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Cognitive Tools and Cognitive Styles:
Windows into the Culture-Cognition System

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by
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Abstract

In recent years, researchers have begun to identify cross-cultural and within-cultural variation with respect to several domains of human cognition. These include the effects of language background on executive control, differences in the attentional patterns of individuals in the United States and East Asia, and the relationship between personality and the use of language. The underlying mechanisms for how cognitive variation arises is likely due to interactions within a complex system that spans the cognition of individuals and the dissemination of information at a cultural level. This culture-cognition system can be seen as dynamic system of cognitive tools, instruments – biological or technological – through which people interact with and understand the world. Each individual acquires a unique bias for using particular cognitive tools – or a cognitive style. Differences in cognitive style arise for two reasons. First, individuals who are exposed to different cognitive tools will acquire different cognitive styles. Second, individuals may need to strengthen certain preexisting cognitive tools if they cannot optimally support the acquisition of a new cognitive tool. In this dissertation, I argue that the understanding of cognitive tools and styles is critical for research on cognitive variation. I illustrate this point with three case studies that examine the effects of language learning on executive control, US-Japan differences in attentional style, and the relation between personality and vocabulary size.

Chapter 1

Introduction

"If all you have is a hammer, everything looks like a nail."
-English Proverb

"A culture, like an individual, is a more or less consistent pattern of thought and action"
-Ruth Benedict, *Patterns of Culture*, pg. 46

Cognitive science can be defined as the interdisciplinary study of the mind. As an interdisciplinary field, cognitive science has recruited the theories and methodologies of disciplines such as philosophy, psychology, neuroscience, anthropology, linguistics, and computer science. The scope of cognitive phenomena studied by the field is quite broad, taking into account human behavior and the brain, artificial intelligence, animals, and even systems of individual agents, such as ant colonies or human societies. Despite this broader scope, much of the discipline is guided specifically to understand the universal properties of the *human* mind. This is especially true of cognitive science studies that are closely tied to cognitive psychology, which specializes in inferring such universals from controlled laboratory experiments.

For various reasons – to be detailed below – cognitive science's focus on the mind has shifted attention away from understanding how the mind varies (D'Andrade, 2000). Such shift has led the field to act as if many of the discoveries made in the field generalize to all human minds. For example, most human behavioral experiments are performed at western universities where undergraduates between the ages of 18 and 22 are used as research participants (see Henrich, Heine, & Norenzayan, 2010 for detailed argument). In order to show that these generalize to all human minds, these same experiments must be performed on other age groups, individuals outside of academic contexts, and those in non-western cultures. Indeed, many experimental studies do *not* generalize when they are performed on individuals of different backgrounds (e.g. Ellen Bialystok, 1999; Henrich et al., 2010; Senzaki, Masuda, & Ishii, 2014b; Takao, Yamani, & Ariga, 2018; Ueda et al., 2018).

Recent attention has highlighted that cognition does indeed vary from person to person, and from culture to culture (e.g. Bialystok, 1999; Henrich et al., 2010; Nisbett & Miyamoto, 2005; Yu, Abrego-Collier, & Sonderegger, 2013). Such attention has coincided with an increased interest in documenting the mental processes of individuals across and within language and cultural divides. This research has covered variation with respect to differences in language (Bialystok & Craik, 2010; Lucy, 2016; Senzaki, Masuda, & Ishii, 2014a), culture (Miyamoto, Nisbett, & Masuda, 2006; Nisbett & Miyamoto, 2005), personality (Deyoung, Quilty, Peterson, & Gray, 2014; Jackson, 2018; Yu et al., 2013), genetics (Chiao & Blizinsky, 2010; Miyake & Friedman, 2012), and various environmental factors (Ueda et al., 2018; Ueda & Komiya, 2012).

The importance of examining cognitive variation appears first and foremost to be the ability to understand which aspects of cognition are truly universal and the degree to which cognition is shaped by the environment. However, the fact that cognition varies with respect to the environment is integral to the understanding of cognition itself. Not only do such studies reveal information about the role of the environment but they also help in the understanding of how all aspects of cognition (e.g. language, vision, action, perception) come together to form cognition as a whole.

The purpose of this dissertation is to introduce a new framework for understanding cognitive variation. I suggest that cognition and culture, together, form a complex dynamic system. As parts of a single system, culture will affect cognition and cognition will affect culture because they share the same information that constitutes this larger system. In particular, culture-cognition systems are comprised of *cognitive tools* – ways of interacting with and understanding the world. Each individual has a unique *cognitive style* – collection of biases for using particular cognitive tools. Individuals will have different cognitive styles if they have different cultural backgrounds, as they will have been exposed to different cognitive tools. Investigating these differences requires (1) detailed understanding of culture-cognition systems and (2) appropriate measures of individual differences.

1.1 The Historical Imbalance

The current state of studies on cognitive variation can be understood by examining the history of cognitive science. A lack of attention towards cognitive variation can ultimately be traced to early theoretical frameworks in cognitive science that split behavioral research into the study of mental processes (e.g. perception, decision making, sentence processing) and mental content (e.g. the concept of 'dog', color terms, cultural beliefs). As the field tended towards the study of processes over content, it shifted away from understanding cognitive variation (D'Andrade, 2000). However, newer theoretical advances suggest that the mind is a complex dynamic system in which there is no distinction between process and content (see Spivey, 2005 for review). Counter to this shift, methodologies that focus on content – especially those of cognitive anthropologists – may be particularly useful in the study of cognition as a complex dynamic system.

Stemming from the early ideas of Noam Chomsky (1957) and later Jerry Fodor (1983), the human mind was believed to consist of innate modules that carry out specific tasks. While each module existed to process specific kinds of information (e.g. sentential word order or low-level visual perception), the organization and purpose of each module were said to be invariant with respect to the information that an individual processed. Such thinking allows one to use a computer as a metaphor for the mind. The modules of the mind act like the hardware of the computer, while the contents of the mind act like the software of the computer. The physical body of the computer can be seen as independent from software and a single hardware architecture is able to take on a myriad of various software programs without needing to restructure the hardware[1].

This view also suggests that the mind, like the computer, takes advantage of symbolic processing. Such processing – akin to algebraic manipulation – can manipulate symbols that stand in for some sort of mental object that is being processed. For example, syntactic theories often suggest that a few specific rules govern how all the words in a single language are ordered in sentences (Chomsky, 1957). These rules are able to be applied to every word because the rules act on symbols that can stand in for any word belonging to a particular category. In English, for example, the phrase 'the cat' is grammatical because 'the' belongs to a class of words (i.e. determiners) that are typically followed by words belonging to another class, nouns (e.g. 'cat'). Such symbolic views of the mind allowed for cognitive science to treat the *content* that the mind operates on as separate from the *processes* that perform such operations. This divide was so great that contents and processes were studied by researchers in separate disciplines (Boster, 2011).

Originally, cognitive science was conceived of as an interdisciplinary endeavor that pulled equally from its parent fields of sociocultural anthropology, experimental psychology, linguistics, neuroscience, computer science, and philosophy. While each field offered

[1] This statement is actually false. Technically, any processing that a computer does requires minute changes in the physical structure of the computer.

a unique set of methodological techniques and theoretical backgrounds, both anthropology and psychology aimed to understand humans through behavioral evidence. This was also true of linguistics, albeit in regard to the more limited scope of language. Traditionally, cognitive anthropology has been housed within sociocultural anthropology, which focuses on understanding humanity by studying human behavior in situ (Blount, 2011). By studying particular peoples and individuals in depth, sociocultural anthropologists gain a broad, yet rich description of the people that they study. In contrast to sociocultural anthropology, experimental psychology emphasizes quick and controlled methods geared towards testing specific falsifiable hypotheses. Due to these different empirical approaches, a natural division was proposed between the anthropologists and psychologists of cognitive science. Cognitive psychologists studied the *processes* through which the mind performs cognition, while cognitive anthropologists studied the *contents* of the mind.

The *contents* of the mind, as studied by sociocultural anthropologists, primarily concerned the categories through which different cultures divided the world (Boster, 2011; D'Andrade, 1981, 1995). These studies originally followed methodologies resembling that of language documentation. Early studies focused on describing the folk concepts embedded within cultures. For example, ethnobotanists studied how particular cultures classified and used plants for medicinal purposes (Nolan, 2014). Others studied kinship terms (D'Andrade, 1995) or cross-cultural color terminology (Berlin & Kay, 1969). Eventually, the field sought to understand complex – or *schematic* – mental models through which humans described and understood the world (Blount, 2011; D'Andrade, 1995). These included, for example, the temporal ordering for the prototypical stages of dating (Munck, 2011) or the average American's folk model of the mind itself (D'Andrade, 1987).

Despite the fact that cognitive science deemed anthropological efforts as geared towards content, cognitive anthropology (as well as its parent field, sociocultural anthropology) itself grew increasingly interested in the relation between culture and behavior. When studying mental models, cognitive anthropologists often asked how the models influenced the individual desires, beliefs, and actions of individuals (D'Andrade, 1995). As such, cognitive anthropologists developed theories for describing how culture influenced the thoughts and behaviors of individuals. These studies closely attended to the relationship between the mind, body, and environment. For example, Edwin Hutchins investigated how the navigation of a ship is computed by the actions of many individuals behaving in culturally defined ways (1995). These earlier approaches to cognition beyond the brain were instrumental in the foundation of distributed and embodied cognition, which are fundamental parts of contemporary cognitive science.

In contrast to examining the *contents* of the mind, cognitive psychology focused on *how* humans came to understand and act upon the information they perceived. Much of this focused on defining the modular mechanisms though which information is processed. This information processing paradigm has remained a dominant perspective within cognitive psychology. The experimental process itself is quite a fundamental aspect of cognitive science. It allows for specific conditions under which processes may be examined with precision. However, relying solely on laboratory experiments for empirical data is problematic in two major ways. First, experimental controls create artificially constrained conditions that fail to capture aspects of the mind associated with most real-world conditions. In contrast, more ecologically valid experiments may be performed outside of the laboratory at the cost of precise control. Second, psychological experiments tend to involve participants from select subsets of the human population, making it difficult to suggest that the results generalize to all human populations.

The defining methodological differences between cognitive psychology and cognitive anthropology are in the scope of the data they examine and the degree to which their theories are data driven and vice versa. Psychologists will begin with theory. Their theories will dictate the specific kinds of data that they are interested in. For example, Buss et al. (1989; 1990; as presented by Boster 2011) argued that men and women would select mates of the opposite sex based on different characteristic traits. He theorized that this was because in the human ancestral past, traits that defined reproductively fit men were different from the traits that defined reproductively fit women; men were selected based on their abilities to provide for sustenance from their families, while women would be selected for based on their fertility. Based on this theory, Buss and collogues measured the degree to which men and women found the traits of physical attractiveness and wealth as important for selecting a mate of the opposite sex. Aligning with their theory, men ranked physical attractiveness higher than women, and women ranked wealth higher than men. Thus, Buss and collogues found empirical evidence that supported their initial hypothesis.

In contrast to psychologists, anthropologists are more likely to begin with data exploration. Rather than selecting a theoretically specified scope, cognitive anthropologists attempt to examine an entire domain. For example, they may document a culture's entire knowledgebase of disease. Then, they would examine patterns in this data, showing the culturally specific dimensions through which individuals categorize different disease. In the case of mate selection, there are numerous traits upon which individuals can choose a mate. Boster (2011) examined how these traits were ranked in importance by men and women. He found that there was a strong linear relationship between the ratings of women and men. While men and women did differ slightly on their ratings of a few traits (as found by Buss et al 1989), these differences were found only among traits that men and women ranked with neither high or low importance. While there were significant differences in how men and women ranked physical attractiveness and wealth, these differences were minor in comparison to the overall pattern of trait preferences. Moreover, this analysis offers an alternative explanation for the data: Only traits that are perceived as neither important nor unimportant may vary in how they are perceived by men and women. This could be because the importance of *other* traits has gone through historical pressures – cultural or evolutionary – while mid-rated traits are *less* culturally salient and are therefore allowed to vary. As illustrated here, anthropology is geared towards examining data systems. While theory driven experiments will always be necessary for cognitive science, the data-driven approaches of cognitive anthropology are equally necessary as they help to contextualize experimental results and offer tools for studying culture and cognition as complex systems of information.

Unfortunately, cognitive anthropology is no longer a thriving field and the presence of its methodologies are rare in contemporary cognitive science. This is primarily due to changes within the field of anthropology itself. Sociocultural anthropology (i.e. the field in which cognitive anthropology is housed) – as a whole – moved away from quantitative methodologies, mainly due to its embrace of postmodernism and a rejection of the ability to measure the non-subjective world (i.e. what is not experienced by the people they study) in the 1980s and 90s (Roy G. D'Andrade, 2000). This is not to say that anthropology produces data that are irrelevant to cognitive science. On the contrary, for example, theoretical advances in biological anthropology have significantly added towards the current understanding of brain evolution (Deacon, 1990). Moreover, archaeological exploration has illuminated a vast history of human tool-use (Dockall, 2006; Richards, 2003). However, these sub-fields of anthropology do not offer the tools necessary for examining culture as a complex system. Such behavioral methods have primarily been used by cognitive anthropologists housed within sociocultural anthropology. Sociocultural anthropology's rejection of these quantitative methodologies weakened the potential for anthropology to contribute fully to cognitive science. As a consequence, cognitive psychology became the dominant contributor of human behavioral research within cognitive science.

Even in the absence of cognitive anthropology, an overwhelming body of empirical evidence within cognitive science now suggests that (1) cognition cannot separated into modules and (2) the processes of the mind are indeed shaped by – or perhaps physically indistinguishable from – the content of the mind (see Spivey 2005 for review). Seemingly unrelated processes – such as language and vision – are highly interactive. For example, as an individual hears a word, they continually update their perception of that word on a millisecond by millisecond basis (Spivey, Grosjean, & Knoblich, 2005). Moreover, this incremental processing of language is permeated by visual cues, which change how a word or sentence is perceived even before processing is complete (Tanenhaus, Spivey-Knowlton, Eberhard, & Sedivy, 1995). The brain itself consists of highly interconnected areas that coincide with particular cognitive processes. For example, dense bidirectional synaptic connectivity link various cortical and subcortical brain regions (e.g. Churchland & Sejnowski, 1992; Felleman & Van Essen, 1991). The brain areas that underlie most cognitive processes tend to be distributed within brain networks rather than specific localized areas (Abutalebi & Green, 2007; Bullmore & Sporns, 2009). Even processes related to seemingly opposite aspects of cognitive, such as perception and action, are integrated so much that they cannot exist independently (Driver & Spence, 1998; Pulvermüller & Fadiga, 2010; Shimojo & Shams, 2001; Spivey, 2005).

Along with a highly interconnected system, it is also clear that cognitive processes are sensitive to minute differences in the content of what is being processed. For example, the time that is takes to understand a word is a function of that particular word's distribution in everyday language (Dahan, Magnuson, & Tanenhaus, 2001), the number of words that are phonologically related to it (Grainger, Muneaux, Farioli, & Ziegler, 2005), and the number of words that are semantically related to it (Buchanan, Westbury, & Burgess, 2001). This runs contrary to a symbolic account, which would suggest that any two words are processed the same as long as they belong to the same symbolic word class (e.g. noun, verb). These contextual effects can be seen even at the smallest scales of cognition. For example, neurons that spike when detecting a particular visual arrangement (e.g. a vertical bar) will spike when detecting different visual arrangements, depending on the environmental context of the viewer (Wörgötter & Eysel, 2000). This is because the neuron will receive contextual signals that change the neuron's bias to spike give certain other inputs. Again, this runs contrary to symbolic accounts, as specific neural response would be the same, regardless of the input, under a symbolic account.

The high interconnectivity and context dependence of cognition completely undermines the original methodological split between cognitive anthropology and cognitive psychology, as process and content cannot be studied separately. Moreover, the field of cognitive science has begun to share theoretical stances that mirror cognitive anthropology's study of the mind as embodied and distributed. Many studies show that the flow of information that defines cognition is not constrained to particular brain regions or even the brain itself. For example, even a simple task to pick up a cup requires information to be transmitted continuously as neural activation, muscle contractions, skin pressure, light, and eye-movements (Ballard & Hayhoe, 2009). Even two individuals sharing a conversation will show neural coupling, despite the fact that the connections between them lack any neural mechanisms (see Spevack, Falandays, Batzloff, & Spivey, 2018 for review). Taking this even further, cognitive information is transmitted and evolved though the interactions of individuals within entire societies over thousands of years (Anthony, 2010).

The evidence touched on here suggests that cognition constitutes what is known as a complex dynamic system. These are systems are characterized by high interconnectivity that results in self-organization and chaotic changes that may result from small perturbations. A school of fish, for example, can be seen as a complex dynamic system. The behaviors of each fish are affected by all of the other fish in such a way that they will move together in synchrony. However, any small fluctuations in the movement of one fish may cascade to the whole system, causing the entire school to change direction. The content – or information – of cognition itself is connected in these ways. Take for example, language as it is within the cognitive system. Each word is influenced by the other words with similar meanings, sounds, and syntactic distributions (Buchanan et al., 2001; Dijkstra, Grainger, & van Heuven, 1999). These so-called 'word neighbors' are integral to how individual words are processed, affecting both the time it takes to understand each word and the potential meanings that can be ascribed to a word given the current context. Thus, understanding how words are processed requires knowledge of the structure of the entire system of words that an individual possesses.

With such interactivity, cognition and culture form a single complex dynamic system that may be known as the culture-cognition system. It consists of a network of interconnections at various spatial and temporal scales. This system connects a variety of content, which includes language, concepts of the everyday world, narratives, behaviors, beliefs, low-level perceptual units (e.g. receptive fields, phonemes), human agents, material artifacts, and even the physical environment. Many of the properties of the culture-cognition system are emergent and cannot be understood without studying the whole of cognition, including one's cultural environment. It is important to complement cognitive science's rich tradition of psychological experimentation with data-driven approaches that are sensitive to the complexities of the culture-cognition system. Moreover, the study of complex dynamic systems require methodologies that are suited to find patterns within complexity. Some of those necessary methods are skin to those of cognitive anthropologists. Many changes to the field of cognitive science, such as the shift towards a complex dynamic systems approach to cognition and an increased interest in embodiment and distributed cognition, make now an opportune and necessary time to reintroduce these methods. Indeed, as I discuss in the following section, the field has included many recent studies of cognitive variation. These studies make important contributions to the field of cognitive science. However, I argue that further research must take particular caution in understanding culture as a complex system.

1.3 Contemporary Studies

As outlined above, the study of human variation within cognitive science has been limited with respect to its full potential. This primarily is due to the historical divide between process and content and methodological shifts within anthropology. By re-incorporating research on cognitive variation, the field can better understand cognition as a complex dynamic system. Indeed, a growing number of researchers have highlighted and exemplified the need and utility in examining variation. These researchers have addressed topics such as the limited subject pool of experimental psychology (Henrich et al., 2010), the role of anthropology in cognitive science (Bender, Hutchins, & Medin, 2010), and the effects of language background on other aspects of cognition (Bialystok & Craik, 2010; Ellen Bialystok, 1999; Lucy, 2016).

One paper by Henrich, Heine, and Norenzayan (2010) draws attention to the fact that experimental psychology relies heavily on participants from a limited range of cultures. These participants often come from Western, Educated, Industrialized, Rich, and Democratic populations. These populations have been cleverly named WEIRD. The paper has been met with positive response, and there is now widespread acknowledgement of the necessity of cross-cultural research in cognitive science. Indeed, it has spurred several efforts to document cross-cultural differences in domains such as economic reasoning (Henrich, 2015;

Jackson & Xing, 2014), motor movement (Bril, 2018), attention (Kardan et al., 2017), and even human-computer interaction (Rehm, 2013).

While this sudden attention to the problems of WEIRD participants is much needed, there is still an aspect of anthropological methodology that is missing from the field. This is cognitive anthropology's data-driven approach that captures the complexities of culture before constraining research to specific hypothesis. Without examining such cultural complexities, these hypotheses may rely on theoretical assumptions that run counter to the majority of data. Two cases of cognitive variation – cognitive differences between individuals in the United States and East-Asia and cognitive differences between bilinguals and monolinguals – help to illustrate the necessity of examining the complexities of culture.

Cross-cultural cognitive differences have been found between individuals in the United States and East Asia. Individuals in the United States appear to rely less on certain kinds of contextual information than those in East Asia. For example, people in Japan will look more at background elements of a visual scene than those in the United States (Senzaki et al., 2014a). These attentional differences also extend to other aspects of cognition, such as categorization (Ji & Nisbett, 2001), reasoning (Norenzayan, Smith, Kim, & Nisbett, 2002), and memory (Schwartz, Boduroglu, & Gutchess, 2014). Many researchers believe that these differences correspond to a cultural variable known as *self-construal*, which captures the degree to which a culture values social harmony (i.e. collectivism) over self-independence (i.e. individualism). However, the exact means through which self-construal affects attention are yet to be well defined and there may be many other aspects of East Asia and the United States that explain these differences. For example, the sentence order of East Asian languages (e.g. Japanese, Korean) differ substantially from English. Japanese and Korean put contextual information first (e.g. house-POS front-LOC bicycle-SUB is*)*, while focal information is put first in English (e.g. There is a bicycle is in front of the house; Tajima & Duffield, 2012). The habitual attention to contextual information first may lead East Asians to attend more towards contextual information in their visual environment.

In another case, monolinguals and bilinguals have been shown to have different cognitive advantages with respect to each other. Monolinguals appear to have advantages for language perception and production. For example, in constrained laboratory contexts, monolinguals are faster to process certain words than bilinguals (Runnqvist, Strijkers, Sadat, & Costa, 2011). In contrast, bilinguals appear to possess certain advantages related to executive control

(Bialystok & Craik, 2010), a set of related cognitive processes which are responsible for organizing, controlling, and executing the various sub-processes involved in a specific task. These processes include maintaining the current task demands in memory, executing the behaviors necessary to complete the task, attending to information relevant to the task, and suppressing information that is irrelevant to the current task goals (Miyake & Friedman, 2012). For example, bilinguals are better at the Stroop task (Zied et al., 2004), which requires participants to recite the colors that color words are written in while ignoring the word itself (e.g. saying 'red' for the word 'blue' written in red ink). These bilingual advantages are believed to stem from the bilingual's constant practice at suppressing one language while using the other. However, the exact differences between monolingualism and bilingualism are both complex and not straightforwardly apparent. A bilingual's two languages may not be represented separately. Intertangled languages imply that a bilingual must utilize complex control in order to suppress one language over another. The degree and complexity of this control depend on exact overlap of a bilingual's languages. This, in return, would depend on the specific languages that they know and the level to which they know each language.

With the numerous studies spawned by the two above examples (as well as many others), there is clear renewed interest in studying the mind as a flexible entity. Given that cognition (and the cultures within which it is situated) is a complex dynamic system (as opposed to a modular system of process and content), these renewed interests place the field in a position to better understand not only the complex dynamics through which cognitive variations arise but also fundamental aspects of the mind in general. However, each individual case that relates culture to cognition comes with its own set of theoretical assumptions. These are appropriate, given that each case addresses specific cultural areas and specific domains of cognition. What is needed, however, is a general framework through which all studies of cognitive variation tie together.

1.3 The Culture-Cognition System

In order to understand the culture-cognition system, it is necessary to use a framework that provides useful methods for identifying ways in which differences at a cultural level will entail differences in the cognition of individuals. As culture and cognition form a single culture-cognition system, parallels may be easily identified because differences on a cognitive level will directly mirror differences at a cultural level. However, as the culture-cognition system is a complex dynamic system, the acquisition of culture will sometimes necessitate specific changes to pre-existing cognitive content. I suggest that identifying the parallels between culture and cognition becomes easier when the content of this system is unified under the term 'cognitive tools,' ways in which individuals are able to interact with and understand their environment. In addition, I define 'cognitive style' to mean the unique biases of an individual to use a particular set of cognitive tools in specific ways. The cognitive styles of individuals will mirror the cognitive tools shared through their culture. The acquisition and use of cognitive tools will depend on each individual's entire cognitive style. As such, understanding individual differences is important because differences in the cognitive styles of individuals illuminate the mechanisms through which individual's acquire and adapt to culture.

1.2.1 Culture-Cognition Parallels

In order to see how parallels may be drawn between culture and cognition, I utilize an example of linguistic relativity, as these studies pay close attention to the intricate patterns of cultural contexts. According to the Sapir-Whorf hypothesis (Whorf, 1941), the habitual use of a particular language will lead to biases in the ways through which an individual will attend to and categorize the world. For example, in English, malleable entities (e.g. water, air) typically follow different grammatical patterns compared to entities with shape (e.g. dog, hat, airplane). In order to quantify such malleable entities, the nouns must be paired with a unitizer – a word that breaks the entity into units (e.g. the word cups in 'two *cups* of water'). In contrast, most other English nouns may be paired with a number without such unitizers (e.g. 'there are two pens'). Thus, a unit of quantification (i.e. shape, size) is embedded into the meaning of most English nouns. This is not the case for mass nouns such as the word 'water.' In languages such as Japanese and Yucatec-Maya, all nouns must be paired with a unitizer in order to be quantified (Imai, 2002; Lucy, 2016). There is an interesting attentional consequence of this difference. English speakers must consistently attend to the shapes of discrete objects, as their shape is encoded in the meaning of the words that refer to those objects. This is not true for Japanese and Yucatec-Maya. When speakers of these languages are given non-verbal tasks in which they must classify novel objects or identify similarities and differences between line drawings, English speakers are more likely to identify differences based on shape, while speakers of Japanese and Yucatec-Maya are more likely to identify differences based on material (Imai, 2002; Lucy, 2016). For example, English speakers and Yucatec-Maya speakers were asked to sort depictions of everyday scenes based on similarity. Many of these scenes were identical except for the number of certain items. Neither group was sensitive to differences in the number of malleable entities (e.g. number of clouds of smoke rising from a fire). However, English speakers were sensitive to difference in numbers of inanimate objects (e.g. plates of food, trees), while the Yucatec-Maya speakers were not sensitive to these differences (Lucy, 2016).

In this example, a very specific structural aspect of language (i.e. the use of unitizers) was selected as the linguistic variable through which cognition varies. The identification of this variable required detailed knowledge of English, Japanese, and Yucatec-Maya (or other languages), with specific attention to the syntactic structures, semantic meanings, and systematic use of words in these languages. Furthermore, there is a direct parallel between the linguistic variable and the cognitive consequence; the absence of a unitizer for most words in English requires speakers to consistently attend to shape when using those words. The cognitive consequence of this directly parallels the linguistic variable, suggesting that habitual *attention towards shape* during language use leads to a bias in *attention towards shape* when not using language. Moreover, unitizers are simultaneously cultural content and cognitive content, as they are shared among groups of individuals who each use these as part of their mental processes. Each individual gains specific cognitive consequences (i.e. attention towards shape) as a result of incorporating the use of this cultural content into their cognition.

Making such detailed claims about the relation between culture and cognition needs a detailed understanding of the contents of the mind and the contents of culture. As culture and cognition form a single culture-cognition system, both sets of content are essentially the same phenomena at different scales of single system. Understanding this content may employ methods that are akin to the rich descriptions of cognitive anthropologists. However, it is also necessary to specify more on the nature of the content being studied. As I discuss in the following section, the content of the culture-cognitive system is usefully described as 'cognitive tools,' as they share much in common with material tools.

1.3.2 Cognitive Tools

Culture is often described as the collection of knowledge systems, beliefs, behaviors, goals, and languages that are shared by a group of people[2]. In addition, another fundamental property of culture is the dissemination of tool use. Tools are a ubiquitous part of human life. While tool use has been documented among a growing number of non-human animals (see Seed & Byrne, 2010 for review), it is the variety and complexity of human tools that represents a defining feature of our species. To give an initial definition that will later be expanded upon, tools are objects external to the body that are used in order to perform an action. While in use, tools extend the physical capabilities of the body. Take for example, the hammer. For its canonical usage, it temporarily converts the human arm into a hardened surface that may be swung in order to apply blunt force to another object, typically a nail. Without a hammer, the human arm is soft and would likely be damaged itself when striking a hard object.

Tools have been innovated to serve various purposes throughout human history. These have ranged in complexity from Oldowan stone tools[3] to CRISPR gene editing[4]. In many of these cases, these tools serve to change the tool-user's environment in a manner that is either directly useful to the tool-user or to others. This environmental change is physical and is conducted via actions of the tool-user. For example, a carpenter might use a set of saws and hammers to turn pieces of wood into a chair. As extensions of the body, tools may also be described as extended actions. In using tools, humans must exert much of the same control and attention as when performing an action with just the body.

The concept of a tool can also be applied to something like glasses. The lenses of the glasses bend light in a specific way tailored to the wearer. With glasses, an otherwise blurry pattern of light becomes a clear pattern of relevant visual information for the wearer. In this case, the change into the environment is technically physical of sorts, as light has been bent. However, the ultimate utility of the glasses appears to be slightly different in that the critical change is in the information status of the light.

Despite its importance in the study of cognition and other fields, the concept of information appears rather difficult to define (Cao, 2012). However, what can be stated is that information is information only insofar as it has utility to a user. Take for example, a book written in an unknown foreign script. While the individual looking at the book could

[2] Culture can be distinguished from society, which refers to groupings of people who interact and share culture.
[3] These are the earliest known stone tools in human history, dating at the earliest to 2.6 million years ago. They are associated with *Australopithecus garhi* as well as some later hominids.
[4] CRISPR stands for clustered regularly interspaced short palindromic repeats. It is a recent bioengineering advancement that allows DNA to be separated at specific locations.

be able to ascertain certain visual characteristics of the book and its writing, the book would possess less utility to them than to person who has (culturally shared) knowledge of the book's language. Thus, there is something about the book's informational content that is dependent on the user of the book. Similarly, in the case of glasses, there was something about the wearer (eyeball shape) that gave a certain informational status to the light refracted a certain way by the glasses. An individual with a different eyeball shape would find the glasses-bent light to be less informative.

The utilization and manipulation of information spans many of the various cognitive processes, including perception, attention, categorization, and memory. For example, attention ultimately constrains the information one can gather from their environment. Any given environment has an abundance of potential information. Without focusing on specific details, individuals would become overwhelmed by the information, which would give no practical utility. Some aspects of the environment are more relevant than others. For example, when driving on a road, the lines on the road indicating different lanes are more important to attend to than trees on the side of the road. There is utility (and safety in the case of driving) in attending to particular features of the environment over others. Particular informational features also aid in categorization. For example, the roundness of a coin is irrelevant in distinguishing a dime from a quarter. Rather, the size and embossing of the coin provide the critical dimensions through which dimes are distinguished from quarters.

Processes such as attention and categorization are ubiquitous throughout cognition. Attention is essential to all perceptual modalities and can be seen as critical in guiding goal-directed tasks and actions. Low-level visual features are categorized into shapes such as horizontal and vertical lines. Speech sounds are categorized into phonemes of an individual's language. Higher level visual features are used to categorize objects using linguistic labels. Both attention and categorization play critical roles in performing complex tasks and decision making. The ubiquity of these and similar processes suggests that cognition as a whole is a system almost entirely defined by the manipulation and utilization of information.

While all such cognitive processes might appear to be rather internal to the brain, a number of studies have found evidence suggesting cognitive processes extend throughout the body and even into one's environment (Clark & Chalmers, 1998; Hutchins, 1995). Much of the ways in which cognition is "offloaded" into the environment is through the use of tools. For example, long division may be performed with a pencil and paper. Not only are material tools used (i.e. the pencil and the paper), but long division also utilizes particular mathematical procedures learned though one's culture. These tools and procedures are integrated together in order to carry out manipulations of information *and* environment. Such manipulations can be seen throughout cognition in the form of complex loops between perception and action. For example, when grabbing an object such as a cup, individuals will constantly update the movement of their arm based on visual feedback and they constantly alter how they allocate attention based on the location of their arm (Smeets, Hayhoe, & Ballard, 1996).

Of note, many of ways in which cognition is extended beyond the body can be described as tool use. Computers, cell phones, long division, books, and hammers all extend functions of the brain and body. They are also tools. As they are used to extend human cognition, these tools are indistinguishable from cognition. Moreover, cognition itself carries out the same process as tools; cognition and tools manipulate and utilize the environment and information. As such, the processes of cognition are tools. Hereafter, I denote all such tools of cognition with the term *cognitive tools*. These cognitive tools are the instruments – biological or technological – through which people interact with and understand the world.

With the concept of cognitive tools, cognition and culture can be defined more parsimoniously. *Cognition* is a collection of cognitive tools utilized together for specific purposes. *Culture* is a collection of cognitive tools shared among a group of people. In many ways, one's cognition – their personal collection of cognitive tools – stems from their culture. By defining cognition and culture in these terms, there is a direct parallel between them. Moreover, they can be seen as aspects of the same culture-cognition system as seen from different spatial or temporal scales.

1.3.2 Cognitive Styles

Cognitive tools inherit many of the properties of tools themselves. Two of these properties are particularly important for this dissertation. First, cognitive tools may be combined in order to make new cognitive tools. For example, the cognitive tool of long division utilizes other cognitive tools such as writing, subtraction, specific eye-movement patterns, and language. These component tools may be restructured to form other tools, such as multiplication, or combined with even more tools to make sophisticated cognitive tools such as calculus. The second property – which is closely related to the first – is that cognitive tools that serve almost the same functionality can be made with different constituent tools. This can be seen easily in the cases of language, where completely different sets of words, grammars, and sounds can serve the purpose of communication. As a result of these two properties, the organization of cognitive tools can be quite fluid, with the organization of cognitive cools varying between and within cultural groups.

Because the organization of cognitive tools is fluid, there is room for variation in the ways that individuals understand and interact with their environment. *Cognitive style* describes a person's biases for using particular cognitive tools. While the term *cognitive style* has been used inconsistently in the literature, it generally refers to preferences for how individuals carry out a given task. Such preferences do not necessarily coincide with advantages or disadvantages. Rather, they represent alternative means for interacting and understanding the world. Some styles may be more suited for particular task environments than others. As cognitive tools provide ways for the utilization and manipulation of information, cognitive style can also be defined in terms of information; different cognitive style have different biases in attention to, categorizing, memorizing, or acting upon information.

Cognitive style is easily exemplified for tasks that have an ambiguous end-goal. For example, an individual can be given a task in which they are given three words and instructed to group two of them together. The end-goal is ambiguous because there are many possible dimensions by which the words can be grouped. For example, if given the set of words *cow, milk,* and *juice,* an individual could group together *cow* and *milk* because there is a real-world relation between cows and milk (e.g. cows produce milk). However, the individual could also group together *milk* and *juice,* because both are beverages. Given the instructions of the task, neither grouping is better than the other. However, the individual's choice usually shows a bias for grouping based on one of these two differing strategies.

Cognitive style can also be seen in one's overall performance in a task with a non-ambiguous goal. For example, in the rod-and-frame task (Wenderoth & Beh, 1977), individuals are given a tilted line and asked to rotate the line until it is perfectly vertical. The line is embedded within a square frame, which itself is tilted at an unrelated angle. Participants are instructed to ignore the orientation of the square frame and rotate the line with respect to absolute vertical. Participants range in performance, and those with lower performance are affected more by the orientation of the square frame. Thus, performance captures a participant's ability to ignore the irrelevant context.

At first glance, the rod-and-frame task appears to capture a capacity, rather than a cognitive style; given the task demands, it is clearly better to be able to ignore the frame. However, the task goals can be compared to an alternative in which participants are asked to ignore absolute verticality and reorient the line until it matches the orientation of the square frame. Participants also range in performance on such tasks, with performance inversely correlated with performance on the canonical rod-and-frame task (Nisbett & Miyamoto, 2005)

Differences in cognitive style permeate all of cognition. Individuals may have subtly different conceptions of what constitutes the color blue, or they may have completely different languages through which they communicate about the world with. They may also have differing dispositions for using technology or socializing with others. All these cases can be described as differences in the cognitive tools through which people interact with and understand the world.

In order to understand how culture influences cognitive style, we must understand the cognitive tools provided by a culture and the task demands that are shared by members of a culture. For example, culture explicitly provides certain cognitive tools. Members of a society may be exposed to education through which they learn certain mathematical or scientific ways of thinking, or they may learn certain familial crafts (e.g. cooking recipes). Much learning will involve the practice of specific actions, attention to particular details, and expert labels for categorizing the world. Moreover, societies will differ in the task demands that they require of individuals. For example, those in Japan must constantly attend closely to social proximity (e.g. friend, acquaintance, boss), as specific language forms must be used based on the social relatedness of two interlocutors.

Importantly, the cognitive styles required of individuals of a culture are not arbitrary. Rather, they are a direct consequence of cultural learning. Thus, cognitive differences that relate to cultural differences should follow directly from the cognitive tools explicitly given by a culture and the cognitive tools required by the task demands of a culture. As argued for in above sections, this requires detailed knowledge of the cultures being studied. However, while cognitive style differences will indeed result from differences in culture, differences in cultural exposure and predetermined cognitive differences will affect cognitive style at an individual level. These differences are critical to understanding the culture-cognition system, as they show the specific conditions under which cognitive variation occurs.

1.3.3 Individual Variation

Culture is non-monolithic. Thus, people within a culture have slightly different exposures to the cognitive tools shared by a culture. Some culturally given cognitive tools may require a high level of shared-ness (i.e. ubiquity, similarity, and precision of the cognitive tool used), such as the basic vocabulary and grammar of a language[5]. For other cognitive tools, a high degree of shared-ness is not required. For example, a person might find their own idiosyncratic words and phrases that they use on a daily basis. These phrases may serve functional equivalents to other words and phrases in their community. This is not to say that people would not pick up their idiosyncratic language from others. Rather there is less necessity to do so, relative to more fundamental aspects of their language.

Another reason that cognitive style may differ between individuals stems from the fact that cognitive tools serving similar functions may be constituted from differing component tools. Two individuals who face the same social pressures to acquired a cognitive tool may implement their versions in slightly different ways because of differences in their currently available cognitive tools. These currently available cognitive tools may have been the result of different previous cultural exposure, but they may also have resulted from different biological dispositions. For example, individuals with dyslexia exhibit neural differences before the onset of reading. Their exposure to language is *may* be inconsequentially different from others within their language group. Yet, they employ a slightly different cognitive style when reading. Thus, there is going to be individual variation within cultural groups of individuals.

As individuals may use slightly different sets of cognitive tools as scaffolding for acquiring a new cognitive tool, the ultimate utility of the acquired cognitive tool may be different. Moreover, the use of certain cognitive tools may be more optimal for this scaffolding than others. Individuals who must rely on suboptimal tools as scaffolding will still need to acquire the new cognitive tool in a way that meets social expectations. In such cases, the individual may need to strengthen the utility of the new tool's component tools. This strengthening is a cognitive consequence of acquiring the new cognitive tool.

Figure 1.1 is a network representation of a community of individuals with varying cognitive tools. Nodes in the network represent individual agents while edges represent the likelihood of interacting with another agent. Each agent begins with a specific set of cognitive tools (depicted as colored squares). Some of these tools have been co-opted together to form larger cognitive tools (colored squares surrounding smaller squares). Agents are likely to gain new cognitive tools as a function of the agents that they interact with. The network on the right shows the cognitive tools of the agents after interacting with

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[5] I am assuming here that this is the case, as all individuals in a culture must learn particular linguistic forms. However, it is possible that differing cognitive styles may meet the same ubiquitously shared task demands.

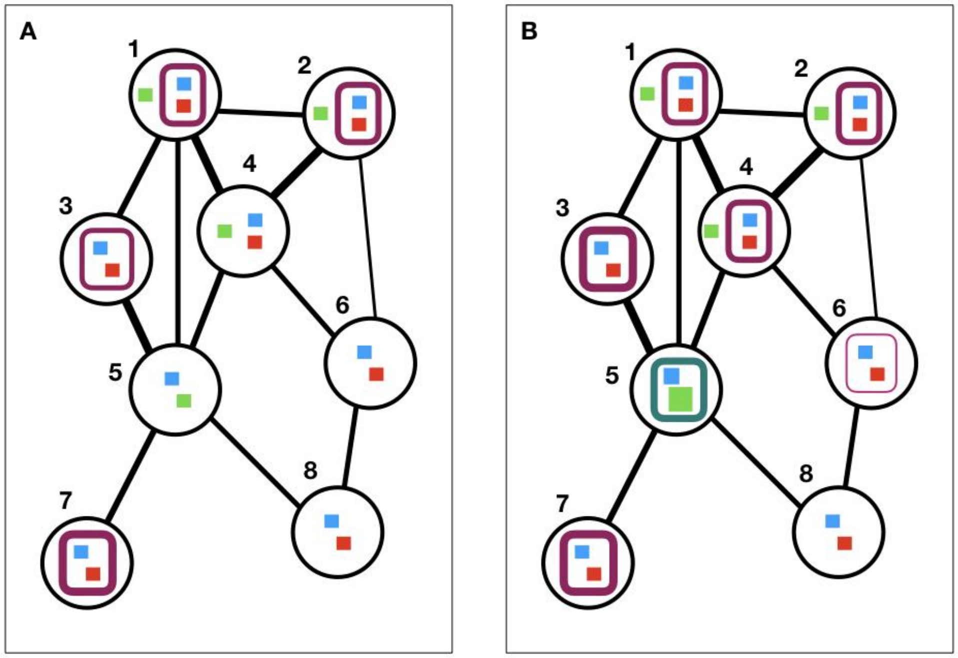

Figure 1.1 An example of a system of agents learning cognitive tools. Nodes represent agents, edges represent the degree to which agents communicate, and colored squares represent cognitive tools. (A) The network at some time. (B) The network after time has passed since A.

others as depicted by the network on the left. Two types of individual differences may be seen within the figure. First, agent 4 and agent 6 have both interacted with agents who previously had the magenta cognitive tool. However, agent 4's magenta cognitive tool is stronger than that of agent 6 because agent 6 only interacted weakly with one other agent (agent 2) that previously had the cognitive tool, while agent 4 interacted with two others (agent 1 and 2). In contrast, agent 8 did not gain the magenta cognitive tool at all because it did not interact with any agents with the magenta cognitive tool. The second type of individual difference may be seen for agent 5. While agent 5 interacted heavily with 3 agents (1, 3, and 7) who use the magenta cognitive tool, it did not have the red cognitive tool, a component of the magenta cognitive tool. As such, agent 5 co-opted the green cognitive tool instead. It's green cognitive tool was strengthened as a result of being used in a non-canonical way. In contrast, the green cognitive tool of agent 4 remained un-strengthened, as agent 4 was able to use the optimal red cognitive tool.

The above reasoning follows a similar line of logic as theories underlying a previously mentioned cognitive variation. Bilinguals are believed to have better inhibitory control, relative to monolinguals, because they must habitually utilized inhibitory control to suppress one language in order to utilize the other (e.g. Kroll, 2015). In this way, inhibitory control may be seen as cognitive tool that is utilized as scaffolding for a bilingual language system. As inhibitory control – as it is used by monolinguals – is not optimized for use with a bilingual language system, it becomes strengthened as it is used within the context of a bilingual language system.

With the above, it clearly follows that there is individual variation within cultural groups. Thus, there will be variation in how individuals are affected by their culture. This is because (1) individuals will be exposed to different parts of their culture and (2) individuals will have different preexisting cognitive styles through which they will learn and adapt to their culture. A full account of cross-cultural variation must be able to account for this individual variation. If a theory cannot account for this variation, then the theory does not truly explain cultural variation as culture itself varies among individuals within a culture.

Studies that measure cognitive differences between cultural groups are quasi-experimental, meaning that the variable that differed between groups (e.g. culture) pre-existed before any measure. Thus, it is difficult to suggest that any given aspect of a culture was responsible for the cognitive differences. These cannot be overcome without experimental manipulations. Measuring individual differences, however, allows one to narrow the possible cultural variables that affect cognition. This can be achieved by eliminating cultural variables for which individual scores do not correlate with performance on specific cognitive tasks.

While differences in performance on cognitive tasks are naturally assessed by the tasks themselves, capturing individual cultural differences can be difficult. In many cases, survey instruments are used in order to capture an individual's background. For example, the LEAP-Q is a survey instrument used to measure the degree to which a multilingual knows each of their respective languages (Marian, Blumenfeld, & Kaushanskaya, 2007). The measure asks the participant to rate various aspects of their linguistic knowledge, including the relative level of reading or spoken proficiency for each language.

All measures that ask participants to self-report rely on the introspective processes of participants. When participants introspect, they are often wrong, not having true privy into their own behaviors and knowledge. Moreover, even if an individual is quite good at introspection, it is difficult to compare that person's rating of themself with another individual's rating. Often, the way in which an individual introspects about themself is cultural. For example, in the case of language experience, native Japanese speakers are more likely to report lower second language proficiency, relative to matched proficiency of Americans due to cultural values of modesty.

Yet, aside from intensively testing cultural knowledge and proficiency, self-report measures provide some of the only means to measure an individual's cultural experience. Additionally, there are means to ensure that self-report measures maintain some form of validity. Such measures can be subjected to statistical tests – such as factor analyses – to ensure that certain questions consistently correlate from participant to participant.

One particular set of survey instruments that have been used within the field of psychology to measure individual differences is personality. Personality measures often rank individuals on a limited set of dimensions that describe differences that are socially relevant (e.g. how talkative or social an individual is, or how likely are they to display a friendly disposition). As they describe socially relevant dimensions, the dimensions outlined in each personality instrument are relative to a particular cultural context (i.e. Japan and the US will have different concepts of what behaviors or lack of are social relevant). However, personality does appear to be linked to differences in cognitive style. Personality has been linked to differences in attention (Poy, Eixarch, & Ávila, 2004), memory (Amin, Constable, & Canli, 2004), language (Jackson, 2018; Pennebaker & King, 1999; Yu et al., 2013), and measures of cognitive control (Murdock, Oddi, & Bridgett, 2013). Differences in the personalities of individuals appear to be driven by both environmental and biological factors (e.g. Jang, Livesley, & Vemon, 1996; Loehlin, McCrae, Costa, & John, 1998). Thus, personality captures aspects of both types of individual differences outlined earlier in this section. As such, a comprehensive measure of personality should correlate with inter-cultural differences in cognitive style.

The relatively few dimensions of personality may be seen as a reduction of a high-dimension space of behavioral variation. Reductions are ubiquitous and essential within cognitive science. As cognition is a complex dynamic system, it is often necessary to infer about the larger system from a single measurement. For example, language processing has been studied using button presses, eye-movements, and mouse-movements. None of these measures capture the full dynamics of cognition. Yet, given careful theoretical grounding, these measures can help reconstruct many properties of the system as a whole. Such can be illustrated with a popular mathematical system known as the Lorenz attractor. The system itself describes a trajectory within 3-dimensional space that loops around two foci indefinitely, such that it creates a shape similar to a bent figure eight or butterfly wings. While the system is 3-dimensional, the dynamics of the entire system can be reconstructed from one single dimension. This can be done simply by plotting the dimension against itself but shifted in time.

Overall, theories explaining cross-cultural variation in cognition must also account for differences in individual variation. If they cannot account for such variation, then different cultural variables are likely responsible for the cross-cultural variation. In this dissertation, I present three case studies that exemplify the study of cognitive variation. these studies place the existence of cognitive variation within the culture-cognition system. Each of these studies account, theoretically and methodologically, for individual differences. These studies are described in the following section.

1.4 The Present Work

Throughout the above sections, I have argued that capturing the effects of culture on cognition require detailed attention to the complex dissemination and use of cognitive tools. Each culture holds a unique set of cognitive tools. These tools are learned by individuals who develop their own cognitive styles, unique cognitive toolsets through which individuals understand and interact with the world. Many of the cognitive tools possessed by individuals are either directly learned from their culture or were necessary to develop in order to meet the task demands of habitual behavior demanded of by their cultures. Thus, differences in cognitive style can be traced to specific cultural differences. It is important to recognize that individuals will differentially be exposed to culture and that they will have unique predispositions for learning and utilizing cognitive tools in specific ways.

Furthermore, many domains of cross-cultural cognitive variation research have yet to truly investigate the mechanisms under which cognitive variation arises. Two of these, as mentioned earlier, are the studies examining the cognitive styles of individuals in East-Asia and the US, and those examining the cognitive styles of monolinguals and bilinguals. In the case of both domains, it is important to understand both (1) the complexities of culture in detail and (2) the role that individuals play in cognitive variation. In this dissertation, I examine these issues in more detail and investigate the role that various cultural variables, individual differences, and personality play in defining cognitive style.

Chapter 2 addresses the recent claims suggesting that bilinguals and monolinguals possess different cognitive styles. Bilinguals tend to have better inhibitory control, the ability to suppress irrelevant information in order to meet the demands of a specific task. Researchers claim that these differences arise because bilinguals must consistently suppress one language while using the other. However, this assumes a monolithic difference between monolinguals and bilinguals. Moreover, language experience, like other domains of culture, are complex amalgams of multiple variables. Thus, isolating the exact mechanisms through which language experience affects cognitive style requires an in-depth understanding of bilingual culture and cognition. The linguistic knowledge of bilinguals – and monolinguals – can be seen as cognitive tools or networks of interconnected component tools such as words, sounds, and syntactic patterns. The organization of these networks depend on the specific linguistic experiences of each individual. Moreover, the connections in these networks can vary in degree (i.e. how dense or sparse the connections are) and in type (i.e. semantic overlap between words or phonological overlap between words). Bilingual networks may generally display particular properties that are different than monolingual networks, but the exact ways in which these networks vary are individual specific. I re-examine bilingualism and its cognitive style consequences and suggest specific variables (overall phonological or semantic density) which might affect cognitive style. I then test how these specific variables relate to cognitive style with a controlled laboratory study. In the experiment, I give participants a task measuring inhibitory control (the attentional network task) before and after they engage in a tasks where they learn to associate pairs of words and objects. Individuals who learned to associate familiar English labels (e.g. 'dog') with novel objects showed improved inhibitory control abilities. The results of the study hint that individuals with densely overlapping phonological networks but sparsely overlapping semantic networks will require greater enhancement of cognitive control. Moreover, individuals who struggled more with the object-word association task showed a bigger increase in inhibitory control. This result suggests that certain individuals possessed pre-existing cognitive tools (inhibitory control) already suited for the task. It was the individuals who possessed slightly different pre-existing cognitive tool-sets that showed improvement in inhibitory control.

In Chapter 3, I address recent studies showing cognitive differences between those in East-Asia and the US. As mentioned above, these studies have shown the individuals in East-Asia tend to possess cognitive styles in which they attend more towards context (i.e. the background of a visual scene) than those in the US. While the exact cultural variables underlying these differences are unknown, many believe that they stem from differences in self-construal (i.e. the degree to which the individual is valued over the group). In order to pinpoint the responsible cultural variable, I take advantage of individual cultural differences and give the participants self-report measures that gauge their cultural experience in several cultural domains. I compare these measures with performance on two tasks that measure attention. The first of these tasks follows many of the cross-cultural studies and measures eye-fixations towards the foreground and background elements of visual scenes. The second task is a mouse-tracking experiment that measures each individual's ability to attend to the local (fine-grain details) and global (overall shape) of objects. The results of the study are quite surprising. Interdependence – a measure of self-construal – correlated with task performance in both studies. However, the direction of the correlation was opposite for the American and Japanese participants. For American's interdependence was associated with context-free attention, while for Japanese, it was associated with context-dependent attention. I argue that individuals who possess self-construal that are deviant from cultural norms must habitually suppress their personal dispositions in order perform in socially competent ways. This habitual suppression, in parallel with bilingualism, leads to cognitive consequences.

The studies in Chapter 2 and 3 both illustrate cases in which the acquisition of particular cognitive tools (language and self-construal patterns) likely result in the strengthening of particular component tools *for particular individuals.* As such, these studies align with the framework outlined here in Chapter 1; individual variation is particularly relevant to the study of cognitive variation. However, these two studies examine individual differences in a limited manner. As the culture-cognition system is particularly complex, the ways that individuals may vary within the system are quite extensive. While these two studies did find correlations between cognitive variation and individual differences, it is still difficult to ascertain exactly what aspects of individual differences mechanistically drive differences in the cognitive consequences of culture acquisition. What is needed is a better understanding of how individual variation in cognition is situated within the larger space of individual differences. As with any high dimensional space, this is difficult. However, particular measures, such as personality, specialize in capturing individual differences with a high dimensional space with a minimal number of higher-order dimensions.

In the final case study, which I present in Chapter 4, I examine cognitive variation within one such measure of personality. I present a project that examines how one model of personality – the Myers-Briggs Model of Personality – is able to capture differences in real-world behavior. The project utilizes an online forum where users have self-identified their Myers-Briggs types. Overall, these results suggest that individuals who are more open to experience (intuitive Myers-Briggs types) have higher vocabularies. This aligns with previous studies showing a link between several of the Myers-Briggs dimensions and language learning/accommodation. These dimensions align with openness to experience and possibly the ability to emphasize with others. Additionally, using a word2vec model (a machine learning algorithm that infers semantic relationships between terms from word distributions), I explore how users on the forum conceptualize the Myers-Briggs types. I use new personality dimensions derived from this analysis to further explain differences in the vocabulary sizes of users and the degree to which they accommodate their language to other users on the forum. The analysis shows the social construction of personality in action, with the online language community ascribing a greater range of behavioral diversity than the original model. Overall, the study demonstrates that similar cognitive differences may stem from different sources of individual variation (different personality dimensions), as multiple dimensions of Myers-Briggs and the word2vec model jointly predicted individual variation.

The three studies of this dissertation together demonstrate that individual differences can arise from the complex interaction of culture and cognition. Each study exemplifies cases in which the dispositions of individuals influence the ways in they acquire or sharpen cognitive tools form their cultural environments. Moreover, the three studies – while examining three seemingly independent examples of cognitive variation – share many similarities, suggesting that the mechanisms through which these cases of variation arise overlap. In the case of bilingualism, individuals will strengthen their inhibitory control abilities because they must be able to suppress competition that arises from the interaction of various aspects of their linguistic knowledge. More complexities in linguistic knowledge will result in more competition. A very similar process appears to take place for the attentional differences in Japan and the USA. Individuals who have dispositions for culturally dis-preferred self-construal patterns show a greater ability to ignore context when exercising visual attention. As with bilingualism, this likely occurs because these individuals must utilize attentional mechanisms to negotiate between multiple cultural/linguistic patterns.

Chapter 2

The Effects of Lexical Learning on Executive Control

Language, like many other aspects of the mind, is inseparable from the rest of cognition. This idea runs contrary to modular conceptualizations of language, which assert that human language faculties carry out their processes independently, without interference from other modules. Such would suggest, for example, that sentences may be processed by a syntax module without it even being privy to the *meanings* of those sentences. However, it is rather clear that such modular views of the mind ignore the recent decades of behavioral and neuroimaging research on language. Language processing, for example, is incrementally constrained by visual cues and affordances in our environment (C. G. Chambers, Tanenhaus, & Magnuson, 2004; Tanenhaus et al., 1995). Moreover, not only is language privy to and affected by other aspects of cognition, language processing itself recruits brain areas involved in seemingly non-linguistic aspects of cognition, such as the sensorimotor cortical regions (e.g., Pulvermüller & Fadiga 2010, Knoeferle, Habets, Crocker & Münte 2007, see Spevack, Falandays, Batzloff, & Spivey 2018 for review).

One particular interaction between language and cognition that has been at the center of much debate is the linguistic relativity hypothesis. While various degrees and types of linguistic relativity have been tested (e.g. Boroditsky, 2001; Bowerman, conceptual, & 2001, n.d.; Lucy, 2016; Lupyan & Spivey, 2010; Matlock, 2004; Whorf, 1941), the general claim of the hypothesis is that an individual's language background will bias how they reason, perceive, categorize, or interact with their environment. Generally, linguistic experience does impact seemingly non-linguistic behaviors. However, while the exact nature of linguistic relativity is debated (see Wolff & Holmes, 2011 for review), there does exist a connection between language and other aspects of cognition.

Among studies examining the relationship between language and cognition, there has been recent attention with respect to language and executive control, a set of related cognitive processes which are responsible for organizing, controlling, and executing the various sub-processes involved in a specific task. These processes include maintaining the current task demands in memory, executing the behaviors necessary to complete the task, attending to information relevant to the task, and suppressing information that may be relevant to the current task goals (Miyake et al., 2000). Recent literature has suggested that bilinguals possess improved inhibitory control, the ability to suppress information that is irrelevant to an individual's current goals or task demands (Ellen Bialystok, Craik, Klein, & Viswanathan, 2004; Albert Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009). Such improvements are suggested to arise because of an increase in the need to regulate two interacting languages.

One implication of these bilingual advantages is that language processing relies on executive control in specific ways. It is clear that something about bilingualism increases the degree to which language processing relies on executive control. However, the mechanisms through which this advantage occurs are rather unexplored. Thus, there is a need to perform precise experimentally controlled studies that examine the relation between language and executive control.

1.1 Review

1.1.1 Bilingualism and Executive Control

Bilingual advantages related to inhibitory control have been shown in various tasks such as the flanker task (Albert Costa et al., 2009) and the Simon task (Bialystok et al., 2004). In all of these tasks, participants must attend towards and respond to the particular features of a target stimuli, while ignoring non-essential features of the target stimuli and non-target stimuli. For example, in the flanker task (Eriksen & Eriksen, 1974), participants are asked to report the direction (i.e. left or right) of a centrally fixated target arrow. This rather trivial task is rendered more difficult by the presence of four additional 'flanker' arrows presented simultaneously with the target. Two of the flanker arrows are presented on either side of the target arrow, such that all arrows together form a line of five arrows. In the congruent condition, all five arrows face the same direction (←←←←←). In the incongruent condition, the flanker arrows face in the opposite direction of the target arrow (←←→←←). On average, participants are slower and less accurate when reporting the direction of the target arrow during incongruent trials. This difference is consistently interpreted to mean that participants must inhibit irrelevant information coming from the flanker arrows during incongruent trials. Thus, the difference — or inhibitory cost — in the average response times (RTs) between congruent and incongruent trials can be taken as a measure of the cost of inhibiting the irrelevant flanker information, as participants can accurately complete incongruent trials with less cost to their RTs. Participants with a lower inhibitory cost are presumed to be more efficient at inhibiting this information.

While the bilingual advantage literature has primarily focused on inhibitory control, as revealed through the flanker and similar tasks, the bilingual advantage appears to extend more generally to various tasks involving executive function. Executive function is recruited for all tasks in order to maintain and carry out task goals, attend to relevant information, and inhibit irrelevant information. While executive function is rather ubiquitous, its exact nature is vague, with a consensus that it is made up of several interrelated processes. Much of the bilingual advantage literature points to Miyake et al. (2000), who identified three separable processes that make up executive function: switching, updating, and inhibitory control. Miyake and colleagues derived these from a factor analysis on individual performances on a battery of several behavioral tasks related to executive function.

Switching involves engaging, maintaining, and disengaging the goals of the current task at hand (Miyake et al. 2000). Behavioral tasks that exemplify this process often require participants to switch from carrying out one set of rules to another. For example, in the Wisconsin Card Sorting Task (Grant & Berg, 1948) — children are given cards, each with a varying number of objects with the same shape and color. Participants are asked to sort the cards into piles based on one feature (e.g. color) and then are asked to sort the cards based on another feature (e.g. shape). Children with less developed switching abilities have difficulty sorting cards based on the second category.

Updating involves the maintenance and manipulation of information that is relevant to the task at hand (Miyake et al., 2000). It is critically related to the notion of working memory. One task that exemplifies monitoring is the N-back task (Kirchner, 1958). In this task, participants are presented with a series of stimuli (e.g. numbers) and asked to report if the current stimuli is the same as the Nth stimuli before it. The task requires participants to hold N-number of stimuli in working memory. The ability to accurately perform the task when being required to hold a larger number of stimuli in working memory indicates better updating abilities.

The existence of a complex set of interrelated processes suggests that the effects of language on executive control may in return be complex. Indeed, early research on the bilingual advantage showed that bilingual children displayed several metalinguistic abilities that surpassed that of their monolingual peers (Bialystok, 1988) as well as other problem solving abilities related to general increases in executive control ability (Bialystok & Majumder, 1998).

Inhibitory cost has been reported on several studies to be significantly less for bilinguals than for monolinguals (Bialystok et al., 2004; Yang, Yang, & Lust, 2011). These effects extend to children (Ellen Bialystok, 2001), adults (Ellen Bialystok, Craik, & Luk, 2008) and even those who learn their second language as an adult (Luk, de Sa, & Bialystok, 2011). The advantages also appear to hold when confounding factors, such as socioeconomic status, are controlled (Calvo & Bialystok, 2014).

Perhaps even more compelling than these behavioral differences, bilingualism has also been shown to affect the onset of Alzheimer's Disease symptoms. When bilinguals and monolinguals are matched by degree of neural atrophy in the brain, bilingual patients will show a delay of behavioral symptoms by up to five years (Craik, Bialystok, & Freedman, 2010). As much of the symptoms of Alzheimer's Disease are related to — but not limited to — executive control, it appears that bilingualism allows individuals more efficient use of physiologically degraded brain areas related to executive function (and other various aspects of cognition).

1.1.2 Bilingual Language Competition

According to the predominant explanation (e.g. Kroll et al. 2015), bilinguals are able to seamlessly produce or understand utterances in a target language, despite the fact that they have an alternative set of sounds, words, and grammatical forms. This entails that bilinguals must be good at inhibiting one language while using the other. Thus, over time, the bilingual must utilize inhibitory control to a larger degree than the monolingual. Because inhibitory control and other aspects of executive control are domain general, with the same brain networks responsible for all processes that require similar control, bilinguals will show increased inhibitory control abilities even for tasks that do not invoke language, such as the flanker and Simon tasks. Evidence for the predominant view can be seen both in behavioral tasks and neuroimaging. The behavioral evidence primarily exemplifies that the language production and perception of one language are affected by and require the suppression of a second language. The neuroimaging evidence in contrast, demonstrates that the control processes network utilized during bilingual language use indeed overlaps – or is perhaps identical – with the general executive control network.

On average, bilinguals tend to be slower when naming images compared to their monolingual peers. However, these same participants will not differ from their monolingual peers when sorting these same images into natural or hand-made objects, subjecting that bilingual latency differences are purely linguistic (Gollan, Montoya, Fennema-Notestine, & Morris, 2005). Such suggests that these latencies are limited to *linguistic* processing. Similar latencies have been shown in word reading times. When reading cognates — words with similar meaning and phonology/orthography in two languages — bilinguals are faster than their monolingual peers (Costa, Caramazza, & Sebastian-Galles, 2000). These effects hold even when these cognates are embedded in a sentence, suggesting that the effects of bilingualism on cognate recognition still holds even when there is a strong context which would prime for one language over another (Schwartz & Kroll, 2006). Moreover, bilinguals have slower recognition times when reading homographs or 'false cognates' — words with similar orthographies but different meanings (Lemhöfer & Dijkstra, 2004). And, their spoken word recognition exhibits interference from similar-sounding words in the other language (Marian & Spivey, 2003; Spivey & Marian, 1999). These latencies are usually taken as evidence that a bilingual's two languages consistently compete, even when the bilingual is within a monolingual context.

Evidence for the active inhibition of one language in order to utilize the other can be seen in the language switching task. In this paradigm, bilingual participants are asked to name objects (often these are digits, but in some cases other images are used) in one of their two languages. The target language is indicated by color of the image or other cue. Interestingly, bilinguals that are dominant in one language show greater naming latencies when switching from their L2 to their L1 than from their L1 to their L2. This asymmetrical switching cost is often presented as unintuitive, as L2 words should be harder to produce, because the L2 is less automatic and individuals have been exposed to words in their L2 less on average than words in their L1. Green (1986, 1998) suggests that when naming an object in one language, the other language is inhibited. When switching form one language to the other, an individual must overcome the inhibition of the previous target language. Because the L1 is dominant, the L1 must be suppressed more when an individual is speaking the L2 than vice versa. Thus, there is a larger latency when switching from the L2 to the L1 because the L1 was inhibited to a higher degree. These results suggest that the presence of a second language does indeed require control in order to utilize or switch between languages, those providing a general mechanism through which bilingualism leads towards greater executive control abilities.

Green and Abutalebi (2018) argue that Bilingual Language Control utilizes a cooperative network that recruits several regions of the brain, including the prefrontal cortex, anterior cingulate cortex, the parietal cortex, basal ganglia, and the cerebellum. The roles of these areas tend towards conflict resolution (PFC), conflict detection (ACC), bottom-up language selection (PC), maintaining the target language (Basal Ganglia), and temporal control (Cerebellum). This network itself, as well as the roles of its component areas, overlaps considerably with the executive control network. Together, these studies suggest that language processing for bilinguals does involve executive control. However, this does not necessarily indicate that only or all bilinguals will utilize a strong degree of control when processing language.

1.1.3 Degrees of Competition

The abovementioned findings show a clear indication that language competition occurs for certain bilingual individuals. However, these findings also suggest that a bilingual's degree of competition is a function of language dominance (i.e. the relative degree to which each language is used). If switching costs are incurred for transiting from a non-dominant language to a dominant language, then it would follow that the degree to which the L1 is dominant – relative to the L2 – affects the switching cost. Moreover, Green and Abutalebi's (2013) adaptive control hypothesis suggests that the degree to which cognitive control is affected by bilingualism is a consequent of the degree to which language-switching occurs within community settings. For example, there should be a greater effect for individuals within a dense code-switching community, while there should be a smaller effect for individuals living in a community where each language is spoken in a separate context (e.g. school versus home). It follows that studies examining the bilingual advantages should pay close attention to the language dominance of research participants. Moreover, any studies examining the connections between language and executive control should closely attend to the linguistic knowledge the participants.

One example of different degrees of the bilingual advantage can bee seen in age of acquisition (AOA, i.e. the age at which the second language was learned). While much debate has centered around how the AOA affects ultimate attainment of proficiency in the L2, it is now generally understood that rough fluency is attainable regardless of the AOA, even if less common (Abrahamsson and Hyltenstam 2008). Regardless, differences in the AOA will affect an individual's linguistic system. These extend to the executive control advantages. Luk, De Sa, & Bialystok (2011) looked at the performance of bilinguals with early and late AOAs with a flanker task. Only early bilinguals showed more efficient inhibitory controls over monolinguals. However, Tao et al. (2011) showed a slight advantage over monolinguals in a lateralized attentional network task (ANT). This advantage may have been revealed in this study due to the more difficult nature of the lateralized ANT. Additionally, Tao and colleagues found that the late bilinguals showed improved monitoring, compared to early bilinguals.

There is also an implicit assumption within the bilingual advantage literature that a bilingual's two languages are separable. If an individual must suppress one language in order to speak the other, it follows that each language is suppressible, separately form the other language. In contrast, there is evidence to suspect that a bilingual's languages are likely intertwined, with cognate and other forms of linguistic competition occurring because of shared neural substrates. One example of language overlap can be seen in interlanguage cognates. Most competition effects for cognates can be seen between two words, with similar sounds, but different meanings. However, in some cases, similar sounding words share meanings between language. Facilitation effects caused by true cognates suggest cases in which a similar level of competition is absent, as true cognates may produce very overlapping or perhaps identical activations; they are treated as one word despite patterning in two languages. Such homograph effects on word reading are not limited to interlanguage homographs processed by bilinguals. When monolinguals read within-language homographs (e.g. "lead" as in the metal and "lead" as in the act of leading) they are slower to read them than non-homograph words of similar frequencies (Kawamoto and Zemblidge 1992; Gottlob et. al 1999). The parallels of interlanguage and intralanguage homographs offer two implications: (1) interlanguage homographs behave as if bilinguals possess a single interconnected network of linguistic knowledge and (2) the same linguistic competition that is necessary for bilinguals is present – perhaps to a lesser degree – for monolinguals.

Connectionist models of language learning demonstrate that the L1 and L2 interconnectivity naturally occurs within biologically inspired neural networks (Elman, 1990.; French & Jacquet, 2004). Such neural networks are able to successfully learn two languages without explicitly separating them into non-interacting partitions. In fact, when the learning of one language after the other has been learned to some degree, the second language becomes distributed among the first language. Thus, any operation performed that would suppress one language would be rather complex. Complex patterns of language suppression are mirrored by studies showing that switching may constrain subsets within languages, rather than full language suppression. For example, Finkbeiner, Almeida, Janssen and Caramazza (2006) employed a language switching task in which bilingual participants named both digits and line drawings. Line drawings were always named in L1, but digits were named in either the L1 or L2. When naming line drawings in L1, participants were equally fast, regardless of the language of the previous item. Moreover, the phonological and semantic overlap of two languages can vary between language pairs and individual learners (Arbesman, Strogatz, & Vitevitch, 2010; Malt, Li, Pavlenko, Zhu, & Ameel, 2015).

As with homographs, parallels can be drawn with intralanguage competition. Abutelebi and Green (2008) gave bilinguals a language switching task, a switching task in which participants were cued to identify an image with a noun or verb, and an image naming task with no switching. Naming latencies for the noun/verb switching task were comparable to those of the language switching task. Furthermore, Abutelebi and Green acquired fMRI activations during each trial. The noun/verb switching task and the language switching task shared common areas of activation, including the middle and inferior frontal gyrus. As these areas are critical in conflict resolution, it would appear that executive control is needed for within and across language competition alike.

These qualifiers of the overlap between any given bilingual's two language suggest that the bilingual advantage depends on the specific language background of the bilingual. Furthermore, even if bilingualism generally led to improved executive control, it should not be the case that bilingualism reliably leads such advantages. Indeed, despite a large number of studies reporting executive function advantages among bilinguals and many others showing the need to suppress one language in order to speak another, some studies have reported mixed results and failures to replicate (Paap & Greenberg 2013, Paap, Johnson & Sawi 2015). Together, studies on bilingualism indicate that the relation between executive control and language use is complex, needing further exploration.

1.1.3 Testing the Link between Language and Executive Control

Up until this point, the exact relation between language and improved executive control is speculative. It is unclear as to the specific kinds of language competition and interactions that require the use of certain kinds of executive control. As the field gradually is able to pinpoint the exact situations under which the bilingual advantages arise, it is also necessary to build a stronger framework through which to understand the relationship between language and executive control more generally. By understanding the kinds of linguistic processes that that recruit executive control, better hypotheses may be made concerning the specific instances in which bilingual advantages arise, as well as general correlates between language use and executive control.

Two potential sources of competition are the presence of phonological and semantic density within an individual's linguistic network. Within this network, words are connected based on the degree to which they are phonologically or semantically similar. As described above, bilinguals and monolinguals alike are influenced by such similarities between words, as seen in the effects of cognates and false cognates. In cases where density leads to inhibition, processing will require greater inhibitory control. However, the exact effects of phonological or semantic density – the number of connections to a particular word – are debated in the literature, with there being evidence that density facilitates or inhibits the processing of a word (Abdel Rahman & Melinger, 2019; Siew & Vitevitch, 2019). As such, it is yet unclear how the organization of a linguistic network requires the use of inhibitory control.

As with other aspects of linguistic relativity, controlled laboratory settings are necessary in order to examine such mechanisms in precision. Otherwise, it is difficult to ascertain how very specific aspects of language may lead to cognitive differences. One behavioral approach that can assist in this understanding is task transfer. In task transfer, one task is performed in-between two identical tasks (i.e. Task-A, Task-B, Task-A). In most cases, there is improvement in the second performance of task-A, due to practice effects from the first performance of task-A. For some task combinations, however, there is improvement from the first task to the third task that is beyond improvement seen when a control task is used (ie. Task-A, Control, Task-A). If such occurs, then it can be inferred that practice during the intervening task (in addition to practice form the first performance of task-A) transferred to the other task because both tasks require similar processes.

Performance on executive function tasks have been shown to improve after training. Facilitated performance has been shown with training tasks that test similar aspects of executive control (near transfer) and tasks that are dissimilar (far transfer). Following such labels, near transfer may be described as akin to practice affects, while far transfer demonstrates the processes that underlie specific tasks are domain general and are utilized in the execution of a large array of differing tasks. Far transfer has been shown for many executive function related processes, including working memory (Au et al., 2015; Jaeggi, Buschkuehl, Shah, & Jonides, 2014) and switching tasks (Karbach & Verhaeghen, 2014).

There is limited evidence suggesting the effects of transfer *from* inhibitory control tasks. Indeed, several studies show an absence of transfer (Enge et al., 2014). However, several studies do show transfer from various tasks *to* inhibitory control. For example, Karbach and Kray (2009) showed that performance on the Stroop task was improved if participants are trained on a task that involves switching. This improvement was less if the training task did not involve a switching cost. Many similar studies have shown inhibitory control improvements from working memory tasks (e.g. Thorell, Lindqvist, Nutley, Bohlin, & Klingberg, 2009)

Prior and Gollan (2013) had participants undergo four blocks of switching tasks. The second two blocks were separate from the first two blocks by a week. Half of the participants performed a language switching task for the first, second, and fourth block, with a color-shape switching task for their third block. The other half of participants performed the color-shape task for their first, second, and fourth blocks, with the language task for their third. They found that the third language block of the second group performed more quickly than the first block of the first group. In other words, performance on the language switching task was significantly greater if participants had performed a color-shape switching task the week before. However, the reverse effect of language switching transferring to the color-shape task was not observed. While the Prior and Gollan (2013) study did not show transfer from a language task to an executive control, the task transfer paradigm none-the-less offers a way to study individual mechanisms through which language processing shares processing with executive control tasks.

Task transfer appears to be a promising paradigm that can be used in order to test how the relation between specific aspects of language relate to specific aspects of executive control. As the bilingualism literature suggests that the learning of a second language strengthens executive control, this study presents an experiment in which individuals learn novel word-object pairings. As homographs have been shown to be particularly competitive, the vocabulary items varied in the degree to which they matched the sound structures of English words. In addition, conditions varied in if the object being learned was a familiar or novel object.

2.3 Experiment

2.3.1 Methods

Participants

A total of 300 undergraduates at the University of California, Merced participated in this experiment. All participants received extra credit in one of their university courses as compensation for their participation. A total of 60 individuals participated in each of the five conditions. All participants were above the age of 18 and provided written consent for participation in the experiment.

Stimuli

All parts of the experiment were presented on a 27-inch monitor using MatLab Psychophysics Tool Box 3 Psychophysics Toolbox Version 3 (Brainard, 1997). For each trial, a central fixation cross appeared alone in the center of the screen for 1300 ms. The fixation cross remained in the center of the screen for the duration of the trial. After 1300 ms, either an asterisk-shaped cue would be displayed above or below the cue for 100 ms or the central fixation cross would remain alone on the screen for 100 ms.

For the language-learning task, twenty word-object pairs were constructed for participants to learn. A set of twenty everyday objects were gathered with a Google image search. I selected a set of twenty novel objects from images in the novel object and unusual name database (Horst & Hout 2016). All images were selected such that they showed a single object set to a white background. For each of the twenty everyday objects, audio files of their English labels were generated using Apple text-to-speech. In addition, twenty novel words were generated such that each word matched one of the twenty English labels by syllable (e.g. the English label 'dog' with the novel word 'hin'). These were also made into audio files with Apple text to speech. The images and words were paired together as follows: everyday objects with their English labels (the control condition), everyday objects with non-matching English labels (familiar-object/familiar-label), everyday objects with novel words (familiar object novel label), novel objects with everyday words (novel-object/familiar-label), and novel objects with

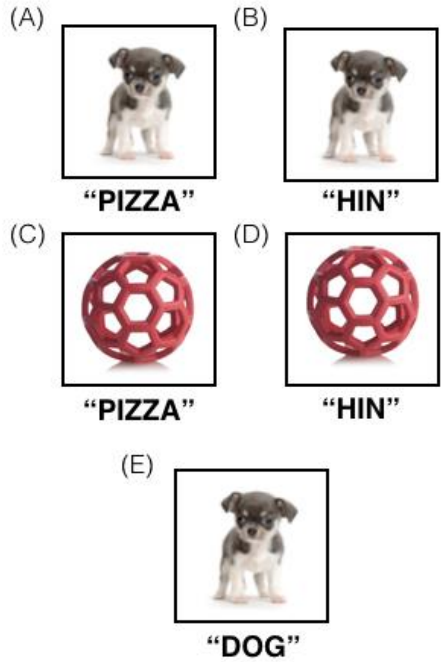

Figure 2.1 Examples of object-word pairings for all conditions. (A) a familiar object paired with a familiar word, (B) a familiar object with a novel word, (C) a novel object with a familiar word, (D) a novel object with a novel word, and (E) the control, a familiar object with its English label.

novel words (novel-object/novel-label). Example object-label pairs for each condition are shown in Figure 1.

We decided to present object-label pairs to participants in a way that did not test their knowledge of the object-label pairs as they were learning them. In case where participants give feedback that is incorrect, incorrect labels will be learned (McCandliss, Fiez, Protopapas, & Conway, McClelland, 2002). Thus, we presented participants with a continuous loop of on the computer screen for 3 seconds. After the first second, the audio label was played, and the orthographic representation was displayed below the image. Each object-label pair was presented a total of 20 times and in a randomized order. The entire presentation lasted 20 minutes.

Procedure

After giving informed consent, participants were first asked to carry out the ANT. Instructions were given both on the screen and verbally. Participants were instructed to press the button 'P' or 'Q' on the keyboard to indicate the direction of the target arrow. Participants were given five practice trials, and then completed two blocks with 96 trials each. In between the two blocks, participants were given a short break to rest.

After the ANT task, participants were given one of 5 object-label association tasks. Regardless of the condition, participants were given the following set of verbal instructions: "You are learning a 'secret code.' You may already know parts or all of the code, but you will be tested on your knowledge of the code when you are done." Participants were then instructed to repeat the label while looking at the object after each time the label was played by the computer. Participants were monitored during the language learning task to verify that they were verbally repeating the label throughout the task. After the association task, participants were given another ANT task.

2.3.2 Results

Data Preparation

Trials were included only if participants gave the correct response. In addition, individual trials were removed if they were from incorrect trials or if they exceeded 2.5 times the standard deviation from the mean RT of each participant. In total, 9.03 % of all trails were eliminated because of these criteria.

Vocabulary Recall Accuracy

All participants in the control condition got all 20 items on the vocabulary recall test. This is unsurprising as all items for the control group consisted of everyday objects and their English labels. The familiar-object/familiar-label group scored an average 89.6 percent accuracy, the novel-object/familiar-label scored an average of 98.5 percent accuracy, the familiar-object/novel-label scored an average of 86.9 percent and the novel-object/novel-label scored an average of 86.2 percent.

A 2 (label familiarity) by 2 (object familiarity) ANOVA was performed on the vocabulary test scores. There was a significant main effect for object familiarity ($F(1,228)= 6.469$, $p=0.0116$), as well as a significant main effect of label familiarity ($F(1,228) = 11.377$, $p<0.001$). In addition, there was a marginally significant interaction of label and object familiarity ($F(1,228) = 3.417$, $p =0.0658$).

Analysis of Reaction Times

This primary goal of the analysis was to examine how performance on the ANT task changed after participants completed the object-label association task. Many previous studies – especially in the bilingual literature – have used calculations of inhibitory cost (i.e. the difference in means between the congruent and incongruent trials for each participant). However, Costa and colleagues (Albert Costa et al., 2009) have suggested that overall RT should be considered. In addition, the design of this experiment makes it difficult to use methods such as performing analyses on singular data per individual because they fail to fully consider within individual variance. Thus, a mixed effects linear model was selected for data analyses.

A total of six fixed effects were included in the model. A dummy coding scheme was used for these factors. The first two fixed effects were (1) if a trail had congruent or incongruent flankers (congruency) and (2) if a trial took place in a block after the association task (block). Both of these two factors and their interactions were also included as random factors. The next two fixed effects accounted for the familiarity of objects (object familiarity) and labels (label familiarity). For image familiarity, only trials after an association task with novel images were coded as 1. Trials that took place before the association task were dummy coded as 0, even if they were performed by participants who would later perform an association task with novel images. This was done because there is no theoretical reason to suspect group-level differences in participants before the association task beyond those captured by individual random effects. The same coding scheme was done for trials after association tasks with novel words.

A fixed effect was created to separate the control group form the familiar-word familiar-image group. The baseline is the only group where participants were asked to pair images and words for which they already knew the paring (i.e. the word 'puppy' with the image of a puppy). As with image and word familiarity, this effect – henceforth called alignment – was dummy coded as a 1 only for trials after completing the aligned association task.

Finally, score on the vocabulary task was included as the final factor. All scores for trials before the association task were coded as 0, while all the scores for trials after the association were mean centered. Again, there is no theoretical reason to suspect that performance on an association task will affect trails that preceded it. The interactions of all factors were included in the model.

As participants must inhibit irrelevant information in incongruent trials, participants are expected to have slower RTs in these incongruent trials. Indeed, there is significant main effect of congruency, with participants performing an estimated 68.7 ms slower for incongruent trials ($F(1,543.16)=48.1979$, $p < .0001$)[6]. In addition, trials taking place in the second block, after the image-word association task are an estimated 26.2 ms faster than trials before the association task ($F(1,288.16)=5.2463$, $p = 0.0227$). This is also expected, as practice effects from the first block will help participants to perform the second block with familiarity and efficiency. However, there is no interaction between congruency and block, meaning that inhibitory cost is not significantly different in the second block. This suggests that practice had a general effect on task performance, but the specific mechanisms underlying inhibitory control have not benefited from this practice.

A baseline group (the 'aligned' group) was included in this experiment in order to understand if the effects of the vocabulary tasks were simply due to practice. There were no significant effects of alignment, meaning that the baseline did not differ significantly differ from the unaligned familiar words and familiar images group. However, this does not rule out the possibility that other groups differed from the baseline. Due to the dummy coding of the model, these differences will appear as effects of the association tasks via the factors of word familiarity or image familiarity.

The model showed several effects related to the specific association task assigned to each participant. Trials that took place after completing the association task with familiar-labels are an estimated 10.2 ms faster than those after novel-labels association tasks ($F(1,309.55) = 17.2988$, $p < 0.0001$). There is also a significant effect of object familiarity, with trials after novel-object tasks being an estimated 182 ms faster than trials after familiar-object task ($F(1,288.54)=6.1012$, $p=0.0140$). However, there is also an interaction, with RTs being an estimated 183 ms slower for trials after the novel-object/novel-label association task ($F(1\ 288.54) =11.010$, $p=0.001$). Together, these effects show that participants who learn to pair familiar labels with novel objects had faster RTs in the second block.

The difference between congruent and incongruent trials was also affected by the special association task that the participant was given. After being given a novel-object association task, incongruent trials were an estimated 11.8 ms slower than other trials ($F(1,522.88) = 11.3520$, $p = 0.0008$). After being given a novel-label association task, incongruent trials were an estimated 13.1 ms faster than other trials (F(1 522.88 13.8065 0.0002245). However, incongruent trials after the novel-object/novel-label task were an additional 9.5 ms slower than other

[6] P-values have been estimated with type III sum of squares, using the lmerTest package.

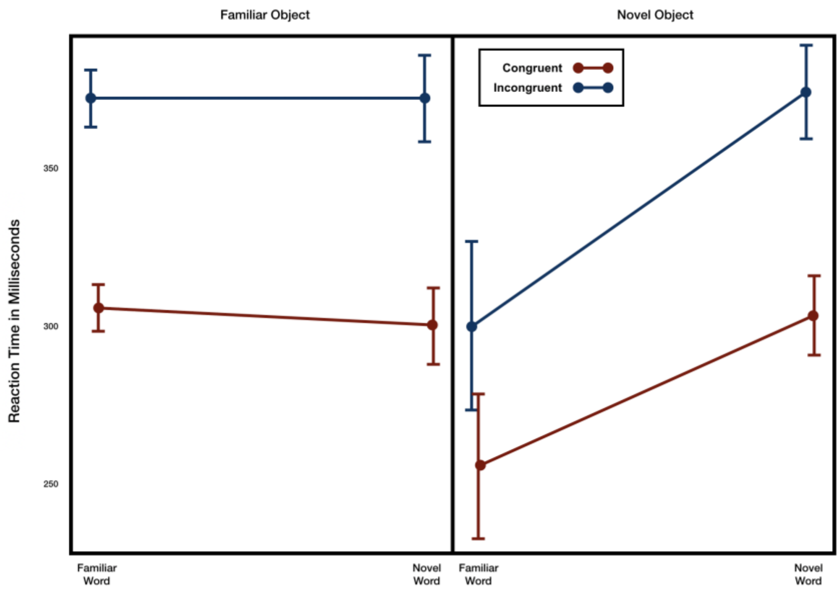

Figure 2.2 Model estimates for the congruent and incongruent trials after the four experimental group association tasks. Error bars indicate 95% confidence intervals for the model estimates.

trials ($F(1,522.89) = 7.3490$, $p = 0.0069$). Together, these results show that inhibitory costs are lower for incongruent trials taking place after the novel-object/familiar-label association task. These affects are shown in Figure 2.2. Overall, the decreased inhibitory and better overall efficiency seen after the novel-object/familiar-label suggests that inhibitory control my be slightly strengthened when learning new words that are phonologically similar but conceptually different form words and concepts known by individuals.

There are also several effects of score. These include a main effect of score ($F(1,311.13) = 10.9032$, $p = 0.0010$), a congruency and score interaction ($F(1,540.49 = 4.0271$, $p = 0.0452$), a score and label-familiarity interaction ($F(1,311.13) = 24.6141$, $p < 0.00001$), a score object-familiarity interaction ($F(1,311.13) = 18.8132$, $p < 0.0001$), a score, congruency, and label-familiarity interaction ($F(1,540.47) = 8.5657$, $p = 0.0035$), a score, congruency, and object-familiarity interaction ($F(1,540.47) = 7.8610$, $p = 0.0052$), a score, label-familiarity, and object-familiarity interaction ($F(1,311.13) = 20.755$, $p < 0.0001$), and a score, congruency, object-familiarity, and label-familiarity interaction ($F(1,540.48) = 4.5333$, $p = 0.0336$). As interactions within a complex dummy coded mixed-effects model, these interactions are difficult to interpret.

Overall, the model estimated that for the familiar-label/novel-object condition, overall RTs correlate with score on the vocabulary test.

In other words, those who performed lower on the vocabulary test had faster RTs. Because this condition has the overall highest vocabulary scores, it is possible that correlation between score and performance is highly influenced by a few individuals who scored low on the vocabulary test. As such, this effect should be interpreted cautiously. However, if the effect is treated seriously, it appears to run counter to the previous results. As other effects show a link between the familiar-label/novel-object group and higher efficiency, it might be expected that those with higher scores would have higher efficiency. In addition, it might be the case that those with higher scores were able to complete the tasks with such efficiency that they did not need to utilize inhibitory control beyond their capacities in order to complete the task. However, for those who were not able to complete the vocabulary task with full competence, it is likely that they struggled to exercise inhibitive control beyond their normal capabilities. Thus, those with lower vocabulary scores would show higher transfer effects of inhibitory control.

2.3.3 Discussion

The purpose of this chapter was to examine the mechanisms under which bilinguals will increase specific cognitive abilities know as inhibitory control. In process that involve inhibitory control, individuals must suppress irrelevant information in order to meet the demands of a particular task (Miyake & Friedman, 2012). For example, in the case of ANT task given in this study, participants had to suppress information from distractor arrows in order to report the direction of a centrally fixated arrow. Several studies have reported increased inhibitory control abilities in bilinguals (Bialystok et al., 2004, 2008, 2008; Calvo & Bialystok, 2014; Albert Costa et al., 2009).

A common explanation for these bilingual advantages is that bilinguals must habitually inhibit one language in order to utilize the other (e.g. Kroll et al. 2015), While this explanation is warranted given the immense control involved in bilingual language production and perception, it fails to recognize the complexities of the bilingual mind. The languages of a bilingual likely influence each other and overlap in many ways. This can be seen in the literature examining bilingual processing and production, as well as in neural network models of second language learning.

With such a complex overlap between languages, the need for inhibitory control likely varies in degree, depending on the exact nature of this overlap. Psycholinguistic studies examining language perception in monolinguals and bilinguals show various effects of phonological and semantic density (Abdel Rahman & Melinger, 2019; Siew & Vitevitch, 2019). In some cases, the presence of phonologically or semantically similar words help to facilitate processing (Blumenfeld & Marian, 2011; Gordon, 2002; Vitevitch, 1997). In other cases, the presence these lexical neighbors slow processing (Ziegler, Grainger, & Brysbaert, 2010; Cluff & Luce, 1990; Dell & Gordon, 2003; Gordon, 2014; Munson & Solomon, 2004; Scarborough, 2010, 2013; Vitevitch & Luce, 1998). It is likely that bilinguals must use inhibitory control when language overlap leads to competition, rather than facilitation. However, with ambiguities in the literature, it is difficult to suggest how the specific overlap between languages necessitates the use of inhibitory control.

This chapter aimed to broadly examine how potential overlaps with one's current linguistic knowledge affect inhibitory control. This was achieved by giving participants a task measuring inhibitory control (i.e. the ANT) before and after learning a set of image-word pairings. If a participant's ability to use inhibitory control changed in the time between the first and second ANT, then much of this change may be attributed to the use of inhibitory control during the image-word association task. Specific kinds of overlap between the language learned during the association task and the learner's linguistic knowledge will cause more changes in the second ANT. Thus, the task may help to identify which aspects of linguistic overlap are potentially relevant to understanding the bilingual advantages.

As a first attempt to understand the mechanisms that underlie the bilingual advantage, the experiment conducted in this chapter tested extreme cases of language learning. In the object-label association task, participants were asked to learn labels that were either novel words or words that were identical to English words. They were also asked to pair these labels with either familiar or completely novel objects. Pairing objects with known English words is an exaggerated case of learning false cognates, while paring words with novel objects is an exaggerated case of learning vocabulary words for novel concepts. While both cases are exaggerated, the effects of learning these parings on inhibitory control are useful for the understanding of bilingual advantages, as they help to further understand the relationship between lexical overlap and inhibitory control.

A total of five object-label association conditions were used. One of these acted as a baseline control in which participants 'learned' to pair objects with their everyday English labels. The other four consisted of a 2 by 2 design, with a familiar-object familiar-label group, a familiar-object novel-label group, a novel-object familiar-label group, and a novel-object novel-label group. Of these groups, the novel-object familiar-label group showed a decrease in overall RT in the second block of ANT trials. In addition, this group also showed a decrease in the inhibitory cost for incongruent trials. This result suggests that the use of inhibitory control was transferred form processes utilized in the novel-object familiar-label task to the second block of ANT trials. Therefore, the process of pairing a familiar label with a new object utilizes inhibitory control. This is interesting, given that none of the other trials showed any differences relative to the aligned group.

It is important to note that, of the four experimental groups, participants scored the highest on the novel-object familiar-label vocabulary test. In the novel-label condition, participants would have had to memorize a set of words. This memorization might have added to the particular difficulty of the novel-label condition. However, the familiar-label familiar-object also had lower vocabulary scores than the novel-object familiar-label group. In the familiar-label familiar-object task, participants would have had to simultaneously suppress the label for the familiar object while suppressing the object that usually pairs with the familiar label. Perhaps this dual suppression made the task particularly difficult. Regardless, the ease of the novel-object familiar-label group supports the fact that this condition was particularly different form the others.

Taking the results of this study into consideration, there must be something about pairing novel objects with familiar labels that utilizes inhibitory control. The language networks of bilinguals – and monolinguals alike – may overlap in many ways. Moreover, overlap can pertain to different levels of linguistic information, such as phonological or semantic. These familiar-label novel-object pairings perhaps are most akin to learning alternative meanings to previously known words or to learning words for novel concepts in a second language (or first!) that have considerable phonological overlap with previously known words. As such, the results of this study suggest that the bilingual advantages are related to similarities in the phonological patterns of words and differences in the semantics categories of the two languages.

Overall, this study supports the notion that bilingualism should not be treated as a monolithic category. The internal systems of linguistic knowledge that individuals possess are part of the larger culture-cognition system. Just like all cognitive tools, the spread and organization of linguistic information is highly interactive, fluid, and difficult to measure in its entirety. However, in order to understand these systems, a certain level of research must be done in understanding the organization of information (i.e. the *content*) within the system. In the case of language, the culture-cognition system consists of a rich network of sounds, words, syntactic patters, and social contexts.

As the necessity of inhibitory control appears to be necessary for only *specific* types of linguistic overlap, the mechanisms underlying bilingual advantages do not stem from the general existence of a second language. In other words, bilingual advantages do not arise because of the habitual suppression of a full language. Rather, it is the specific organization of the linguistic system determines the degree of inhibitory control necessary for language processing or language learning.

Chapter 3

A Cross-National Study Examining the Effects of Culture on Attention

Attention is a fundamental aspect of human cognition. It is an integral component of visual processing and is used in a variety of tasks such as communication and decision making. Yet, visual attention varies significantly between individuals and cultures. A particular body of work has shown that individuals from East-Asian (i.e. Japan, Korea, and China) and Anglo-American (i.e. Canada and the USA) countries vary in their attentional styles (e.g. Nisbett et al. 2001, Kuwabara & Smith 2012, Masuda & Nisbett 2001). These differences have most abundantly been shown between individuals in the United States and Japan.

East-Asians tend to rely more on context and a broader set of details than Anglo-American[7] nationals while attending to information. For example, while all individuals attend to objects in the foreground more than the background of a visual scene, Japanese attend to the elements of a visual scene that surround a foregrounded object more than Americans. Americans attend more to a foregrounded object itself, while largely ignoring the context that surrounds the object (Masuda & Nisbett, 2001; Senzaki et al., 2014b).

These stylistic differences extend to a variety of cognitive behaviors, such as eye-movement patterns while viewing natural scenes (Masuda & Nisbett 2001), the recognition of basic geometric shapes (Kitayama, Duffy, Kawamura, & Larsen, 2003), categorization (Gutchess, Hedden, Ketay, Aron, & Gabrieli, 2010), reasoning (Norenzayan et al., 2002) and social cognition (Markus & Kitayama 1991). For example, given the choice to categorize an object into one of two sets of objects, Anglo-Americans will identify a singular feature that is true for all objects in each set (i.e. a particular petal shape for a group of flowers), and then categorize the object with the group with which it shares this singular feature (Norenzayan et al., 2002). However, East-

[7] Throughout this chapter, participants born in the United States are referred to as Americans.

Asians will categorize the object with the group that overall has the most features in common with the object.

One particular cultural variable has been proposed throughout the literature as the underlying reason for these differences in cognitive style. This variable is self-construal, the degree to which members of a culture will hold the needs of an individual above the needs of a group (Kühnen & Oyserman, 2002; LeFebvre & Franke, 2013; Takahiko Masuda & Nisbett, 2006b; Nisbett & Miyamoto, 2005; Oyserman & Lee, 2008). While East-Asian and American cultures do indeed possess different modal self-construal patterns, it is not clear how self-construal causes such differences in cognitive style. Because cultures are complex and vary in many ways, there exist other cultural variables that differ between East Asia and the United States. Among these are differences in the languages and structural environments of these cultures. Moreover, if a cultural variable is truly responsible for the cognitive styles of individuals within culture-cognition system, then the degree to which individuals are exposed or adhere to that cultural variable will correlate with that specific aspect of cognitive style.

In this chapter, I assess the cognitive styles of individuals in the United States and Japan. For this work, I give participants a series of survey instruments which measured individual differences with respect to several cultural variables: self-construal, language background, syntactic preferences, and exposer to physical layouts typical of Japanese and American cities. In addition, I have participants complete two experiments that measured their attentional styles. Finally, I examine the relations between the attentional styles and self-reported cultural experiences.

3.1.1 The Scope of Cognitive Style Differences

Throughout the literature, the American attentional style has been labeled 'analytic' while the East-Asian attentional style has been labeled 'holistic.' The analytic/holistic distinction appears to relate to the classic cognitive style of field-independence. For example, in the rod and frame task (Witkin, Lewis, Hertzman, & Machover, 1954), participants are asked to rotate the position of a rod until it is vertical. This rod is placed within a frame that has itself been rotated. Participants are scored as more field-independent if they are able to ignore the orientation of the frame and position the rod with respect to absolute position. Americans perform better at the rod-and-frame task than Chinese nationals (Ji, Peng, & Nisbett 2000). In contrast to the traditional rod-and-frame task, where ignoring context improves performance, Kitayama, Duffy, Kawamura, and Larsen (2003) gave participants a variant of the rod-and-frame task in which participants were shown a line embedded in a square and then asked to reproduce the line in a second square. As the second square was a different size than the first square, ignoring context in this task will hinder performance. When participants were asked to draw the line such that the length was proportional to the size of the new square, the Japanese participants performed better than the American participants. In a similar task where participants had to identify if line lengths were the same as the line in the previous square, East-Asian born individuals showed greater activation in frontal and parietal regions when asked to make judgments based on absolute line lengths (Hedden, Ketay, Aron, Markus, & Gabrieli, 2008). Those born in the United States had similar activations when judging based on relative line lengths. Given the role of these brain areas in cognitive control, their activation likely represented the detection and suppression of culturally-prefered information and actions.

Attention

Eye-tracking studies have shown a general tendency for Americans to focus their attention more on the salient features of their visual scene. For example, Chua, Boland, and Nisbett (2005) had Chinese and American participants rate a series of images consisting of a central focal object against an appropriately matched background. Chinese participants had more fixations towards the background than American participants. In addition, American participants had an earlier initial fixation on the object than the Chinese participants. Similar results have been repeated in moving scenes (Masuda & Nisbett, 2001; Senzaki, Masuda, & Ishii, 2014).

There is also evidence from change blindness studies. When two similar images are presented sequentially one after another, separated by a small gap in time, participants find it difficult to detect subtle differences between the images. Masuda and Nisbett (2006) gave American and East-Asian participants image pairs that changed either in the foregrounded object or the background. While the groups were equally good at detecting changes in objects, the East-Asian participants were better at detecting changes in the background.

Several studies have shown that the attentional differences between East-Asia and Anglo-America also affect covert attention. Boduroglu, Shah, and Nisbett (2010) used a change detection task to show differences in the spatial degree to which East-Asian and American participants allocate their attention. Participants had to look at a central fixation and identify a color change in one of four stimuli presented to them. The East-Asian participants were better than the Americans at identifying changes farther from the fixation, while the American participants were better than the East-Asian participants at identifying changes closer to the fixation. These results would suggest that East-Asians naturally allocate their attention more widely than the Americans.

Takao, Yamani, and Ariga (2018) gave Japanese and American participants a variant of the Posner cueing task (Posner, Snyder, & Davidson, 1980). In such cuing tasks, participants must detect and respond to stimuli on the left or right side of the screen. Before the stimuli, a location cue is given. This cue is not predictive of the actual location of the stimuli. When stimuli are presented quickly (100 ms) after a cue, RTs are significantly faster for trials where the cue is in the location of the stimulus. However, the effect does not hold for longer durations (300 ms), suggesting that attention is directed towards the direction of the cue, but reallocates back to the fixation after 300 ms. When stimuli were presented 700 ms after a cue, American participants continued to benefit from the location of the cue, while the Japanese participants showed the traditional decrease in the effect of the cue. Takao and colleagues suggest that their results indicate that the Japanese rely more on the cue to orient their attention.

Memory

East-Asians also appear to remember aspects of context better than Anglo-Americans. When East-Asian participants are asked to describe images after memorizing their content, they will report more details about the background of the image than Anglo-American nationals (Masuda & Nisbett, 2001; Senzaki, Wiebe, Masuda, & Shimizu, 2018). Similar effects have been shown in studies in which participants are asked to identify if a portion of a picture belongs to a previously seen larger image. East-Asians are more likely to recognize portions from the background of the larger image than Anglo-Americans (Kveraga, Ghuman, & Bar, 2007).

In addition to having a higher tendency to remember more details about the backgrounds of scenes, East-Asian participants rely more on background context when recalling information about foregrounded objects. Masuda and Nisbett (2001) asked participants to remember a set of objects set on a series of backgrounds. They were then shown these objects again and asked if they were seen already. Half of the objects were set on the same background as seen previously, while the other half were not. The East-Asian participants were more likely remember images if they were set against the background they were previously paired with.

Categorization

Ji and Nisbett (2001) gave participants a word and asked them to group it with one of two other words (e.g. squirrel with dog or acorn). In all cases, the first word was related to both of the other words. However, the first relation was one due to the first word being in the same category as the second (i.e. a squirrel and a dog are both animals), while the first word was related to the third word because they are associated in a real-world context (i.e. a squirrel eats an acorn). East-Asian participants were more likely to pair words based on real-world relations. Gutchess, Hedden, Ketay, Aron, & Gabrieli (2010) gave participants a similar categorization task. However, they gave participants explicit instructions to sort words based on category or real-world relationships. For both instruction sets, East-Asian participants showed frontal-parietal activation, while Americans showed temporal and cingulate activation. Both of these regions are associated with conflict. Such a difference is consistent with the arguments outlined in Chapter 1. While two individuals may possess cognitive tools that perform similar operations, the scaffolding upon which these cognitive tools may differ greatly based on other aspects of their cognitive style and an individual's cultural experience.

Global/Local Processing

McKone et al. (2010) showed East-Asian and Australian participants Navon figures (letters made of smaller letter), and asked them to respond if a target letter was present either on the global or local level. Relative to the Australian participants, the East-Asian participants showed a significant advantage detecting target letters at the global level. These results were replicated by Hakim, Simons, Zhao, and Wan (2017).

Oishi et al. (2014) gave participants a Navon figures (shapes comprised of shapes) and asked American and Japanese participants to indicate which of two other Navon figures it was most similar to. Unlike McKone et. al (2010), Oishi and collogues found that the American participants preferred to use global processing strategies. They replicated this finding among children, college age youth, and older adults.

Lao, Vizioli, & Caldara (2013) showed East-Asian and generically western participants two Navon figures (shapes made of shapes) consecutively. Participants were asked to report if the two shapes were completely incongruent, congruent at the local level, congruent at the global level, or congruent at both local and global levels. While East-Asian participants showed no differences when responding to locally or globally congruent trials, western participants showed quicker responses for globally congruent trials.

The local/global studies show mixed results. It is possible that global and local processing do not share the same exact underlying mechanisms as the differences in holistic/analytic cognitive styles. However, given that large cultural differences were found by each of these studies, it still remains plausible that global/local difference in attention relate to the differences outlined previously in this section.

3.1.3 Mechanisms for the Cognitive Differences

With the abovementioned review, it is clear that the cognitive differences between East-Asian and American individuals are robust, affect a range of cognitive processes, and consistently align with a cognitive style preference for different degrees of context sensitivity. With these cognitive styles extending to such a wide range of cognitive phenomena, it is difficult to pinpoint the mechanisms for such stylistic difference without in-depth investigation. However, several candidates have been proposed as sources for the difference. I outline each of these candidates in the following subsections.

Self-Construal

The predominant explanation in the literature suggests that differences in cognitive style arise because of differences in self-construal. This social dimension – known prevalently as the individualism-collectivism continuum – describes the degree to which individuals construe the self as an independent agent or as belonging to a larger collective unit (Triandis, 2001). Collectivist self-construal, the adherence to interindividual harmony is an extremely common cultural theme in East-Asia. In contrast, Anglo-American countries, such as the United States, stress individualist self-construal in which self-agency is valued above the societal collective (Chiao & Blizinsky, 2010). Several have suggested that collectivist self-construal requires individuals to incorporate greater context from their environment in order to attend to the rules and patterns of their social world. Collectivist oriented cultures often have customs that require individuals to attend to in-group and out-group membership. For example, in both Korean and Japanese, speakers must adhere to particular grammatical forms that reflect the relationship between the speaker and the listener.

There is some evidence to suggest that measures of individualism-collectivism correlate with the cross-national differences in cognitive style. In a study by Hedden and colleagues (2008), frontal-parietal activations of American participants performing a context incorporating response task (i.e. judging line lengths relative to the size of a square) correlated with their scores on a measure of individualism-collectivism. In contrast, East-Asian participants living in the United States showed frontal-parietal activations during a context-free task (i.e. judging line lengths irrespective of the size of a square) correlated with their scores on acculturation to the United States.

In addition, there have been several studies that attempt to prime individualism or collectivism before a task measuring cognitive style. For example, Kühnen and Oyserman (2002) primed participants with passages consisting of first person or third person pronouns. They then had participants complete both a global and local Navon task. Participants primed with third person pronouns performed between at the global task than those primed with third person pronouns. It is important to note that this study attempted to prime individualism and collectivism with linguistic cues. Thus, it is difficult to separate the influence of self-construal from language.

Japan has been the primary East-Asian country represented in studies measuring the cross-cultural differences in cognitive style. It is unclear, however, the degree to which Japan represents a true collectivist culture. In multi-national studies of self-construal, Japan scores in the middle of most countries, with countries such as the United States, the United Kingdom, and Australia towards the most individualistic. However, the East-Asian countries of China and Korea score among the highest collectivist nations (Hofstede, 2001). Furthermore, some have argued that Japan has increasingly adopted individualistic tenancies in the past two decades. Individualistic values have risen in Japan through globalization and the spread of Euro-American culture (Elliot, Katagiri, & Sawai, 2012). For example, divorce rates have steadily increased in the past two decades. Collectivist cultures value marriage commitment over the individual and thus tend to see lower rates than individualistic cultures. Moreover, individualism itself will manifest differently in Japan and the United States (D'Andrade, 2008; Heine et al., 2010). For example, people with individualistic values in Japan are likely to isolate themselves from friends and develop lower senses of well-being, while individualistically minded people in the United States are as likely as collectively minded people to form interpersonal relationships (Ogihara & Uchida, 2014).

Thus, it is unlikely that individuals with similar self-construal will behave the same across cultures. A parallel to draw upon is emotional disposition. There is an interaction between emotional style and culture because individuals with culturally dis-preferred emotional dispositions are more likely to change their affect than those with culturally preferred dispositions (Tsai, 2017).

Even if Japan represents a primarily collectivist culture, it is necessary to measure individual differences in order to assess how particular aspects of a culture affect cognition because each individual has a unique set of experiences. Individual scores on an individualism-collectivism questionnaire have significantly predicted performance on an attentional task for people within the United States (Hedden et al. 2008). However, it is unknown how scores on an individualism-collectivism questionnaire relate to the differences in attentional styles between individuals in Japan and the United States.

A second criticism is related to the nature of self-construal itself. While the dimension has been re-proposed by a number of authors (Hofstede, 2001; Triandis, 2001), Singelis (1994) argues that self-construal can be described by a 2-dimensions space, rather than a single continuum. He divides individualism-collectivism into a measure of independence and interdependence. As such, individual can simultaneously maintain values related to self-independence and group harmony. If such, then it is unclear if cross-cultural differences in cognitive style relate to differences in independence or interdependence.

Language

Recent studies have suggested that language could also explain Japanese and American cognitive differences. Going beyond the holistic/analytic cognitive styles literature, there is a robust tradition identifying cognitive variation that arises form differences in language structure (e.g. Whorf 1956; Lucy 1996; Boroditsky 2001; Lupyan & Spivey 2010; Matlock 2004; Bowerman & Choi 2001). As with the holistic/analytic distinction, language differences may cause speakers of the language to attend to particular elements over others. For example, speakers of languages with classifiers[8] such as Yukatec Maya and Japanese are more likely to categorize objects based on material, while those without robust classifier systems such as English are more likely to classify based on shape.

[8] Such systems require special classifier words to identify the shape of an object being referenced by a verb. Thus, nouns in these language naturally refer to material without specifying shape. Mass nouns in English share this property. For example, a quantity of want cannot be referred to without specifying a container.

Duffield and Tajima (2012) suggest that the cognitive style differences between those in Japan and the United States arise because of syntactic differences between English and Japanese. The difference they cite centers around how the language refers to objects (i.e. figures) and their backgrounds (i.e. ground). The order in which figure and ground information is canonically given is different in English and Japanese. In English, figure information typically comes first, while ground information typically comes first in Japanese. Examples of figure and ground sentences for English and Japanese are given in the following example.

(A) The bicycle is in front of the house.

(B) house-POS[9] front-LOC bike-SUB is.

In example (A), the English sentence, the figure 'bicycle' is mentioned before the ground 'house.' However, in (B), 'house' comes before the word 'bicycle' in the Japanese sentence. Because figure information comes first in English, speakers must be quick to focus on foregrounded objects and concepts and hold them in working memory until the end of the sentence (or longer). In Japanese, the same is true instead for ground information in the case of Japanese.

However, the tendency to put ground information first is inconsistent across the languages of East Asia. In Mandarin, for example, the order of figure and ground information is more evenly distributed among canonical sentences. Thus, speakers of Mandarin should fall between the cognitive styles of English and Japanese speakers if these perceptual differences are due to language. Indeed, in a task asking participants to recall elements of visual scenes, Japanese speakers remembered more elements of the background than the Mandarin speakers (Duffield & Tajima, 2012).

Additional evidence of the involvement of language comes from a study by Senzaki, Masuda, and Ishii (2014). They performed a replication of the eye-tracking experiments in which background elements are fixated more by Japanese participants than American participants. However, for their study, participants were either told to describe the videos they saw after viewing or simply instructed to passively view the images. Japanese and American participants exhibited differing attentional patterns when watching videos that they expected to describe later. However, the Japanese and American participants did not differ when they were passively viewing the images.

[9] POS = possessive particle, LOC = location particle, SUB = subject particle

This would suggest that eye-fixation differences arise because participants are actively planning how to describe the images with language.

In addition to specific language effects, there may be a relation between cognitive style and overall language background. A growing body of evidence has indicated that bilinguals have certain advantages when performing tasks that require participants to suppress task-irrelevant information. While such advantages do not necessarily align with an analytic/holistic style distinction, many of the tasks that investigate the distinction require participants to suppress either analytic or holistic information in order to meet the demands of their current task. Moreover, some studies have shown bilingual advantages for some analytic/holistic style measurements, such as the embedded figures task (Bialystok & Shapero, 2005). Thus, language experience presents a confound that should be considered carefully when measuring cross-national differences in cognitive style.

Physical Environment

Miyamoto, Nisbett, and Masuda (2006) had Japanese and American participants examine scenes of Japanese and American cityscapes. Participants rated the scenes on the number of objects, the ambiguity of object boundaries, the organization of the objects in the scene, and the occlusion of objects in the scene. When controlling for city size, the Japanese scenes had a greater number of objects and these objects were more ambiguous to interpret. Differences in visual scenes between the United States and Japan extend beyond cityscapes. Japanese comic books, for example, are more likely to divide larger scenes into individual panels (Cohn, Taylor-Weiner, & Grossman, 2012). As such, each comic panel is more likely to have detailed attention to background elements.

In a second experiment by Miyamoto, Nisbett, and Masuda (2006), participants were shown images from either Japan or the United States then given change blindness tasks. When primed with Japanese cityscape scenes, both Japanese and American participants were better able to identify changes in contextual information. Takahiko Masuda and Nisbett (2006) examined change blindness for images of Japanese and American scenes. Both American and Japanese participants detected changes in focal information better than contextual information. Ueda and Komiya (2012) showed Japanese participants cityscape images from Japanese and the United States and then had the participants look at culturally neutral images. The eye-fixations of the participants focused on context more if they had been shown Japanese cityscapes, rather than American cityscapes.

Ueda et al. (2018) suggest that the attentional differences are a result of bottom-up tuning to different environmental stimuli, rather than a holistic-analytic distinction. They examined Japanese and American performance on several asymmetrical visual search tasks. In such tasks, the search for an item with feature A (e.g. a Q) in a group of items with feature B (e.g. an O) is more difficult than a search for an item with feature B among items with feature A. Ueda and colleagues found differences in the degree and directions for various asymmetrical search tasks between American and Japanese participants. They argued that because these searches relied on low-level attentional processes, that the differences arise because early visual processes are tuned to different physical environments.

3.2.1 Goals of the Study

Given the current literature, it is difficult to suggest that self-construal collectivism is the sole underlying reason for the differences in cognitive style seen between East-Asians and Anglo-Americans. In addition to individualism-collectivism, cultures can differ in many other ways such as language and physical environment. While there is some evidence to support the relation between self-construal and cognitive style, there are equivalent volumes of research indicating that language and physical environment play a role. Furthermore, language structure and physical environment are highly integrated with sociocultural values such as self-construal. As such, attributing attentional variation to one particular factor is difficult and perhaps misguided.

Furthermore, general statements about the differences between cultures ignore the high levels of individual variation within a culture. Very few studies have examined individual differences in the studies addressing cross-cultural cognitive style. However, exploring individual differences allows for a comparison of several cultural factors simultaneously.

This project examines how self-construal, language, and physical environment modulate differences in cognitive style. Participants performed two perceptual tasks that measure their cognitive style. Then they completed four survey instruments which measures their self-construal, physical environment, figure-ground language judgments, and language backgrounds.

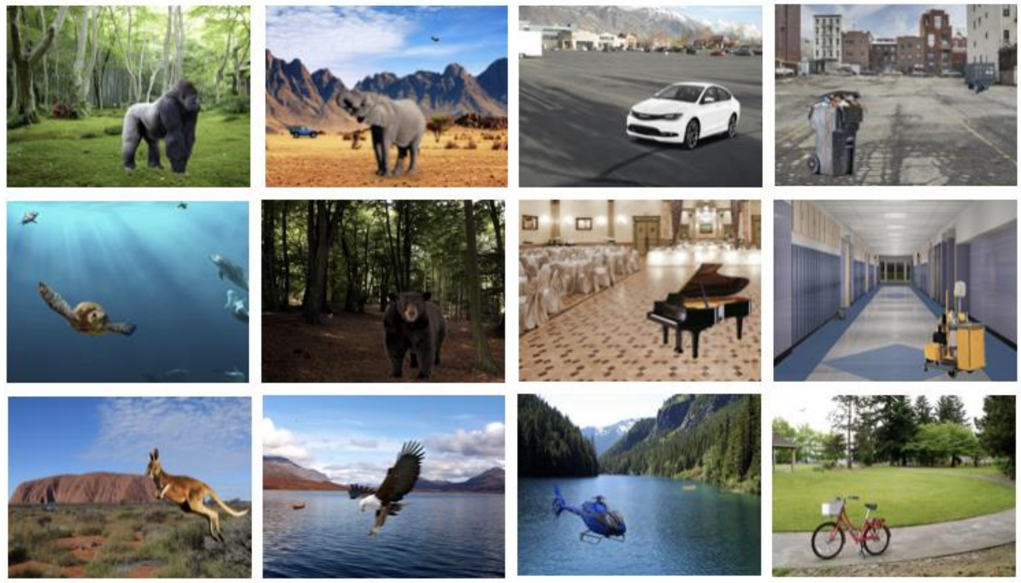

Figure 3.1. Examples of images used for the eye-tracking study. Images on the left have animals as focal objects while images on the right have non-living entities as focal objects.

3.2 Experiment 1

The goals of the first study are two-fold. First, the study attempts to replicate the eye-tracking findings that show that the backgrounds of visual scenes are attended to more by East-Asians than Anglo-Americans (Chua et al., 2005; Rayner, Li, Williams, Cave, & Well, 2007; Senzaki et al., 2014a). The second goal of this project is to show how performance on this task is predicted by individual differences in self-construal, figure-ground preferences, language background, and/or familiarity with certain physical environments (i.e. everyday scenes from Japan and the United States).

3.2.1 Methods

Participants

Fifty Japanese participants were recruited from undergraduate classes at Kyoto University. These participants received a voucher to buy items at their school bookstore as compensation. Fifty American participants were recruited from undergraduate classes at the University of California, Merced. All American participants received extra credit for their participation. Unfortunately, some of the datafiles from each group were corrupted, leaving a remaining forty-three Japanese data files and forty-four American datafiles available for analysis.

Materials

Twenty visual scene stimuli were constructed such that they contained a single foregrounded object set against an appropriately matched background. Ten of these scenes used inanimate objects, while the other ten used animals. Examples of these are shown in Figure 3.1. These were presented on a computer display using MatLab Psychophysics Toolbox. As the Japanese and American participants participated in separate locations, two slightly different eye-trackers were used. American participants were measured using a head mounted Eyelink II, while the Japanese participants were measured using a desktop mounted Eyelink 1000. Both pieces of equipment used combined pupil/corneal reflection tracking and a 9-point calibration. The screen resolution and relative size of the images were set such that participants in both groups saw the same sized images.

Four survey instruments were included in the experiment: (1) An individualism-collectivism questionnaire, (2) a measure of familiarity with physical layouts of cityscapes in Japan/America, (3) a measure of the degree to which participants rate non-canonical sentences, and (4) a measure of bilingualism.

Self-Construal. Self-construal traditional looks at a dimension of independence and interdependence, or individualism and collectivism, respectively. While some view these as two ends of the same dimensions, there is evidence to treat them as orthogonal (Singelis, 1994). As such, I chose to use a self-construal instrument that separates these two dimensions. The self-construal questionnaire used was the Singelis scale (Singelis, 1994). The measure consists of 30 items. Each item is ranked by the participant in order to indicate the degree to which they believe the item describes themselves along a 7-point scale. The items are divided into two subsets used to score participants along two dimensions, independence and interdependence. Example C shows an item that measures independence, while Example D shows an item that assesses interdependence.

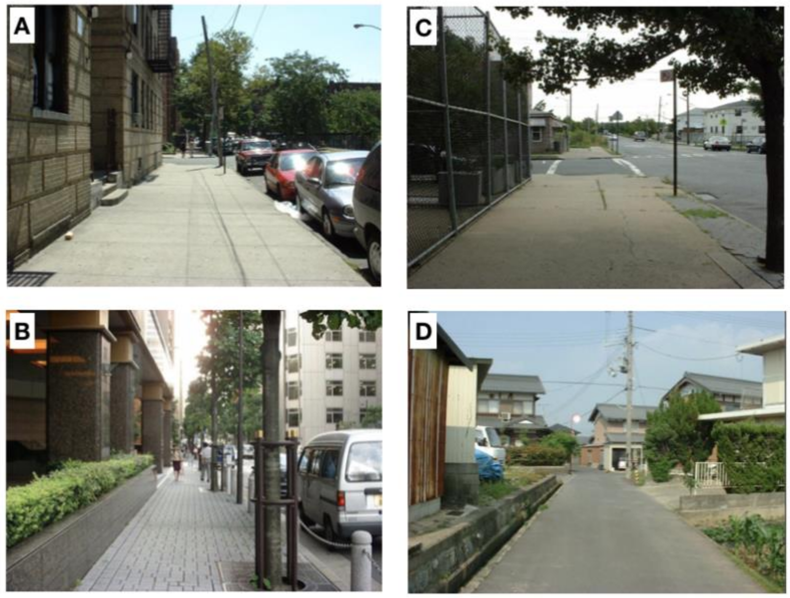

Figure 3.2. Four examples of images given for the physical familiarity survey. (A) An urban photo taken in Japan. (B) An urban photo taken in the USA. (C) A suburban photo taken in the USA. (D) A suburban photo taken in Japan

(C) I enjoy being unique and different from others in many respects.

(D) Even when I strongly disagree with group members, I avoid an argument.

Physical Familiarity. The physical familiarity index was constructed using images from both the United States and Japan. These images belonged to a larger set used in in several studies (Miyamoto et al., 2006; Ueda & Komiya, 2012). The pictures were taken at culturally neutral sites, showing cityscapes at varying levels of urbanization. A total of 20 images were taken from the set. 10 were from each country. Photos were selected in pairs (from the US and Japan), such that they shared the same level of urbanization. Any signs or language present in the photos were blurred, so that participants could not directly infer the country that the photo was taken in. Participants were asked to rate their familiarity with the physical features of the photo. In particular, they were asked to ignore the presence or absence of specific objects or areas in the photos (e.g. a brand of car or mountain range they know form childhood) and make their judgment purely on the physical layout (e.g. the relative size of roads and buildings). Ratings were given on a scale form 1 through 9, with 1 being very similar and 9 being very unfamiliar. Example Images are shown in Figure 3.2.

Figure-Ground Sentence Ratings. The Figure-Ground sentence questionnaire consisted of ten paired sentences. Each of the pairs consisted of two sentences with identical meaning. However, one sentence was constructed with figure information first, while the other had ground information first. All sentences pairs were constructed such that they contained identical words, except in different orders. For each pair, participants were asked to select the sentence they believed they would be more likely to say. Then they were asked to indicate the degree to which they believed that sentence was better than the alternative. Ratings were given on a scale form 1 through 9. Examples E and F show canonical and non-canonical examples from the English version of the survey.

(E) There are lots of little red fish swimming around a big rock.

(F) Around a big rock there are lots of little red fish swimming.

Language Background. The Leap-Q questionnaire, commonly used in bilingual studies, was used to measure linguistic background (Marian et al 2007). The questionnaire contains questions asking the languages they know and their relative proficiency in each of their languages.

Both English and Japanese versions of the survey instruments and experimental instructions were necessary for the study. The Leap-Q and Singelis individualism-collectivism scale have versions translated into Japanese. For experiment, the physical familiarity index, and the figure-ground sentences, items and instructions were first written in English and translated into Japanese by a native speaker of Japanese. To check for consistency, the Japanese versions were translated back into English by a native speaker of English who was fluent in Japanese.

Procedure

Before the start of the experiment, American participants gave signed consent and Japanese participants indicated their consent with a hanko stamp[10]. This experiment was carried out in the same session

[10] Signatures are not common in Japan. Rather, individuals use a stamp engraved with their name. This stamp is called a hanko.

as a second experiment, described later in this chapter. Thus, each participant completed two computerized experiments and four survey instruments. So that participants could remain naïve to the survey questions, these were always given to participants after completing the computerized perceptual tasks. Additionally, the two experiments were given to participants in a random, counterbalanced order.

For the experiment, participants were first calibrated with a 9-point calibration. Participants were given each of the 16 images in a random order. Before each image, a drift correction was performed in order to ensure the equipment maintained an accurate log of fixations from trial to trail. In each trial, the participant was given 20 seconds to study the image. They were then given 40 seconds to describe the image.

3.2.2 Results

Survey Measures

LEAP-Q. While the LEAP-Q measures many different aspects of language background, the percentage of time an individual decides to speak their primary language was chosen to represent an individual's language background. The Japanese participants scored an average of 90.76 percent, while the Americans scored an average of 78.13 percent. The difference is significant ($t(78.43) = 3.46$, $p < 0.001$), suggesting that this population of American participants had a more diverse language background than the Japanese participants. The most frequently listed second language of the Japanese participants was English, while the most frequently listed second language of the American participants was Spanish.

Self-Construal. For the individualism-collectivism survey, items were divided into independent and interdependent items. Items in each category were averaged together for each participant. A regression was performed to assess the correlation between the two dimensions. As with previous reports by Singelis (1994), there was no significant correlation between the two dimensions ($f(1,85)= 0.1298$, $p=0.720$). Thus, the interdependent and independent dimensions were kept as separate dimensions for further analysis.

For each dimension of self-construal, a t-test was performed in order to see how the American and Japanese participants differed. For the independent dimension, Japanese participants ($M = 4.25$) scored an average of 0.6 lower than American participants ($M = 5.03$; $t(84.97) = -4.95$, $p = < 0.001$). The direction of this difference is expected, as Japan has been seen as traditionally less individualistic than the United States. However, the 0.6 difference is small relative to the scale of the self-construal instrument, which is on a 7-point scale. This smaller difference could be because many of the American participants are Hispanic and influenced by more aspects of collectivist culture than prototypical Americans. In other studies, individuals in Mexico have been found to be more collectivist than individuals in Japan (Chiao & Blizinsky, 2010). However, as these measures conflate independence and interdependence, it is difficult to suggest how such would specifically affect the independence dimension. To investigate this, a regression was performed looking at monolingualism scores and independence. No significant effect was found ($F(1,42)= 0.0227$, $p= 0.$ 0.881). In addition, a t-test was used to look at independence differences between individuals who listed Spanish as a language they spoke (n=22) and those who did not (n=29). Again, no significant differences were found ($t(42) = -1.5434 = 0.1302$).

For the interdependent dimension, Japanese participants (M = 4.33) scored an average of 0.66 lower than American participants (M = 5.10; $t(78.40) = 5.63$, $p = < 0.001$). This result is particularly surprising, as American are expected to be less interdependent than Japanese. Again, this could be because of the particular demographics of the American participants. Because of this result, however, it might be expected that the Americans also have greater likelihood of looking at visual context, assuming that interdependent self-construal does affect attentional style. Again, these differences could be because of Hispanic influence on self-construal. A regression was performed with level of monolingualism predicting interdependence. No significant effect was found ($F(1,42) = 2.479$, $p = 0.1229$). As with independence, a t-test was performed looking at individuals who listed Spanish as a language they spoke (n=22) and those who did not (n=29). Again, no significant effect was found ($t(42)= -1.5434$, $p= 0.1302$).

Given that there is no significant correlation between self-construal and language background, it is difficult to attribute the American patterns of self-construal specifically to the Hispanic backgrounds of many of the participants. However, previous studies have found specific student populations in rural areas to be unusually collectivist for American culture (Tweed & Sokol, 2001). Regardless of the reason for these findings, they are important to consider when interpreting correlations between self-construal and the attentional measures.

Figure-Ground Preferences. Due to an error in the digital form for the English version of the survey, scores for one of the items failed to log. Analysis was performed on the remaining 9 items. For each item, if participants selected the sentence with figure information first, the item was scored the same as the rating. However, if the ground-first sentence was selected, then the item was scored as 1 minus the rating. Thus, all items had a score from -8 to 9.

Japanese participants had a slight preference for ground information first (m = -0.65), while the American participants had a preference for figure information first (M = 5.09). This difference was significant ($t(81.61) = 12.54$, $p < 0.001$). It is expected, as Japanese sentences canonically have ground information first, while English sentences canonically have figure information first.

Physical Familiarity. As images were divided into those in Japan and those in the USA, a separate score was calculating for Japan images and USA images. These scores were calculated by adding image ratings for each participant. A regression was performed to assess the correlation between the two dimensions. Surprisingly, there is a significant correlation between the two dimensions ($f(1,83) = 174.18$, $p < 0.001$). This would suggest that a single factor could be extracted from these two dimensions. However, such a factor would give scores for participants that closely resembles the average degree for which they were familiar with the physical layout of any image. Such a dimension does not carry theoretical significance in this experiment. Thus, a single dimension was created by subtracting a participant's ratings of Japan images form their ratings of USA images, with higher scores indicating more familiarity with Japan images.

The two groups were compared with a t-test. The Japanese participants (M = 14.80) scored higher than the American participants (M = -10.36; $t(80.86) = 7.25$, $p < 0.001$), meaning that each group preferred images from their respective nations.

Eye-tracking Analysis

This study hypothesizes that the eye-fixations of Japanese and American participants will differ in the degree to which they look at foregrounded objects in a photograph versus their surrounding elements. Both groups will look at objects in the scene. However, Japanese participants are more likely to look at aspects of the scene surrounding the objects. As the scenes from this study comprise complex scenes, focal objects occupy multiple parts of the images. Thus, differences in fixations towards objects and context will appear in the overall spatial distributions of fixations. In order to assess attention in this study, a measure of spatial distribution was calculated by averaging the standard deviations of fixation in the X and Y dimension (see also, Huette, Winter, Matlock, Ardell, & Spivey, 2014). These calculations were used as the dependent variable for analysis.

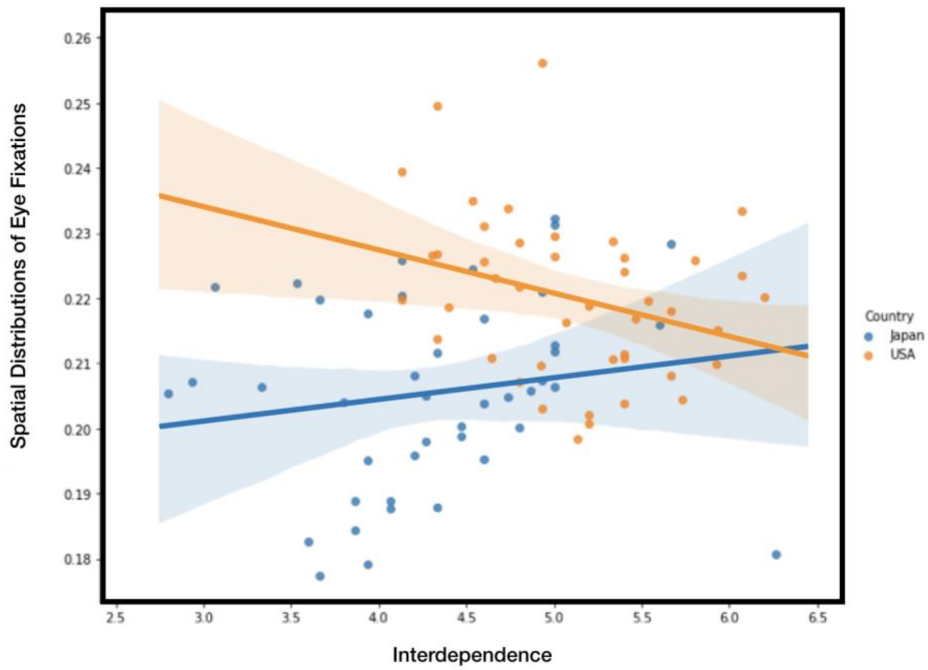

Figure 3.3. Model Estimates for the correlation between Interdependence and spatial distributions of eye fixations. Model estimates for Japanese and American participants are shown in separate colors.

A linear mixed-effects model was used to analyze the data. For the model, country, independent self-construal, interdependent self-construal, figure-ground preference, physical familiarity, percent monolingual, and image type (animal vs non-living object) were included as fixed effects. The interactions of country with each of the other five factors were also included as fixed effects. Participant and image type were included as random effects. The model revealed a significant effect of country, with American participants having a spatial spread that is an estimated 1.9 percent larger than the Japanese participants ($F(1,75.28) = 23.094$, $p < .001$). This effect goes in the opposite direction of previous studies. However, the result is consistent with the fact that the American participants scored higher on interdependence. There is no main effect for any of the survey measures. However, there is an interaction between interdependence and country ($F(1,76.030) = 4.1078$, $p=0.04619$). The model estimate for this effect can be seen in Figure 3.3. With this interaction, the spatial distributions of eye-fixations positively correlate with the interdependence scores of Japanese participants, while they negatively correlate with the interdependence scores of American participants.

While these findings do support claims that there is a relation between visual attention patterns and self-construal, the patterns found here are more complex than as suggested by previous accounts. These patterns appear to indicate that the more they have a self-construal that is culturally dis-preferred, the less likely they are to look at contextual information. Differences in attentional style, then, may result from habitually balancing between an individual's preferred self-construal and their culture's preferred self-construal.

3.2.3 Discussion

This experiment served to (1) replicate the findings showing differing eye-fixation patters in American and Japanese participants and (2) to show which – if any – specific cultural factors are able to predict variation in the spatial distributions of the eye-fixations of individuals. While the Japanese and American participants did indeed perform differently, the direction of this difference is contrary to the direction in previous studies. The American participants had larger spatial distributions in their fixations than the Japanese participants. In all previous studies, Japanese participants were more likely to look at the context that surrounds objects.

There are several possible reasons for the overall difference. First, many have claimed that self-construal affects attentional styles. While the attentional patterns in this study were opposite of what is found in the literature, the participants also showed self-construal patterns that were opposite of the literature. Specifically, American participants showed higher levels of interdependence and were more likely to look at visual context than their Japanese peers. These results are consistent with the claim that self-construal affects attentional style.

The interdependence scores of the American participants were quite unexpected. It is important to note that the undergraduate population at UC Merced is not necessarily representative of other undergraduate bodies in the United States. Much of the university's student population consists of first-generation college students and there is a high Hispanic population. However, there were no significant correlations between the self-construal scores of participants and their language backgrounds. It is still possible that Hispanic culture has had some influence on the UC Merced population in general. In this case, all participants at the university would have been affected, regardless of their languages. Moreover, cross-national surveys of self-construal have shown that Japanese individuals tend to be among the most homogenous culture, while the United States is significantly more heterogeneous (Neuliep, Chaudoir, & McCroskey, 2011). Groups within the United States will vary considerably. Previous studies have found that even among college student populations, high levels of collectivism can occur. Such high levels of collectivism have been shown especially in rural communities (Tweed & Sokol, 2001).

The second objective of the experiment was to see if individual difference measures will predict the attentional styles of individuals. A total of four survey instruments, with a total of five factors were given used to assess individual differences. Of these, interdependent self-construal was the only factor found to be predictive of eye-fixation spread. The most prominent views in the literature would suggest that interdependent self-construal styles would be predictive in this experiment. However, interdependent scores had differing effects for Japanese and American participants. While Japanese who had higher interdependent scores had higher spatial distributions, Americans who had lower interdependent scores had higher spatial distributions. In both cases, individuals who possessed culturally dis-preferred interdependence scores were less likely to focus on context. Several studies have shown that the behavior of individuals is an interaction between cultural norms and individual dispositions. When there is a mismatch cultural norms and individual dispositions, individuals will find it difficult to adhere to cultural norms or develop particular habits that place them within cultural norms. For example, in East-Asian culture, low arousal states (e.g. serenity) are preferred to high arousal states (e.g. excitement). East-Asian individuals who have particular dispositions towards high arousal states are more likely to pick low arousal activities such as yoga or meditation than individuals who are already have a predisposition towards low arousal states (Tsai, 2017). The behaviors that individuals with culturally mis-matched self-construal patterns may result in a need to attend to contextual information.

Another alternative is that individuals with mis-matching self-construal patterns must consistently ignore salient cultural cues in order to behave within the framework of their preferred self-construal. Thus, they will have habitualised to ignore contextual information. This argument is similar to the claims of bilingual research, which suggest that individuals exercise executive control from the continual suppression of one language in order to utilize another (Bialystok et al. 2004; Costa, Hernandez, & Sebastian-Galles 2008). In this study, there was no effect of bilingualism on attentional style. However, the attentional mechanisms affected by the suppression of cultural information are likely different than the cognitive control responsible for bilingual language control.

3.3 Study 2

The first experiment attempted to replicate the findings of several eye-tracking studies investigating cross-cultural differences between individuals in East-Asia and Anglo-America (Chua et al., 2005; Nisbett & Miyamoto, 2005; Senzaki et al., 2014b). These studies, and others examining the processing of visual objects and their context show robust differences between East-Asian and Anglo-American participants, with contextual elements being attended to more by East-Asian participants. However, experiments looking at global and local processing – rather than analytic/holistic style – are fewer in number and have inconsistent results. Thus, the partial purpose of the second experiment is to add to the few studies examining global/local processing among Japanese and American individuals.

In this experiment, two tasks were created with Navon shapes. In the first, participants are asked to focus on the global properties of the Navon figure (e.g. a circle made of small triangles). Then, the participants are asked to select the shape that matched the global shape of the Navon figure (e.g. a circle). In the second task, participants were asked to attend to the local features of the Navon figure and select the shape that matched the local features (e.g. a triangle). Both tasks had two trial types. In the first, the competing choice matched the non-target features of the Navon figure. In the second trial type, the alternative choice did not overlap with either the global or local features of the figure (e.g. a square).

Both tasks were constructed such that choices would be made with a computer mouse rather than the button presses of traditional RT experiments. Thus, mouse trajectories could be measured. A number of studies have shown that mouse movements may reveal dynamic information about the processes that underlie decision tasks (Freeman & Dale, 2013; Freeman, Dale, & Farmer, 2011). For example, a participant may have an equally long RT in two different trials. However, the reason for these long RTs may differ. One may be long because the stimuli itself takes time to process. The other might be long because of the time it takes to decide between the two possible responses. In the first case, a participant might simply have a slower velocity when moving towards their choice or a late onset of movement. For the second, the actual trajectory of the mouse movement might gravitate to the competitor before the participant ultimately clicks on their response. Thus, mouse movement trajectories will give insight into the processes responsible for response selection. As there have been ambiguous results regarding differences in local/global processing of East-Asian and Anglo-American participants, mouse-tracking may be particularly useful in identifying specific differences in cognitive processes that do not appear in RT differences.

3.3.1 Methods

Participants

The same participants for the previous experiment were used for this experiment. They performed the tasks in the same session as the previous experiment.

Materials

Twenty Navon figures were created. All figures consisted of one shape type constructed from many of a single different type of shape (e.g. a square made of several small triangles). The shapes used for construction included circles, squares, triangles, diamonds, and hexagons. Target shapes were constructed as whole shapes, rather than Navon figures. The tasks were programmed with the MatLab PsychToolBox (Brainard, 1997; Pelli, 1997; Pelli and Zhang, 1991).

Procedure

As reported earlier in this chapter, the tasks in this experiment were given in the same session as the eye-tracking experiment. The order in which the eye-tracking experiment and the Navon figure experiment were given were counterbalanced. In addition, the order of the global and local tasks were further counterbalanced.

For the local task, participants were instructed to attend to the smaller shapes that made of the large Navon figures. To begin each trial, participants clicked on a button located at the bottom of the screen. 100 ms after the button was pressed, the Navon figure was displayed for 300 ms. The Navon shape then disappeared and two shapes were displayed in the upper left and upper right sides of the screen. One of these shapes matched the Navon figure on the local level. In half of the trials (competition trials), the other shape matched the Navon figure on the global level, while in the other half of trials (no competition trials) it was a shape that matched neither level of the Navon figure. These shapes remained onscreen until the participant clicked on either of them. Feedback was provided to the participant with either a checkmark for a correct response, or an X for a wrong response.

The global task was identical to the local except that participants were told to attend to the global level of the Navon figure. Additionally, the response images always contained a shape that matched the global level of the Navon figure. The other shape matched the local level in half of the trials.

3.3.2 Results and Discussion

Four mouse trajectory features were investigated. These included RTs, maximum deviation, initiation time, and maximum velocity. All mouse trajectories were calculated with the mousetrap package in R (Kieslich & Henninger, 2017). A linear mixed effects model was run for each of the trajectory features. These models included country, task (i.e. global/local), and competitor type as fixed effects, as well as their interactions. The interaction of task and competitor was included as a random effect. In order for the model to properly treat overall means and group means as intercepts, all continuous factors were mean centered within each group of participants (see Winter 2013). Because the analysis examines a number of outcome variables, this section groups the reporting of significant effects by predictor variables. All effects were calculated with the lmerTest toolbox (Kuznetsova, Brockhoff, & Christensen, 2017), which calculates the significance of each factor – including interaction effects – by individual dropping them from the model.

Overall Task Effects

This study examined differences in the global and local processing abilities of participants in Japan and the United states. In order to do so, participants were given two tasks. In the global task, participants were presented with a Navon figure and asked to attend to the global features of the image. They were to then select between two shapes that matched the global features of the presented figure. In congruent trials, the distractor shape had features that were not consistent with any features of the Navon figure. In competition trials, the distractor shape matched the local features of the Navon figure. Local task was identical to the global task, except that target shapes matched the local features of the Navon figures. As some studies have suggested a general preference for global processing over local processing (Navon, 1977), it would be expected that participants might show a difference in performance in these two tasks. Indeed, there is a main effects of condition on maximum deviation, with trials in the global task deviating towards the competitor more than trials in the local task ($F(1,75.57)$ =

4.389, p = 0.0395). In addition, there is an interaction of effect of condition and competition on maximum deviation. The difference between competition and no-competition trials is larger in the global task, with competition trials having larger maximum deviations ($F(1,74.53) = 6.3033$, $p = 0.01422$). This same pattern can be seen in a marginally significant interaction effect of condition and competition on RT ($F(1,1122.82) = 2.793$, 0.0949). As maximum deviations measure the degree to which the competitor competes with the target response, it is expected that larger deviations would occur in competition trials compared with no-competition trials. These results also suggest that the degree of this competition is less in the local condition. This would suggest that participants are biased towards attending to the local features of the Navon figures.

Country of Origin Difference

Global processing styles presumably align with attentional patterns that focus highly on context. In contrast, local processing styles presumably align with attentional patterns that are context independent. Thus, Japanese participants should greater performance on the global task, while American participants should show greater performance on the local task. However, this study revealed no overall differences of country. There are several possible reasons for this. First, the American participants do not adhere to certain cultural norms, relative to American in other cross-cultural studies. Thus, the same differences between Japanese and American participants found in other studies would not be likely to replicate here, assuming that adherence to these cultural norms is related to attentional style. Indeed, the previous study revealed a pattern opposite of literature. If non-adherence to American cultural norms did explain an absence of overall differences, then both groups would be expected to have better performance in the global task. However, both groups showed greater maximum deviations in the global task competition effects were greater in the global task. This suggests that both groups had a preference towards local information. A second possible explanation for no main effect of country is the nature of the task itself. In some of the other global/local paradigms, stimuli were presented sequentially and participants were to indicate if the second stimuli was similar to the first. Thus, participants had to attend to both local and global information and then compare both sets of information. However, in this study, participants were instructed to attend only to kind of information at a time and compare three images based on that information.

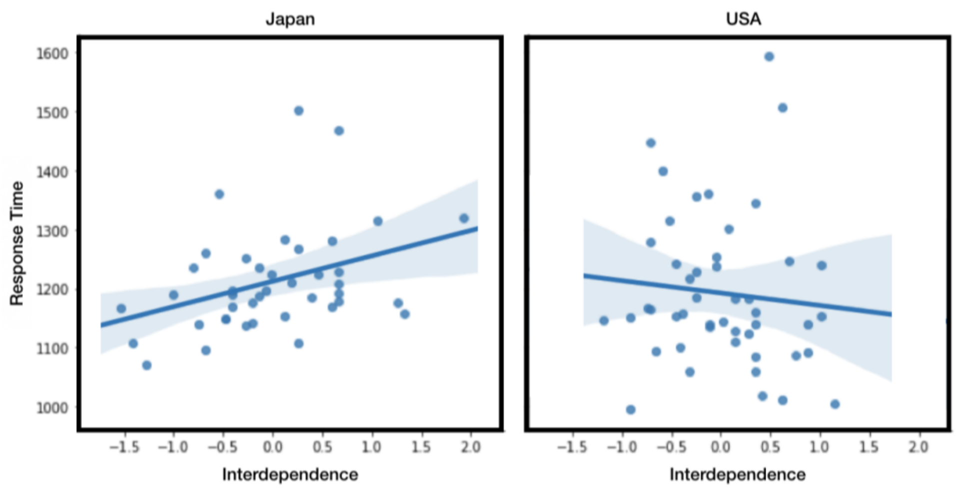

Figure 3.4. Relationship between interdependence and response time.

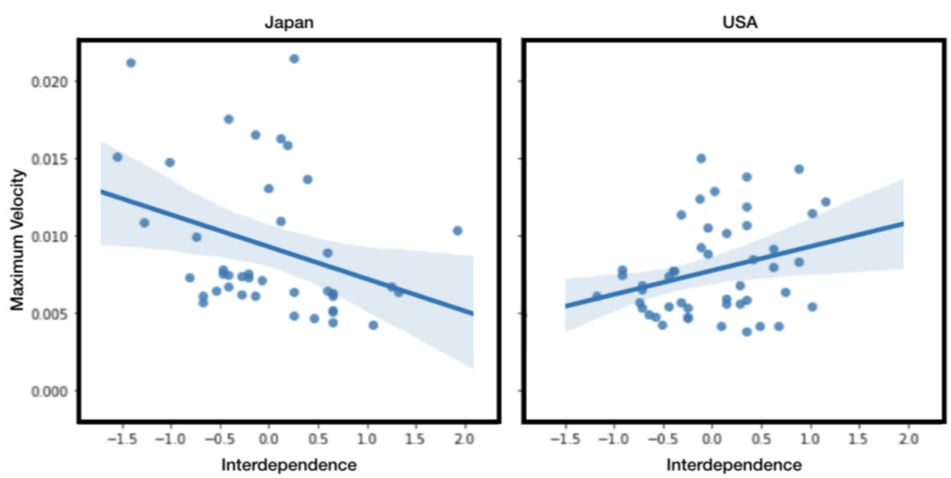

Figure 3.5. Relationship between interdependence and maximum velocity.

Interdependence

Overall, this work hypothesized that individual differences in either independence, interdependence, physical familiarity, or figure-ground ratings would correlate with a preference for local or global processing. If the processes that underlie global/local processing are subject to the same cross-cultural affects as overt visual attention towards objects and their context, then interdependence will also predict performance for this experiment. As with the first study, interdependence is expected to interact with country. Indeed, there are several significant effects related to interdependence. There is a significant interaction of interdependence and county on RT. For

Japanese participants, higher interdependence correlates with higher RTs. For American participants, higher interdependence correlates with lower RTs ($F(1,74.59) = 4.0463$, $p = 0.04788$). There is also a significant interaction of interdependence and country on maximum velocity. These interactions are shown in Figure 3.4 and Figure 3.5. Japanese participants have higher maximum velocities when they have lower interdependence, while American participants have higher maximum velocities when then have higher interdependence ($F(1,75.0) = 7.7182$, $p= 0.0069$). In some cases, maximum velocity can indicate a tradeoff between movement earlier in the trajectory and movement later in the trajectory. However, as higher velocities coincide with low RT, these high velocities may simply reflect higher overall efficiency. These interactions also mirror the country and interdependence interactions seen in the previous study. Those with culturally dis-preferred self-construal styles had showed more efficient performance on this task than those with culturally preferred self-construal styles. In addition to these significant effects, a marginal interaction of condition, country, and interdependence on maximum velocity suggests that the correlation is steeper (more positive Americans and more negative for Japanese) for the local task ($F(1,75.0) = 3.3514$, $p=0.0711$).

Such effects were not found. However, each of these factors did show effects on the mouse trajectories of participants in unexpected ways. Two of these – interdependence and figure-ground ratings – interacted with country. Individuals with interdependence that differed further from their cultural norms had faster RTs and higher maximum velocities. These effects were exaggerated in the local task. As participants were overall more efficient at the local task, this suggests that distance from interdependence norms is associated with abilities both to efficiently attend towards information different special scales and to inhibit attentional biases (towards local information).

Independence

There was also no significant main effect of independence. This would have been expected if independence drives the attentional differences between the U.S. and Japan. However, there is a significant interaction between independence and the presence of competition. Trials with competition had a more negative correlation with maximum velocity than trials without competition ($F(1,355.3) = 5.0730$, $p=0.024911$). This suggests that participants who are more independent have slightly higher abilities to process trials that have competition than those who are less independent. However, visual inspection shows that the effect is small. The independence measure focuses primarily on

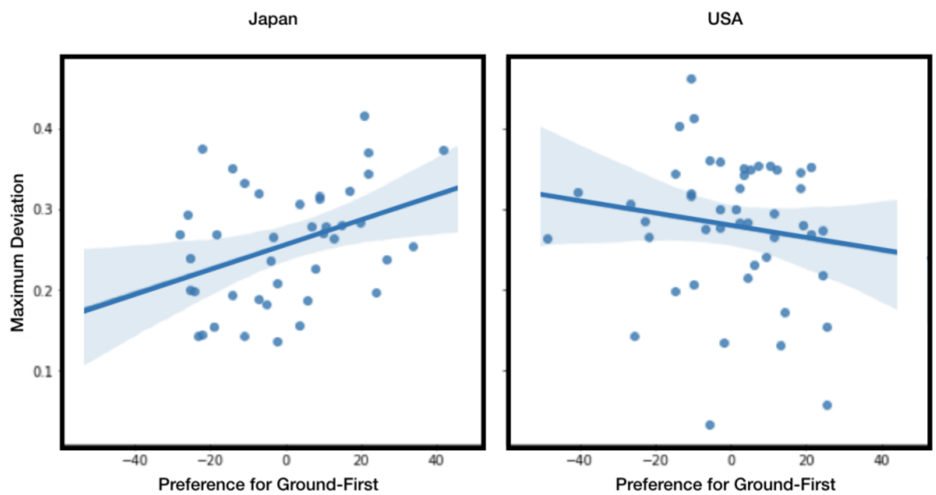

Figure 3.6. Relationship between group-first syntactic preferences and maximum deviation.

maintaining a sense of unique individuality. It is possible that an increased ability to process the competition of local and global information is related to one's ability to self-reflect or introspect. Indeed, there is evidence to suggest that attention overlaps with self-directed attention (see Humphreys & Sui, 2016 for review).

Figure-Ground Ratings

Ground information canonically is given early in Japanese sentences, while figure information is canonically given later sentences. As such, individuals who speak Japanese will be required to keep ground information in working memory longer than figure information. The order of figure and ground information is reversed in English. Therefore, English speakers will likely keep figure information longer in working memory. With this, it is predicted that figure-ground ratings would correlate with a preference for relative performance on the global or local tasks. There was no significant effect of figure-ground ratings on any of the mouse-tracking outcomes. Given the previous study, these results are unsurprising.

As with interdependence, there was a significant interaction of figure-ground ratings and country on maximum deviation, with Japanese who preferred canonical Japanese syntactic orders having lower maximum deviations and Americans who preferred canonical English syntactic orders having lower maximum deviations ($F(1,74.79)=4.3384$, $p = 0.04068$). This effect is shown in Figure 3.6. There is also a marginal interaction of figure-ground ratings and country on maximum velocity, with those who prefer canonical sentences in their language having lower maximum velocities (F(1,75.0)=3.1898, p=0.078144). Together, these suggest that those who prefer non-canonical figure-ground orders are more likely to deviate towards the competitor and then quickly correct towards the target response. There is an additional marginal effect of condition, competition, country, and figure-ground ratings (F(1,74.28) =3.3284, p=0.07211). However, as a weak 4-way interaction, it is difficult to interpret.

Unlike interdependence, figure-ground ratings affected maximum deviation; participants who prefer non-canonical figure-ground orders were more likely to deviate towards the distractor. This suggests that the aspects of the task affected by figure-ground ratings related to the selection of the two competing responses. The differences in how these two factors affected the mouse trajectories suggests that these factors affect the processing in slightly different ways. Interdependence relates to the modulation the difficulty of these specific tasks, while figure-ground ratings relate to the degree to which participants entertain competing information.

Monolingualism

Many studies have suggested that individuals who know more than one language are more efficient at inhibiting irrelevant information (e.g. Bialystok & Craik, 2010). As such, those who are highly monolingual would be expected to perform competition trials with less efficiency than those who speak multiple languages. There is also evidence suggesting that bilinguals have overall better performance on tasks that involve competition between responses (Albert Costa et al., 2009). Indeed, monolingualism did have an effect on RT. However, this affect showed that for Japanese participants, monolingualism was correlated with faster RTs. There is an interaction of monolingualism and country. For Japanese participants, monolingualism is negatively correlated with RT, while the correlation is slightly positive for American participants (F(1,74.53)=3.970, p=0.0499). This would suggest that Japanese participants who are bilingual are less efficient at the task. This seems to go against the bilingual literature. In close examination of the data, however, the affect appears to be driven by a single outlier. The effect is no longer significant when the outlier is removed. This aligns with the significance of the effect, which barely fell below the .05 threshold.

Physical Familiarity

Physical familiarity was also hypothesized to interact with task. However, there are no significant effects of physical familiarity. However, there is a marginally significant interaction of condition, competition, country, and physical familiarity on maximum velocity ($F(1,5935.4)=2.7434, 0.0977$). However, as a weak interaction, it is difficult to interpret.

3.4 General Discussion

Together, the results of these two studies show a complex interaction between cultural variables and cognitive processes. For both studies, I hypothesized that several cultural variables (independence, interdependence, figure-ground order, and physical environment) would correlate with the attentional differences between participants in Japan and the United States. Each one of these factors presents an alternative explanation for why individuals in Japan prefer to attend to contextual information more than individuals in the United States. If any if these factors were responsible for these differences, then individual differences among these factors would explain attentional variation for participants from both countries. In the case of study one, a factor would correlate with the spatial distributions of eye fixations. In the case of study two, a factor would interact with the task type (local vs global), indicating that the factor correlates with a preference for one type of processing.

Rather than straightforward correlations between any of the cultural variables and task performance, several similar interactions were observed in which two of these cultural variables had opposite effects on participants in Japan and the United States. These cultural variables were interdependence and figure-ground preferences. Japan and the United States have cultural norms that are opposite with respect to both of these cultural variables. Japanese tend to be high in interdependence and prefer ground information first. Americans tend to be low in interdependence and prefer figure information first. Therefore, the interactions found here can be reinterpreted. Deviation from cultural norms within the dimensions of interdependence and figure-ground preferences correlate with task performance. Such an effect may easily stem from reasoning found within the bilingual literature. In a sense, these individuals are bicultural. They live in cultures that have particular standards of behavior. Yet, they had individual preferences for behaving in non-normative ways. As members of their culture, they will likely acquire cognitive tools that will help them adhere towards these norms. However, as these individuals come with predispositions that oppose their culture norms, they must habitually negotiate between their individual and cultural preferences. This habitual negotiation results in the strengthening of certain cognitive tools.

The exact cognitive tools that have been strengthen because of habitual negotiation between individual and cultural preferences appear to be related to (1) the ability to focus attention away from context and (2) general abilities to perform tasks that require participants to deciding between competing responses. Assuming that these two effects are related, then then it is possible that more effortful to make eye-movements towards objects then to make them to objects and their context. Contextual information will aid in the processing of objects. However, attending to this information may be costly for certain aspects of describing the details of a scene. In the Navon task, participants generally had a preference for attending towards global information. This corroborates the idea that these participants generally preferred contextual or global attentional strategies.

For the original hypothesis each cultural variable had an independent mechanism through which they affected attentional strategies. In contrast, the results of these studies suggest that more general mechanisms are responsible for the effects of culture on attention. These mechanisms might be akin to the effects of bilingualism on cognition. Moreover, these effects can be seen in multiple cultural variables. This suggests either that these factors can independently have similar effects on attention or that these factors interact within a complex ecosystem of cognitive tools, with an individual's placement within this dynamic as the true factor that necessitates the modulation of attentional style.

Chapter 4

Personality Describes Behavior

The cognition of individuals varies. This individual variation may actually be more important than group level differences when examining cross-cultural variation. This becomes apparent when culture and cognition are as seen as a single culture-cognition system. The very cognitive tools with which individuals understand and interact with their environment are shared and disseminated among the individual agents within the culture-cognition system. As this dissemination process relies on the interconnections and locations of individuals, cognitive tools will naturally be non-uniformly distributed across members of a culture. Identifying these individual differences help to identify the particular cultural variable responsible for cognitive variation. For example, if self-construal is responsible for the cross-cultural differences in visual attention, then individual differences in self-construal should also correlate with individual differences in attention. Otherwise, a different cultural variable is likely the origin of this cognitive variation.

In some cases, however, cognitive tools are gained/strengthened because individuals must do so in order to competently function in their environment. In other words, individuals will rely on previously acquired (cultural or biological) tools as scaffolding for the target tool. As agents come with unique biological predispositions and previous environmental experience, each individual will differ in the specific scaffolding that they use when gaining a new tool or strengthening a previously acquired one. For example, if an individual learns a second language, much of their second language knowledge will be heavily influenced by their first language knowledge.

The cognitive styles of individuals develop over time in order for them to be competent members of their culture. Individuals will be unaware of many aspects of their cognitive style. In some cases, this is because specific tools themselves are not under normal privy of the conscious mind. In some cases, the use of these cognitive tool will be so commonplace, that there is little awareness that use of the tool could vary. However, in many cases, variation in cognitive style is socially salient. Such cases are likely to motivate individuals towards certain cognitive styles. Moreover, these differences are likely captured by personality instruments.

According to the American Psychological Association, "[p]ersonality refers to individual differences in characteristic patterns of thinking, feeling and behaving" ("Personality" n.d.). In other words, measures of personality should theoretically capture individual differences in cognition. In line with the definitions of cognitive style outlined earlier in this chapter, individuals with different personalities have different cognitive styles. However, much of the psychological literature utilizes definitions of personality that differ from the APA definition. These definitions suggest that one's personality consists of the *socially relevant* traits that differentiate them from others (e.g. McCrae & Costa, 1997)

While the personality overlaps with cognitive style, they refer to slightly different concepts. Cognitive style refers to the entire set of cognitive tools that an individual possesses. Some of these cognitive tools may be more or less socially relevant. For example, a person's verbose communicative style might be quite noticeable to others and cause them to be labeled with an 'extroverted' personality. However, if a person has a particular eye-movement strategy while reading, this strategy may go unnoticed by their peers. Thus, the strategy affects their cognitive style, without necessarily affecting their personality. Moreover, personality might categorize particular cognitive tools together. For example, a person who likes to make jokes and a person who likes to talk constantly about art may both be labeled as 'extroverts,' but the underlying reasons for why they talk frequently are different.

The most popular approaches to personality stem from what is known as the lexical hypothesis, which assumes that any and all socially relevant aspects of individual human variation will emerge in language (Galton, 1884). In other words, if people do not talk about a particular aspect of cognitive variation, then that aspect of variation is probably not a robust dimension of personality. This runs contrary to cognitive style, which captures all aspects of cognitive variation.

The most persistent view of personality is the five-factor model, which follows the lexical hypothesis. It was derived from an analysis of English personality trait terms, words that describe long-term behavioral characteristics of individuals (e.g. talkative, caring, shy, artistic). The approximately ~3500 English trait terms were introspectively grouped into 37 categories. Then, through several studies, participants were asked to rank themselves and others on these 37 categories. Factor analyses on these ratings consistently showed that English speakers group these 37 categories into five dimensions. Based on the psychology literature, these dimensions were named:

Extraversion, Agreeableness, Conscientiousness, Neuroticism, and Openness to Experience.

Many questionnaires have been created from these five dimensions. Factor analyses on these questionnaires, even when translated into other languages, consistently show five factors that more or less align with the original five derived from English (McCrae & Terracciano, 2005). However, when the original analysis is performed on trait terms from other languages, novel dimensions arise. For example, in Korean, there is a dimension of honesty-humility (Hahn, Lee, & Ashton, 1999). Even within other proto-Indo-European languages, such as Italian or Hindi, there are stark differences from the English analysis. Such inconsistencies suggest two ideas. First, personality dimensions are parts of larger folk models through which cultures explain human behavior. Thus, each culture will identify only the culturally relevant differences in behavior as personality. Moreover, the dimensions through which individuals self-introspect about their own behavior and thoughts are *culturally defined*. Second, even when personality measures are derived from a particular culture, individuals from outside that culture may introspect about themselves within that cultural framework.

There are many personality measures. Some, like the big five based measures, have gone through rigorous testing to ensure that within-questionnaire measures show internal validity across a large number of participants. Such ensures that different questions measuring extroversion will reliably correlate with one another. While the internal validity of other personality measures – such as the Myers-Briggs Typology Indicator – have been questioned, all such personality questionnaires are based on folk models of human behavior and rely on the self-introspection of participants. Interestingly, however, some personality measures – like the big five – have been discovered via data-driven approaches akin to those of cognitive anthropology.

4.2 Personality Folk Models

The idea that culture can be discovered through language is shared by sociocultural anthropologists and advocates of the psycholexical approach to personality. The psycholexical approach, following the lexical hypothesis, suggests that the socially relevant aspects of individual human variation will emerge in language (Galton, 1884). Inspired by this idea, Allport and Odbert (1936) were among the first to exhaustively identify English words that described individual characteristics. From an American-English dictionary, they identified words which they labeled personality traits. These described long lasting behavioral characteristics (e.g. agreeable, imaginative, stubborn). They did not include physical traits (e.g. fat, tall, skinny, short), temporary states (e.g. happy, sad, mentally exhausted), or evaluations (e.g. awesome, good, bad). They identified ~4500 personality trait terms in English.

As there are thousands of personality trait terms in English, several attempts have been made in order to reduce these into larger category groupings. The first was made by Cattell (1946), who discovered 35 categories based on his personal intuitions and participant judgments. Following Cattel, Tupes and Christal (1961) were the first to discover that English personality trait terms could reliably be placed into a five-factor structure (the five-factor model; FFM). This was soon verified by Norman (1963), and many thereafter (e.g. McCrae & Costa, 1997; McCrae et al., 2005). The contemporary names for these factors are: (1) Extraversion, one's likelihood to be associated with attention seeking and social dominance, (2) Agreeableness, one's likelihood to be compassionate, trusting, and helpful, (3) Neuroticism, ones likelihood to have stress of negative emotions, (4) Conscientiousness, one's likelihood to be organized and focused, and (5) Openness to Experience, one's likelihood of being intellectually curious and creative.

The original discovery of the FFM can be considered a cognitive-anthropology-like discovery. Indeed, the cognitive anthropologist, Roy D'Andrade (1965) reconstructing the five-factor model using cognitive-anthropological techniques. Rather than having individuals judge the behavior of individuals using personality traits of individuals, D'Andrade (1965) had 10 individuals judge the similarity of personality trait words (e.g. How similar is the term silent to the term cautious?). Factors extracted from these judgments replicated the original big five factors, indicating that the participants did indeed have internal conceptualizations of these. A larger scale study by Hakel (1974) also replicated the FFM. However, rather than similar judgments between words, Hakel ask participants, "Suppose a person is _____ - how likely is it that he is also ____?" With 480 respondents ratings of 100 pairs, Hakel replicated the Big Five factors. As these tasks did not ask people to describe an external person, trait similarity must exist in the minds of the participants.

It is important to note, that as a folk model derived from English, the FFM is not necessarily consistent across different languages and cultures. Early attempts to rediscover the FFM in Germanic languages did succeed quite well. Angleitner, Ostendorf, and John (1990) found that German trait adjectives gave five factors that seemed identical to English. De Raad (1992) only found minor differences between five factors that emerged in Dutch and the American-English factors. Mainly, the fifth Dutch factor contained terms such as progressive or rebellious, terms that did not contribute to the American fifth factor (Openness). While these do show a rediscovery, Dutch and German are quite related to English in a historical sense, compared to other languages (Konig & Auwera, 2013).

Analyses of personality traits have been conducted on a total of 30 languages with at least 3 millions speakers (de Raad & Mlacic, 2017) Of these, 19 are from the Indo-European language family. Of these, Hindi and Farsi are the only ones spoken in areas outside of Europe. Many language families, such as the Niger-Congo, Dravidian, or Amerindian, have been completely ignored. An analysis of Hindi by Singh, Misra, & De Raad (2013) revealed six significant factors quite different from the big five. For example, the first factor was highly associated with traits such as hypocritical, brutish, and cruel. Singh, Misra, & De Raad suggest that the first three factors aligned with the ancient Indian concepts of Rajas, Sattva, and Tamas, which correspond to egoistic and driven, peaceful and virtuous, and apathetic and disordered. Markus & Kitayama (1998) argue that the concept of personality itself is quite different in many Asian cultures. Rather than a view that society is a collection of independent individuals (i.e., individualism), personality is understood by an individual's behavior within a collective (i.e., collectivist).

Clearly there is deviation from the FFM as one examines languages that are historically unrelated to and geographically separate from English. However, even within English, it is not clear that the FFM is stable. Piedmont and Aycock (2007) examined the historical entry of personality trait words into the English language. They found that the average trait term for Extraversion and Agreeableness entered English in the mid-1500s, the average trait term for Conscientiousness and Neuroticism entered English in the 1600s, and the average Openness trait terms entered English in the early 1700s. Interestingly, the timing of trait term entry resembles the ranking of the big five. Earlier trait terms might be more relevant to the English language, and thus behaviors centered around these traits might be more relevant. Overall, this shows that personality models evolve over time, possibly changing as certain individual differences become salient at different times in a culture's history.

4.2 The Myers-Briggs Type Indicator

While instruments based on the FFM have been used extensively within the field of psychology to measure individual differences, they do not represent the personality measures within the popular culture. Perhaps the most popular personality measure in online media is the Myers-Briggs Type Indicator (e.g. *Human-Metrics*, n.d.; *16Personalities*, n.d.). The MBTI is a personality measure that was created by two amateur psychologists, Katherine Briggs and Isabel Myers, who based the indicator on an adaptation of Carl Jung's theory of *cognitive functions*.

Jung's original theory suggested that there are four major functions that characterize behavior. Two of these, Sensing (S) and Intuition (N), Jung classified as functions geared towards attending to particular kinds of information (i.e., Perceiving 'P' Functions). Sensing refers to attention towards sensory information gathered by a perceptual modality, while Intuition refers to attention towards abstract theoretical information. Jung also classified two functions, Thinking (T) and Feeling (F), as functions geared to sorting and classifying information in order to make decisions (i.e. Judging 'J' Functions). Thinking involves the use of conceptual manipulation (e.g. logical deduction) in order to make sense of information, while Feeling seeks to utilize particular subject experience and values in order to make sense of information. Each of these four functions could be oriented in either an extraverted or introverted orientation, making a total of eight cognitive functions. Jung believed that each individual employed all functions, but a particular function was dominant for each individual. In this way, Jung's theory behaves very much as a folk model of cognitive style.

The amateur psychologists, Katherine Briggs and Isabel Myers, refined Jung's theory of cognitive functions and built the MBTI. The indicator assigns individuals to one of 16 types. These assignments are based on four binary dimensions: (1) Extraversion-Introversion, similar to the big-five dimension of Extraversion, (2) Intuition-Sensing, measuring if an individual prefers to take in abstract information or concrete information, (3) Thinking-Feeling, measuring a preference for making decisions based on objective conceptual manipulation or based on personal experience and values, (4) Perceiving-Judging, a person's preference for taking organizing information and making decisions. The indicator itself went through many refinements, both by Myers and later the Educational Testing Service. It is now prominently used in social media, career counseling, and industry/organizational psychology.

Each type – according to the Myers-Briggs Model – stood for a specific cognitive function style, with one of the eight functions as dominant. For example, the ENFP (Extraverted, intuitive, feeling, and perceiving) type has dominant extraverted intuition. The indicator independently assesses individuals within the binary dimensions and does not test explicit preferences for the cognitive functions. Thus, there is the rather simple indicator that groups individuals into 16 categories, and there is a more complex folk model of these types which suggests complex interactions between cognitive functions and particular ways in which individuals mature through time. This is interesting, because the ways in which people might talk about Myers-Briggs types will involve the discussions of dynamics that are more complex than the indicator itself. Given the origins of Jungian theory, it is difficult to suggest that these models give a high-fidelity model of human cognition. However, as a folk model ever being redefined by communities of individuals, it is likely that the Myers-Brigs model takes on the socially-relevant discoveries of these communities. Thus, a personality type might represent a corner within a 4-dimensional space, or a personality type might take on a representation more completely defined by the community. This is, in a sense, ideal for understanding how cultures evolve personality theories. If these theories pick up on true behavioral differences, then the more complex communicative folk model of the 16 types should have larger explanatory power than the binary 4-dimensional space.

Moreover, the MBTI can be used as a proxy for the Big Five model. This is especially useful when looking at large online datasets, as people often disclose their Myers-Briggs personality types in social media. Several studies have looked at the correlations of Myers-Briggs and the Big-Five (Furnham, 1996; McCrae & Costa, 1989). Among all three, strong correlations were found between MBTI Extroversion and Big Five Extroversion, MBTI Intuition and Big Five Openness, MBTI Judging with Conscientiousness, MBTI Feeling and Big Five Agreeableness. These studies also report minor, yet significant, correlations between Big Five Neuroticism and MBTI Extraversion and Feeling, Big five Openness with MBTI Extraversion, Intuition, Thinking, and Perceiving, and Big Five Conscientiousness with Sensing. Clearly, there do exist relations between the two measures – due in part to the pervasive use of a shared language to describe these various personality traits.

4.3 Language Variation

Language is a cognitive tool. It is used to both interact with the world and to understand it. People use language in order to express their intentions, needs, beliefs, and desires. In addition, language provides ways in which to understand the world. For any give language, that language provides categories for identifying both real world entities and abstract concepts. In other words, a language helps to constrain and identify information that is relevant to a speaker of that language.

There are over 6,000 languages (*Ethnolouge*, n.d.). While there do appear to be some universal commonalities among most of them, it is quite uncontroversial to say that language varies. Much of the discipline of linguistics is dedicated towards understanding how language varies. Cross-linguistic analyses show differences in the sound inventories, morphological complexities, and word orders among the world's languages. Moreover, each language groups objects in the world and abstract concepts into unique categories. For instance, English and Japanese group colors differently. While English speakers can label the color of the sky and the color of a sapphire as 'blue,' Japanese speakers must identify these separately as *mizuiro* 'water-color' and *aoi* 'green-blue,' respectively (Athanasopoulos, Damjanovic, Krajciova, & Sasaki, 2011). Such linguistic differences – grammatical and categorical – affect the ways in which speakers of a language attend to and categorize the world even in non-linguistic tasks. This corroborates the notion that language acts as a tool to understand and interact with the world, particularly because language biases the ways in which we understand and interact with the world.

While stark differences can be seen across languages, there is also variation within language[11]. Sociolinguists and linguistic anthropologists have documented widespread variation within languages. Such variation can be seen due to geographic location (J. Chambers & Trudgill, 1998), social class (Labov, 1986), gender (Tannen, 1994), and one's generation (Labov, 1962). Moreover, individuals will use distinct variations of language within different social settings (Gregory, 1967). For instance, a person will likely talk differently with their friends than with their parents.

One aspect of linguistic variation that has only recently been studied in great detail is the relationship between personality and language. A limited number of studies, however, have shown that personality – especially openness to experience – affects the language use of individuals.

4.4 Language and Personality

Most research examining the link between personality and language use is quite recent. However, in the past half-decade, these studies have begun to show that personality predicts fine-grain

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[11] Sometimes it is quite difficult to distinguish between two languages and varieties of the same language.

psycholinguistic processes, language learning, and the use of particular language forms in online media.

Several studies have shown that personality is related to variation in language use. These have especially focused on the usage of lexical items. These differences are akin to language variants or dialect differences, as different personalities are more likely to utilize particular words than others. For example, Lee, Kim, Young, and Chung (2007) examined the relation between personality and free style writing by Korean participants. Participants with higher openness to experience scores were likely to have more sentences, more likely to use personal pronouns, less likely to use proper nouns, used less adverbs, and were less likely to refer to sleep. Other five factor correlates were found, including verb usage with extroversion and emotion words with neuroticism. In addition to the five factor dimensions, participants were also scored on the MBTI. For example, the overall number of phrases, morphemes, and suffixes coincided with the sensory dimension. The use of swear words and words about thinking coincided with the judging dimension.

Kern et al. (2014) examined the text of Facebook users who took an online assessment of the big five. They analyzed how unigram frequencies (i.e. single word counts) correlated with the five dimensions. They were able to successfully find different frequency patterns along each dimension. For example, mentions of the word “anime” were correlated with introversion, while mentions of the word “party” associated with extroversion. In addition, the authors looked at frequencies of words within semantic categories as defined by the Linguistic Inquiry Word Count (LIWC) template. For example, openness to experience correlated with the frequency of insight words such as ‘accept,’ ‘believe,’ or ‘know.’ Interestingly, openness to experience was also correlated with the use of articles (e.g. ‘the,’ ‘an,’ ‘some’). Unigram frequency based scoring of personality is reliable, with correlations between vocabulary based predicted scores having up to a r=.46 correlation with questionnaire scores (Park et al., 2014). Schwartz et al. (2013) examined how the big five personality traits correlated with eh vocabulary of Facebook users. They found significant correlations for all five factors. For example, extraversion was correlated with words for group activities such as ‘party’, while introversion was correlated with words for solo activities such as ‘anime.’ Neuroticism was associated with profanity, or ‘depression.’ This Facebook dataset was also used to predict the personality of users. Using word frequencies and meanings, Park et al. (2014) were able to predict the big five personalities with correlations of at least .35 for each of the big five dimensions.

Several studies have shown a particular influence of the big five factor, openness to experience, on language. These studies have shown that individuals more open to experience have better abilities to learn languages and to adapt their language to that of other speakers. Openness to experience has often been associated with intelligence and tendencies to seek novel experiences, and it has been experimentally linked to areas of cognition outside of language such as musical abilities (Thomas, Silvia, Nusbaum, Beaty, & Hodges, 2015) and statistical learning (Kaufman et al., 2010).

Yu, Abrego-Collier, & Sonderegger (2013) gave participants a word production task before and after listening to a narrative. Participants were also given a questionnaire assessing their personality on the five factor dimensions. The authors measured the phonetic properties of the speech of participants before and after the narrative and compared these properties to those of the narratives. Along with other factors, the degree to which participants assimilated the phonetic properties of the narrative correlated with openness to experience.

Verhoeven & Vermeer (2016) gave second language speakers of Dutch a battery of measurements assessing linguistic competence. Openness to experience significantly predicted performance on almost all of their measures. These included the ability to define words, and, reading comprehension, pragmatic competence. In addition, these authors gave native Dutch speakers these same linguistic measures. While their performance was overall higher than the second language speakers, openness to experience significantly predicted many aspects of their linguistic competence. These included abilities to define words and pragmatic competence.

When learning a second language, those with high openness to experience are able to more accurately make judgments about multi-word phrases (Kerz & Wiechmann, 2017). Kerz & Wiechmann gave non-native speakers of English multiword phrases with high frequency (e.g. Don’t have to worry) and low frequency (e.g. Don’t have to wait). These were intermixed with ungrammatical phrases. Typically, native-English speakers are sensitive to the frequency of multiword phrases, and are quicker to process more frequent phrases. Second language learners who had higher openess to experience showed a more native-like effect of multiword phrase frequency.

Jackson (2018) gave participants a task where he had participants learn vocabulary items in a pseudo-language. Participants were asked to view pictures paired with novel words. They were then given a vocabulary test, assessing their ability to remember the word-image pairings given to them. Participants who scored higher in openness to experience had higher overall accuracy when completing the vocabulary test. In addition, the author asked participants to report the specific strategies that they used in order to memorize the vocabulary. In cases where participants did not use explicit strategies, those who were more open to experience performed especially above those who were unopen to experience. Of importance, this study closely mirrors the association tasks performed by participants in chapter 2 of this dissertation.

4.5 Goals and Hypothesis

The abovementioned studies suggest that there is indeed a relation between openness to experience and language. Overall, this relation suggests that those who are open to experience have higher abilities to adapt to and learn language. Many of these studies specifically relate to second language acquisition and ultimate attainment, with more open individuals having more native-like fluency. Interestingly, even native speakers showed differences in linguistic competence based on their personality (Verhoeven & Vermeer, 2016; Yu et al., 2013). In addition, there are many studies showing that personality differences may be readily found in online data. Thus, language-related competence should be seen in the language of online communities.

While personality does appear to correlate with language use and other aspects of cognition, measures of personality are still constructed from folk models of the ways individuals differ. On the one hand, this means that personality measures will not capture all aspects of cognitive style. On the other, personality is likely to capture individual differences that measure the degree to which individuals adhere to certain cultural norms. Personality systems have been discovered via social processes through years (perhaps decades or millennia). Thus, these folk models have been optimized to capture individual variation with respect to culture. Therefore, it follows that differences in personality will align with the degree to which individuals take on linguistic and cultural competency, as suggested by the abovementioned studies.

The purpose of this study is twofold. First, this study seeks to expand the growing evidence suggesting a relation between personality – specifically openness to experience – and language. Based on previous studies, I hypothesized that the Myers-Briggs personalities of online forum users will predict aspects of their language use related to overall language knowledge and language accommodation. To test this, I examined proxies for the vocabulary sizes of users on an online forum, and assessed the degree to which they conformed their language patterns to other users on the forum.

Moreover, I examined language use specifically on a forum where people talk about personality. As such, I performed a secondary analysis that captures their folk intuitions about personality. Using a word2vec model to quantify this folk model, I re-analyzed the effects of personality on the measures of vocabulary size and accommodation. I hypothesized that the components derived from the word2vec model more significantly predict these measures.

4.6 The Data

All data were acquired from an online forum dedicated to the discussion of personality. Typical forum topics include: how certain Myers-Briggs types behave in specific situations, the Myers-Briggs types of celebrities, and alternative personality systems, as well as non-personality related material such as science, the news, and popular culture. Each user has the option of tagging their posts with a self-identified Myers-Briggs type. At the time of data acquisition, there were a total of 1,983,279 posts on the forum with 10443 users.

4.6.1 Acquisition of the Data

The entire set of publicly available forum posts were scraped from TypologyCentral.com. For each post, the post content was acquired, along with username, self-identified Myers-Briggs type, date, time, and sub-forum identification number.

4.6.2 Data Cleaning

All posts were anonymized, tokenized, stripped of punctuation, and changed to lowercase. There are many ways to identify as one of the 16 Myers-Briggs types. All such ways were converted into canonical labels (i.e. 'ENFP').

4.6.3 Basic Descriptive Statistics of the Data

The data comprise a total of 10443 users. Of these, 7320 users self-identified a Myers-Briggs type. The posts by these users comprise 1,558,901 of the total 1,983,279 posts on the forum. The users are not evenly distributed among the 16 Myers-Briggs types. The total number

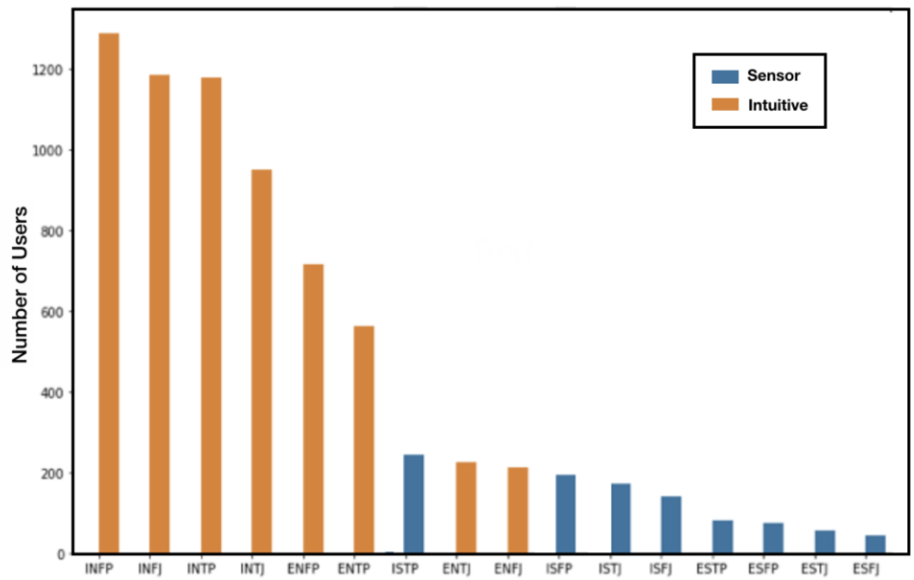

Figure 4.1. Number of users grouped into each of the 16 Myers-Briggs types. Intuitives are plotted in orange and sensors are plotted in blue.

of users for each type have been plotted in Figure 4.1. The INFP type consists of the highest number of users (n= 1287), while the ESFJ type consists of the lowest number of users (n=44). A clear pattern can be seen among the user counts for each type; There are more individuals who identify as intuitives on the forum than those who identify as sensors. This is surprising given the Myers-Briggs Foundation estimates that sensors comprise 73.3% of the population (Myers-Briggs, n.d.). This imbalance suggests one of two possibilities: (1) intuitive types are more likely to find interest in a forum that discusses personality types or (2) given the descriptions of intuitive types, individuals are more likely to self-report as an intuitive.

4.6.4 Initial Data Analysis

Based on previous findings in the literature, personality should correlate with overall linguistic knowledge and with accommodation to other speakers. While the vocabulary size of users in this study could not be assessed directly, two proxies for vocabulary size were used. These proxies were number of unique words per post and average word character lengths. While participants will not use their entire vocabulary on the forum, the relative vocabulary sizes of users can be inferred from the number of unique words per post as users with higher

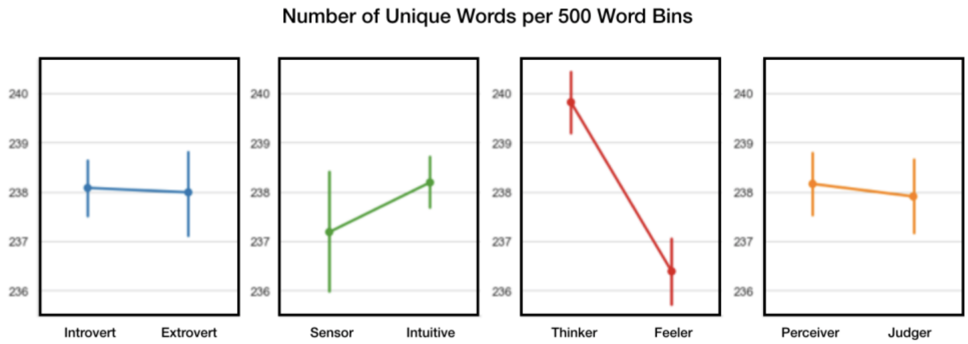

Figure 4.2. Number of unique word for each 500 word bin. Individual plots show differences within each of the four binary Myers-Briggs dimensions.

vocabularies are able to pull from a large baseline of vocabulary items in order to make their posts. As the number of unique words in a text do not grow linearly with the size of a text, counts were restricted to the first 500 words of a user. Thus, posts with more unique words relative to the size of the post will be used by users who have larger vocabularies. Moreover, users who have higher vocabularies will be more likely to know words that are less frequent. Word length correlates with frequency. Thus, individuals who use words that are longer will likely have larger vocabularies.

As users of an online forum, individuals will have opportunities to interact with other individuals and change their language such that it matches others on the same forums. To operationalize this accommodation, each post was compared to the last 5 posts on a forum that preceded it utilizing a measure known as Jaccard similarity. For each post, two bigram sets were created. The first contained unique bigrams in that post and the second contained unique bigrams pooled form the 5 preceding posts. Jaccard similarity scores were calculated by dividing the intersection of these two sets by the union of these two sets.

Vocabulary Size

In order to examine the effect of personality on number of unique words per user, a linear regression was performed, with each of the 4 binary MBTI dimensions as predictors. There was a significant effect of thinking, with thinkers having an average of 1.75 more unique words per 500 words than feelers ($F(1,3924) = 52.584$, $p < 0.00001$). This effect

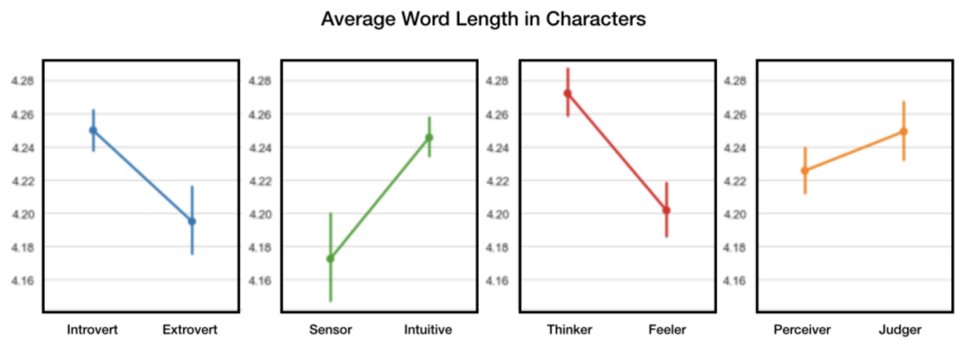

Figure 4.3. Average word length in characters per user. Individual plots show differences within each of the four binary Myers-Briggs dimensions.

is plotted in Figure 4.2. This is particularly surprising as thinking is anticorrelated with openness to experience. However, as a dimension of Myers-Briggs, thinkers tend to be naturally curious and may be likely to explore new topics and ideas more than feelers.

In order examine the effect of personality type on word length, a linear mixed effects model was created with each of the 4 binary MBTI dimensions as fixed effects. Two random intercepts were included in the model. These were user and forum. Random slopes could not be included in the model as most users did not post in most forums. Three of the four binary dimensions significantly predicted average word length per post. Introverts used words that were an average of 0.018 characters longer than introverts ($F(1,3114) = 20.90$, $p < .00001$). Intuitives used words that were an average of 0.0148 characters longer than sensors ($F(1,3027.419) = 9.522185, p=.00204$). Finally, thinkers used words that were an average of 0.029 characters longer than feelers ($F(1,3436.7)=68.27$, $p < 0.00001$). This effect is plotted in Figure 4.3.

As both of these measures are proxies for vocabulary size, they should correlate. Indeed, a regression revealed a significant correlation of mean word lengths and unique words ($F(1, 322) = 321.97, p<0.00001$). However, the effects of introversion and intuition were only significant for the character length model. The number of unique words model pooled across the posts of individual users as many posts were too short for accurate analysis. As a result, it is likely that these effects only showed in the character length model because it was able to account for variance due to the random effects of user and forum. With this reasoning, three of the four dimensions – introversion, intuition, and thinking – have effects on vocabulary size. Only one of these dimensions (i.e. intuition) aligns with openness to experience. However, the

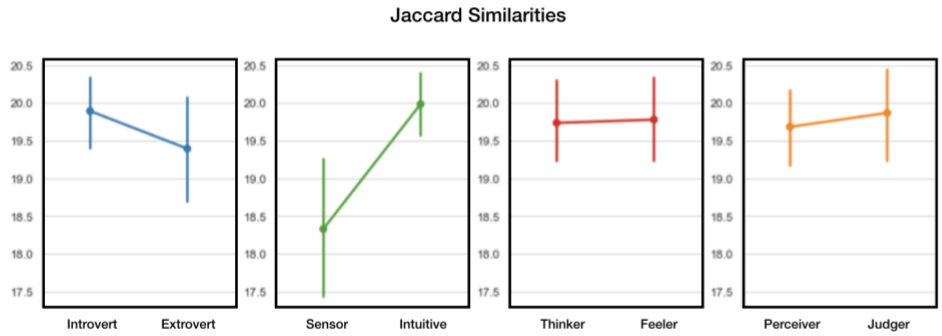

Figure 4.3. Average Jaccard distance from previous forum posts per user. Individual plots show differences within each of the four binary Myers-Briggs dimensions.

dimension of intuition does have the strongest correlation with openness to experience. It is possible that introversion and thinking predict vocabulary sizes for other reasons. Of note, however, one study has looked at the relation specifically between Myers-Briggs and language Ehrman (2008). It reports that among a sample of language learners, INTJs comprised the biggest proportion of students at the highest level. This aligns with the findings here.

Jaccard Similarity

In order to examine Jaccard distances, a linear mixed effects model was created with each of the 4 binary MBTI dimensions as fixed effects. Two random intercepts were included in the model. These were user and forum. Random slopes could not be included in the model as most users did not post in most forums. There was a significant effect of intuition, with inutitives being more likely to use words that overlapped with previous posts ($F(1,1774.3) = 5.1161$, $p = 0.02382$). This effect is plotted in Figure 4.4. In other words, intuitives are more likely to accommodate their language use to that of others. Given that intuition is most highly correlated with openness to experience, this effect could be driven by the fact that these users are more open.

4.7 Exploring the Myers-Briggs Folk Model

The above section explored the effects of each of the binary Myers-Briggs dimensions on vocabulary size and accommodation to the language of other on the forum. It is important to note that models of personality – even as systems that are constrain by folk intuitions – are more complex than binary 4-dimensional systems. They stem from complex behaviors of individuals within a culture. Individuals observe these patterns and ascribe traits or even psychological processes to those individuals.

Even the Myers-Briggs model has complexities that go beyond four dimensions. The Myers-Briggs model of personality is explicitly outlined in many resources and among members of the forum of interest's community. The original model suggests that each type prefers to use a specific set of underlying cognitive tools. Types that are similar in 3 out of 4 of the binary dimensions may or may not share the same cognitive tools. For example, the model suggests that an ENFP and an ENFJ will have similar surface level behaviors, but do not share the same cognitive tools. In contrast, the model suggests that an ENFP and an ISTJ will show dissimilar outward behaviors but rely on similar sets of cognitive tools. While the Myers-Briggs indicator makes no attempt to confirm these speculations or to understand the cognitive tools of individuals, talk about these unintuitive relations between the 16 types is ubiquitous among serious users of the Myers-Briggs model. It is possible that the definitions of the 16 types, as formed through communities of talk, have taken on such complexities.

Myers-Briggs has a rich history of use and has much popularity online. Much of this popularity has led to the existence of unofficial Myers-Briggs quizzes (e.g. *Human-Metrics*, n.d.; *16Personalities*, n.d.). Thus, these dimensions have been placed within a social context. This would suggest that the Myers-Briggs personality types themselves have taken on richer meanings than were originally constructed. In addition, the forum of interest has specifically dedicated to the discussion of personality. Therefore, these users have assigned distinct meanings and identities to each of the Myers-Briggs types. These attributes have likely captured some socially relevant features of personality. It is possibly that – more so than the four dimensions themselves – the ways in which people on the forum talk about personality indexes the aspects of language use analyzed above. In order to quantitatively capture relationships between the 16 personality types as talked about by forum users, I utilize a word2vec model.

4.7.1 The Word2Vec Model

In a Word2Vec model, a feed-forward neural network is trained to predict the context of a word given a word that appears in that context. The network contains a single hidden layer. Once the model is trained, each word is assigned a vector equal to the hidden layer activations when that word is given to the network. Word2Vec works well to capture semantic relationships between words. For example, in well-trained Word2Vec models, the vector for 'king' minus the vector for 'boy' plus the vector for 'girl' will return a vector that is closest to the vector for 'queen.' As such, word2vec models can give insights into the semantic relationships between words. If given the right dataset, these relationships can capture rich distinctions between words. In the current dataset, users talk frequently about the Myers-Briggs types. They use labels for each type (e.g. 'ENFP') in order to compare and contrast people or understand the complex dynamics of how people behave and interact with others. As such, the labels for each Myers-Briggs type will be used in a slightly different way. The nuances of these linguistic contexts will affect how each Myers-Briggs label is treated by the word2vec model. I will then use the results of this model to reanalyze the linguistic variables from the previous section (number of unique words, word lengths, and Jaccard similarities to previous posts).

For the current analysis, a Word2Vec model with 50 nodes in the hidden layer was trained on the entire set of posts from the forum. A vector was obtained from the model for each of the 16 personality types. The mode was set to create a vector for the most frequent 20000 words that appeared on the form. Among these 20000 vectors were vectors for each of the 16 personality type labels. Pairwise comparisons between the vectors for each of the types were made using cosine distance. Multidimensional scaling followed by a principal components analysis was performed the cosine distances. A total of four components were extracted. These components are visualized in Figure 4.4.

The original four dimensions of the Myers-Briggs do appear to be captured Examining the first four components, there appears to be alignment with the four binary dimensions of Myers-Briggs. Component 1 appears to primarily capture the dimensions of sensing-intuition, as well as some of the introversion-extroversion dimension and to an even lesser degree, the feeling-thinking dimension. Component 2 appears to capture the dimension of feeling-thinking, and to a lesser degree, introversion-extroversion. Component 3 appears to capture the interaction of the of judging-perceiving dimension and the intuition-sensing dimension. The difference in component three between sensors and intuitives is reversed, depending on if the types are judgers or perceivers. Component 4 appears to capture the dimension of introversion-extroversion and the dimension of feeling-thinking. While the components do capture the four binary dimensions, there does appear to be extra information about each specific type. For example, even though the second component appears to capture the thinker-feeler distinction, the difference (as measured within component two) between an ISFP and ISTP is much greater than the difference between ESTJ and ESFJ.

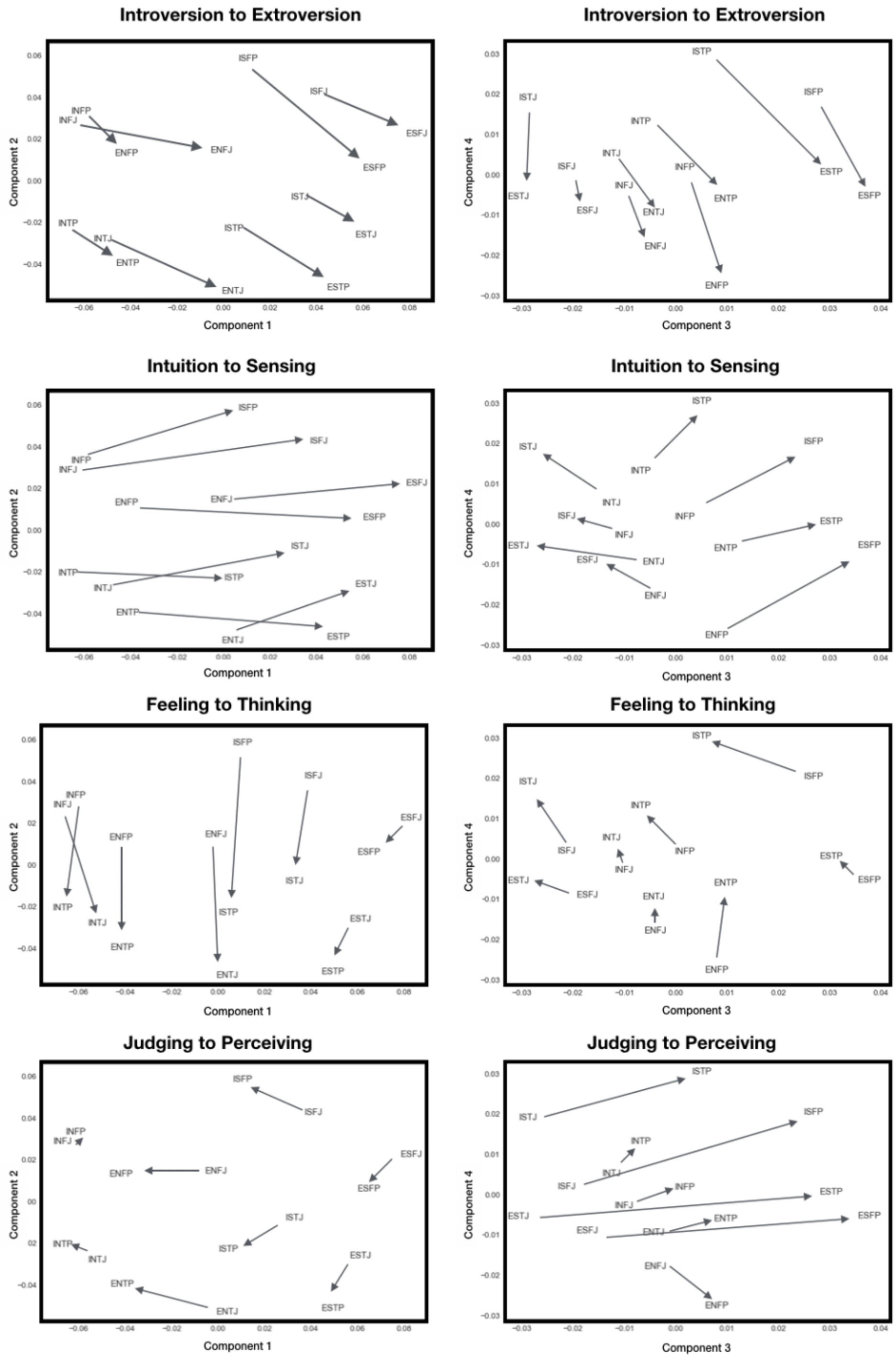

Figure 4.4. Each of the 16 Myers-Briggs labels plotted within the four components derived from the word2vec model. Components 1 and 2 shown on the left, while components 3 and 4 are shown on the right. Each row shows labels paired along each dimension (e.g. INFP and ENFP paired for introversion-extroversion).

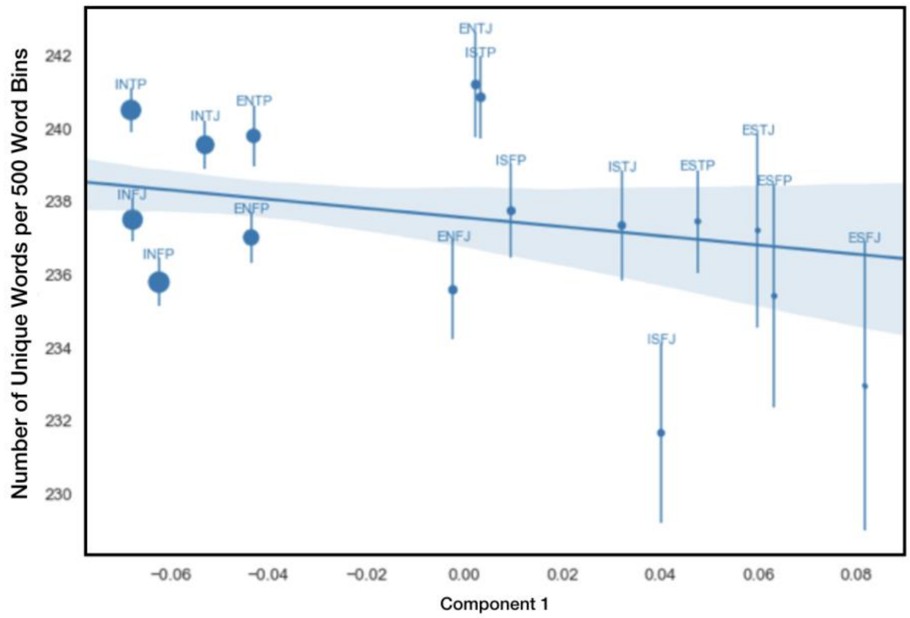

Figure 4.5. Number of unique words per 500 word bin plotted against Component 1.

4.8 Second Analysis

The word2vec components can be used see how the ways in which users talk about the Myers-Briggs types are able to better predict linguistic differences. Each user has self-identified themselves as one of the 16 personality types. For each user, four new scores were given, based on how their self-identified Myers-Briggs type was embedded within the four word2vec components. Thus, each user was scored within each of the four word2vec components.

Vocabulary Size

As before, the effects of personality on number of unique words was analyzed with a linear regression. The original four binary dimensions were included as predictors. In addition, the four word2vec components were included as predictors. As before, there was a significant effect of thinking ($F(1,3920) = 52.6558$, $p < 0.0001$). In addition, there was a significant effect of the first word2vec component ($F(1,3920) = 5.1079$, $p = 0.02387$). This effect is plotted in Figure 4.5.

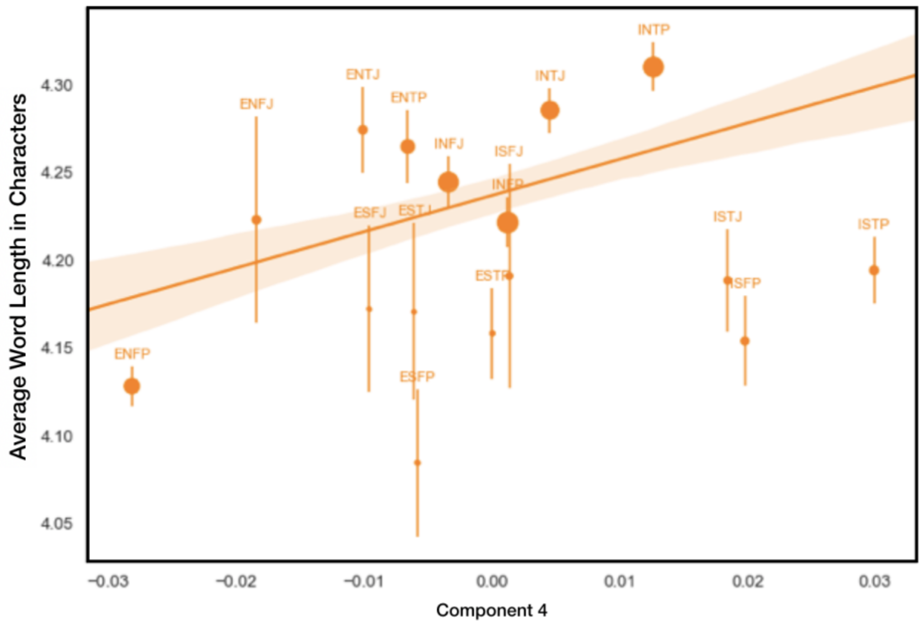

Figure 4.6. Average word length in characters plotted against component 4.

A second model was also created for word length. As with the previous model looking at word length, all four MBTI dimensions were included as fixed effects. In addition, the four word2vec components were also included as fixed effects. Two random intercepts were included in the model. These were user and forum. In the original model, three of the four factors showed significance. These were introversion, intuition, and thinking. However, only one of these factors was significant in the new model. Intuitives had significantly longer word lengths than sensors ($F(1,3175.5) = 5.1451$, $p = 0.0233$). In addition, the judging-perceiving dimension is now significant, with perceivers having longer words than judgers ($F(1,3236.7)=5.5863$, $p=0.0181$). The absence of significant effects for thinking and introversion may likely be due to correlations with the word2vec components. If any of the variance previously accounted for by the previous model were better accounted for by any of the components, then indeed, one component would show significance over the original dimension. Indeed, the fourth component significantly predicted word lengths, with higher component scores correlating with longer words ($F(1,3150.4) = 10.2068$, $p = 0.0014$).This effect is plotted in Figure 4.6. The fourth component aligned with the introversion-extroversion dimension and mildly with the thinking-feeling dimension. This coincides with the fact that introversion and thinking are no longer significant. However, the fact that component four significantly captures variation in word length suggests that the true individual differences underlying word length are more complex than the binary Myers-Briggs dimensions. Interestingly, the binary dimension of judging-perceiving significantly predicts word length when the four components are included in the model, with judgers having longer word lengths than perceivers ($F(1,3236.7)=5.5863$, $p = 0.018$).

Jaccard Similarities

A second linear mixed effects model was also made predicting Jaccard similarities. As with the first model, each of the 4 binary MBTI dimensions as fixed effects. In addition, the four word2vec components were included as fixed effects. Two random intercepts were included in the model. These were user and forum. In the original model, intuitives had significantly higher Jaccard similarities than sensors. However, in the new model, there were no significant effects for the four binary Myers-Briggs dimensions. Moreover, there were no significant effects from the four word2vec components. An absence of any significant findings is likely due to the explained variance being split between the binary dimensions and the components.

4.9 Conclusion

This chapter explored the relationship between language and personality. While language variation has been studied throughout the history of linguistics, the study of how language varies in relation to personality is has only recently gained attention. The current literature, however, does suggest there are indeed relationships between certain personality dimensions and differences in language learning (Verhoeven & Vermeer, 2016) and accommodation (Yu, Abrego-Collier, & Sonderegger, 2013). These correlations primarily relate to the big five dimension, openness to experience. In addition, there also appear to be general correlations between the words people use and all dimensions of the big five (Kern et al., 2014; Park et al., 2014).

Given that openness to experiences generally aligns abilities to acquire language and to adapt to the language of others, I decided to examine the relation between three linguistic variable and Myers-Briggs personality types. To do the analysis, text data from an online forum where individuals self-identify their Myers-Briggs types was used. Two of these variables served as proxies for vocabulary size, which should be higher for individuals who have general proclivities for acquiring language. These were unique word counts and average word lengths. The third variable was a calculation of the degree to which the language of a user's post matched the posts of the most recent posts within that post's sub-forum. These were calculated with a Jaccard similarity, which measured the overlap between unique bigrams between posts.

The intuition-sensing dimeson of Myers-Briggs most closely aligns to openness, and those who are self—report as intuitive types indeed show higher overall character lengths. A similar effect was not ound for the unique word model. It is important to note, however, that the number of users who reported to be sensors were much fewer than the number who reported to be intuitives. Given that the unique word model was weaker (i.e. data points were aggregated within users) than the word length model, it follows that an effect of intuition-sensing would be less likely to be detected in the unique word model. In addition, there was also an effect of intuition-sensing on Jaccard similarity, with intuitives have higher chance of using the same bigrams as previous users in the same sub-forum. As such, the overall results here are in support of the relationship between openness to experience, language learning, and language accommodation. As effects were seen for both word length and Jaccard similarity, it may be the case that intuitive individuals gain larger vocabularies because they pick up on new vocabulary as they accommodate the words of others.

Introverted and thinking types also had higher word lengths. However, while the Myers-Briggs dimensions of introversion and thinking are most correlated with the big five dimensions of introversion and dis-agreeableness, these dimensions have mild anticorrelations with openness to experience. Given that dimensions that both correlate and anticorrelate with openness to experience are predictive to word length, it is more likely that multiple dimension of personality drive vocabulary size. Indeed, when the word2vec components are added to the model, the thinking-feeling dimeson remains significant, while the significance of the intuition-sensing dimension is encompassed by component one. This suggests that these dimensions represent distinct sources of variation. It is unclear why dis-agreeableness would correlate with higher vocabulary scores. One possibility is that those who are agreeable are more likely to be attentive to prosodic and pragmatic features of language, as they may have higher degrees of empathy (Claxton-Oldfield & Banzen, 2010). In contrast, those who are less agreeable are more likely to attend to the literal meanings of words. Thus, they will be more likely to learn specific lexical items. This possibility is supported by studies suggesting correlations between agreeableness and the use of empathy (Graziano, Habashi, Sheese, & Tobin, 2007), as well as with psychological dispositions such as autism spectrum which can characterized by differences in the ability to read social cues (Schriber, Robins, & Solomon, 2014).

The second purpose of this chapter was to examine the ways in which the online community talks about personality. Dimensions of personality are the socially relevant differences between individuals. As such, personality dimensions are discovered through social interactions. While the originally Myers-Briggs dimensions were created by armature psychologists, it is possible that users of the Myers-Briggs model consistently extend the model in order to incorporate their own observations about social behavior. Thus, the talk surrounding Myers-Briggs may be more informative about individual differences than the original Myers-Briggs dimensions themselves. In order to see this, a word2vec model was created in order to capture differences in how the forum users talk about each of the 16 Myers-Briggs types. Four components were extracted from the word2vec embeddings of the 16 Myers-Briggs labels. While these components aligned in some ways with the original four dimensions, they appeared to capture additional differences between the 16 types that are not captured by the 4 dimensions. For example, within component 3, there was a greater difference between judgers and perceivers who were sensors than between judgers and perceivers who were intuitives. This suggests that user conceptions of what it means to be a judger is more important for individuals who are sensors than intuitives. The component space shows other, more subtle, distinctions between the 16 types. At least from a qualitative inspection of these components, it appears that users do indeed have more complex model of personality than the 4 binary dimensions.

In addition, the components were added to the original models predicting unique words, word lengths, and Jaccard similarities. Component 1 was found to be a significant predictor for number of unique words, while component 4 was found to be significant for character length. Component 1 appeared to primarily align with the dimension of intuition-sensing, with some aspects of the introversion-extroversion and judging-perceiving dimensions. Of note, the original unique word model did not show a significant effect of intuition-sensing, a dimension which did significantly predict the other vocabulary proxy. This likely indicates that nuisances related to intuition-sensing that users are aware of explains variation in the number of unique words enough that component 1 was significant while the binary sensing-intuition dimension was not. As intuition-sensing correlates with openness to experience, this suggests that number of unique words does indeed relate to openness to experience, even though the originally binary sensing-intuition dimension did not show significance.

Component 4, which significantly correlated with word length, appears to relate primarily with the thinking-feeling dimension and the introversion-extroversion dimension, with some influence of intuition-sensing. This aligns to the fact that the thinking-feeling dimension and the introversion-extraversion dimension were no longer significant in the with-components word length model. It appears likely that these two dimensions, together, are influenced by a latent factor responsible for an increase in vocabulary size. As with agreeableness, extroversion also correlates with empathy (Claxton-Oldfield & Banzen, 2010). This corroborates the above hypothesis, suggesting that individuals with more empathetic tendencies will attend more towards prosodic or pragmatic features, while introverts and those who sore as more disagreeable will attend more towards literal word meanings. Indeed, there is evidence to suggest that an individual's degree of empathy modulates the ability to understand pragmatic cues (Li, Jiang, Yu, & Zhou, 2014).

Given that some of the four components explained the variance of word length and number of unique words better than some of the binary Myers-Briggs dimensions suggests that the users of the forum are indeed able to capture real-world differences in the behaviors of individuals. This is important because personality measures tend to be derived from the intuitions of individuals. As such, these measures may only be reliable if socially constructed models can references true differences in the world. The big five, which is the most widely used personality measure in academic contexts, was constructed from such folk models. The embeddings of the 16 types within the word2vec space suggest that personality dimensions interact heavily and that these interactions are privy to socially constructed personality models. As such, it is likely that personality folk models are more complex than five dimensional spaces. The big five were derived from similarity ratings of personality trait terms. However, given advances in data science and understandings of cultural knowledge, it is likely that other techniques will be able to extract more sophisticated models of individual differences that indeed explain real-world differences in human behavior and cognition.

The fact that the intuition-sensing dimension remained significant when adding the components to the word length model suggests that the variance explained by intuition-sensing truly comes from a different source than the variation explained by introversion and thinking. As such, it appears (at least) two separate mechanisms are responsible for difference sin vocabulary size. As mentioned above, these are likely openness to experience and possibly empathetic abilities. If this is indeed the case, then this study exemplifies two different kinds of individual differences. In the case of openness to experience, individuals would be more willing to attend to the linguistic styles of other individuals. As a consequence, they will be exposed to a wider range of word forms to learn. Thus, they will have larger vocabularies. This is supported by the fact that Jaccard similarity was also larger for intuitives. Those who are more intuitive are more likely to adapt to the linguistic styles of others, and thus will gain aspects of those styles. This would suggest that intuitives/those open to experience would also have a wider repertoire of prosodic patterns, phonological flexibility, and syntactic flexibility. In contrast, Jaccard similarities were not predicted by introversion and thinking, even though these dimensions did predict vocabulary size. The variance in vocabulary size related to introversion and thinking likely modulates a trade-off between attention towards contextual cues and attention towards the meaning of individual word forms. While this variation exists, it is unlikely that the majority of these speakers use language in ways that inhibit that abilities to operate within social contexts. As such, it appears that language users may gain competencies with similar functionalities, but by employing different strategies.

Chapter 5

Conclusion

Throughout this dissertation, I have examined the role of culture and individual differences in cognitive variation. Specifically, I have presented studies that show how language experience, cultural background, and personality affect the behaviors and cognition of individuals. Each of these studies have helped to exemplify that it is important to understand the nuances of the culture-cognition system. This culture-cognitive system is made up of thousands of interconnected cognitive tools. Each individual within a culture is privy to many of the cognitive tools shared within a culture. Individuals will gain and utilize cognitive tools depending on their specific cultural exposure and pre-existing dispositions. Thus, individuals will vary in how they form cognitive styles – biases for using particular cognitive tools – both because of cultural exposure and because of their pre-existing cognitive tools.

It is important to understand the complexities of the culture-cognition system and how individuals vary within it in order to understand how culture modulates cognitive variation. In order for cultural variables to properly explain cognitive variation, there need to be direct correspondences between the cultural variable and the cognitive consequences. For example, exposure to a certain cognitive tool will result in the acquisition of that cognitive tool. Thus, the cognitive consequence of the cultural variable is the variable itself. However, cognitive tools are often complex and consist of other cognitive tools. Thus, the acquisition of a cognitive tool requires the presence of other cognitive tools upon which it is scaffolded. For example, a proper acquisition of an English verb requires previous understanding of the English lexicon, English grammar, English phonology, and English syntactic structure. However, the exact scaffolding for a cognitive tool may vary. For example, speakers of two English dialects may acquire the same new verb, even though they possess slightly different lexicons, grammars, phonologies, and syntactic structures. However, in some cases, individuals may only possess cognitive tools which are non-optimal as scaffolding for the new cognitive tool. In order to competently gain the cognitive tool, however, the individual will upregulate the utility of the sub-optimal tools which are being used as scaffolding. Thus, changes to the components of the acquired cognitive tools will vary along with individual differences.

While understanding the complexities of culture-cognition systems is important for understanding cognitive variation, much of the recent literature examining cognitive variation does not focus on understanding culture as a dynamic system. Indeed, cognitive science itself has a long history that focuses on the cognitive process, divorced from the rich interactivity of the context within which those processes occur. Nonetheless, there has been renewed interest in examining cognitive variation. Such studies have touched on topics such as the cognitive advantages of bilingualism, cross-cultural differences in the attentional styles of individuals in Japan and the USA, and the relationship between personality and language. In this dissertation, I examined each of these cases of cognitive variation though a dynamic systems perspective. In all cases, I show that cognitive variation arises through complex interactions within the culture-cognition system.

5.1 Contextualizing the Findings

Here, I review the findings from each of the three studies presented in this dissertation. Along with these findings, I suggest how each study examines individual differences within the culture-cognition system. I also give possible future directions for each of the three studies.

5.1.1 Language Learning and Inhibitory Control

In chapter 2, I presented a study examining the role of language learning on inhibitory control. Throughout the literature, bilinguals appear to have certain cognitive advantages relative to their monolingual peers. These advantages primarily relate to inhibitory control, the ability to suppress information that is task-irrelevant. The predominant theoretical explanation for this is that bilinguals possess two distinct language representations (e.g. Kroll, 2005). Both language representations will become active, regardless of the target language. This activation will interfere with processing of the target language. Thus, bilingual individuals must constantly inhibit the non-target language in order to process the target language. This habitual inhibition will eventually necessitate the strengthening of inhibitory control.

Despite this explanation, there is evidence to suggest that the linguistic knowledge of a bilingual is heavily interwoven. It is likely that these interlanguage connections are the source of competition between word forms, sounds, syntactic patterns, and semantic categories of a bilingual's two languages. This competition, while especially strong for bilinguals, exists for monolingual linguistic knowledge networks as well. This would suggest that the effects of bilingualism are a matter of degree, rather than of type. However, it then follows that specific differences in linguistic networks drive these differences in degree. Connections within these networks can exist because of overlap on all linguistic levels, including phonological, semantic, syntactic similarity between words. However, it is not clear what kinds of connections drive the types of competition that necessitate inhibitory control.

In order to investigate the link between certain kinds of linguistic knowledge and inhibitory control, I conducted an experiment that measured how the use of inhibitory control in a word learning task transferred to a task directly measuring inhibitory control. Individuals were asked to learn associations between objects and labels. The objects were either familiar everyday objects and the labels were either words that existed in English or novel words. Participants showed increased inhibitory control abilities only in the condition where they learned to map existing English words with novel objects. The results of this study hint that inhibitory control will be particularly needed in cases where there is lots of phonological similarity but semantic dis-similarity.

As with other aspects of cognition, linguistic knowledge is part of the larger culture-cognition system. Individual words, syntactic frame, phonemes can all be seen as miniature cognitive tools that can be pieced together to a larger communication system. As a complex dynamic system, all of these linguistic tools interact with each other. Language processing – including the use of inhibitory control – can be seen as emerging from the properties of an individual's entire linguistic knowledge. As such, it is important to understand the constituents of these systems in order to understand how these complex dynamics arise. Each individual will have a unique system of linguistic knowledge, with its own dynamic properties. Inferring these dynamics requires detailed knowledge of which aspects of linguistic knowledge cause what emergent properties. In this case, the necessity of inhibitory control is the emergent property.

In this study, a limited number of properties were tested that loosely connect to specific aspects of linguistic knowledge. A clear next step is to pinpoint in more detail the exact ways in which these effects extend to similar situations. With the same experimental paradigm as used here, a variety of object-label parings could be used. These could include labels that are selected such that they overlap in very specific ways with the linguistic knowledge of participants. For example, words of various frequency, phonological density, semantic density, or even syntactic frame density could be used in order to precisely see how these linguistic properties affect inhibitory control. The same could be applied to novel objects. Objects could be constructed to share or not share various degrees of properties with known everyday objects.

In addition to mapping linguistic knowledge systems to inhibitory control, there exist other aspects of cognitive control that may align differently with such knowledge systems. These include task switching and updating. Together with inhibitory control, these three loosely connected processes allow for individuals to meet the demands of their current task and goals. However, as these processes likely perform different – yet slightly overlapping – roles, they are likely affected by the structure of linguistic knowledge networks in slightly different ways. Just as the attentional network task was used in the current study, other tasks could be used before and after a word learning task in order to see how these processes are involved in language learning.

Going beyond the current experimental paradigm, there are other methodological implications of the current research. If particular properties of linguistic knowledge networks result in certain levels of inhibitory control, then there will be predictable individual differences in inhibitory control advantages. Thus, measures of individual linguistic background – such as the LEAP-Q – will be invaluable in linking the structure of linguistic knowledge to cognitive control or other cognitive consequences of language. Moreover, in the case of bilingualism, the structure of the linguistic knowledge system will greatly depend on the similarities and differences between the languages. Therefore, bilinguals of different language pairings will likely rely on different – yet predictable – degrees of inhibitory control.

5.1.2 Cross-Cultural Differences in Attentional Style

In Chapter 3, I presented a study examining cross-cultural differences in the attentional styles of individuals in Japan and the USA. A robust set of studies have demonstrated the individuals in East-Asian cultures tend to rely more on context than Western-American individuals (Senzaki et al., 2014a; Miyamoto, Nisbett, & Masuda, 2006; Nisbett & Miyamoto, 2005; Kuwabara & Smith 2012; Masuda & Nisbett 2001). For example, when looking at a visual scene, individuals in Japan are more likely to look at background elements than individuals in the USA. These differences extend to other aspects of cognition, such as memory (Schwartz, Boduroglu, & Gutchess, 2014), reasoning (Norenzayan, Smith, Kim, & Nisbett, 2002), and categorization (Ji & Nisbett, 2001). The predominant theoretical explanation for these differences is that East-Asian countries stress collectivist self-construal, the belief that the needs of the group should outweigh the needs of the individual. In contrast, those in the USA are more likely to place the individual before the needs of the group. For East-Asians, constant attention towards the needs of the group facilities an attentional style towards context.

As I argued in Chapter 1, in order for there to be a cognitive consequence of culture, (1) there either needs to be a direct one-to-one identity between the element of culture being acquired and the cognitive tool gained, or (2) the cognitive consequence arises because certain cognitive tools are co-opted in order to acquire new cognitive tools. If self-construal was the mechanisms through which these attentional differences arise, then there must be something about a habitual collectivist mindset that necessitates the use of contextual cues. However, the relationship between self-construal preferences and attentional style is not clear. Thus, without evidence for parallels between self-construal and attention, it is unlikely that self-construal represents the mechanism through which variation in cognitive style arises.

While differences in self-construal do quite well in dividing East-Asian and Western-American cultures, it is important to understand that this is only one of many variables that can distinguish these cultures. As cultural variables are part of a larger culture-cognition system, it is important to understand the entire cultural space of possible variables. Given the current literature, there are several other aspects of these cultures that serve as alternative candidates for the mechanisms though which attentional style differences arise. These included differences in how the languages of these cultural groups treat contextual information and the physical layouts of man-made environments (i.e. buildings, streets). Moreover, a closer look at self-construal suggests that it may be broken into two separate cultural variables. Interdependence measures the degree to which individuals attend to the needs of a group, while independence measures the degree that an individual will attend to the self. In addition, I also identified overall language experience as a potential modulator of attentional style, due to its relation with other aspects of cognitive variation. While these cultural variables do represent possible sources of cognitive variation, it is important to note that they are by no means exhaustive. A true set of potential mechanisms would require in depth ethnographic-level analysis of the cultures in question.

In order to see if any of the proposed cultural variables do indeed relate to attentional style, I carried out a study that examined the relationship between individual variation within these cultural variables and attentional style. Individual differences are quite important to the study of cognitive variation, as differences in exposure to these cultural variables should mediate the degree to which these cognitive consequences occur. In line with this, I gave participants two tasks measuring attentional style. The first measured the eye-fixations of participants towards elements of a visual scene. The second measured participant abilities to attend towards the global and local features of Navon shapes (i.e. shapes made of smaller shapes).

I expected that some of the cultural variables would correlate with individual differences in attentional style, as measured by eye-fixations and preferences for global and local information. Two of these variables, interdependent self-construal and preference for contextual information early in sentences, did indeed predict individual differences in attentional style. However, the direction of the correlations between these variables and attentional style was reversed for individuals in Japan and the USA. Looking at both groups simultaneously, it appears that individuals who possess self-construal or linguistic preferences that mis-align to cultural norms are less dependent on contextual information. This line of reasoning is similar to that of the bilingual literature. These individuals essentially have two sets of competing desires: (1) to function as competent individuals within social contexts and (2) to carry out their own individual preferences. As such, these individuals must be able to carry out behaviors within two different cultural contexts. This would result in a greater ability to process information independent of a strong context.

This study intended to examine one type of individual difference, individual differences in cognitive variation that arise due to differences in cultural exposure. However, it appears that this study highlights a different type of individual difference; individuals in this study appear to differ because they possess different predispositions for acquiring cognitive tools. Here, the cognitive tools in question are the cultural variables being measured. Individuals in Japan must acquire linguistic and social competencies that allow them to produce and understand sentences that place contextual information first and to operate within a collectivist social context. In contrast, individuals in the United States must produce and understand sentences that place focused/figure information first and operate within a non-collectivist social context. However, certain individuals will have predispositions that are align more or less to these socially necessitated behaviors. While individuals reported varying preferences for these behaviors – even within cultural groups – it is unlikely that any of the participants were socially incompetent. Thus, those individuals who were less predisposed to gain the competency to use these cognitive tools must have had to utilize a slightly different set of underlying processes to support the acquisition of cultural competence. This resulted in slightly different attentional patterns for individuals with culturally dis-preferred tendencies.

While significant patterns were found in this study, it is important to note that the study was quasi-experimental. In other words, while particular variables were identified, these variables were not established via controlled laboratory manipulation. Instead, they are the consequence of variation within a complex culture-cognition system. Within such a system, many cultural variables interact and influence each other in complex non-linear ways. As such, it is difficult to suggest that variables measured here are indeed the sources of cognitive variation. If they are not, however, they at least align with the sources of cognitive variation or perhaps jointly contribute along with other unknown variables. In order to know better how specific cultural variables affect cognition, the relation between these and cognition need to be tested in controlled laboratory settings. For example, paradigms similar to the one used in Chapter 2 could be employed here. Participants could be given a task where they must utilize a particular self-construal style or read sentences with specific syntactic orders. They could be given a measure of attentional style before and after this task in order to assess the degree to which the particular variable influences attentional style.

5.1.3 The Relation Between Personality and Language Use on an Online Forum

In chapter 4, I examined the relation between individual variation in personality traits and the use of language. Previous studies have linked dimensions of the big five personality model with language acquisition (Verhoeven & Vermeer, 2016; Yu, Abrego-Collier, & Sonderegger (2013) and accommodation (Yu, Abrego-Collier, & Sonderegger (2013). These studies specifically showed correlations with the personality dimension of openness to experience. Those who are more open to experience are more likely to engage in novel topics and take in new kinds of information. Thus, those who are more open will naturally attend to a larger variety of content. This translates into better abilities to learn language and to match the language styles of other individuals.

The first purpose of this study was to see if the relation between personality and language use extended to lexical diversity. Utilizing data from an online forum where users provide self-identified Myers-Briggs Type personality types, I specifically looked at proxies for the vocabulary sizes of users, as well as the likelihood that they use language constructions (in the form of bigrams) that match users who posted most recently with the same sub-forum as the user's current post. The second purpose of this study was see how the social construction of personality is able to explain real-world variation in behavior. While the Myers-Briggs model of personality aligns well with other personality measures, like the big five, it does not necessarily capture all aspects of personality. However, it is likely that the ways in which individuals talk about personality – including the Myers-Briggs system – includes additional information about human behavior that is socially discovered. As such, a word2vec model was created that was able to quantify how users talked about each of the 16 Myers-Briggs types. Four new components were extracted from the word2vec model, which were later used to predict user language (in addition to the original four binary Myers-Briggs dimensions).

Dimensions related to openness (e.g. the intuition-sensing dimensions of Myers-Briggs) significantly predicted both user vocabulary size and likely to accommodate the language patterns of recent user posts. This result aligns with previous findings suggesting that those who are more open to experience are more likely to adapt their language production to others and to are more able to gain second language proficiency to a native-like fluency. Here, those who are more open are likely attending to a wider range of linguistic differences. Thus, they are more likely to acquire a larger range of linguistic forms.

In addition to the intuition-sensing dimension, introverts and thinkers also had higher vocabularies. However, neither of these dimensions predicted user accommodation to other users. In addition, when the four word2vec derived components were added to the model, these effects disappeared, with the significance from both of these dimensions being pooled into a single component. As these pooled into a single component, it is likely that a latent variable – common to both introverts and thinkers – drives the effect of introversion and thinking on vocabulary size. I suggested that a possible factor could be the degree to which individuals attend to extralinguistic context versus literal semantic meaning. Extroversion and feeling align with the big five dimensions of extroversion and agreeableness, which both are associated with empathy (Graziano, Habashi, Tobin, and Sheese, 2007). As such, these types would be more likely to attend towards intonational and pragmatic cues, while introverts and thinkers would be more likely to attend to specific word forms in more detail.

In addition to findings about the relationship between specific dimensions of personality and language, this study also showed that the language of users does indeed better explain variation in the behavior of individuals than the original Myers-Briggs personality dimensions. One implication of this is that personality models themselves, as models derived from the folk models of individuals, are reliable enough to contain real-world relevance. Moreover, these folk models likely contain relevant information about individual differences in behavior that are not captured by dimensionality reductions personality trait terms. Folk models of personality, while dimensionality reductions themselves, likely pick up on the dynamic relationships between individual personality traits. These dynamics are likely much more complex than 4 or 5 dimensional non-interacting systems (like the big five). With modern data science techniques it would be relatively trivial to investigate the dynamics of such systems. The original big five dimensions were created because early personality researchers felt that describing individuals with thousands of traits was impractical. Intuitions about these traits clustered into five dimensions. However, this clustering does not entail that English speakers only think about personality within a five-dimensional space. With modern computational power, it is less cumbersome to explore individual variation within a much higher dimensional space.

Personality is a measure of the culture-cognition system. Individuals with different personalities have different cognitive styles. As personality is a reduction of the culture-cognition system, it is simultaneously useful for understanding cognitive variation, whilst making it difficult to pinpoint the exact mechanisms through which cognitive variation arises. Here, several dimensions of personality were linked to differences in language use. However, as these dimensions are reductions of the entire culture-cognition space, it is difficult to suggest which aspects of the system are responsible for these effects. For example, the dimension of openness to experience aligns with general intelligence, creativity, and even a wider range life experiences. These in return are related to thousands of different aspects of the culture-cognition system.

Regardless of the exact variables responsible for the relation between personality and language, it is clear that measuring personality does help to explain variance in the use of language. Moreover, this study appears to exemplify two different types of individual variation. First, in the case of openness to experience, users appear to take on different cognitive styles because they expose themselves to differing diversities of cognitive tools. Second, in the case of introversion and thinking, users appear to have different dispositions for attending towards certain kinds of information. Introverts and thinkers attend more towards word forms, while extraverts and feelers attend more towards extra-linguistic cues. Both strategies will lead to linguistic competency. However, the cognitive consequences of these strategies result in different vocabulary sizes.

5.2 Examining the Culture-Cognition System

In this dissertation, the culture-cognition system was examined from several different angles. The culture-cognitive system itself is a complex dynamic system within which cognitive tools spread and interact. At the level of the individual, cognitive tools make up the innerworkings of cognition. Individual cognitive tools are made up of other cognitive tools and are used by the individual in order to interact with and understand their environment. They take the form of cognitive processes and knowledge such as attentional patterns, individual word forms, semantic categories, entire languages, actions, or problem-solving strategies. At the level of culture, cognitive tools take the form of shared knowledge and behaviors. As members of a culture, individuals will acquire the cognitive tools disseminated among other members whom they interact with.

When measuring variation in the culture-cognition system, measurements can examine cognitive tools as they manifest at a cultural level or at a cognitive level. While cognitive tools exist within the entire culture-cognition system, the ways in which they interact or are talked about by people differ at these levels. For example, people will often talk about knowing a specific language, but do not often talk about knowing particular syntactic structures. Yet, these syntactic structures are critical aspects of linguistic cognitive tools. Moreover, the ways in which cognitive tools may pattern will take different forms at these levels. This is especially true because the dissemination of cognitive tools at a cultural level can result in different cognitive tools organizations at the individual level. The existence of a cognitive tool within a culture does not inherently depend on a particular scaffolding, despite the fact that a particular scaffolding is optimal for that cognitive tool. Thus, it only makes sense to measure differences in the construction of cognitive tools at an individual level, unless the component tools are explicitly disseminated.

The language-learning task presented in Chapter 2 attempted to measure cognitive tools as defined at the cognitive level. Very particular cognitive tools were explicitly given to participants to incorporate into their existing linguistic knowledge systems. Given the English knowledge of these participants, it is reasonable to infer the ways in which these new object-word pairings integrated with their existing linguistic knowledge. Thus, the study was able to examine how the patterning of particular cognitive tools at the cognitive level affect inhibitory control, which also might be seen as a cognitive tool at the cognitive level. In contrast, the cross-cultural study shown in Chapter 3 measured variation in the culture-cognition system at the cultural level.

The surveys given in the study measured cultural variables without much attention to the ways in which the cultural knowledge is embodied within individuals. While such measures are indeed important in understanding how culture effects cognition, it will be necessary in the future to understand the exact cognitive tools that comprise self-construal patterns. However, broader culturally based categories are nonetheless useful in understanding cognitive variation. This claim is corroborated by Chapter 4, which further demonstrates that culturally established dimensions (personality, in this case) are able to capture aspects of individual variation.

While the degree to which each of the three studies examined the content of culture-cognition systems differed, it is clear that more detailed knowledge of culture-cognition systems is necessary for the study of cognitive variation. The study of the cognitive consequences of language bilingualism needs to understand the complex network properties of linguistic knowledge systems and how each of these properties (e.g. phonological density, semantic overlap) relate to inhibitory control and other aspects of cognition. As such, studies that examine cognitive differences between bilinguals and monolinguals will be unable to discover the true mechanisms through which the bilingual advantage arises. Moreover, many studies will likely be unable to find differences, as not all monolingual/bilingual distinctions will result in different enough linguistic knowledge systems to show distinct differences in inhibitory control. The cross-cultural study clearly demonstrated that other cultural variables present possible mechanisms through which attentional differences arise. In particular, both interdependence and figure-ground preferences predicted attentional strategies. Given that these cultural variables are unexhaustive of the differences between Japan and the USA, it is reasonable to expect that other variables may affect attentional style. In addition, the ways in which these variables affect attentional style suggest that the possession of a behavioral disposition that runs contrary to a cultural norm may cause domain general attentional strategies to be upregulated. As such, it should be the case that many other cultural variables have a similar modulatory effect on attentional style.

Finally, the results of the personality study in Chapter 4 suggest that individual differences can be – in part – discoverable by the individuals of a culture. Specifically, complex interactions between certain cognitive variables may be privy to the folk models of a culture. This suggests that personality research can benefit from more complex analyses of the folk models of personality. More importantly, however, this suggests that any studies of cognitive variation may be able to map the complexities of the culture-cognition system though the language of individuals within that system. This aligns with the original methodologies of cognitive science, which sought to understand the relationships between human behavior and the rich systems of knowledge that individuals encode into their languages. With modern data science techniques, such as the word2vec model used in Chapter 4, complex systems of cultural knowledge may be extracted easily from the language of individuals. While mapping entire culture-cognition systems may need research methodologies that extend beyond the analysis of text, the large majority of cultural variables may be discovered through future explorations using these data science techniques with little effort.

5.3 Connecting the Dots

While the three studies exemplified in this study touched on seemingly different topics, they are relevant to each other in interesting ways. First and foremost, they each exemplify a fundamental way through which different cognitive styles arise; groups of individuals who must acquire the same cognitive tools will do so differently, depending on other cognitive tools within their repertoire. In the case of language learning, the effect that learning a new word has on cognition depends on the existence of other words in an individual's linguistic system. Moreover, the necessity of developing inhibitory control in order to speak two languages will likely depend on the exact relationship between those two languages. Thus, the pre-existing linguistic knowledge of an individual affects how they acquire new linguistic information. In the case of cross-cultural attentional style, individual dispositions for particular linguistic structures or self-construal patterns will modulate the degree to which certain attentional strategies are preferred when acquiring the language and social values of their culture. Finally, in the case of personality, individuals who are more open to experience will more likely gain larger vocabularies than those who are not, despite belonging to the same language communities. The same is true for introverts and thinkers. However, the underlying mechanisms for such are likely different.

In addition to the above commonalities, each of these studies have further theoretical implications when considered together. The language learning study and the cross-cultural study exemplify how the existence of conflicting information may affect domain-general processes. In the case of lexical conflict, competing information relates to inhibitory control. In the case of self-construal and syntactic order, competing information relates to attentional style. In both cases, more overall competition results in ability to or preference to ignore context. While these effects are similar, it is interesting that they affect slightly different processes. In the case of lexical competition, individual must suppress information that inadvertently arises due to the structure of their linguistic system. Inhibitory control, in parallel, suppresses information that arises inadvertently in order to meet task goals. However, in the case of figure and ground information, both kinds of information are task relevant. The distinction is which information is prioritized. This is perhaps also similar for individuals with self-construal patterns that deviate from cultural norms. While they might always need to display culturally normative behavior in public settings, they might also always wish to do so in ways that navigate both desires, rather than suppressing one over the other. They might also need to reference their own tendency in order to properly compensate for their personal dispositions. As such, these differences might result in different attentional styles, rather than better inhibitory control abilities.

The study on language learning and the study on personality both examined the acquisition of vocabulary. In the case of the language learning study, the acquisition of certain kinds of vocabulary resulted in increased inhibitory control. In the case of the personality study, higher vocabulary correlated with higher openness to experience. Taking the two studies together, these results hint at a possible connection between inhibitory control and openness to experience. Indeed, openness to experience is generally related to executive functioning (Schretlen, van der Hulst, Pearlson, & Gordon, 2010; Williams, Suchy, & Kraybill, 2010). Given this possible connection, it may be quite important to track personality when assessing the effects of bilingualism on inhibitory control, as these factors will likely interact.

In the personality study, introversion and thinking correlated with increased vocabulary scores. I suggested that this may be the case because both extraversion and feeling are linked to empathy. As such, these individuals are more likely to attend towards extralinguistic features, while introverts and thinkers are more likely to gain vocabulary because they attend to individual word forms. However, when examining this study within the context of the other two studies of this dissertation, an alternative explanation arises. Introverts and thinkers are less common in the population (*Myers-Briggs*, n.d.) and agreeable and extroverted behaviors are culturally normative within the USA (Schmitt et. al, 2007). As such, these individuals possess culturally dis-preferred behaviors and have gained certain cognitive consequences (i.e. vocabulary size) as a result of negotiating between their personal disposition and culturally appropriate behaviors. However, it is not clear how vocabulary size is a cognitive consequence of such cognitive negotiation.

While the connections between these three studies are merely speculative, the results of these studies do indicate that there may be relevant connections between different domains of cognitive variation. Future research on cognitive variation should be alert to the possible links between the mechanisms that underlie different sources of variation.

5.4 Final Remarks

This dissertation presented a novel framework for looking at the mechanisms through which cognitive variation arises. This framework advocates strongly for (1) detailed descriptions of the culture-cognition system in order to understand the complex dynamics through which the cognitive tools of culture and cognition may interact and (2) attention towards individual differences in cognitive variation, as individual differences reveal direct parallels between cultural exposure, the cognitive styles of individuals, and the cognitive requirements of acquiring new cognitive tools. The studies in this dissertation exemplified cases whereby adding nuanced information about culture-cognition systems enhanced the explanatory value of theories that explain how cognitive variation arises. By providing these nuanced descriptions, a range of cultural variables were identified as potential sources of cognitive variation. Furthermore, each of these studies demonstrated how measuring (or experimentally creating in the case of the language learning study) individual differences was critical in understanding the role that these cultural variables play in modulating cognitive variation. Overall, this dissertation paints an optimistic picture for the future of research on cognitive variation. By using a combination of methods – including data science explorations of culture-cognition systems, cross-cultural and intercultural documentation of cognitive variation, and the experimental testing of the effects of cultural variables on cognition – cognitive science will be able to fruitfully gain understandings of cognitive variation.

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