 7

3. *The upcoming speech task is a positive challenge.*
   1 2 3 4 5 6 7

*Indicates a reverse scored item

Appendix C: Post-task Questionnaire

1. The speech task was stressful to complete.
   1 2 3 4 5 6 7

2. The speech task was a threat.
   1 2 3 4 5 6 7

3. *The speech task was a positive challenge.*
   1 2 3 4 5 6 7

*Indicates a reverse scored item
EFFECTS OF PREFERENCE AND STRATEGY ON LEARNING TO READ AN ARTIFICIAL SCRIPT

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ABSTRACT

Reading proficiency in the English alphabetic system requires mastery of common letter-to-sound mappings as well as rapid recognition of familiar words. Previous research has suggested that readers differ in their preferences for the two strategies of word reading, with some preferring to focus on the letter-to-sound correspondences within a word, a grapheme-phoneme (GP) strategy, while others preferring to match entire visual to spoken words, a whole-word (WW) strategy. The goal of this study was to assess what impact such preference differences might have on learning dynamics as readers learned a new writing system. First, typical adults’ reading preference for a GP vs. WW strategy in English was determined via a series of reading tests. Next, participants were trained to associate a novel script of artificial characters with spoken English words. Entire visual characters could be mapped onto whole spoken words (WW strategy) but if the hidden alphabet was taught, individual letters within the character could be mapped onto corresponding sounds (GP strategy). Participants in the two-day training learned one list of words using the GP strategy and another list using the WW strategy. It was hypothesized that preferences evident in reading English would elicit differences in learning dynamics for the novel script. Results revealed that participants’ preferences significantly predicted their learning patterns and outcomes. Specifically, WW preference learners suffered high transfer costs when applying letter knowledge to decoding novel words. Conversely, after learning new words, GP preference learners suffered from high interference costs on previously memorized words. These findings suggest that reading strategies may help uncover differences in cognitive challenges faced during reading acquisition, which in turn may inform effective teaching strategies in early reading instruction.

INTRODUCTION

The notion that children have different learning styles has had a long history in educational research (Honey & Mumford, 1992), especially in content areas such as early literacy acquisition. The construct of learning styles and strategies may provide insight into why some students excel at learning to read while others are merely mediocre or even lag behind. Is the difference something inherent within the student that allows them to excel at any type of learning or is the difference in response to the particular teaching method used? For instance, Baron and Strawson (1976) proposed two learning styles that correspond to the most commonly used methods for reading instruction in English. One is grapheme-phoneme (GP) in which readers map letters (graphemes) to sounds (phonemes) within spoken words. The second is whole word (WW) in which words are memorized as a complete unit. They proposed that readers could be classified based on how much of a preference a reader had for either of the two styles. Readers who relied more on the GP strategy were termed “Phoenician”, and those that relied more on the WW strategy were dubbed “Chinese” (referring to the Phoenician’s consistent alphabetic writing system, and the Chinese’s writing system of ideographs representing individual words). Phoenician readers were characterized by their superior knowledge of the pronunciation rules of English and were shown to be faster at reading lists of pseudowords (i.e., pronounceable nonwords such as ‘smuncrit’) than lists of exception words (i.e., words that do not conform to conven-
tional pronunciation rules such as ‘colonel’). Chinese readers, conversely, were characterized by their ability to recognize the correct spelling of difficult to spell words and were shown to read lists of exception words faster than lists of pseudowords.

While numerous studies have employed the method of list reading to determine reading preference in order to examine the potential effects of preference on reading skills (e.g., Bowey & Rutherford, 2007; Treiman, 1984; Seghier, Lee, Schofield, Ellis, & Price, 2008; Freebody & Byrne, 1988; Bowey, 2008), the exact utility of such segregation is still a matter of debate. For instance, as readers become more experienced, preference groups might not show advantages in reading ability over other groups (Bowey, 2008). Further, segregating adult skilled readers into meaningful groups based on their potential preference has not always been successful (Brown, Lupker, & Colomb, 1994). Moreover, the actual advantage of having an extreme preference, (showing an imbalanced profile by leaning heavily toward a Phoenician vs. Chinese preference) has also been challenged. In fact, Bowey and Rutherford (2007) consider readers who show equal ‘preference’ to be the most balanced profiles in that they show no deficits on any reading measures compared to the preference readers.

Notably, an aspect of this issue that has remained elusive is examining the contribution of an individual’s learning style on new learning. Given the important implications these effects may have on future teaching programs, it is important to consider whether, and how, underlying preference might bias the learning outcome when learning a writing system. However, because preferences would emerge as readers first learn their native orthography, it is difficult to separate experience effects from preference effects in children. Compounding the challenge is the fact that when first learning to read in elementary school, students might receive explicit instruction in one type of reading strategy or another. This may cause young readers to rely on strategies they are specifically taught, instead of those they have a natural inclination towards. In order to control for all these factors inherently confounding preference in a typical learning situation, previous research has trained skilled adult readers to read an artificial orthography (or made-up writing system) as a model system for isolating specific factors relevant to reading acquisition (Bishop, 1964; Yoncheva, Blau, Maurer, & McCandliss, 2010). For instance, an artificial orthography has been used successfully in previous research to demonstrate differential behavioral outcomes based on specific training strategies (Bitan, Manor, Morocz, & Kari, 2005; McCandliss, Schneider & Smith, 1997). In fact, relevant to studying potential differences in learning style preference, Yoncheva et al. (2010) designed a study to examine the differences between the two prevalent reading instruction methods: emphasis on GP strategy vs. emphasis on WW strategy. Their artificial orthography created a unique symbol for each letter, and therefore, words were composed of specific letter parts, but symbols for each word could be also viewed as a whole word as well. This feature of the artificial orthography allowed for examining the effects of both a GP strategy and a WW strategy trained on the same set of characters. Furthermore, since the writing system was new to all participants, they were all at the same starting point in learning, and thus obtained the same amount of experience over the course of training.

**CURRENT STUDY**

The aims of the current study are to examine the validity of learning style subgroups, as defined by differential performance on various list reading tasks, by examining how different subgroups perform in a novel learning task that involves learning to read a new writing system. Previous studies have used artificial orthography to demonstrate how differences in instruction lead to learning differences in a between-subject design (Yoncheva et al., 2010). In this study, we aim to use a similar technique, but investigate learning differences in a within-subject design: each participant will learn using both strategies. We hypothesize that preference readers will show some sort of benefit in learning in their preferred strategy and a disadvantage in their unpreferred strategy relative to the opposite preference group. Given that they are adults, we expect all participants to be able to learn under each strategy to a sufficient degree, regardless of potential preference. Thus, group differences may not manifest as simply better or worse performance during training, but rather, during later tasks that are designed to capture the
type of skills optimal for one learning strategy but not the other. Therefore, we will examine differences in transfer ability and interference effects between different preference groups. Transfer ability is an important skill for being able to read unfamiliar words by applying letter knowledge to unfamiliar words. In this study, transfer ability will be tested using novel ‘transfer’ words that have not been trained, but can be read using the letter knowledge gained in training. In order to assess transfer ability, we will contrast performance on assessments of trained GP words to performance on assessments of Transfer words. Interference effects, on the other hand, can manifest during WW learning. These are exhibited when performance on previously memorized words suffers after additional word learning. It is important not to suffer from these effects when trying to learn an increasing number of exception words in WW learning. In order to examine interference effects, we will compare assessments of a list of words both prior to and after additional word learning.

Because Chinese readers rely more on memorization of trained characters, it is hypothesized that Chinese readers will demonstrate poor transfer ability while Phoenician readers will perform the same on assessments of GP trained words and transfer words. Second, because Phoenician readers rely more on decoding, they may suffer from interference effects when additional WW words must be memorized, while Chinese readers would show little to no effects.

**METHODS**

**Participants**

All participants were right-handed (as confirmed by Edinburgh Handedness Inventory), native English speakers with no reading disabilities, as determined by a battery of standardized assessments: Test of Word Reading Efficiency (TOWRE), Nelson Denny Reading Fluency, and Comprehensive Test of Phonological Processing (CTOPP). Participants were excluded if reading scores on the combination of standardized measures were below 15th percentile, performance was below 70% on the behavioral tests on trained characters on either Day 1 or Day 2 (2 participants), or did not complete Day 2 (5 participants). The final analysis included 29 participants. The North American Reading Test (NART) and the Phonemic Decoding (PD) portion of the TOWRE test were used to determine a participant’s preference. The NART is composed of a series of increasingly more infrequent exception words, therefore measuring use of the WW strategy, while the PD of the TOWRE is composed of increasingly longer pseudowords, measuring use of the GP strategy. However, the NART is designed for ages 18 and above, while the TOWRE is designed for ages 6-24, but uses the same entry point for all ages. Given this imbalance in age range of the tests, a preference score was obtained for each participant by subtracting errors on the first 30 items on the NART from errors on the last 30 items on the PD portion of the TOWRE test. Errors were compared in this manner to match for item difficulty. This method for determining preference ensured that a participant’s preference was relative to his own performance, not that of the overall group. Therefore, high (or low) scores alone on either of the tests did not determine preference in and of itself, and preference reflected a large difference in individual’s TOWRE versus NART scores, rather than the absolute magnitude of either test separately. Categories were created using a tertile split to ensure equal group size (optimizing statistical power) as well as consistent grouping of scores (i.e. all participants with a score of -1 were in the same group). The mean preference score was 0, and participants 0.5 standard deviations away from the mean were classified as Phoenician or Chinese readers, while the rest were considered Balanced readers. Participants with a positive score of 2 and above (more errors on the TOWRE than the NART) were classified as Chinese readers (10) and those with a negative score of -2 or below (more errors on the NART than the TOWRE) as Phoenician readers (10). There were no significant differences between the three groups on reading tests aside from those used to classify. Demographics and test scores for each group can be seen in Table 1.
Table 1
Demographic Profiles and Mean Standardized Test Performance Scores of Participants by Preference

<table>
<thead>
<tr>
<th>Preference Rank</th>
<th>Phoenicians Readers</th>
<th>Balanced Readers</th>
<th>Chinese Readers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>sd</td>
<td>Mean</td>
</tr>
<tr>
<td>Preference Rank</td>
<td>-3</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Number of Males</td>
<td>6</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Age</td>
<td>22.90</td>
<td>5.59</td>
<td>22.33</td>
</tr>
<tr>
<td>Years of College Education</td>
<td>2.85</td>
<td>1.51</td>
<td>2.33</td>
</tr>
<tr>
<td>RS TOWRE PD</td>
<td>57.70*</td>
<td>4.83</td>
<td>57.67</td>
</tr>
<tr>
<td>RS NART</td>
<td>31.30*</td>
<td>8.87</td>
<td>40.22</td>
</tr>
<tr>
<td>RS TOWRE SWE PR ND Reading Fluency</td>
<td>99.10</td>
<td>6.66</td>
<td>101.67</td>
</tr>
<tr>
<td>PR ND Reading Fluency</td>
<td>78.50</td>
<td>35.35</td>
<td>94.22</td>
</tr>
<tr>
<td>SS WASI Matrix Reasoning</td>
<td>13.60</td>
<td>2.12</td>
<td>15.11</td>
</tr>
<tr>
<td>SS WASI Block Design</td>
<td>56.80</td>
<td>8.12</td>
<td>57.67</td>
</tr>
</tbody>
</table>

Note. RS = raw score; PR = percentile ranking; SS = scaled score. * p < .05

Stimuli
Participants were trained on an artificial script similar to that used by Yoncheva, Blau, Maurer, and McCandliss (2010). The script was composed of letter-like characters combined to make words, which were composed of 6 consonants (b, d, k, n, s, t) and 4 vowels (a, e, i, u). Participants were trained on 24 words that could be read using the letter characters (a GP strategy) and 24 words that could only be learned by memorizing the whole symbol (a WW strategy). To aid in the reading process and make the WW script dissimilar from the GP script, the letters in the GP characters were stacked horizontally, and the potential ‘letters’ in the WW characters were stacked vertically. In order to ensure that a WW strategy was used on these characters, the ‘letters’ within the written symbol were never consistently mapped to sounds within the words. Therefore, even if a participant attempted to use his letter knowledge and learn using a GP strategy, it would not be helpful (e.g., for one word, the visual symbol for ‘b’ might be paired with the auditory ‘m’ and on another with the auditory ‘k’). Participants were trained on lists of 12 words at a time. Within each list, each consonant was in both the first and last position of a word twice, and each vowel appeared three times.

Procedure
Participants took part in a two day study, during which they were trained on words using the artificial script described above. On each day, participants were trained on two lists and were instructed to use GP strategy on one list and WW strategy on the other. Participants completed three alternating training sessions on each list. Stimuli lists were counterbalanced across participants to control for strategy, day, and training order. Therefore, across different participants each list was presented as both a WW and a GP strategy list as well as in both first and second position on Day 1 and Day 2 for a total of 8 orders. A training session consisted of seven repetitions of each word followed by a test on the trained words to track learning progress. In the GP training session, the test of trained words was followed by a test of 6 ‘transfer’ words that participants were not trained on, but could read using the letter knowledge learned from training. This
ensured the acquisition of GP strategy on GP words (despite not being able to specifically prevent WW strategy) since transfer words could not be recognized using a WW strategy. On each training trial, a word was presented for 2000 ms followed by the corresponding auditory word which lasted approximately 600 ms. Participants were asked to sound out each letter during GP training and say the entire word during WW training during the trial. Each test trial presented a trained word for 225 ms followed by an auditory word. Participants were instructed to decide whether the symbol matched the auditory word or not. Each visual word was presented twice: once matched with its audio, and once mismatched. The foil for a target was a matched word from the trained list that shared at least one letter with the target word. In order to prevent learning from the test, foil pairs were always presented together resulting in 24 test trials.

In addition to training, on Day 1, participants completed a standardized testing session. This consisted of the Reading Fluency portion of the Nelson Denny, the NART, the TOWRE, the performance portion of the WASI, and the Non-Word Repetition test in the CTOPP.

Before training on Day 2, Day 1 learning was assessed with a retention test. The second training session then began with two lists with 24 new words following the same procedure as Day 1. Day 2 ended with a final assessment of all trained words and a list of new transfer words. Participants completed five groups of short tests (24 trials) on each list for a total of 25 minitests, five repetitions of each list. Each group presented the lists in a different order to minimize effects from practice and fatigue.

RESULTS

Standardized Tests

No significant differences between the three groups on any one test were found, except for those tests used in classification: the NART and TOWRE PD. In order to better compare performance across tests, scaled scores were converted to z scores. Z-scores for all verbal tests not used in classification (Nelson Denny, TOWRE SWE, and CTOPP) were then averaged together to get one verbal performance test score for each participant. There were no significant correlations between test scores (both single test scores and averaged z-scores) and preference ranking. However, when comparing the absolute value of the preference score, there was a significant negative correlation between extremity of preference and average verbal test z-score \( r(27) = -.603, \ p < .001 \). This shows that regardless of what the preference is, the stronger the preference, the poorer the results on standardized reading tests.

Learning Task

Accuracy and reaction times were measured after each training session such that each participant had three data points (s1, s2, and s3) for each word list. RTs for incorrect trials and outside two SD away from the participant’s mean were excluded. Accuracy and RTs were compared at each time point, as well as collapsed across sessions. Overall, there was a main effect of Day, with all participants regardless of preference performing faster on Day 2 than Day 1, \( F(1,28) = 16.34, \ p<.001 \), reflecting a general practice effect. This improvement was equal across all tasks, as there was not an interaction between Day and Strategy \( F(2,17) = 1.62, \ p = 0.22 \). No significant accuracy differences emerged between groups based on strategy at any point during both days indicating that training was equally successful for all preference groups for both strategies.

Between group differences on the learning assessments are summarized in Figures 2 and 3. We assessed learning for Day 1 at two different time points: prior to Day 2 training during the retention test and after Day 2 training session during the final testing. Day 2 was assessed only during the final tests. Analysis revealed no accuracy differences between groups on any GP or WW tests, all \( Z \)'s (19) < 2.0, \( p \)'s > .05. RT differences revealed that Balanced readers were faster than both Chinese and Phoenician readers on all tests of WW, all \( Z \)'s (19) > 2.0, \( p \)'s < .05. Balanced readers were also faster than Chinese (but not Phoenician) readers on the post-training test of Day 1 words, \( Z(19) = 2.36, \ p = .018 \). Both Phoenician and Balanced readers performed significantly faster than Chinese readers on the final transfer test, \( Z(19) > 2.1, \ p < .05 \).
Figure 1. Reaction times in ms for each test taken over each of the three sessions over the two days. Decreasing RTs over session indicate successful learning in both strategies (red vs. blue) for each of the three preference groups (left, middle, right panel).

Figure 2. Accuracy for each assessment of learning for each of the three preference groups. The lack of significant differences indicates that all groups were able to learn under each strategy.
Transfer Ability and Interference Effects

In order to test for transfer ability, we compared tests of GP trained words against transfer words. In order to demonstrate the most robust effects, RTs and accuracy from the final test of GP Day 1 words were compared with the novel Transfer test also taken during final testing. We calculated a transfer cost for each participant by subtracting Transfer performance from GP performance such that a higher number indicated a higher cost to transfer knowledge to a new word than to read a trained one. There were no significant differences found between groups on transfer cost of accuracy, but there were in RTs. All participants showed a positive score indicating that regardless of preference there was a cost to transfer knowledge to a new word than to read a trained one. Phoenician readers, however, had a significantly lower transfer cost than both the Balanced and Chinese readers, $Z(19) > 2.0$, $p < .05$. Balanced and Chinese readers, though, did not differ, $Z(19) = .33$, $p = .74$.

To examine interference effects that result from training on more words in the WW strategy, we compared accuracy and RT data from the WW retention test and the final test of WW Day 1. We calculated an interference cost by subtracting final test performance from Retention Test performance such that a higher number indicated a higher cost to performance. In this case, analysis revealed no differences in RT, but differences in accuracy. Phoenician readers had a negative score; they performed worse on WW trained words learned on the first day after learning more words. Chinese readers, conversely, had a positive score, improving in their performance. Balanced readers performed similarly on both tests. Though there was a significant difference between the cost scores between Chinese and Phoenician readers $Z(20) = 2.47$, $p = .011$, Balanced readers did not perform significantly differently from either Chinese or Phoenician readers.
Figure 4. Transfer cost in reaction time (left) and interference cost in percentage points (right). *p < .05. Left panel demonstrates an advantage for Phoenician readers in a GP skill and Right panel demonstrates an advantage for Chinese readers in a WW skill.

**DISCUSSION**

The present results indicate that differences in reading preferences, as defined by list reading tasks, may lead to significant differences in the cognitive profile of new learning. The current study contrasted different aspects of reading tests of English to independently classify participants as having a preference for one learning style over another and demonstrated that this preference had a robust impact on the type of new knowledge that was acquired when learning to read a novel writing system. Results showed that having a preference in either direction had both a positive and a negative effect on learning in some way, while having a balanced profile led to steady, progressive learning throughout, relative to the other groups. Chinese readers had a higher cost when transferring letter knowledge to new words compared to Phoenician readers, and Phoenician readers had a higher interference cost on WW trained words compared to the Chinese readers. In order to decipher whether the differences in learning profile reflect an advantage or disadvantage for the preference reader, results can be compared to the Balanced readers that showed equal preference. Phoenician readers can be considered to have an advantage in transfer ability over the other groups since they had a lower transfer cost than both Chinese and Neutral readers. However, the interference effect results are less conclusive. Because neither preference group performed differently from the Balanced readers the current data do not answer whether Phoenician readers demonstrated a deficit, Chinese readers demonstrated an advantage, or possibly both. Current research in our lab is investigating whether the advantage is worth the disadvantage for the preference learners, or if being a Balanced reader is overall the more desirable position, since the differences between learning are not so drastic between the two styles. Although further research is still needed, the score profiles from this study lend support to the notion that it is better for overall reading performance to not have a preference.

Further research is also necessary to determine how having an imbalanced reading profile compares to that of a balanced one. This study used tests that were designed to be optimal for each of the major reading strategies, but not for an approach that is balanced between the two. Therefore, the current study cannot speak to exactly what strategy Balanced readers are applying when learning using different strategies; whether they are flexible between the two styles and choose the most optimal strategy for the particular word or using a combination of both strategies...
for each word. If Balanced readers were performing optimally during each strategy, it would be expected that their performance would be similar to the preference readers who showed an advantage. However, these results did not indicate that Balanced readers had any advantages, merely no disadvantages when compared to both preference groups. The implications of this are currently under investigation in our lab.

Broader Implications

This current study, as a piece of a larger research program, has important implications for improving educational practices, specifically in determining the best method to teach reading. Many might assume that the best way to teach a burgeoning reader is to first determine what strategy he prefers to use to read and to then emphasize that strategy while teaching. However, this study indicates that preference readers do not necessarily learn better in their preferred strategy as opposed to their unpreferred strategy. Rather, they excel in their preferred style and suffer in their unpreferred strategy. Since both strategies are necessary in the reading process, instead of trying to accommodate preference readers by teaching using their preferred strategy, it may be better to try to lead imbalanced reading profile readers to have a more balanced profile by instructing them in the opposite strategy. Further research is needed to see just how affected readers’ performance would be if allowed to use their preferred strategy to learn new words without any restraints on the reading strategy used such as those that were in place in the current study. If participants were allowed to use any strategy as desired, the deficits found for the preference readers in this study could be magnified. For example, if Chinese readers never used a GP strategy, perhaps they would completely fail to read transfer words instead of merely being slow to respond to them. This could also shed light on the relationship between balanced and imbalanced readers. The implications from this line of research could become important when readers progress in their education and are expected to learn increasing amounts of vocabulary, but receive less formal instruction in the classroom as to how to learn them, and increasingly rely on personal preference and available strategies instead.

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Authors should submit their work via e-mail to the Indiana Undergraduate Journal of Cognitive Science Editorial Board at icogsci@indiana.edu. Once your submission is received, a confirmation e-mail will be sent by the Executive Editor, as well as a timetable for the review, revision, and acceptance processes. Submission is rolling. Candidate articles may be submitted at any time of the year for consideration in the upcoming volume of the journal. All submissions will be considered equally, and no preference will be given to any particular discipline within cognitive science. There is no limit to the number of articles to be published in a given volume of the journal. However, only articles of sufficient quality, accuracy, originality, and scientific soundness will qualify for publication.

III. Review and Acceptance Process
After submission, the Editorial Board will review all articles and will decide which papers qualify for publication in the upcoming volume of the journal. Authors will be notified by e-mail as to whether or not their paper is accepted for publication. If accepted, authors will be given suggested revisions as tracked changes and comments in their submitted document. While these revisions are not mandatory, authors are expected to show significant consideration of editorial suggestions in their final draft. Once necessary changes have been made, the author should return the revised article to the Editorial Board via e-mail. After final formatting of the publication, the Executive Editor will contact the authors to obtain final approval of any additional changes, and to obtain written permission to publish.

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