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# Investigation of Mirror Image Bias: Evidence For the Use of Psychophysiological Measures as Indicators of Cognitive Heuristics

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# INVESTIGATION OF MIRROR IMAGE BIAS: EVIDENCE FOR THE USE OF PSYCHOPHYSIOLOGICAL MEASURES AS INDICATORS OF COGNITIVE HEURISTICS

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**I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY CAROLINE SALCHAK ENTITLED Eye Tracking and Physiological Measures: An Alternative to Mirror Image Bias BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science in Engineering**

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# ABSTRACT

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The Mirror Imaging Bias (MIB) is gaining attention as a prominent quality factor in analysts' performance. MIB is an irrationality in which analysts perceive and process information through the filter of personal experience. As evidenced by notable historical events, the consequences of this bias can be dramatic. A way to understand MIB in humans is sought. How analysts analyze data, are trained, and interact with biases is explored. An experiment testing for the appearance of MIB was designed and completed. Measures from an eye tracker as well as physiological measures were collected. Results show a significant correlation between pupil diameter and the appearance of MIB. There is a significant correlation between response time as well as the number of fixations and the viewpoint of the question. These results support that MIB is used as a shortcut to minimize mental workload in decision making in uncertain situations.

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# I. INTRODUCTION

The Mirror Imaging Bias (MIB) is one of the most prevalent biases among analysts and has caused many failures in detecting harmful attacks through assessment mishaps. Mirror Imaging and Theory of Mind are understood to be tightly interwoven as cognitive biases; they both occur when judging or predicting the actions of a third party. Mirror Imaging is an irrationality in which analysts perceive and process information through the filter of personal experience; this may be driven in part by cultural differences. In the case of Mirror Imaging Bias (MIB), if looking at a situation that another person is experiencing, you predict what **you** would do. In comparison, Theory of Mind (ToM) is the ability to predict and interpret the thoughts and actions of another by taking on their perspective. In the case of MIB, if looking at a situation that another person is experiencing, you predict what **they** would do.

This paper seeks to find an explanation and a way to determine and detect the MIB in humans who are faced with the analysis of other cultures and their actions. It will do so by looking into past occurrences of the MIB such as the sinking of the Lusitania, Pearl Harbor, and 9-11's attack on the World Trade Center. It will then go into several possible reasons on why these failures of analyst work appear so frequently by looking into how analysts analyze the data they are given, the training that they receive, and cognitive biases that affect the population. When analyzing MIB, this paper will go over the three possible reasons for the bias. The first is that MIB is the failure of ToM. ToM is

explained and broken down further into 1) inhibition of one's own self, and 2) belief reasoning. The second possible cause for MIB is a cultural bias. It is felt that much of the reason behind MIB in analysts is that we assume that other cultures will think and act a certain way even though there might be clear evidence otherwise. The third explanation for MIB is cognitive action – or mindreading. Mindreading is the activity of representing specific mental states of others, for example, their perceptions, goals, beliefs, expectations, and the like (Gallese & Goldman, 1998). The final part of the paper will go into the steps taken toward an experiment: building of the stimuli, testing, and analysis of the data collected. Through this experiment it is found that Mirror Imaging Bias is enticed 40.1% of the time and Theory of Mind is enticed 21.2% of the time when viewing stimuli. Similarly it shows that when comparing the overall results of participants, the average pupil diameter shows a significant difference between MIB and ToM and therefore would be a good method to detect the bias. However when delving into each individual participant, each had different types of data that showed significance to prove one bias occurs over the other.

# II. BACKGROUND

The following sections will review topics such as the Intelligence Analyst, the potential reasons behind their successes and failures, and several cognitive biases that affect most people.

## INTELLIGENCE ANALYST

The Mirror Imaging Bias isn't necessarily a well-known problem within the mainstream population. However within the Intelligence community, it is extremely important. Analysts are well aware of the problems that MI causes. In fact, MI is the most common ISR irrationality, is an unavoidable cognitive trap, and has been blamed for catastrophes such as Pearl Harbor and 9/11 (Pipes, 1995; Heuer, 1999). Well trained analysts are able to see that they are falling prey to the bias when they are unwilling to examine variants of what they consider most reasonable in light of their personal frame of reference (Witlin, 2008), but analysts who haven't been trained to recognize the signs are more likely to partake in the bias. To fully understand the problems that analysts face with the Mirror Imaging Bias, we must go in depth into why analysts came to be within our government and what their job entails.

Intelligence, whether it's in the United States or in other countries, has only one function: to uncover foreign threats to national security. The Central Intelligence Agency was created in 1947 with the signing of the National Security Act by President Harry S.

Truman. The National Security Act charged the CIA with coordinating the nation's intelligence activities and correlating, evaluating and disseminating intelligence affecting national security (Central Intelligence Agency, 2013). He [Truman] did so despite protests that he was setting up an "American Gestapo." (Pipes, 1995) Intelligence analysis involves predicting thoughts and reactions of allies and adversaries, who often have values and beliefs different from those of the analyst. This has been the case throughout the years and these differences in beliefs and values have caused plenty of issues.

There have been many successes and failures that have come from the CIA; these will be outlined later in this section. For now we'll focus on some facts that form around what goes into and comes out of the CIA.

- By far, the largest recipient of intelligence appropriations is the Department of Defense. Leaks from Congress in 1995 indicated that of the $28 billion budgeted annually for intelligence, the CIA receives only $3 billion (Pipes, 1995). Clearly this number has changed since then, but it is a good representation on how much of a focus the government has on intelligence.
- The CIA is headed by a Director, who is appointed by the President with the advice and consent of the Senate (Hayden, 2009).
- They collect intelligence through human sources and by other appropriate means – however they do not exercise police, subpoena, or law enforcement powers (Hayden, 2009).

- They correlate and evaluate intelligence related to national security and provide appropriate dissemination of such intelligence (Hayden, 2009).
- There is a 21.4% failure rate of Ops Intelligence Apprentice in the Advanced Training. (Casebeer, 2012) These high wash out rates may be due to lack of a cognitive flexibility – this includes the MIB.

Betts (1978) brought up the point that "Particular failures [for analysts] are accorded disproportionate significance if they are considered in isolation rather than in terms of the general ratio of failures to successes; the record of success is less striking because observers tend not to notice disasters that do not happen" (Betts, 1978). While there have been many successes that have come from analysts – which far outnumber the failures – the failures are much more costly and continuously seem to overshadow the successes. "There should be absolutely no tolerance of analysts who consistently produce flawed assessments or assessments that hedge to the point of being useless" (Pipes, 1995). Some of the main failures of analysts can be seen outlined below. In each case, as suggested by Betts (1978) there are two phenomena that occur: first, "evidence of an impending attack was available, but did not flow efficiently up the chains of command," and second, "fragmentary indicators of alarm that did not reach decision makers were dismissed because they contradicted strategic estimates or assumptions" (Betts, 1978). The MIB is tightly knit into the threads of these failures and will be explained as we go along. In each case, it brings to life the phrase "*Hindsight is always 20-20.*"

# EXAMPLES OF MIB

## PRE-CIA: 1915: WWI - SINKING OF THE LUSITANIA

America had remained neutral during the start of World War One. And although America didn't join the war until two years after the sinking of the Lusitania, it is believed that it had a major impact in the relationship between the USA and WWI. In 1915, the Lusitania set off from New York to Liverpool. The path the ship would take brought it directly through a known "European War Zone" in which submarines had already brought many ships to their end (Lusitania, ship, 2013). This should have been enough to cause pause to potential passengers. On top of that, there were advertisements in the New York newspapers paid for by the German Embassy that any ship that sailed into the "European War Zone" was a potential target for German submarines. It was printed in forty U.S. newspapers as follows:

> *"Travellers intending to embark on the Atlantic voyage are reminded that a state of war exists between Germany . . . and Great Britain . . . and that travellers sailing in the war zone on ships of Great Britain or her allies do so at their own risk"* (The National Archives, n.d.).

It is told that many passengers even received anonymous telegrams advising them not to travel. However, the passengers dismissed these warnings and "came to the conclusion that the luxury liner simply was not a legitimate target of the Germans as it had no military value." The ship was sunk on the 7th of May and only took 18 minutes to sink. In a response to the German government, the American government wrote "that no warning that an unlawful and inhumane act will be committed can possibly be accepted

as an excuse of palliation for that act or an abatement of the responsibility for its commission." which essentially meant that it was not an excuse to attack the innocent people even though a warning was posted (Wilson, 2009). Needless to say, anyone who had received the warnings or had seen the advertisements experienced a form of Mirror Imaging Bias by assuming that the Lusitania was not going to be a target to the German U boats.

PRE-CIA: 1941: NAZI INVASION OF THE USSR

On June 22, 1941 Nazi Germany invaded the Soviet Union ("Invasion of the," 2013). This was a surprise to not only the Soviet Union, but also to the rest of the world. One specific quote by L. Trotsky several years prior to the invasion brings light to the false assumption that the Nazi's would not do such a risky thing:

> *"The very possibility of a rule of the Nazis over the German people was created by the unbearable tenseness of social antagonisms in Germany. These antagonisms have not been removed, and not even weakened, but only suppressed, by the lid of fascism. A war will bring them to the surface. Hitler has far less chances than had Wilhelm II of carrying a war to victory." (Trotsky, 1937, p. 104)*

As human beings, analysts and decision makers back then had assumed that Hitler would make decisions like a "normal" person such as themselves. However, what these people failed to notice was the fact that he was from an entirely different background and mindset than what they were used to. This is why the Mirror Imaging Bias showed itself

in this situation – they assumed incorrectly that Hitler, and therefore the Nazis, would make the same decisions that they would.

PRE-CIA: 1941: WWII – ATTACK ON PEARL HARBOR

At another turning point in a war – this time World War II – Americans were "shocked by the Japanese bombing of the American Naval Base at Pearl Harbor, Hawaii. There was mayhem everywhere; over 3,500 Americans were killed or wounded, 350 aircraft were destroyed or damaged, and all eight battleships of the U.S Pacific Fleet were suck or badly damaged" ("Why did japan," n.d.). However, even though it seemed as though this attack was completely out of the blue, there were signs that seemed extremely obvious after the fact.

After the attack, analysis revealed that the U.S. had had plenty of information about a pending Japanese strike – enough to anticipate and prevent it. However, the U.S took no action because it "lacked an organization capable of collating the diffuse bits and pieces of intelligence information" (Pipes, 1995). Similarly, Roberta Wohlsetter in her 1962 study Pearl Harbor: Warning and Decision "demonstrated that although the U.S. Government picked up Japanese signals (including conversations, decoded cables, and ship movements), it failed to distinguish signals from noise. [They were unable] to understand which signals were meaningful because it was unimaginable that the Japanese might do something as "irrational" as attacking the headquarters of the U.S. Pacific fleet" (McFate, 2005). This erroneous assumption is the core of the Mirror Imaging Bias.

## 1962: CUBAN MISSILE CRISIS

"In 1962, it [The CIA] denied that Russia intended to install missiles in Cuba up to the very moment when photographic imagery proved beyond the shadow of a doubt that the missiles were being deployed" (Pipes, 1995). After an American spy plane secretly photographed nuclear missile sites being built by the Soviet Union in Cuba, President Kennedy did his best to avoid any crisis. He met with his advisors, created a blockade around the island, and spoke to the nation about the crisis through a televised address ("Cuban missile crisis," n.d.). There were thirteen days in which the USA and the Soviet Union were on the edge of a nuclear crisis (Allison, 1969). Had the crisis not been resolved and instead a war started, millions of lives would have been lost. The Cuban Missile Crisis was ended by an agreement between the U.S. and the Soviet Union in which the Soviets would remove the missiles from Cuba and in return the U.S wouldn't invade Cuba. This agreement avoided the possibility of a nuclear war – which would have been devastating to both parties.

The US might have seen it coming even before the Soviet Union began building the sites in Cuba. In the early 60's it could not see any conceivable interest on the part of the Soviet Union in placing nuclear missiles in Cuba since Moscow had to be aware that the United States would not tolerate such deployments: they were simply "too risky" (Pipes, 1995). Even though there might not have been any observable information that the U.S. would have seen prior to 1962, they should not have dismissed the Soviet Union from doing something such as setting up a nuclear site so close to the United States. Doing so placed them within the boundaries of the MIB.

## 1998: INDIA'S NUCLEAR TESTS

"The Republican chairman of the Senate Select Committee on Intelligence alleged Tuesday that U.S. intelligence gathering suffered a "colossal failure" in not detecting India's intention to set off three nuclear blasts this week" (Begleiter, 1998). That's how one CNN article described the failure to detect the coming of nuclear tests in India. It should have not been a surprise, even though India did a good job of hiding their efforts; there were plenty of signs that should have been caught by analysts. Especially after the potential issue for Indian nuclear tests had been given "close scrutiny" in 1995. Similarly, India refused to endorse the Comprehensive Nuclear Test Ban Treaty (CTBT) in August 1996, and it had been discussed that they might test nuclear warheads in light of the Bharatiya Janata Party's (BJP) advocacy of the 'Hindu bomb' (Walker, 1998). The Indian government had apparently given repeated warnings of its intentions to proceed with nuclear tests (Begleiter, 1998).

The major failure was not the fact that when India performed nuclear tests on 11 and 13 May, 1998 it caught analysts off guard. Again, there were plenty of signs that India was prepping for nuclear tests that were missed by analysts. The real problem – and consequently the relation to the MIB - was an "assumption by intelligence analysts and policymakers that the Indians would not test their nuclear weapons because Americans would not test nuclear weapons in similar circumstances" (McFate, 2005).

## 2011: 9/11 AND THE BATTLE WITH IRAQ

One of the most recent CIA failures came to be within the event of 9/11. The entire world seemed to be in shock as they watched the news about how the World Trade

Center had been struck by not one, but two, aircraft in the form of a terrorist attack. There are countless stories about people who were directly and indirectly affected by what happened; still to this day, people rally around the concept of 9/11 and people are still touched by the stories that emerge.

The chances of this event being prevented are slim. However, analysts could have done a better job at anticipating a massive terrorist attack such as this one. There were signs leading up to 9/11: the main one that had been released by the White House was the fact that on August 6th, a classified review of threats posted by Osama bin Laden and Al Qaeda had been placed on the presidents' desk. Analysts had seen some sort of premonition that something was coming, but the White House took no steps to resolve it. They thought it was just "bluster" and that they assumed "Bin Laden was merely pretending to be planning an attack to distract the administration from Saddam Hussein, whom the neoconservatives saw as a greater threat" (Eichenwald, 2012). Again, this failure to comprehend beyond what we assume shows the Mirror Imaging Bias.

Beyond 9/11 and into the war on terror, U.S. Representative "Ike" Skelton wrote a letter Secretary of Defense Donald Rumsfeld in which he said: "In simple terms, if we had better understood the Iraqi culture and mindset, our war plans would have been even better than they were, the plan for the postwar period and all of its challenges would have been far better, and we [would have been] better prepared for the 'long slog' ... to win peace in Iraq" (McFate, 2005).

Many intelligence failures can be attributed to identifiable and remediable flaws of methodology (Pipes, 1995). Failures within the analyst environment can be attributed to three separate causes: improper data, lack of training or knowledge of the culture, and cognitive biases.

## IMPROPER DATA: LACK OF DATA, POOR DATA, TOO MUCH DATA

The first potential reason, of many, failures occur within the analyst environment has to do with the data that analysts receive. It is said that the most frequent sources of breakdowns in intelligence "lies in the process of amassing timely data, communicating them to decision makers, and impressing the latter with the validity or relevance of the information" (Betts, 1978). Each individual case is different, but it always seems that the data that is given to the analysts isn't necessarily the best that it could be. It is said that for analysts the data analysis, and more specifically divining political intentions from the data, is the most difficult aspect (Pipes, 1995). Similarly, in failures of intelligence, the most mistakes are made by "decision makers who consume the products of intelligence services", not necessarily by those who collect raw information or those who produce analyses (Betts, 1978). Betts makes a point that "optimal decisions in defense policy depend on the use of strategic intelligence: the acquisition, analysis, and appreciation of relevant data" (Betts, 1978, p. 35). Analysts must take whatever data they are given – whether it is too much data, poor data (that has gaps of information), or not enough data – and be able to produce a usable analysis that could potentially save the United States from an impending attack. Similarly, the more ambiguous data is, the more likely analysts are going to rely on their preconceptions about the situation or culture. Betts

point out that uncertainty from analysts reflects inadequacy of data or lack of information. However, uncertainty can also come about because there is an excess of data. For example, in a war setting there is an overload of analyses, battlefield statistics, reports, bulletins, and communications intercepts at a rate too fast for analysts to fully analyze them in a short amount of time (Betts, 1978).

Information Warfare (IW) is defined by Johnson (2004) as a series of elements including: attack and defense capabilities and techniques, supporting intelligence collection for targeting information (locations, strengths, vulnerabilities, defenses), supporting intelligence collection for battle damage assessment, and supporting intelligence collection for attack indications and warning. Johnson describes the target of IW as the adversary's decision process. It is reached through a "campaign that involves generation of effects on the adversary's information that prevents or prompts certain actions, thereby creating an advantage for the attacker" (Johnson, 2004, p. 50).

There are multiple types of attacks that analysts seek to prevent through Intelligence warfare. These can be seen in Table 1. It also shows what kind of damage could be done if the attack is not prevented (Functional Effect). There are three different target types that could be attacked, as shown in Table 1: the information layer, which if attacked can create technical effects, the information-management layer, which if attacked causes functional effects, and the decision-process layer, which if attacked creates operational effects (Johnson, 2004).

*Table 1:* Johnsons (2004) chart explaining types of attacks prevented by Information Warfare shows the span of damage that can potentially be done through a failure in preventing attack.

| Type of Attack | Target Layer | Technical Effect | Functional Effect | Operational Effect |
|---|---|---|---|---|
| Communication Jamming | Information System | Signal Blockage | Information Loss | Delayed or wrong decision |
| Communications intrusion – short control message | Information Management | None | Information misrouting, self-generated overload (diagnostic, correction, repeat messages | Delay, confusion |
| Communications intrusion – short information message | Decision Process | None – link continues to exist | Negligible – short message does not affect routing/handling/storage | Delay, confusion, wrong decision |
| Computer Virus | Information System | System Paralysis | Loss of data, loss of function at node | Delayed or wrong decision |
| Network Worm | Information Management | None | Delay or overload amounting to loss of function | Delayed decisions; deliberate shutdown of unaffected nodes |
| PSYOPS/ propaganda messages | Decision Process | None | None | Decision Influence |
| Military operation as PSYOPS maneuver | Decision Process | None | None | Perception Manipulation |

So, in order for intelligence agents to be able to perform all aspects of IW, they have many kinds of information that comes in to them. This information may or may not be useful or actually informative for the purpose of detecting any potential harmful occurrence to the United States. In the case of poor data taken in by intelligence military/operational agencies tends to be analyzed and assessed more optimistically compared to ambiguous data analyzed by nonoperational units/CIA which tends to be analyzed and assessed more pessimistically (Betts, 1978).

PHASES OF ANALYSIS

Analyst work can be broken down into two types of phases: time-related phases and task-related phases. The first, time-related phases are shown in Table 2, and include real-time, near real-time, and forensic analysis. Paul (2013) mentions these phases in the detection of vehicles that might be a threat (Paul, 2013). These phases can be correlated to actions of an individual or group and detecting whether or not they might be a threat. MIB can show itself in any given phase, although is most prominent in the immediate or real-time decisions that have to be made without any time for analysis or thinking more in-depth about what the other individual or group might do in relation to their own culture or beliefs. Similarly, each of the phases in either one of the categories, time or task, have improper data. This data is not necessarily relevant data, so analysts could hypothetically have both ends of the spectrum: too much data to sort through as well as not enough relevant data. The difference between any of the given phases is the time available or the kind of task done to the data.

*Table 2*: Time-related phases of analyst work have three phases: real-time, near real-time, and forensic. The Mirror Image Bias can appear in any of the phases, although it is most likely to happen in the real-time phase.

| | Type of Analysis | Supporting Information |
|---|---|---|
| **Phase 1** | Real-Time | Sensor data is used to detect immediate events |
| **Phase 2** | Near Real-Time | Groups or patterns are detected and analyzed with short delays |
| **Phase 3** | Forensic | Groups or patterns are detected and analyzed with a week or more delays |

The second group, task-related phases, are mentioned by the work of Goodall, Lutters, & Komlodi (2004). In the experiment, performed by analysts, all participants followed a similar three-phase process: monitoring, analysis, and response (Goodall, Lutters, & Komlodi, 2004). These phases are described in Table 3. Although the research

by Goodall et al. was done to analyze how analysts detect system intrusion, it can easily be correlated to how analysts would detect threats on a larger and more general scale. The first phase, monitoring, encompasses the daily "mundane" tasks of ongoing surveillance in order to look for "indications of anomalous or malicious activity" (Goodall et al., 2004, p. 1423). In this stage, analysts must deal with information overload and have to find ways to reduce the data into a more manageable level by either scanning through it faster or by some other method. In the second phase, analysis is done. Goodall describes the transition from the first to the second phase as beginning with a "security trigger event" (Goodall et al., 2004, p. 1424). In this phase, analysts must determine whether the trigger is an actual threat, and if it is to determine how severe of a threat it is. In this phase it is important for the analyst to have knowledge of the environment so they can easily determine severity of a threat. For example, what seems like normal activity in one environment may be indicative of illicit activity in another (Goodall et al., 2004). In the third and final phase, response, a final assessment must be done and a decision be made on what to do. The most common responses come in the form of intervention, feedback, and reporting (Goodall et al., 2004).

*Table 3:* Task-related phases of analyst work are broken down into: monitoring, analysis, and response. The Mirror Imaging Bias can appear in any of the phases, although it is most likely to happen in the phases that require analysts to make decisions quickly.

| | **Type of Analysis** | **Supporting Information** |
|---|---|---|
| **Phase 1** | Monitoring | Ongoing surveillance, mundane daily tasks, information overload |
| **Phase 2** | Analysis | Assessment of trigger events and severity, important for analyst to have extensive knowledge of environment |
| **Phase 3** | Response | Intervention, feedback, reporting |

As with the first set of phases, MIB can show itself in any of the given task-related phases. It is important to understand when MIB appears and how to take steps to resolve the problems it elicits.

## LACK OF TRAINING AND KNOWLEDGE OF THE CULTURE

The second possibility why analysts have failures has to do with a combination of not having sufficient training and knowledge of the culture with which they are dealing. More failures of intelligence have come about in the stages of interpretation and response of data (Betts, 1978). In other words, analysts who are tasked to analyze and interpret data are likely to fail by assuming something falsely from the facts. Knowing the culture with which you are dealing is extremely important, not only in a general sense, but also in terms of MIB. Pipes, in his paper "What to do About the CIA," explains that analysts should be required to have a profound knowledge of the societies they deal with in order to avoid MIB. If they do this, they will slowly learn to avoid the American viewpoint and understand that not all cultures are the same (Pipes, 1995).

This lack of training creates an issue because the insufficient training rests upon a very strong tendency of a specific culture thinking that all other cultures behave and make decisions like their own culture. People are, understandably, drawn to thinking like their own culture. Americans tend to have a false understanding that is embedded within themselves that "fundamentally all peoples are the same – that is, like white, middle-class Americans – and if given a chance will behave like white, middle-class Americans" (Pipes, 1995). Of course, this doesn't hold true for everyone. There are some individuals who are born with a natural understanding that not everyone will think and act as the

individual would if faced with the same situation – this trait is ideally what one looks for in an analyst. Some of this understanding can be taught, but it must be ingrained into a person for it to become effective.

Those that are either taught or have the natural skill to know that not all decisions are made alike between cultures are more likely to have successes in analyzing the data and situations they are given. Arthur Cebrowski, Director of the Office of Force Transformation brought forth the point that "knowledge of one's own enemy and his culture and society may be more important than knowledge of his order of battle" (McFate, 2005). Many times analysts are faced with data that seems to lay out the "order of battle", or their potential plans to harm a countries people, but it is dismissed because the analysts don't know why they would do those things – they don't have an understanding of the culture. However, when versed in the culture itself it makes much more sense and they are able to better detect why and what the adversary will do in the future. One example of a success because of knowledge of the culture comes from Sir Robert Vansittart. In the 1930's he provided an "accurate assessment of Nazi capabilities and intentions, including the likelihood of Germany's rapprochement with the Soviet Union. He succeeded because he knew Germany better than the professionals of the Secret Service" (Pipes, 1995). Another example is in Joseph G. Grew, who had spent an extensive time in Tokyo, Japan as an American ambassador. He responded to judgments that the Japanese could not contemplate an attack on the US by warning against "any possible misconception of the capacity of Japan to rush headlong into a suicidal conflict

with the US. National sanity would dictate against such an event, but Japanese sanity cannot be measured by our own standards of logic" (Pipes, 1995).

To bring this section to a conclusion, another quote by Pipes summarizes the need for training and knowledge of the culture with which the analyst is dealing:

> *"The more imaginative the analyst and the better versed in the cultures with which he deals, the less likely he will be to attribute to others his own values and objectives"* (Pipes, 1995).

## COGNITIVE BIASES

The third potential reason why analysts experience failures has to do with cognitive biases. It is suggested by Levin (1988) that there are two standpoints that a person can take: the "assertoric" gaze and the "aletheic" gaze. If a person takes the assertoric gaze, they only see things from one perspective, one standpoint, or one position and therefore tend to be "narrow-minded, dogmatic, inflexible, and unmoved" (Schaller, 2008). If a person takes the aletheic gaze they are more inclusive and therefore tend to be more "caring, interdependent, and reciprocal" (Schaller, 2008). In the assertoric gaze, the perspective taken is typically that of one-self – which is the basis for many cognitive biases. Cognitive biases are flaws in judgments which occur in particular situations as a result of flawed perception of incoming information. These biases are particularly prevalent when decision makers have to weigh evidence from many different sources (Davidow & Levinson, 1993) or face data that is scarce, ambiguous or of low quality (Tverseky & Kahneman, 1974). Cognitive biases result in reduced objectivity in selection decisions (Proenca & de Oliveira, 2009), causing decision makers to:

- Be too quick to make a decision and ignore contrary evidence
- Be overly zealous in justifying personal decisions
- Selectively search for evidence that will support past judgment rather than objectively evaluating all information

Biases are a way for humans to simplify a complex social world; humans rely on these heuristics to allow for more efficient information processing, memory, and retrieval of complicated stimuli humans are faced with on a day-to-day basis (Fiske & Taylor, 1991). If humans considered every single option in any given situation in a day they would be completely overloaded mentally. Therefore, they succumb to the biases, for the most part, without even knowing what they are doing. Typically, as proposed by Pipes (1995), if reality clashes with a person's wishes, the wishes usually win out (Pipes, 1995). Cognitive biases are practically impossible for humans to completely avoid altogether. However, with proper training and understanding, it is possible to understand when an individual experiences these biases – and then understand how to take steps to alleviate the experienced bias.

There are countless types of cognitive biases that have been explored in literature, in businesses, and in the analyst world. Several of these are presented in Table 4.

*Table 4:* A small selection of the types of Cognitive Biases related to the Mirror Image Bias.

| Bias | Definition |
|---|---|
| Contrast Bias | Involves making an evaluation based on the standard of the preceding information. (Petty & Wegener, 1993; Perrin, Barnett & Walrath, 1993; Wegener & Petty, 1995; Shapiro & Spence, 2005) |
| Anchoring and Adjustment Bias | Results from decision makers over-relying on a pre-existing anchor, or initial estimation when making evaluations. (Perrin, Barnett & Walrath, 1993; Strack & Mussweiler, 1997; Kahneman, Slovic & Tversky, 1982; Brewer, Chapman, Schwartz & Bergus, 2007) |
| Order Effects – Primacy and Recency Effect | Primacy effect - when information first presented to the person influences the final judgment more than information presented later during the session. Recency effect - information presented later in the session has a greater influence on the final decision made. (Morgeson & Campion, 2010; Peggy, Wegener & Fabrigar, 1997; Haugtvedt & Wegener, 1994; Krosnick & Alwin, 1987) |
| Availability Bias | Results from inaccurately basing the frequency of events on the ease with which they can be recalled to memory (Morgeson & Campion, 2010; Perrin, Barnett & Walrath, 1993; Dube-Rioux & Russo, 1988; Tversky & Kahneman, 1973) |
| Confirmation Bias | The tendency to seek evidence to confirm an initial preconception and ignore any contradictory information. (Dror & Fraser- McKenzie, 2008; Perrin, Barnett & Walrath, 1993; Nickerson, 1998; Mynatt, Doherty & Tweney, 1977) |
| Representativeness Bias | The tendency of people to judge the degree of relationship between two things based on their similarity to each other. Also might inadvertently result in stereotyping. (Morgeson & Campion, 2010; Perrin, Barnett & Walrath, 1993; Tversky & Kahneman, 1973). |
| Attentional Bias | When someone focuses on one or two choices despite there being other possible outcomes. (Mather & Carstensen, 2003; Fox, Russo & Dutton, 2002; Mogg, Bradley & Williams, 1995; MacLeod, Mathews & Tata, 1986) |
| Belief Bias | A bias where people make faulty conclusions based on what they already believe or know. (Evans & Curtis-Holmes, 2005; Klauer, Musch & Naumer, 2000; Sá, West & Stanovich, 1999; Markovits & Nantel, 1989) |
| Conservatism Bias | Where people believe prior evidence more than new evidence or info that has emerged. (Redlawsk, Civettini & Lau, 2007; Huq, Garety, Hemsley, 1988) |
| Empathy Gap | Where people in one state fail to understand people in another state. (Sayette, Loewenstein, Griffin, Black, 2008; Lowenstein, 2005; Read, Van Leeuwen, 1998; Van Boven, Dunning, Loewenstein, 2000) |

Two biases that are centered on different cultures and beliefs include Ethnocentrism and the Mirror Imaging Bias. Ethnocentrism is one bias that analysts might experience. From a sociological viewpoint, Ethnocentrism is a tendency to view alien groups or cultures from the perspective of one's own (Ethnocentrism, n.d.). This type of bias is especially dangerous on a national-security context because it can distort strategic thinking and result in assumptions that the adversary will behave exactly as one

might behave (McFate, 2005). Another cognitive bias that analysts experience is the Mirror Imaging Bias. It is without a doubt the most common error of intelligence-estimating (Pipes, 1995) and frequently results in gross distortions of intelligence and raw data (Witlin, 2008). Analysts essentially fit the data into a "box" to which it is not suited. One of the prominent issues that come from the MIB is that it increases analysts' susceptibility to surprise attacks by adversaries. This is clearly something that needs to be fixed to be able to minimize the risk to the country.

Fortunately, there are ways to counteract the cognitive biases. "The intelligence community is aware of the dangers of mirror-imaging. The most effective way to combat mirror-imaging is supplementing an analyst's personal experiences… the more training and experience that can be given to these individuals the less likely they will be to substitute their own cultural values and perceptions when they encounter informational gaps" (Witlin, 2008).

## MIRROR IMAGING BIAS

The Mirror Imaging Bias, as pointed out earlier, is the most common bias experienced by intelligence analysts. It is an analyst's irrational assumption that the people being studied think and act like the analyst themselves and [the analysts] are unable to consider variants in the opposing country and culture because they are viewing the information through the filter of personal experience. Another definition by Richard Pipes in his paper *What to do About the CIA* explains the MIB as "the tendency to interpret the actions of others in one's own terms. The analyst looks at the situation which his subject confronts and asks himself: "What would I do if I were in his shoes?" The

propensity to think in this way derives from a mixture of deficient imagination and, where other nations are concerned, ethnocentricity" (Pipes, 1995).

This cognitive bias is dangerous. If in a serious enough situation, where lives are potentially in danger – as they were in 9/11 or Pearl Harbor, or other examples that were listed above – the MIB can prove to be fatal. When the analyst says to themselves "What would I do if I were in his shoes," they put their own perspectives and background rather than taking into consideration the perspectives and background of the adversary. This in turn undermines objectivity (Witlin, 2008). A warning from Frank Wantabe states that "simply because something is logical doesn't mean that the subject being analyzed will see it that way" (Witlin, 2008). When differences in thought processes and beliefs are taken into consideration, it almost seems obvious that the analyzers viewpoint is not the same as that of the person being analyzed.

Within literature, there are many viewpoints on why the MIB occurs within analysts. While the MIDAS group believes it is a standalone cognitive bias, there are still others that think that it comes along with other biases. These pairings can be broken down into three sections: the failure of Theory of Mind, a racial bias, and mindreading.

## FIRST POTENTIAL CAUSE OF MIB: FAILURE OF THEORY OF MIND

The Theory of Mind (ToM) is the ability to attribute mental states – beliefs, intents, desires, pretending, knowledge, etc. – to oneself and others and to understand that others have beliefs, desires, and intentions that are different from one's own (Call & Tomasello, 2008). ToM expresses itself in the TPJ (temporal parietal junction), which is important in making the distinction between self and other. For example it allows a

person to be able to answer the question: *Did I generate this action or did I merely observe the action of the other?* (van der Meer, Groenwold, Nolen, Pijnenbork, Aleman, 2011). Figure 1 shows the distinction between MIB and ToM.

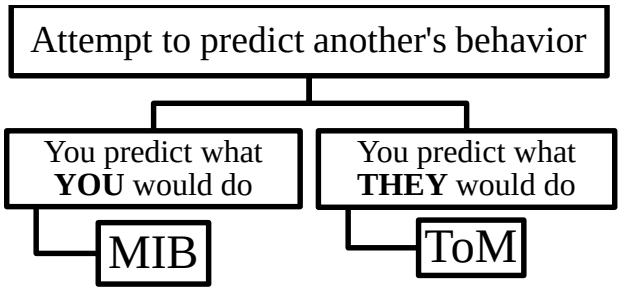



*Figure 1:* MIB is when you predict what you would do when analyzing and predicting another persons' behavior whereas ToM is when you predict what the other person would do.

Research has shown that young subjects, in comparison with adults, are less capable to perform ToM tasks (van der Meer et al., 2011). Before their brain is completely developed and before they are concerned with other people, and even other cultures, they are unable to understand the difference between their beliefs and others' beliefs. Development of ToM is between the ages of 3 and 5 (Nickerson, 1999). Another study by Tamm, Menon, & Reiss (2002) investigated brain maturation in relation to response inhibition. The results showed a positive correlation between activation in the left Inferior Frontal Gyrus (IFG) and age. This showed that younger subjects were not as good at ToM tasks (Tamm, Menon, & Reiss, 2002; van der Meer et al., 2011).

As with many other cognitive biases, ToM entails more than one step. Van der Meer has explained that the Theory of Mind, in two parts, involves 1) inhibition of one's own perspective, which leads into 2) belief reasoning. The first, inhibition of one's own

perspective, may well be a necessary feature of perspective taking according to van der Meer (van der Meer et al., 2011).

The first part of Theory of Mind, inhibition of one's own perspective, is known by several different names: empathic accuracy and knowledge imputation. Empathic accuracy is a person's ability to accurately infer the specific content of another person's thoughts and feelings (Marangoni, Garcia, Ickes, Teng, 1995). "Empathically accurate perceivers are those who are consistently good at "reading" other people's thoughts and feelings. All else being equal they are likely to be the most tactful advisors, the most diplomatic officials, the most effective negotiators, the most electable politicians, the most productive salespersons, the most successful teachers, and the most insightful therapists" (Nickerson, 1999). Imputation is a noun that is the act of imputing – saying or suggesting that someone or something has or is guilty of something - as an attribution, accusation, and insinuation (imputation, n.d.). Knowledge imputation, therefore, is the attribution, accusation or insinuation that someone has knowledge of something, whether or not they actually do in reality. "It seems clear that the imputation of knowledge to others may be done with different degrees of awareness. One may impute some knowledge (e.g., the knowledge that Wednesday follows Tuesday,) automatically without being conscious of doing so; in other cases, one may impute knowledge as a consequence of a thought process of which one is very much aware (e.g., "She undoubtedly knows of who wrote Middlemarch, because she is very interested in the English Literature")" (Nickerson, 1999).

One term for the failure of inhibition, which in turn can help us understand the success of inhibition, is called Egocentrism. According to Jean Piaget, egocentrism is an inability on the part of a child in the preoperational stage of development to see any point of view other than their own ("Egocentrism," n.d.). This concept doesn't necessarily have to only pertain to children – it can be extended to all others who have a failure to understand beyond their own point of view. In children, egocentrism isn't shown in more errors of social judgment. Instead it shows itself in the fact that they make one particular kind of error: attributing their own knowledge, viewpoint, feelings, etc to others (Shantz, 1983; Nickerson, 1999). Egocentrism is when people don't set aside their own perspective when adopting another's but instead use [their own perspective] as a starting point, or judgmental anchor (Epley, Keysar, Van Boven, Gilovich, 2004). This 'egocentric assumption' was first suggested by Fenigstein and Abrams (1993). Individuals whose heads are tilted will judge straight lines as tilted if they are simultaneously distracted but will recognize the biasing influence of their tilted head and identify the line as straight if they are not distracted (Epley et al., 2004). In the absence of compelling, identifiable reasons for some other assumption, the best default assumption one can make regarding another's knowledge on a particular subject is arguably one's own knowledge of that subject (Nickerson, 1999). These misapprehensions potentially are grounded in a tendency to impute one's own perspective to others (Ruby & Decety, 2003). To fix this tendency, a dimension of cognitive flexibility must be added in order to assess others' states of mind accurately (Ruby & Decety, 2003).

The second part of Theory of Mind, belief reasoning, is the reasoning about mental states like beliefs, desires and intentions in an attempt to explain, predict, and manipulate human behavior (Apperly, Riggs, Simpson, Chiavarino, Samson, 2006). Saxe et al. (2004) suggests that belief reasoning must meet two criteria: generality and specificity. He points out that "First, the candidate region must show increased activity to any stimuli that invite the attribution of beliefs, both true and false. Second, the response must be specific to belief attribution" (Saxe, Carey, Kanwisher, 2004). Belief reasoning is an everyday behavior that is argued to be automatic (Friedman & Leslie, 2004; Sperber & Wilson, 2002; Stone, Baron-Cohen, & Knight, 1998). "It is unknown whether [the belief reasoning] is made automatically when people attend to the behavior of agents, or whether such inferences are made ad hoc, according to need" (Apperly, Riggs, Simpson, Chiavarino, Samson, 2006). As with many of the other cognitive biases, belief reasoning – considering other peoples beliefs and desires – is a way to simplify a situation that might otherwise be difficult to understand.

The typical formats for tests on belief reasoning in humans are described as follows. These can be seen in action through experiments by Sommer et al. (2007), Birch and Bloom (2007), and van der Meer (2011). There are a series of images or videos that show a "story" of what is going on in a room. Specifically in the experiment by Sommer et al. (2007) the first set of pictures show a girl and a boy in a room with two boxes. The girl takes a toy that is lying on the floor and places it in container #2 and then leaves the room. There are two separate cases: true belief, and false belief. In the true belief case, the boy takes the toy out of container #2 and is holding it when the girl re-enters the

room. He then places it in container #1 while the girl is watching. In the false belief case, the boy takes the toy out of container #2 and places it in container #1 while the girl is out of the room. The girl then re-enters the room. A question is then asked as to where the girl thinks the toy is. In the true belief case, the expected response is that the girl will think the toy is in container #1 because the girl saw the boy switch the toys location in front of her. Therefore the unexpected (false) response would be the girl thinking the toy is in container #2 even though the toy, in reality, is in container #1. In the false belief case, after being asked the same question, the expected response is that the girl will think the toy is still in container #2 because she didn't see the boy switch the toys location. The unexpected (false) response is that the girl the girl thinks the toy is in container #1 even though she didn't see the boy switch the toys location.

These sorts of experiments are normally only done with the false belief case, but Sommer et al. chose to consider the other side in the true belief case. Similarly, these belief reasoning experiments have been run with both adults and children. Adults seem to be able to use belief reasoning in their everyday lives easily. However, children have a more difficult time understanding complex mental states. The cutoff, as suggested by Kovács (2009) is around the age of 4. Before then, children are normally unable to understand any viewpoints besides their own (Kovács, 2009). "Younger children fail on ToM tasks because they cannot reason about complex mental states, such as beliefs (Perner, 1991 via Kovács, 2009). If so, successful performance on false-belief tasks reflects the emergence of an understanding of others (and oneself) in terms of mental conditions" (Kovács, 2009). Responses from experiments show whether the participant is

capable of belief reasoning – if they follow the expected response – or not – if they follow the unexpected response.

## SECOND POTENTIAL CAUSE OF MIB: CULTURAL BIAS

> *"Most of our misunderstandings of other people are not due to any inability to hear them or to parse their sentences or to understand their words ...A far more important source of difficulty in communication is that we so often fail to understand a speaker's intention."*(Miller, 1974, as found in Thomas, 1983, p. 91)

The second potential cause of the Mirror Imaging Bias is due to a cultural bias in the person. It is clear that each culture, and even further - each person, has different beliefs and experiences. "When, in daily human interactions, persons have reflected back to them not themselves but the cultural assumptions of others, they experience a failed mirroring. Thus, failed mirroring is not merely an interpersonal interaction; it is a cultural phenomenon when societal representations are assumed and projected" (Schaller, 2008).

Further, the mindset of the analyst tends to take over when hard evidence runs out (Heuer, 1999). This fact indicates that American analysts tend to project "American values and conceptual frameworks onto the foreign leaders and societies, rather than understanding the logic of the situation" (Heuer, 1999, p. 12). This cultural bias – thinking that "everybody thinks like us" – is completely falsified. People in other cultures do not think the same way that we do.

## THIRD POTENTIAL CAUSE OF MIB: MINDREADING

The third potential cause of the Mirror Imaging Bias is through a cognitive action known as Mindreading. This action is the activity of representing specific mental states of others, for example, their perceptions, goals, beliefs, expectations, and the like (Gallese & Goldman, 1998). There are two predominant approaches when researching this subject: theory theory (TT) and simulation theory (ST). The TT explains that ordinary people accomplish mindreading by acquiring and deploying commonsense theory of mind, something akin to a scientific theory (Gallese & Goldman, 1998). ST suggests that attributors use their own mental mechanisms to calculate and predict the mental processes of others (Gallese and Goldman, 1998). The core difference between TT and ST, according to Gallese and Goldman (1998), is that TT depicts mindreading as thoroughly 'detached' theoretical activity, whereas ST depicts mindreading as incorporating an attempt to replicate, mimic, or impersonate the mental life of the target agent (Gallese and Goldman, 1998).

Baron-Cohen (1995) explains mindreading as the "cognitive ability to represent the psychological states (perceptions, emotions, intentions, desires, beliefs, etc.) of oneself and others" (Jacob, 2008). If the consideration of self is included in mindreading, it is possible to think that another person would act as you would - which would be a representation of the Mirror Imaging Bias - rather than just taking into consideration what the other person would do in reality. Mindreading, therefore, is "essentially a motor phenomenon of action synchronization, not inference" (Pineda, 2009). In the brain,

Mindreading activates areas such as the medial prefrontal cortex and temporoparietal junction. (Pineda, 2009)

Mindreading not only pulls from the ability to represent feelings or emotions to another, it also deals with the cognition of sentences or passages of information. Depending on how they are viewed or presented can completely change the context and therefore perception of the information. This concept pulls in many of the related cognitive biases previously mentioned that deal with the perception of facts and knowledge. Therefore, it is important to take into consideration how a person would look at the knowledge and how they might present it in different situations.

# RESEARCH COMPONENTS

Hofstede's country classification scale was used to decide which cultures to use in the stimuli for the experiment. "Hofstede's (1980) study is one of the most frequently cited research efforts regarding the relationship between national culture and work-related values (Bhagat & McQuaid, 1982 via Fernandez, Carlson, Stepina, & Nicholson, 1997). His research has been instrumental in furthering an understanding of cross-cultural management theory and practice, revealing that members of different societies hold divergent values concerning the nature of organizations and interpersonal relationships within them" (Fernandez, Carlson, Stepina, & Nicholson, 1997). Hofstede's cultural contrasts have standard scores for each culture. These scores were used in order to choose which cultures to include in the testing stimuli. Those with scores the most different from U.S. were considered to be different enough from our cultures viewpoint to be able to test for a significant difference in opinion on these dimensions: Individualism vs. Collectivism, Uncertainty Avoidance, Masculinity vs. Femininity, and Power Distance. Table 5 shows some standard scores found by Hofstede and used in our study.

*Table 5:* Cultural Contrast Standard Scores (Fernandez et al., 1997). Those with a significant difference from U.S. scores were countries and contrasts that were included in our experiment.

| **Individualism vs. Collectivism** | |
|---|---|
| U.S. | 1.52 |
| Russia | -1.89 |
| China | -0.96 |
| Japan | -0.53 |
| **Uncertainty Avoidance** | |
| U.S. | 0.59 |
| Mexico | -1.2 |
| Germany | -1.16 |
| Japan | -0.81 |
| **Masculinity vs. Femininity** | |
| U.S. | -0.58 |
| China | 2.2 |
| Mexico | 0.62 |
| Japan | 0.42 |
| **Power Distance** | |
| U.S. | -0.01 |

Each image used in the experiment was tested through the International Affective Picture System (IAPS) rating scale to ensure consistency. The IAPS was "developed to provide a set of normative emotional stimuli for experimental investigators of emotion and attention … The existence of these collections of normatively rated affective stimuli should: 1) allow better experimental control in the selection of emotional stimuli, 2) facilitate the comparison of results across different studies conducted in the same or different laboratory, and 3) encourage and allow exact replications within and across research labs who are assembling basic and applied problems in psychological science" (Lang, Bradley, Cuthbert, 1999). Although their images were not used, the scale was used to make certain that the images were all of the same approximate rating – this ensured that no images were statistically any different than the others.

## VISUAL MEASURES

In terms of the visual measures, this section will be broken down further into the different types that will be collected as well as how they could potentially relate to the cognitive workload of the human. Each of these measures will be collected and analyzed through the Tobii eye tracking system.

### *FIXATIONS AND SACCADES*

Fixations, or a fixation point, is "the point in the visual field that is fixated by the two eyes in normal vision and for each eye is the point that directly stimulates the fovea of the retina" (*fixation point,* n.d.). In other words it is a point in which both eyes focus for a certain period of time. On the other hand, a saccade is a "small rapid jerky movement of the eye especially as it jumps from fixation on one point to another" (*saccade,* n.d.).

Liversedge and Findlay (2000) researched the use of saccades in visual search and reading to see if it could be related to cognitive processes. Although they didn't come to a specific conclusion on a direct correlation, they did note the importance of fixations in understanding cognitive processes. They argued that "deciding where and when to move the point of fixation are key aspects of eye-movement control and that understanding the relationship between the two is necessary to understand fully the cognitive processes reflected by eye movements" (Liversedge & Findlay, 2000, p. 12). A study by Loftus and Mackworth (1978) on visual search patterns in a picture, found that the fact that "observers fixate earlier, more often, and with longer durations on objects that have a low probability of appearing in a scene" implies that cognitive factors play a role in peripheral

visual processing (Loftus & Mackworth, 1978, p. 565). Another study by Just and Carpenter (1978) looked at visual patterns of rotation detection and found that as the tasks became harder, and therefore more cognitively involved, that people gaze at the figures for much longer (Just & Carpenter, 1978).

*BLINK RATE AND PUPIL DIAMETER*

Blink rate is the number of times per minute that a person closes their eyes and the pupil diameter is the length of the pupil from side to side. A study by Bentivoglio, Bressman, Cassetta, Carretta, Tonali, & Albanese (1997) looked at blink rate in relation to a reading task that required mental and visual concentration. They found that blink rate decreased during reading and increased during conversation. In a study by Siegle, Ichikawa, and Steinhauer that crosses over the concepts of both blink rate and pupil diameter in relation to information processing, found that blinks flank periods of change in cognitive load as well as that there were a burst of blinks peaking before the pupillary response (Siegle, Ichikawa, & Steinhauer, 2008). Again, this study showed that as the peak pupil dilation is delayed from neural and muscular activity, blinks may precede cognitive load. Similarly, they found that "sustained cognitive load was accompanied by sustained pupil dilation but not sustained blinks" (Siegle et al. 2008, p. 684).

*GAZE PATTERNS AND HEAT MAPS*

Gaze patterns are the paths that a persons' eye travels while viewing a picture or scene in their visual path. Heat maps are a way to analyze how frequently a person looks at a certain area in comparison to other areas. Henderson, in a research article on gaze control, points out that eye movement is "smart" because it not only draws on currently

available visual information, but also on several cognitive systems like short term memory, long term visual, special and semantic information, and also goals and plans of the viewer (Henderson, 2003). Although there is very little research done on how these factors can correlate to cognitive activities, it is extremely interesting to see what in a particular picture draws a persons' attention. An example of a heat map on an image can be seen in Figure 2. Areas of the heat map that are red are frequented more often than areas with no color at all.

*Figure 2:* An example of a heat map when a participant views a picture shows that several areas of the picture attract more attention than others.

## PHYSIOLOGICAL MEASURES

The term cognitive load is used to refer to the load that performing a particular task imposes on the person's cognitive system (Paas et al., 1994; found in Nourbakhsh, 2012). It has extremely profound impacts on many aspects of human life including, but not limited to: learning (Sweller, 1994), safety in driving (Engstrom, Johansson, &

Östlund, 2005), aviation (Huttunen, Keränen, Väyrynen, Pääkkönen, & Leino, 2011; Wilson, 2002), and user interface design (Saadé & Otrakji, 2007). Cognitive overload often leads to performance reduction and errors that in some cases such as air traffic control can have serious consequences (Nourbakhsh, 2012). Five forms of physiological measures were collected from participants during the experiment: galvanic skin response (GSR), heart rate variance (HRV), respiration, skin temperature, electromyography (EMG(F)) of the medial frontalis, and right-unilateral EMG(E) of the orbicularis oculi. Each of these will be outlined and related to cognitive workload in this section.

*GALVANIC SKIN RESPONSE (GSR)*

Many studies have explored the relationship between the Galvanic Skin Response (GSR) and cognitive load. GSR data is collected by attaching one or two sensors to the skin of the subject, typically to the index and middle finger pads, and is measured in micro Siemens. In the MIDAS Tobii study, two CAPTIV GSR sensors are attached to the middle and index finger pads to measure the electrical conductance of the skin.

Many studies have looked into GSR and what it means for cognitive load. Landis and Hunt (as found in Mundy-Castle, 1953) concluded that it may indicate change of direction of mental activity, but not a direct measure. Another study by van der Merwe and Theron (1947) to study the "value of the Groetz finger plethsymograph in measuring emotional stability" found a positive correlation between rates of change in finger pulse volume [which is an early measurement of GSR] and emotional liability; which supports the claim that GSR is associated with emotion (Van der Merwe, Theron, 1947, p. 109). Mundy-Castle and McKiever didn't find any significant correlation between

psychophysiological data and GSR in a study with harsh-audio stimuli to see if "individual differences in GSR adaptation rate are related to a temperamental factor underlying differences in excitatory/inhibitory balance", they did find that there was significance between age and GSR (Mundy-Castle and McKiever, 1953, p. 16).

> *"The association between GSR groups and age immediately suggests that stability may be a function of maturity; there is increasing evidence to show that there are centers for autonomic control in the frontal cortex"* (Mundy-Castle, McKiever, 1953, p. 22).

Another study by Tarankar et.al (2013) showed that GSR and respiratory responses are relatable and correlated to each other. (Turankar et al., 2011). Nourbakhsh, Want, Chen, & Calvo (2012) found that there was a correlation between GSR and cognitive load measurement in a study on text reading tasks and arithmetic tasks. Nourbakhsh, Wang & Chen (2013) furthered their previous study to see if there was any correlation between blink rate, GSR, and cognitive load. They found that both are good detectors of how mentally involved people are. The higher the GSR frequency, the more mentally involved a subject is as well as the lower a persons' blink rate, the more mentally involved they are. What's more, the combination of blink number and GSR frequency power resulted in the highest classification accuracies (Nourbakhsh, Want, Chen, 2013). However, they did mention that since there are differences from person to person, the GSR rating must be calibrated. They used the following equation:

$$calibrated\_feature(i,j) = \frac{feature(i,j)}{\frac{1}{m}\sum_{j=1}^{m} feature(i,j)}$$

Where m is the number of tasks. This equation essentially normalizes the data by dividing each individual data-point by the mean rating of the entire study. Shi, Ruiz, Taib, Choi, & Chen (2007) did a similar study to look at the correlation of GSR to stress level and found that as a person becomes more or less stressed, the GSR increases or decreases respectively (Shi, Ruiz, Taib, Choi, Chen, 2007). They analyzed their data by using a mean GSR value for each stimuli and followed up with an ANOVA test to see if there was a correlation. As the difficulty of the task increased, the GSR value increased. Conway, Dick, Wang, & Chen (2013) used a similar method to normalize the GSR values in order to analyze the mean ratings for their stimuli set (Conway, Dick, Wang, & Chen, 2013). For the purposes of this study, a normalized mean GSR value for each stimuli was used to compare between participants.

*HEART RATE VARIANCE (HRV)*

Heart rate, measured in beats per minute, is the rate at which the heart beats. Using the CAPTIV system, the heart rate is measured by a thoracic belt. Heart rate variability (HRV), therefore, measures the interplay between sympathetic and parasympathetic influences on heart rate (Appelhans & Luecken, 2006).

Heart rate, in a study on driving mannerisms by Mehler, Reimer, Coughlin, & Dusek (2009) showed that average heart rate increased as cognitive task demands increased (Mehler, Reimer, Coughlin & Dusek, 2009). In a study by Hansen, Johnsen, & Thayer (2009) to see if there was a correlation between HRV and anxiety, stress, & coping found that there was a correlation between high HRV and good performance on cognitive function tasks (Hansen, Johnsen, & Thayer, 2009). A study by Huysamen,

Göbel, & Davy (1998) completed a study to compare HRV to different cognitive tasks, the complexity of those tasks, as well as the time of day the task was completed. It was found that memory tasks showed the highest HRV values and heart rate frequency values (Huysamen, Göbel, & Davy, 2013).

While this information is useful, the HRV data collected was unreliable, so this relation will not be explored in analysis.

*RESPIRATION*

Respiration, through the CAPTIV system is measured as a percentage of how much a person has inhaled or exhaled. Respiration rate, however, is the rate at which a person inhales or exhales; essentially breaths per minute. In the study, previously mentioned, by Mehler et al (2009) it showed that as cognitive task demands increased, respiration rate also increased (Mehler et al., 2009). Another study by Novak, Mihelj, & Munih (2011) explained that mean respiration rate decreases as cognitive workload increases, but increases again as the challenge becomes too much to handle (Novak, Mihelj, & Munih, 2011, p. 7). Due to technical restraints in analysis, this measurement will not be explored for the purposes of this project.

*SKIN TEMPERATURE*

Temperature is what it sounds like: the outside temperature of a human. It is typically gathered by placing a thermometer sensor on the wrist on top of one of the main blood carrying veins. Through CAPTIV, it is measured in degrees Celsius, which can be easily transferred over to degrees Fahrenheit if needed. In the previously mentioned study by Novak et al. (2011) they found that temperature might be a good indicator of when a

subject is overworked (Novak et al., 2011). Another study by Or and Duffy (2007) looked into skin temperature in a driving simulator in order to detect a change in mental workload. They found that there was a relation of temperature drop to an increase of mental workload (Or & Duffy, 2007).

As with the HRV, while this information is useful, the temperature data collected was unreliable, so this relation will also not be explored in analysis. All methods not measured in this project will be explored in the future.

*ELECTROMYOGRAPHY (EMG)*

Electromyography (EEG/EMG) is collected through sensors placed on the skin surface; specifically they will be placed on the right temporal area as well as the forehead and is measured with microvolts. They measure the electrical activity of muscles at rest and during contraction. It has been found that increases in slow-wave EEG have been associated with decreased alertness (Wright & McGown, 2001). A study by Wilson, Caldwell, and Russell (2007) found that "with regard to physiological correlates of task performance, the EEG and heart-rate measures collected during the experiment were highly correlated with the performance effects" (Wilson, Caldwell, & Russell, 2007). Therefore, average EMG can be used to quantify muscle activity over time.

Root mean square is a method recommended quantification by Basmajian and DeLuca (1985) and is calculated by squaring each data point, summing the squares, dividing the sum by the number of observations, and then taking the square root. This number represents 0.707 of one half of the peak to peak value (Basmajian & De Luca, 1985). However, average EMG can also be used as a quantification of the muscle activity

over time. A comparison of one participants data using both Root Mean Square and Average of the EMG data-points show that each essentially show the same thing, at a different ratio. The EMG of the medial frontalis can be seen in Figure 3 and shows the same trend ($r^2$ = 0.9688). The right-unilateral EMG(E) of the orbicularis oculi comparison between RMS and Average EMG can be seen in Figure 4 shows the same trend ($r^2$ = 0.9688). Based on these comparisons, the average of the EMG will be used for analysis.

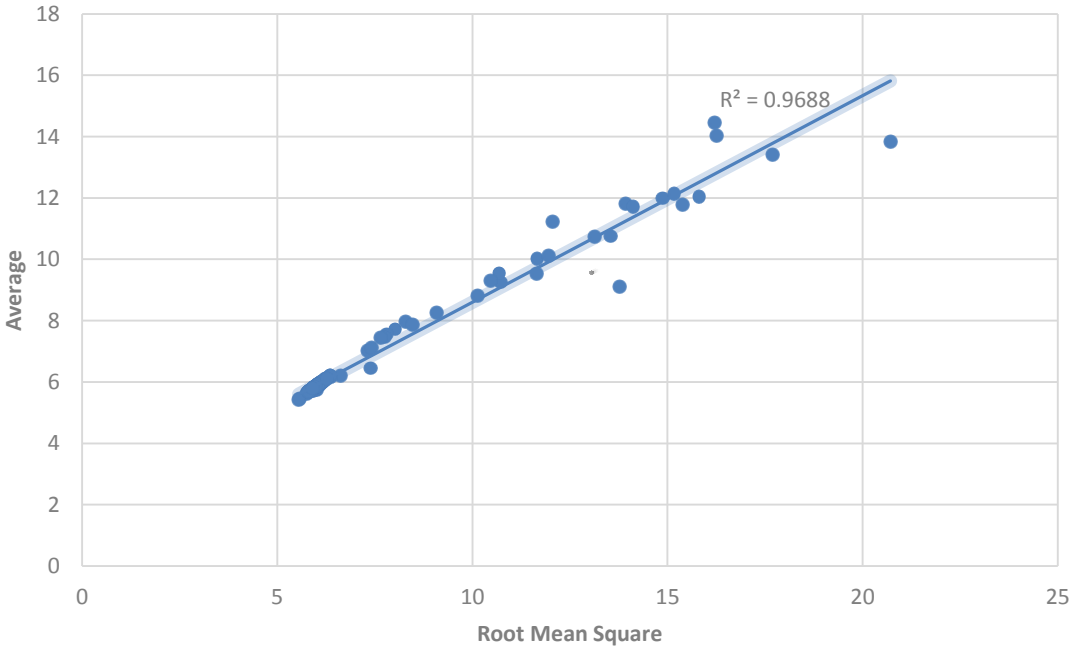



*Figure 3:* Comparison shows that AVG EMG on the forehead shows the same trend (r2 = 0.9688) as RMS data, simply at a different ratio.

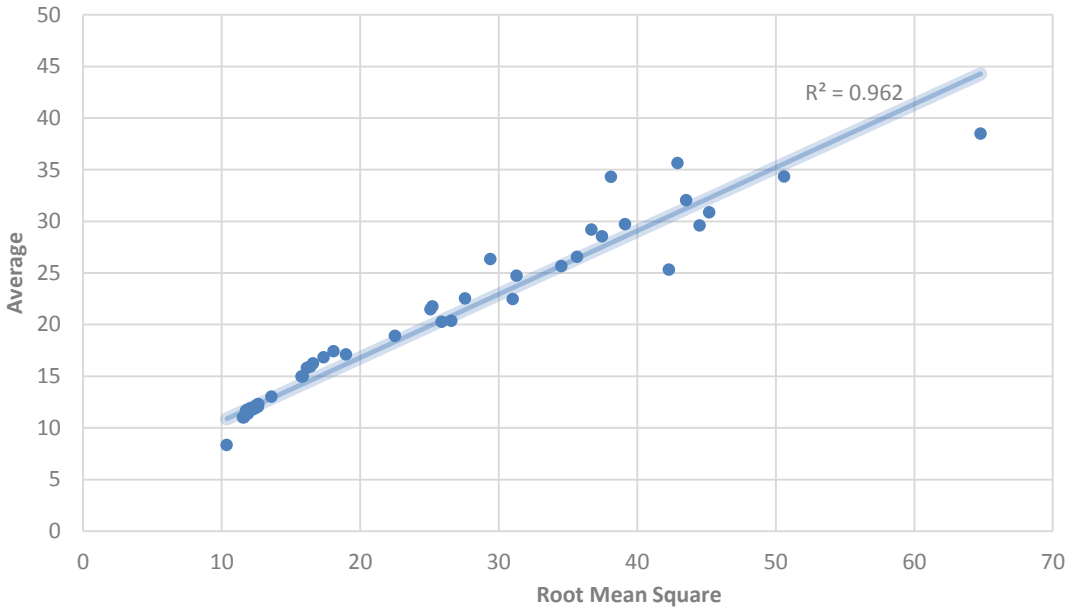



*Figure 4:* Comparison shows that AVG EMG on the temple shows the same trend (r^2 = 0.9586) as RMS data, simply at a different ratio.

# III. METHODOLOGY

Two outside factors were taken into consideration in our experiment: individualism and cultural differences. Individualism, or the fact that each person has their own distinct existence – their own beliefs, experiences, and personalities, was accounted for through pre and post questionnaires. These can be seen in Appendix A and B, respectively. If individuality was not accounted for, the test would have assumed that each participant was of the same viewpoint, experiences, beliefs, and personalities. This assumption would have been completely irrational and non-realistic because, as pointed out earlier, each person has their own individualities. Each tiny difference could potentially be a reason why they would exhibit the MIB. Cultural considerations were also accounted for. As with the last factor, if these were not included the experiment would have been non-realistic. Each culture has a set of their own beliefs and experiences that, theoretically, every person that is a part of the culture adheres to. Similarly, each culture has a set of stereotypes and biases that are assumed by other cultures (for example, All Americans are wasteful, or all Chinese children are great at math) whether or not they are actually correct. Through a partial knowledge of other cultures, people assume that they can understand and think like the other cultures. To analyze these cultural differences in the data, we asked questions about each person's viewpoint to their own culture as well as their thoughts about other cultures in the pre and post questionnaire (ex. In the images, did the persons' race play a role in your answers?)

The first task in building the experimental stimuli was selecting what cultures to present. It was decided to use China, Germany, Japan, Mexico, and Russia. As presented earlier, Hofstede's country classification scale was used as a reference point of standard scores for other cultures. From these standard scores, the topics were chosen for the stimuli. Power distance was excluded because the U.S. scores fall on the mean. The breakdown of topics can be seen in Figure 5. The individual topics are broken down into the three categories taken from Hofstede's scores – each of them fitting within the higher topic (i.e. letting others share falls under individualism vs. collectivism because some cultures are more focused around sharing/collectivism while others prefer to not share/individualism).

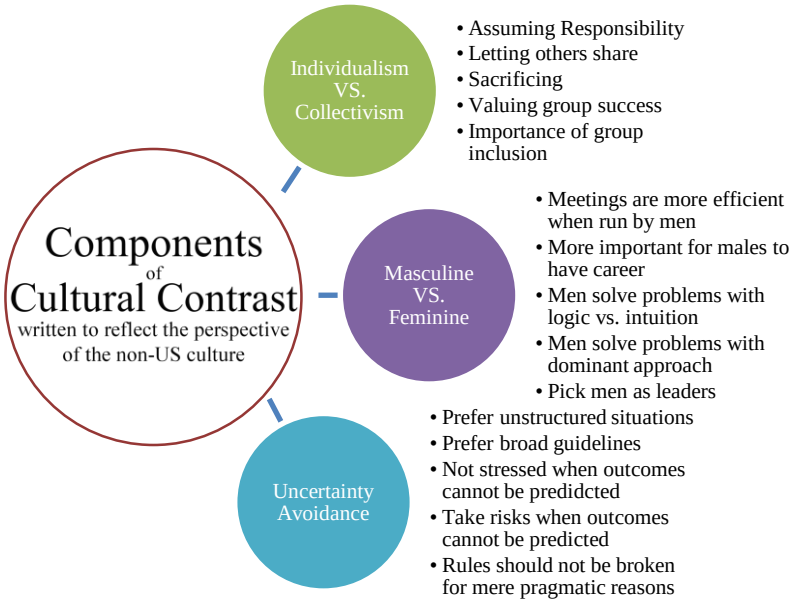



*Figure 5:* Hofstede's country classification aided in deciding topics for the experiments stimuli. Each of the three topics were broken down into five sub-topics.

Each sub-topic was explored with four different stimuli, totaling 60 images. Participants were exposed to each culturally relevant image with an accompanying audio

segment, and two questions. The audio segment was a non-U.S., culturally relevant statement about a single person. Each audio segment averaged 5 seconds, but none went over eight seconds or under four seconds. Each image included a single person or group of people of a single culture. There were an equal amount of stimuli about males and females; 30 stimuli for each gender. An image was displayed for eight seconds while the audio file played. The image was removed after the audio had completed. Participants were to then answer a question regarding if the person in the image would do a certain activity that centered on one of Hofstede's topics.

The questions were formulated from half positive and negative perspectives. Each image was presented twice, to carefully explore MIB and ToM. The first was a question about the others actions, and the second was a question about self. Since both MIB and ToM occur when judging or predicting the actions of a third party (i.e. how the person in the image would act) it was important to compare the difference between the answers (self vs. other). Participants responded to questions–yes or no by left or right clicking a computer mouse. Image order was randomized to minimize a learning effect. Figure 6 illustrates the order of each stimulus. A sample image can be seen in Figure 7. Similarly, the question presented to the participant from the "other" perspective are shown in Figure 8 and the "self" perspective in Figure 9. Appendix C includes all stimuli used in the experiment.

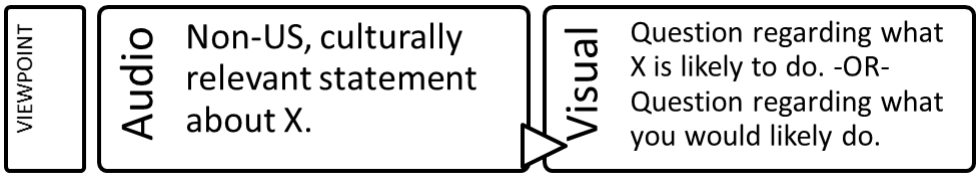



*Figure 6*: The order of each stimuli began with an image and a non-US culturally relevant statement about the person in the image and then moved into a question on the screen regarding what the person in the image is likely to do. Later a question about what the participant would be likely to do appeared on the screen.

*Figure 7:* An example of an image shown in the experiment. This particular image is of a Russian woman. The stimuli audio and question would reflect something that her culture would experience.

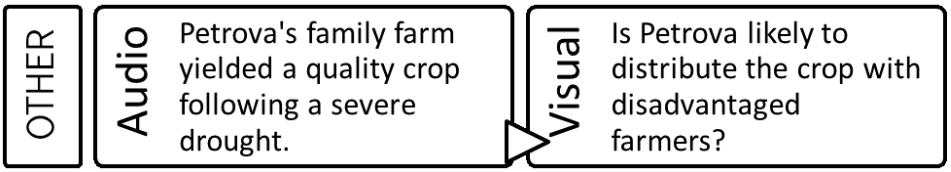



*Figure 8:* In the “other” stimuli linked to Petrova’s image it suggests that her family happened to have a quality crop even though there was a severe drought. The question about "other" asked the participant if they thought Petrova would share her crop with other farmers.

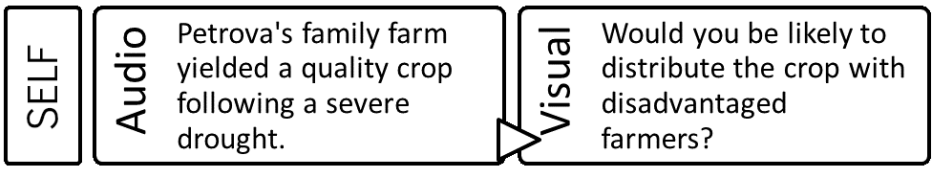



*Figure 9:* In the “self” stimuli linked to Petrova’s image it again suggests that her family happened to have a quality crop even though there was a severe drought. The he question about "self" asked the participant if they would share their crop in a similar situation.

As mentioned earlier, each image was tested through the IAPS rating scale; eight participants provided results. The images were mapped according to a subjective rating on a scale of 1 to 9 of both valence (happiness/unhappiness), where 1 was completely unhappy and 9 was completely happy, and arousal (relaxed/stimulated), where 1 was completely unaroused and 9 was completely aroused. These ratings were then averaged through the different participants and graphed with arousal on the x-axis and valence on the y-axis. Ideally, the ratings would be around the center of the graph or in the third quadrant – a rating of 5 or less for both valence and arousal – the results of the IAPS test can be seen in Figure 10. The IAPS rating was completed so that any physiological reaction from participants can be attributed to whether or not the person reacted according to MIB presented and not because of the image. Since all the stimuli were around the same area, this proves that results were because of the personal biases, not because of the impression of the image.

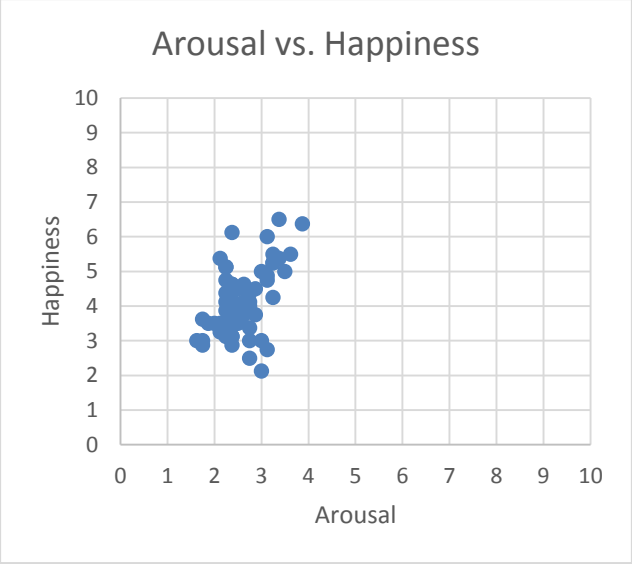



*Figure 10:* Results of the IAPS rating test on the images show that all the images used in the experiment were of approximately the same rating. This showed that results from the experiment were due to emotional, or bias, reasons and not due to a reaction to the images.

Testing of the stimuli was done through a Tobii Studio eye tracker system at Wright State University (WSU). The study was approved by the WSU Institutional Review Board (IRB) and the Surgeon General (SG). The Tobii Studio eye tracker collects gaze data with a sampling rate of 120 Hz from an off body camera located on a stationary monitor. It was used in conjunction with the Captiv-L7000 system which collected six physiological measures: galvanic skin response (GSR), heart rate variance (HRV), respiration, skin temperature, electromyography (EMG) of the medial frontalis, and right-unilateral EMG of the orbicularis oculi.

The study used a randomization scheme for the stimuli set presented to each participant. Fifteen participants from the ages of 21 to 50 were pulled from the Wright State University community. Each participant went through each of the 60 stimuli twice – once to ask how the person in the images would act (referred to as "other") and another time to ask how the participants would act in the situation (referred to as "self"). The distinction between the answer for how the other person would act versus how the participant would act in a situation shows the Mirror Imaging Bias. The timeline that each participant experienced during the Tobii experiment is shown in Figure 11. Each run of the experiment lasted a little under an hour (give or take).

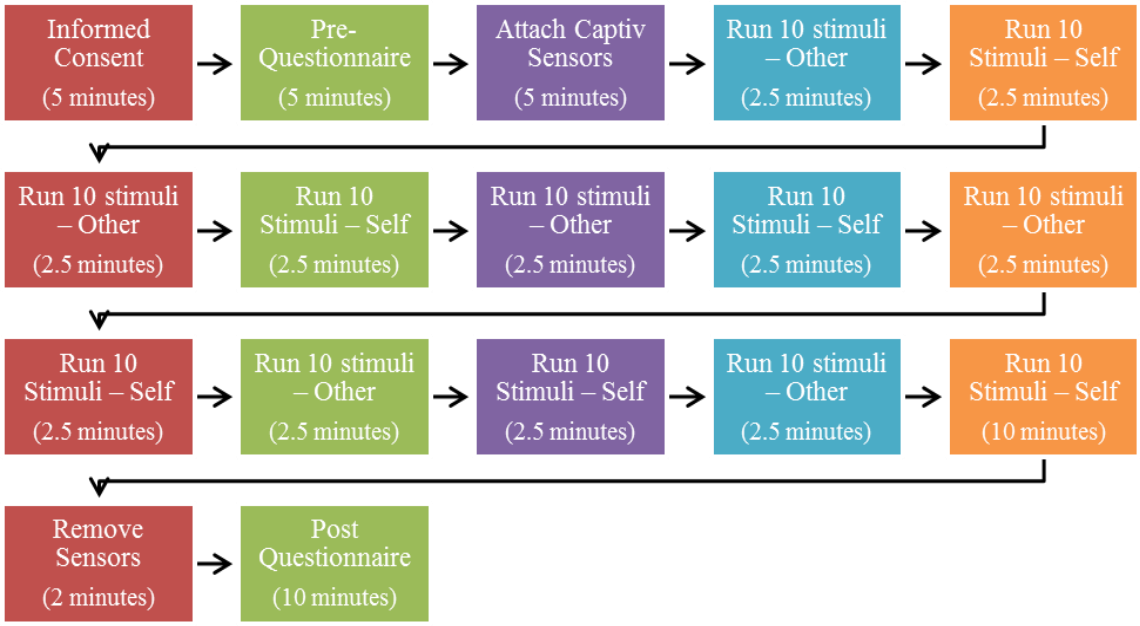



*Figure 11:* The timeline for each run of the experiment began with an informed consent and pre-questionnaire. It then lead into the attaching of the physiological sensors and calibration of the eye-tracker. Each of the stimuli were presented in groups of ten. Once all the stimuli were observed, then the sensors were removed and a post-questionnaire was administered. The entire process took a little under an hour.

Answers provided by the participant (either yes or no) were recorded and analyzed. Since both MI and ToM occur when judging or predicting the actions of a third party (i.e. how the person in the image would act) it was important to compare the difference between the answers (self vs. other). MI is the irrationality in which a person perceives and processes information through the filter of personal experience. If the participant is experiencing MI while answering how the person in the image would act, they would instead answer how they would act in the similar situation. Essentially you predict what you would do. Therefore, the tendency and susceptibility for MIB is the prevalence or frequency that the participant takes their own perspective when attempting to judge a third party. Again, since susceptibility is the percentage of judgments made that correspond to the participants own viewpoint, it is critical to determine what the

participants viewpoint is. In contrast, ToM is the ability to predict and interpret the thoughts and actions of another by taking on their perspective. In the experiment, this would be shown by the participant answering the question of how would the person in the image act correctly – from their viewpoint. You predict what they would do.

# IV. RESULTS

## GENERAL RESULTS

Overall results show that individuals exhibited MIB statistically more frequently ($p = 0.0006$, m. = 40.13%, s.d. = 8.57%) than ToM (m = 21.23%, s.d. = 8.32%). A comparison can be seen in Figure 12.

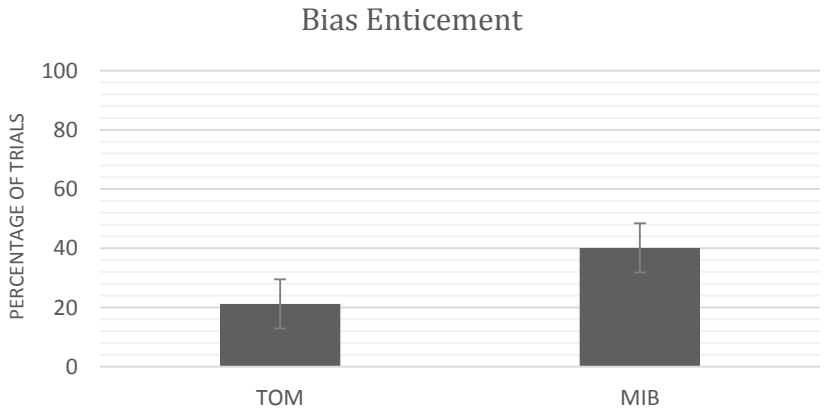



*Figure 12: MIB was enticed almost twice as much as ToM.*

MIB was observed greater in stimuli about females (m. = 48.44%, s.d. = 9.74%) compared to stimuli about males (m. = 32.66%, s.d. = 7.98%). This comparison can be seen in Figure 13. On a similar note, questions about the different cultures resulted in a wide range of MIB enticement, with questions about Germans eliciting the highest (m. = 64.76%, s.d. = 14.15%) and questions about China eliciting the lowest (m. = 33.81%, s.d. = 12.51%). The different culture comparisons can be seen in Figure 14.

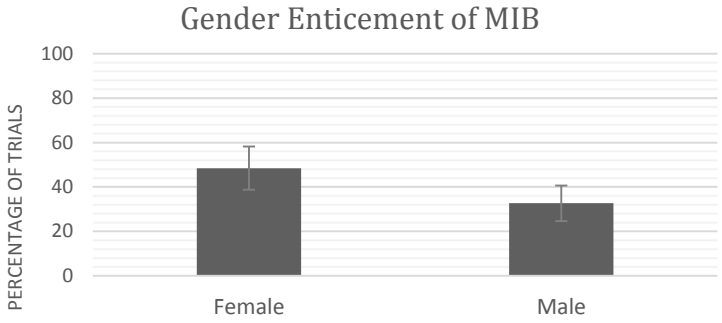



*Figure 13*: Questions about females resulted in more susceptibility to MIB compared to males.

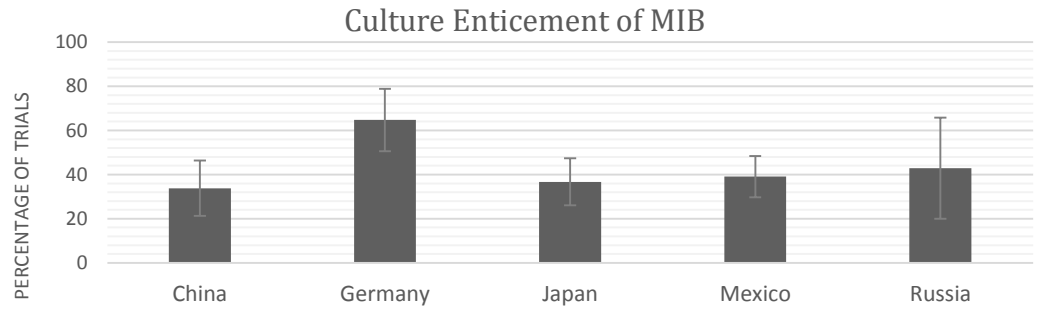



*Figure 14*: Questions about Germans elicited the most amount of MIB.

Delving further into the susceptibility of participants within each different Hofstede's country classification topic; the bias was shown most frequently in Uncertainty Avoidance (m. = 49.00%, s.d. = 11.98%), followed by Masculinity vs Femininity (m. = 37.33%, s.d. = 11.31%) and closely shadowed by Individualism vs. Collectivism (m. = 35.33%, s.d. = 12.74%). This can be seen in Figure 15. Within each of these main topics were sub-topics which can be seen in Figure 16. Full titles of the topics can be referenced from Figure 5: Hofstede's country classification. The "not stressed when outcomes can't be predicted" category had the highest amount of MIB at 65.00% (s.d. = 31.05) while the "Men solve problems with logic vs. intuition" category had the least amount of MIB at 20% (s.d. = 19.3).

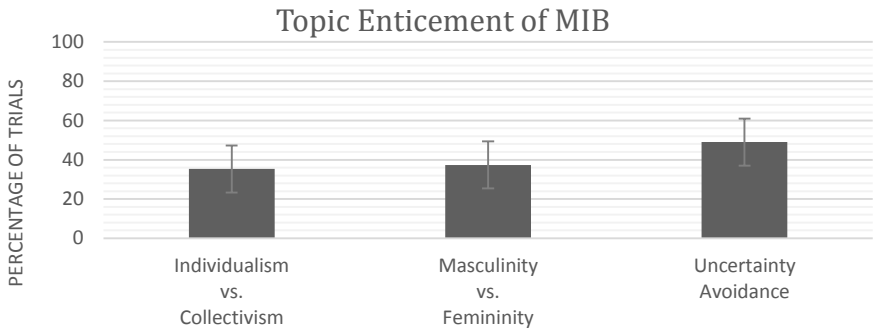



*Figure 15*: Uncertainty Avoidance showed the most amount of MIB in a comparison of each of the topics from Hofstede's Country Classification Scale.

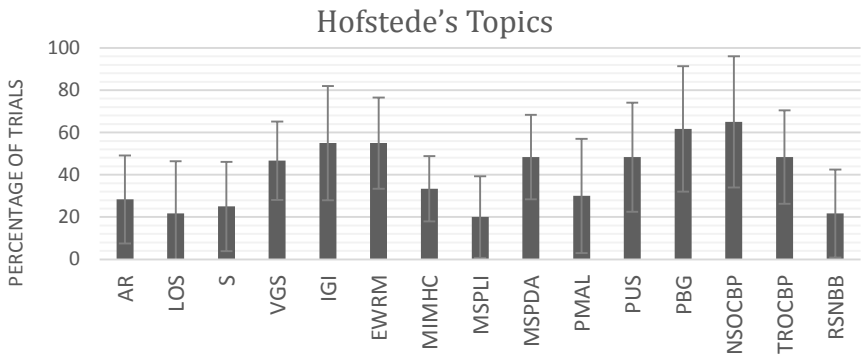



*Figure 16*: Highest MIB was shown in the "Not stressed when outcomes cannot be predicted" sub-topic.

Participants were asked what their biggest influence was when unsure about answers. The responses fell under the following categories: gut feeling, facial expression or demeanor of the person, the assumption that they would do the "right thing," the assumption that the person in the image would do the same thing as the participant, and the assumption that the person in the image would follow their respective cultural cues. The latter two are key: MIB is the assumption that another person would act the same way as you, and ToM is understanding that another person can take an opposing viewpoint. Participants who reported answering questions from the stimuli's culture—by definition ToM—exhibited MIB more so than participants who reported the stimuli individual would act as the participant would—by definition MIB. This result is contrary

to the current paradigm and exemplifies the complexity and criticalness of cultural viewpoints. Similarly, it shows that those who are susceptible to the bias, are so unknowingly.

Participants were also asked if the culture of the individuals or groups affected their responses. Most of the people responded that yes, it did play a role in their response; Figure 17. This supports the hypothesis that culture plays a role in MIB because such a large portion of the participants answered according to culture.

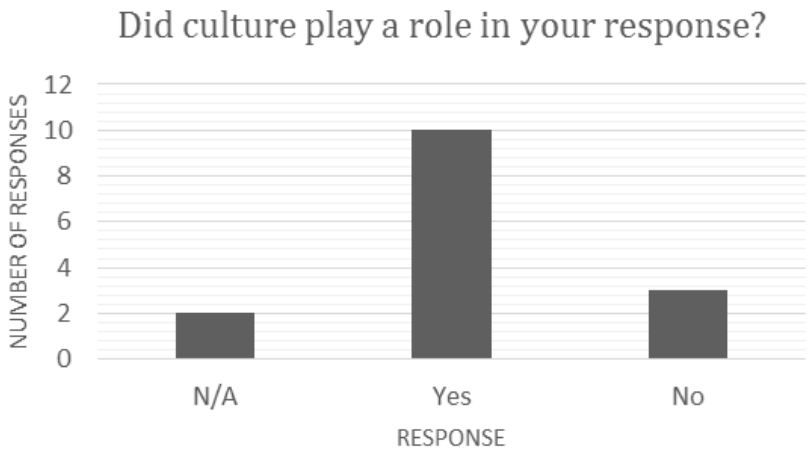
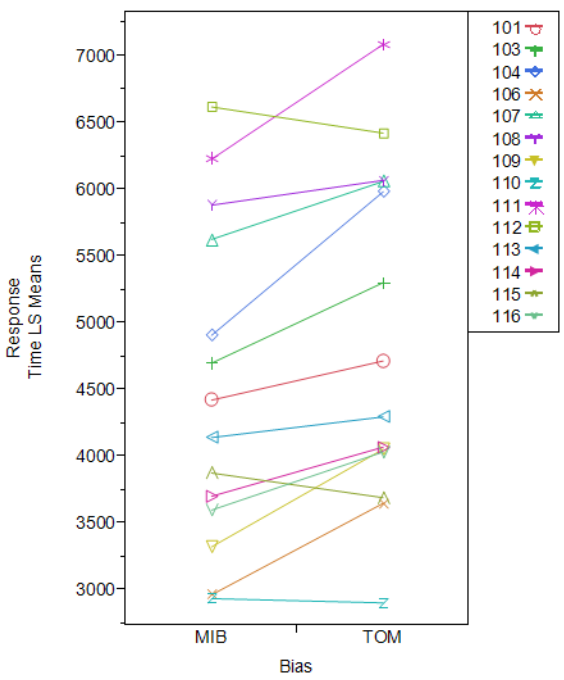



*Figure 17*: Based on the results from a post-questionnaire topic, it shows that culture played a large role in the responses that participants gave.

## RESPONSE TIME

A t-test indicated no significance between the levels (MIB/ToM) with respect to response time ($p = 0.1133$). However, a t-test for one participant revealed a significant effect - response time was lower for MIB compared to ToM ($p = 0.0141$). Response time for each participant with respect to MIB and ToM can be seen in Figure 18. For 11 participants– a t-test revealed a significant effect with respect to response time of the self

vs. other viewpoints. In all cases, the question worded in the viewpoint of self exhibited a response time less than questions worded in the viewpoint of other. Response times for each participant with respect to other and self can be seen in Figure 19. P-values that showed significance for the t-tests for each participant can be seen in Table 6. Participant 102 had unusable data and therefore had to be excluded from analysis.



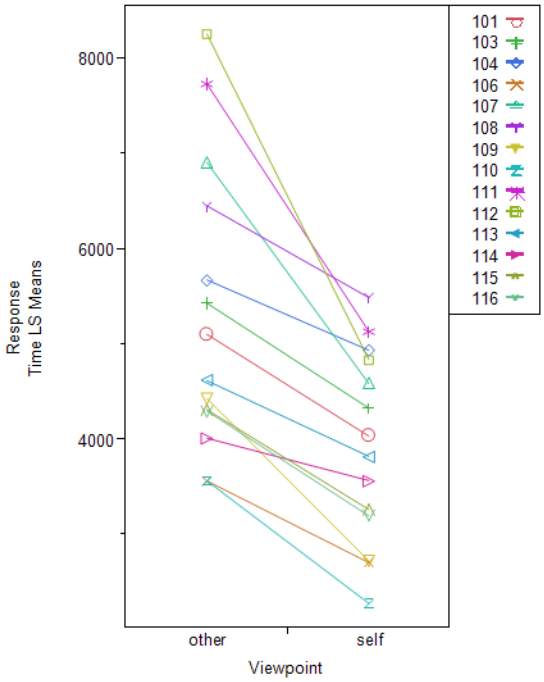




*Figure 18, left:* A LS Means Plot to compare response time of each participant according to MIB and ToM shows that there is a general trend that MIB response time is less than ToM response time.

*Figure 19, right:* A LS Means Plot to compare response time of each participant according to viewpoint shows that the response time of questions about "self" is drastically lower than the response time for questions about "other".

*Table 6*: P-values for all t-tests done for each participant for response time. One participant had a significant difference when comparing MIB to TOM with respect to response time. 11 of the participants showed significance when comparing "self" to "other" stimuli with respect to response time.

| Participant | Compare | | Significance |
|---|---|---|---|
| 101 | Bias Response (MIB/TOM) | Response Time | P = 0.4970 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0069* |
| 103 | Bias Response (MIB/TOM) | Response Time | P = 0.1927 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0043* |
| 104 | Bias Response (MIB/TOM) | Response Time | P = 0.0141* |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0553 |
| 106 | Bias Response (MIB/TOM) | Response Time | P = 0.1628 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0262* |
| 107 | Bias Response (MIB/TOM) | Response Time | P = 0.3842 |
| | Question Viewpoint (Self/Other) | Response Time | P < 0.0001* |
| 108 | Bias Response (MIB/TOM) | Response Time | P = 0.6932 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0250* |
| 109 | Bias Response (MIB/TOM) | Response Time | P = 0.0998 |
| | Question Viewpoint (Self/Other) | Response Time | P < 0.0001* |
| 110 | Bias Response (MIB/TOM) | Response Time | P = 0.9425 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0013* |
| 111 | Bias Response (MIB/TOM) | Response Time | P = 0.1152 |
| | Question Viewpoint (Self/Other) | Response Time | P < 0.0001* |
| 112 | Bias Response (MIB/TOM) | Response Time | P = 0.6578 |
| | Question Viewpoint (Self/Other) | Response Time | P < 0.0001* |
| 113 | Bias Response (MIB/TOM) | Response Time | P = 0.7745 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0976 |
| 114 | Bias Response (MIB/TOM) | Response Time | P = 0.4972 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.2863 |
| 115 | Bias Response (MIB/TOM) | Response Time | P = 0.6421 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0040* |
| 116 | Bias Response (MIB/TOM) | Response Time | P = 0.3240 |
| | Question Viewpoint (Self/Other) | Response Time | P = 0.0039* |

## NUMBER OF FIXATIONS

An ANOVA and t-test showed no significance between MIB and TOM responses when comparing responses between all participants ($p = 0.9519$). However, when comparing MIB and TOM responses within each participant, one participant showed a significant effect ($p = 0.0109$): MIB had a higher number of fixations compared to ToM.

A LS Means Plot that displays number of fixations for each participant with respect to MIB and ToM can be seen below in Figure 20. Seven participants had a significant difference between the number of fixations for questions about other vs. self. A LS Means Plot that displays number of fixations for all participants with respect to other and self can be seen below; Figure 21. P-values that showed significance for the t-tests for each participant can be seen in Table 7. One participant had unusable data and therefore had to be excluded from analysis.

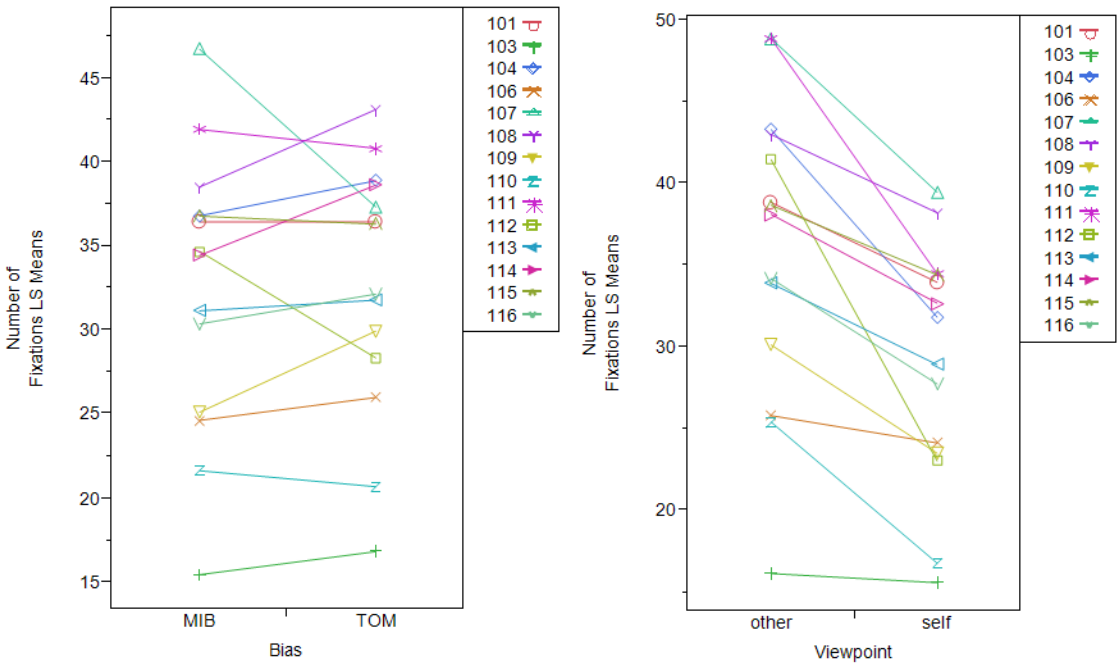



*Figure 20, left:* A LS Means Plot to compare number of fixations for each participant according to MIB and ToM did not show any general trend. This is reflected in the t-test which showed no significance in the difference between number of fixations for MIB and ToM responses.

*Figure 21, right:* A LS Means Plot to compare number of fixations for each participant according to viewpoint showed that questions about "other" resulted in a higher amount of fixations.

*Table 7*: P-values for all t-tests done for each participant for number of fixations. One individual had a significant difference between the number of fixations in MIB and ToM stimuli. There were seven instances of participants having a significant difference between number of fixations for self versus other stimuli.

| Participant | Compare | | Significance |
|---|---|---|---|
| 101 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.9987 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.8506 |
| 103 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.6883 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.8506 |
| 104 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.5174 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.0001* |
| 106 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.7060 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.5749 |
| 107 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.0109* |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.0028* |
| 108 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.1852 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.1495 |
| 109 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.1434 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.0282* |
| 110 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.7716 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.0054* |
| 111 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.7803 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P < 0.0001* |
| 112 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.0665 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P < 0.0001* |
| 113 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.8727 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.1804 |
| 114 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.2959 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.0924 |
| 115 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.8703 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.1299 |
| 116 | Bias Response (MIB/TOM) | Number of Fixations | P = 0.5867 |
| | Question Viewpoint (Self/Other) | Number of Fixations | P = 0.0285* |

## PUPIL DIAMETER

An ANOVA and t-test indicated significance (p = 0.0001) between bias response with respect to pupil diameter. Pupil diameter is significantly lower when the participants viewed stimuli that elicited MIB responses compared to that of ToM responses. Three

participants showed a significant effect between MIB and ToM. In two participants, MIB responses had the lower value of pupil diameter and, interestingly, the third had a higher diameter. The average pupil diameters for all participants by bias category can be seen in Figure 22. One participant showed significance between pupil diameters in comparison to question viewpoint. In this case, questions about self elicited a lower pupil diameter. A comparison of each participant's pupil diameter for the question viewpoints can be seen in Figure 23. P-values that showed significance for the t-tests for each participant can be seen in Table 8. Two participants had unusable data and therefore had to be excluded from analysis.

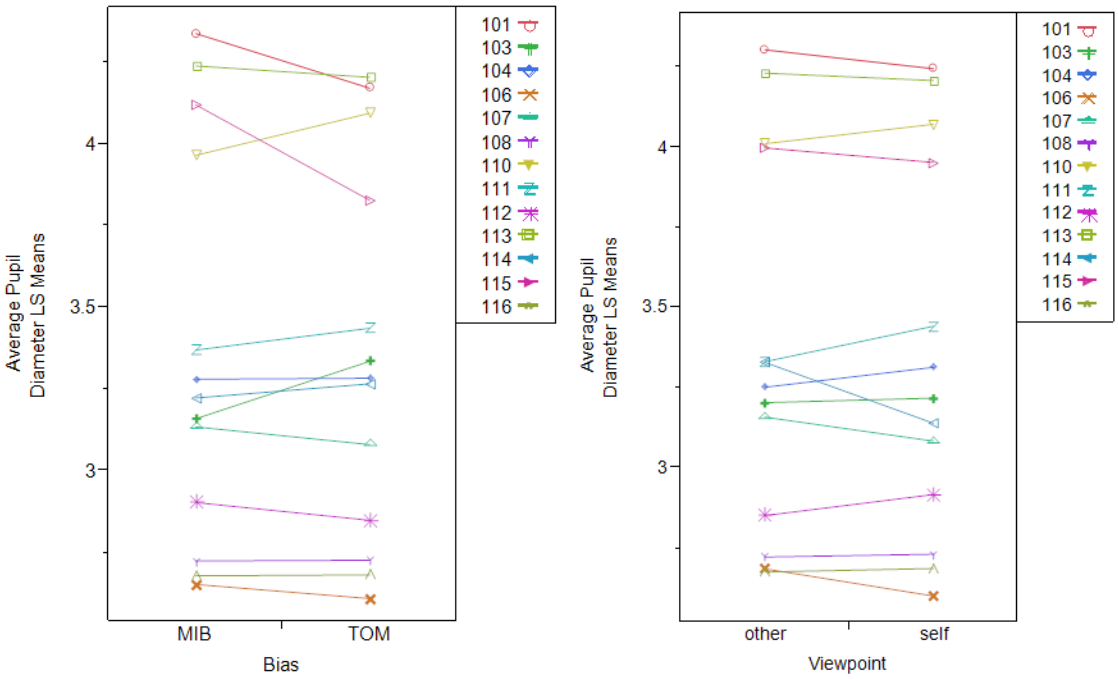



*Figure 22, left*: A LS Means Plot to compare pupil diameter for each participant according to MIB and ToM seems to show no general trend, although a t-test showed significance. Pupil diameter is significantly lower when the participants viewed stimuli that elicited MIB responses compared to that of ToM responses

*Figure 23, right:* A LS Means Plot to compare pupil diameter for each participant according to viewpoint seems to show no general trend.

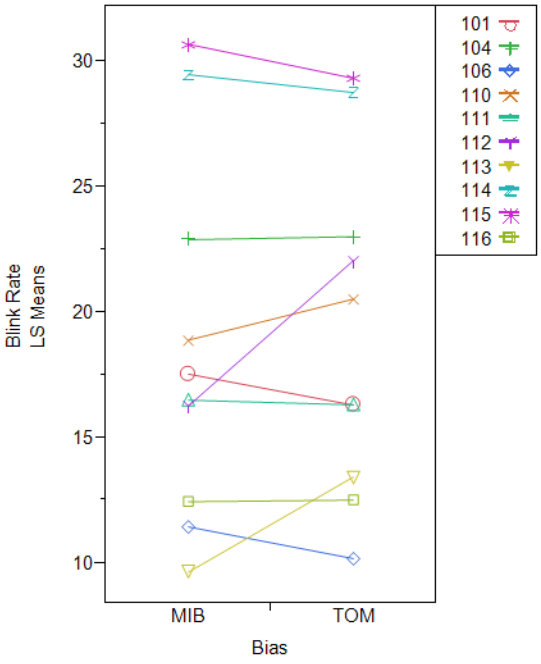
*Table 8*: P-values for all t-tests done for each participant for pupil diameter. Three participants had a significant difference when comparing MIB to TOM with respect to pupil diameter. One of the participants showed significance when comparing "self" to "other" stimuli with respect to pupil diameter.

| Participant | Compare | | Significance |
|---|---|---|---|
| 101 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.0519 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.4876 |
| 103 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.0047* |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.8040 |
| 104 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.9580 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.2714 |
| 106 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.5252 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.1446 |
| 107 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.4098 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.2083 |
| 108 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.9716 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.8890 |
| 110 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.0279* |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.3005 |
| 111 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.3530 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.0741 |
| 112 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.3583 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.2589 |
| 113 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.5594 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.6979 |
| 114 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.5473 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.0019* |
| 115 | Bias Response (MIB/TOM) | Pupil Diameter | P < 0.0001* |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.3944 |
| 116 | Bias Response (MIB/TOM) | Pupil Diameter | P = 0.4817 |
| | Question Viewpoint (Self/Other) | Pupil Diameter | P = 0.8451 |

## BLINK RATE

A comparison of the presented bias to blink rate through a t-test showed no statistical significance (p = 0.1205). Participant 106 had the lowest average blink rate at 11.2 blinks per minute and the highest was participant 115 with 29.95 blinks per minute. The average bpm for all participants was 17.91 (s.d. 7.05). The blink rates for the

participants comparing the different biases can be seen in Figure 24. A t-test comparing the viewpoint of the question (self versus other) to the blink rate indicated no statistical significance (p = 0.2754). Questions about self had a lower average blink rate (m. = 17.457, s.d. = 0.583) than questions about other (m. = 18.349, s.d. = 0.571). A comparison of each participant's blink rate for the different question viewpoints can be seen in Figure 25. The interaction between the bias and the viewpoint of the question also showed no significance on blink rate (p = 0.8237). P-values that showed significance for the t-tests for each participant can be seen in Table 9. Five participants had unusable data and therefore had to be excluded from analysis.



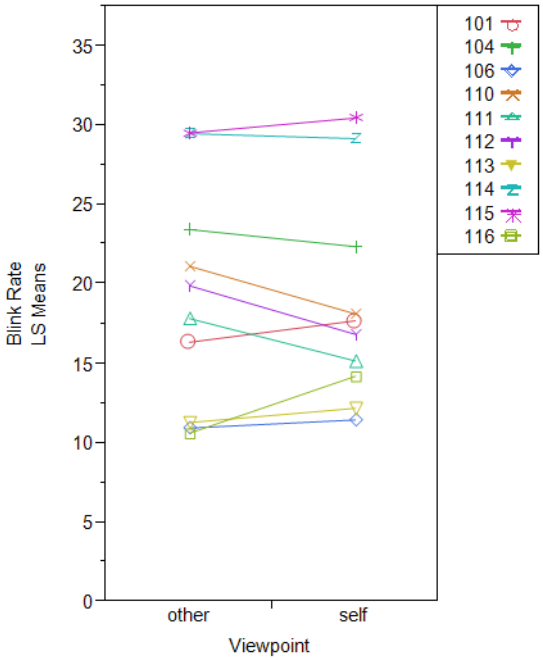




*Figure 24, left:* A LS Means Plot to compare blink rate for each participant according to MIB and ToM shows no general trend.

*Figure 25, right:* A LS Means Plot to compare blink rate for each participant according to viewpoint shows no general trend.

*Table 9*: P-values for all t-tests done for each participant for blink rate. Two participants had a significant difference when comparing MIB to TOM with respect to blink rate. One of the participants showed significance when comparing "self" to "other" stimuli with respect to blink rate.

| Participant | Compare | | Significance |
|---|---|---|---|
| 101 | Bias Response (MIB/TOM) | Blink Rate | P = 0.6100 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.5696 |
| 104 | Bias Response (MIB/TOM) | Blink Rate | P = 0.9473 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.5500 |
| 106 | Bias Response (MIB/TOM) | Blink Rate | P = 0.6262 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.8019 |
| 110 | Bias Response (MIB/TOM) | Blink Rate | P = 0.4161 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.1359 |
| 111 | Bias Response (MIB/TOM) | Blink Rate | P = 0.9338 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.1488 |
| 112 | Bias Response (MIB/TOM) | Blink Rate | P = 0.0037* |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.1213 |
| 113 | Bias Response (MIB/TOM) | Blink Rate | P = 0.0452* |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.6336 |
| 114 | Bias Response (MIB/TOM) | Blink Rate | P = 0.8512 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.9080 |
| 115 | Bias Response (MIB/TOM) | Blink Rate | P = 0.5533 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.6818 |
| 116 | Bias Response (MIB/TOM) | Blink Rate | P = 0.9683 |
| | Question Viewpoint (Self/Other) | Blink Rate | P = 0.0237* |

## NORMALIZED GSR

An example of the GSR output can be seen in Figure 26 for the different categories of response: TOM response for both "other" and "self," and MIB response for both "other" and "self." As seen by this specific example ToM resulted in higher GSR measurements. This exemplifies the fact that research has shown that as GSR increases, cognitive workload also increases. (Shi, Ruiz, Taib, Choi, & Chen , 2007).

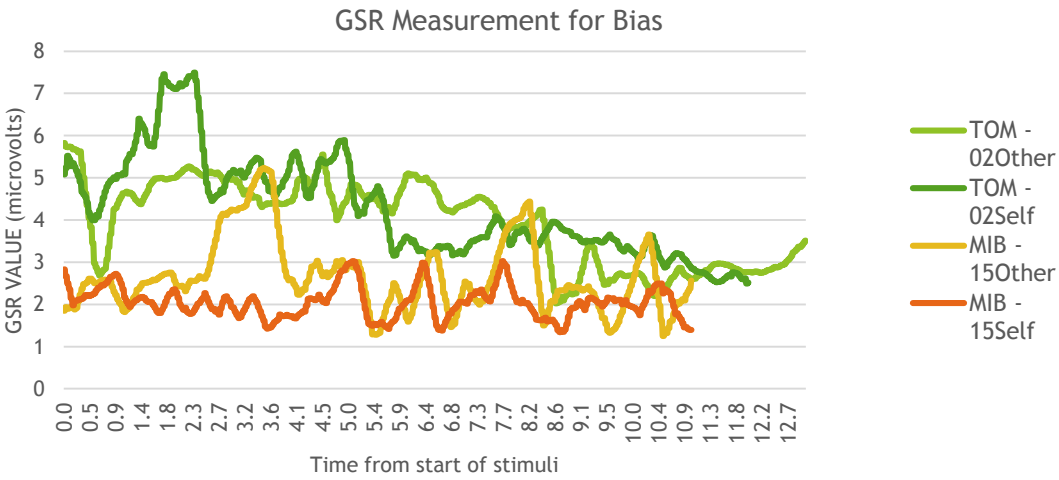
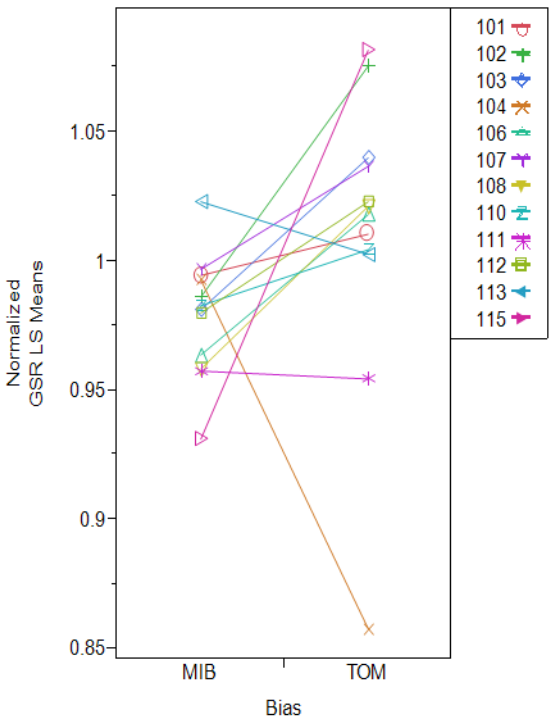



*Figure 26*: An example of the GSR measurements of an example of MIB and ToM response indicates that GSR value was lower over the entire length of a stimuli when participants were viewing a stimuli that elicited MIB.

An ANOVA and t-test indicated no significance ($p = 0.1211$) between MIB and ToM response with respect to normalized GSR. Upon further investigation of the data, two participants showed a significant effect between MIB and ToM. For one participant, MIB GSR was significantly higher. However, for another participant, ToM GSR was significantly higher. Each of the GSR values for the participants comparing MIB and ToM can be seen in Figure 27. None of the participants showed significance between GSR for question viewpoints. Each participant's pupil diameter for the different question viewpoints can be seen in Figure 28. P-values that showed significance for the t-tests for each participant are shown in Table 10. Three participants had unusable data and therefore had to be excluded from analysis.



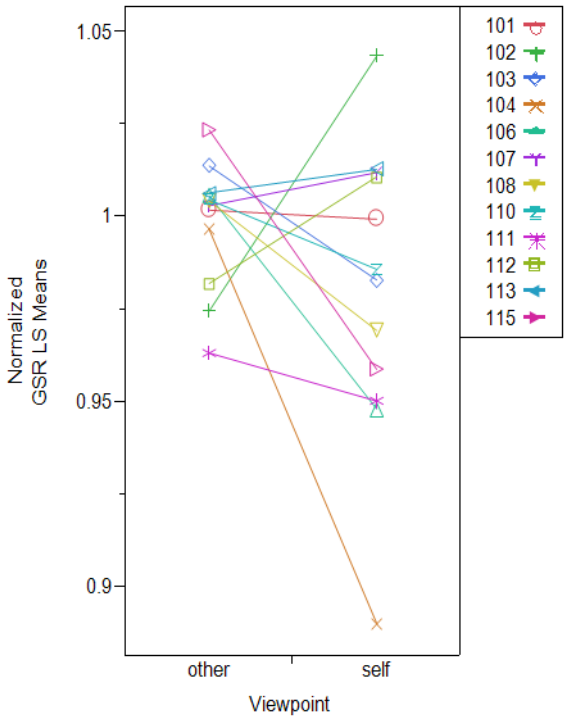




*Figure 27, left:* A LS Means Plot to compare normalized GSR for each participant according to MIB and ToM shows conflicting results. However, the general trend – save one participant - shows that GSR was lower in stimuli that elicited the MIB compared to stimuli that elicited ToM.

*Figure 28, right:* A LS Means Plot to compare normalized GSR for each participant according to viewpoint shows no general trend. In fact, several of the participants had opposing results.

*Table 10*: P-values for all t-tests done for each participant for GSR. Two participants had a significant difference when comparing MIB to TOM with respect to normalized GSR. None of the participants showed significance when comparing "self" to "other" stimuli with respect to pupil diameter.

| Participant | Compare | | Significance |
|---|---|---|---|
| 101 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.8718 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.9799 |
| 102 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.2592 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.3210 |
| 103 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.4043 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.6330 |
| 104 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.0423* |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.0971 |
| 106 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.4656 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.3684 |
| 107 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.5991 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.8942 |
| 108 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.3795 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.6239 |
| 110 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.7472 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.7776 |
| 111 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.9707 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.8534 |
| 112 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.5236 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.6610 |
| 113 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.8370 |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.9468 |
| 115 | Bias Response (MIB/TOM) | Normalized GSR | P = 0.0316* |
| | Question Viewpoint (Self/Other) | Normalized GSR | P = 0.3484 |

## EMG1 - ORBICULARIS OCULI

A t-test to compare average EMG for the orbicularis oculi between participants showed that many were different from others ($p < 0.0001$), which is to be expected. Average EMG for all participants was 12.649 (s.d. 2.87). A t-test comparing bias result (MIB vs. ToM) to the EMG showed no statistical significance ($p = 0.2919$). EMG of MIB responses had a lower average EMG (m. = 12.566, s.d. = 0.128) than ToM responses (m. = 12.787, s.d. = 0.165). Each of the EMG values for the participants

comparing MIB and ToM can be seen in Figure 29. A t-test comparing the viewpoint of the question (self vs. other) to the EMG showed no statistical significance (p = 0.2514). EMG of questions about self had a higher average EMG rating (m. = 12.533, s.d. = 0.143) than questions about other (m. = 12.766, s.d. = 0.143). A comparison of each participant's pupil diameter for the different question viewpoints can be seen in Figure 30. The interaction between the bias and the viewpoint of the question also showed no significance on EMG rating (p = 0.8921). P-values that showed significance for the t-tests for each participant can be seen in Table 11. Two participants had unusable data and therefore had to be excluded from analysis.

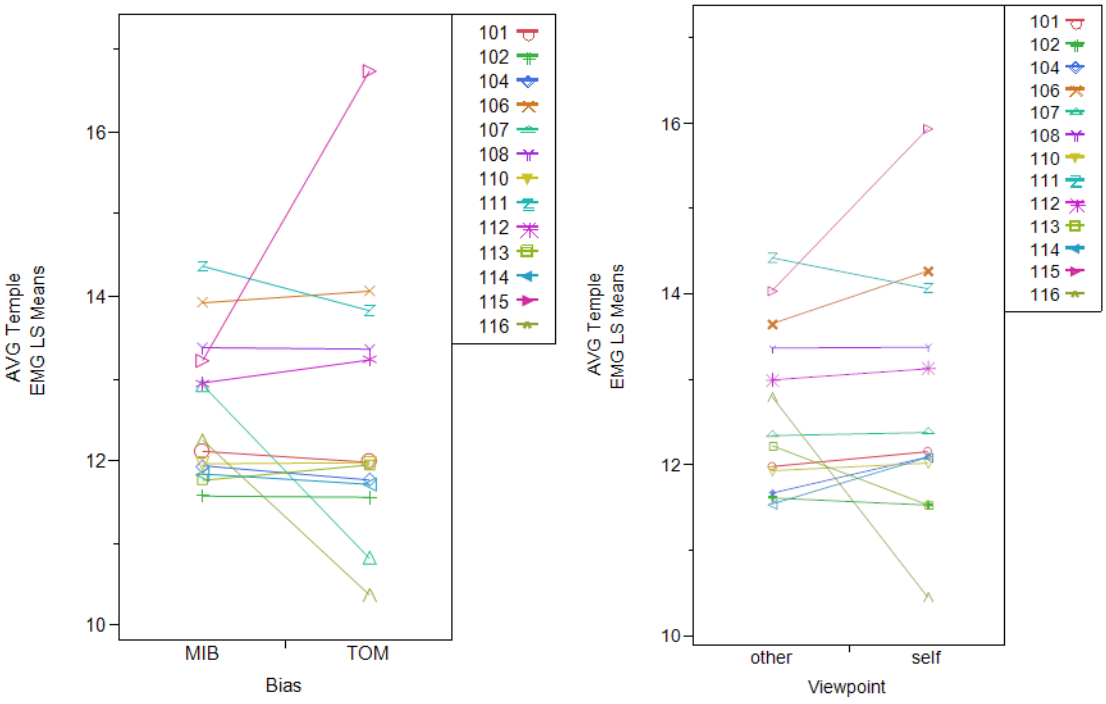



*Figure 29, left:* A LS Means Plot to compare average EMG for each participant according to MIB and ToM shows no general trend. In fact, several of the participants had opposing results.

*Figure 30, right:* A LS Means Plot to compare average EMG for each participant according to viewpoint shows no general trend.

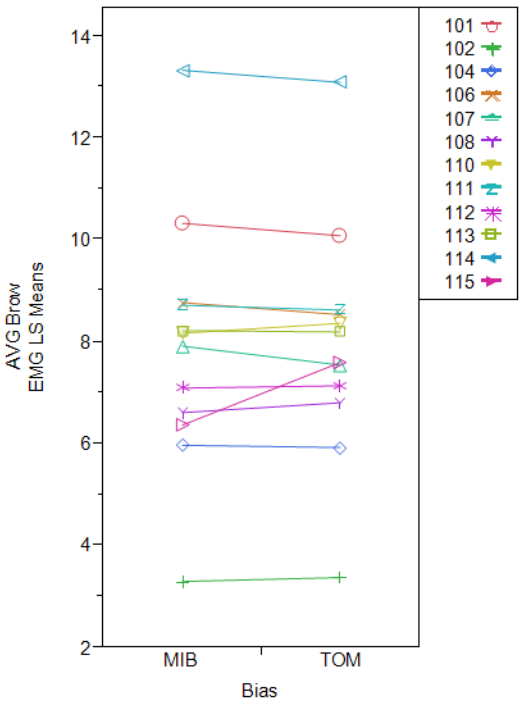
*Table 11: P-values for all t-tests done for each participant for EMG of the Orbicularis Occuli.* Two participants had a significant difference when comparing MIB to TOM with respect to EMG of the Orbicularis Occuli. The same two participants showed significance when comparing "self" to "other" stimuli with respect to EMG of the Orbicularis Occuli.

| Participant | Compare | | Significance |
|---|---|---|---|
| 101 | Bias Response (MIB/TOM) | Temple EMG | P = 0.9224 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.8984 |
| 102 | Bias Response (MIB/TOM) | Temple EMG | P = 0.9900 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.9314 |
| 104 | Bias Response (MIB/TOM) | Temple EMG | P = 0.8518 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.6383 |
| 106 | Bias Response (MIB/TOM) | Temple EMG | P = 0.8923 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.4931 |
| 107 | Bias Response (MIB/TOM) | Temple EMG | P = 0.0528 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.9703 |
| 108 | Bias Response (MIB/TOM) | Temple EMG | P = 0.9848 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.9928 |
| 110 | Bias Response (MIB/TOM) | Temple EMG | P = 0.9891 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.9243 |
| 111 | Bias Response (MIB/TOM) | Temple EMG | P = 0.6416 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.7151 |
| 112 | Bias Response (MIB/TOM) | Temple EMG | P = 0.7671 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.8884 |
| 113 | Bias Response (MIB/TOM) | Temple EMG | P = 0.8448 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.4644 |
| 114 | Bias Response (MIB/TOM) | Temple EMG | P = 0.9128 |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.5745 |
| 115 | Bias Response (MIB/TOM) | Temple EMG | P < 0.0001* |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.0258* |
| 116 | Bias Response (MIB/TOM) | Temple EMG | P = 0.0453* |
| | Question Viewpoint (Self/Other) | Temple EMG | P = 0.0084* |

## EMG2 - MEDIAL FRONTALIS

A t-test to compare average EMG of the medial frontalis between participants showed that many were different from others ($p < 0.0001$). Average EMG for all participants was 7.802 (s.d. 2.87). A t-test compared the bias result (MIB vs. ToM) to the medial frontalis EMG; no statistical significance was shown ($p = 0.6680$). EMG of ToM

responses had a lower average EMG (m. = 7.752, s.d. = 0.146) than MIB responses (m. = 7.832, s.d. = 0.113). EMG values comparing MIB and ToM for the participants can be seen in Figure 31. A t-test compared the viewpoint of the question (self vs. other) to the EMG; no statistical significance was shown (p = 0.0875). EMG of questions about self had a higher average EMG (m. = 7.955, s.d. = 0.126) than questions about other (m. = 7.648, s.d. = 0.126). ). A comparison each participant's EMG for the different question viewpoints can be seen in Figure 32. The interaction between the bias and the question viewpoint also showed no significance on EMG rating (p = 0.9453). P-values that showed significance for the t-tests for each participant can be seen in Table 12. Three participants had unusable data and therefore had to be excluded from analysis.



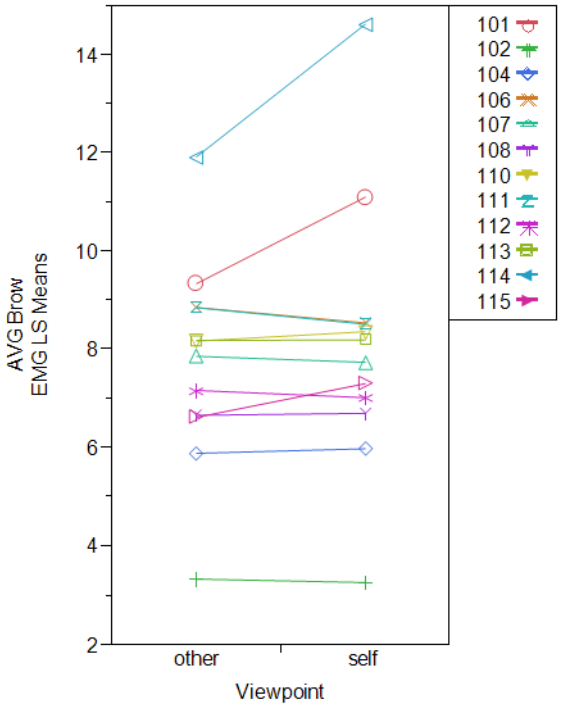




*Figure 31, left:* A LS Means Plot to compare average EMG for each participant according to MIB and ToM shows no general trend.

*Figure 32, right:* A LS Means Plot to compare average EMG for each participant according to viewpoint shows that there is a slight trend where the "other" stimuli has a lower EMG compared to "self" stimuli.

*Table 12:* P-values for all t-tests done for each participant for EMG of the Medial Frontalis. One participant had a significant difference when comparing MIB to TOM with respect to EMG of the Medial Frontalis. Three of the participants showed significance when comparing "self" to "other" stimuli with respect to EMG of the Medial Frontalis.

| Participant | Compare | | Significance |
|---|---|---|---|
| 101 | Bias Response (MIB/TOM) | Brow EMG | P = 0.6138 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.0001* |
| 102 | Bias Response (MIB/TOM) | Brow EMG | P = 0.8427 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.8267 |
| 104 | Bias Response (MIB/TOM) | Brow EMG | P = 0.8945 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.7552 |
| 106 | Bias Response (MIB/TOM) | Brow EMG | P = 0.5130 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.2962 |
| 107 | Bias Response (MIB/TOM) | Brow EMG | P = 0.3154 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.6989 |
| 108 | Bias Response (MIB/TOM) | Brow EMG | P = 0.5792 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.9011 |
| 110 | Bias Response (MIB/TOM) | Brow EMG | P = 0.5511 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.5412 |
| 111 | Bias Response (MIB/TOM) | Brow EMG | P = 0.8171 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.3075 |
| 112 | Bias Response (MIB/TOM) | Brow EMG | P = 0.8891 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.6341 |
| 113 | Bias Response (MIB/TOM) | Brow EMG | P = 0.9343 |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.9722 |
| 114 | Bias Response (MIB/TOM) | Brow EMG | P = 0.5556 |
| | Question Viewpoint (Self/Other) | Brow EMG | P < 0.0001* |
| 115 | Bias Response (MIB/TOM) | Brow EMG | P < 0.0001* |
| | Question Viewpoint (Self/Other) | Brow EMG | P = 0.0160* |

# V. DISCUSSION

Results and statistical analysis show that MIB is a way humans – knowingly or not – mitigate high cognitive workload situations. It is essentially a mental shortcut to be able to come to a decision in a faster manner. This is shown most directly in the statistical test for response time. Although a t-test indicated there was no significant difference in time between MIB and ToM, several participants showed a statistical significance in their results. In each of these cases, MIB had a lesser response time than ToM. In terms of the questions viewpoint, questions about the person in the stimuli took a significantly longer amount of time. This shows that people spent less time thinking about a response for themselves – and that it requires more cognition to understand that another person might not necessarily answer in the same manner.

Another measure that has been used in relation to cognitive workload has been the use of visual measures. Research has shown as tasks became harder, and therefore more cognitively involved, that people gaze at figures for much longer (Just and Carpenter, 1978). Similarly, the location of fixations is important to understand cognitive processes and that if one can understand the relationship between the two that they can understand fully the cognitive processes. Significance between MIB and ToM in terms of the number of fixations was shown in one participant. In this case MIB had more fixations than ToM – suggesting lower overall cognitive workload and therefore are taking "shortcuts" in

their decision making process. With respect to the viewpoint of the question in the stimuli, a general trend shows that participants had a higher number of fixations when looking at questions about "other."

In terms of the next measure, pupil diameter, three participants had a significant difference between MIB and ToM responses. Research has shown that sustained cognitive load was accompanied by sustained pupil dilation. In other words, when a person has a high level of cognitive workload they have a likelihood of having a higher pupil diameter. Two out of three of the participants had a lower diameter when viewing stimuli that elicited MIB, however, one participant had a higher diameter when viewing MIB eliciting stimuli. When looking at the general trend of pupil diameter with respect to question viewpoint, "self" versus "other" had similar responses.

The final visual measure, blink rate, had two participants that showed a significant difference between MIB and ToM responses. In both cases the MIB responses had a lower blink rate. This is reflected in literature that suggests blinks flank periods of change in cognitive load (Siegle, Ichikawa, & Steinhauer, 2008) and that blink rate decreased during reading tasks (Bentivoglio, Bressman, Cassetta, Carretta, Tonali, & Albanese, 1997). When looking at the general trend of blink rate with respect to question viewpoint, "self" versus "other" had similar responses.

Physiological measures have been proven to be good determinants of cognitive workload – and may be potentially good determinants of the possibility of MIB. The first, GSR has shown that the higher the GSR frequency, the more mentally involved a subject is (Nourbakhsh, Want, Chen, 2013). Two participants showed significant difference

between MIB and ToM responses with respect to a normalized GSR rating. In one case, the MIB GSR was lower than that of ToM. However, in the other participant, the opposite was the case. When looking at the LS Means plot, which compares the average of each participant, the general trend of the participants showed a lower GSR rating for MIB responses. This reflects research in the GSR field and helps to support that people are more cognitively involved when following ToM. In terms of the GSR responses with respect to the question viewpoint, there was no visible trend.

In terms of both EMG – of the orbicularis oculi and medial frontalis, both had participants that showed significance between MIB and ToM responses. EMG of the orbicularis oculi had higher rating than that of the medial frontalis. This can be attributed to the different locations. The medial frontalis simply takes the movements when participants are doing hard concentration or confusion – movements in which the participant would furrow their brow. obicularis oculi not only takes the movement of squinting and large movements of the area around the eye, but also normal eye movements like blinking. Therefore, measurements of the obicularis oculi have a higher rating. One participant showed significance in both EMG locations, and in both cases MIB had a significantly lower EMG rating. This supports research that suggests that increases in slow-wave EEG have been associated with decreased alertness, and therefore decreased cognitive workload (Wright & McGown, 2001). In terms of the EMG of both obicularis oculi and medial frontalis, there was no observable trend with respect to the viewpoint of the question.

The metrics employed in this experiment reinforce the notion that humans exhibit MIB in high workload situations. The observed measures align with prior research. Because ToM is the ability to predict and interpret the thoughts and actions of another by taking on their perspective. An individual is more mentally involved in order to consider both viewpoints and come to the conclusion that another person can take a differing viewpoint than themselves. However, in the case of MIB, which is when analysts perceive and process information through the filter of personal experience, a person is less involved cognitively. This may be due to shortcutting to personal experience rather than considering facts presented. Further, it is important to note that MIB is a real-life problem, and our experiment has shown that it may occur at a higher rate than ToM.

# CONCLUSION

> *"Development of a normative theory of intelligence has been inhibited because the lessons of hindsight do not guarantee improvement in foresight, and hypothetical solutions to failure only occasionally produce improvement in practice" (Betts, 1978, p. 36).*

Although it is impossible to eliminate all human error; due to the severe consequences, it is consequential to assist analysts detect and mitigate situations that may lead to erroneous decision making. MIB and ToM were reviewed to investigate their roles in analysts' decision making processes when predicting the future behaviors of an enemy. In predicting other cultures behavior, numerous bias may be present. MIB is thought to have three possible causes: ToM, a cultural bias, and mindreading. All three may be prevalent in the work of analysts.

Through testing, a deeper understanding of MIB has been sought. It is found that MIB is enticed 40.1% of the time and Theory of Mind is enticed 21.2% of the time when viewing imagery of different cultures. The best measure of MIB and ToM in this experiment was average pupil diameter. If this experiment is representative of realistic operating environments, analyst pupil diameter may be a good indicator of MIB. Although the psychological measures employed in this experiment failed to reach significance, additional metrics may provide a more robust understanding of MIB occurrences. When delving into individual participants, several showed a significant effect between MIB and ToM with respect to the measurements. All of this analysis goes to suggest that MIB is a cognitive shortcut people use – whether it's known or un-known – in order to reduce mental workload in an intelligence setting.

Considering that analysts have to deal with these biases on a day to day basis – especially MIB – it is important to be able to find a way to mitigate the full effects of the bias in them. Granted, not all biases are bad. Some, if not all, are used as a mental shortcut. If an analyst were to consider all aspects of the data provided – without the use of some sort of cognitive heuristic – they would be overwhelmed and unable to complete their tasks in a reasonable amount of time. We don't want to completely eliminate the bias, simply alert them to when they might be susceptible to it.

The research presented and the results from the experiment suggest that the use of pupil diameter as an indicator might be a good possibility. A real-time tracking of the pupil diameter could help analysts realize when they are falling prey to MIB. In order to have a proper implementation, analysts would either have to have a computer that tracked

the pupil diameter through the use of cameras, or through the use of glasses that tracked the measurement. As mentioned earlier, a lower pupil diameter in our experiment was significantly related to the possibility of MIB. In research, a lower pupil diameter has suggested a lower cognitive workload. If the pupil diameter of the analyst is decreased to a level that is out of a specific range it could potentially alert them to the possibility of their susceptibility to the MIB.

In the future, bias prevalence in group decision making should be investigated. In reality, most analysts don't necessarily work as a single entity, but rather as a group of people analyzing data. Similarly it would be beneficial to investigate the degree other cultures exhibit MIB. Countermeasures shall also be developed because without effective countermeasures, biases – as well as other human-based errors – will inevitably creep into the intelligence community. Even though modern intelligence communities operate out of the public eye, academic institutions may provide the necessary re-sources to facilitate incremental advancements similar to our findings that highlight aspects of analyst work that can be improved.

# APPENDIX A: Pre-Questionnaire

**PRE-QUESTIONNAIRE**

Please answer the following questions. All answers will be confidential.

1. What is your gender? *Please circle one:* **Male Female**
2. What is your age? _____
3. Are you color blind? *Please circle one:* **Yes No**
4. Do you have any type of visual impairment? *Please circle one:* **Yes No**
5. How would you best describe your cultural background? *Please circle one:*

   **African Arabic Asian Caucasian Hispanic Other: *Please specify*_____**
6. Were your parents or grandparents born in another country? *Please circle one:*

   **Yes No**
7. Do you feel a close affiliation with another culture? *Please circle one:* **Yes No**

   If yes, which and why?

   _____

   _____
8. Have you studied another culture? *Please circle one:* **Yes No**

   If yes, which and for what purpose? _____

   _____

# APPENDIX B: Post-Questionnaire

**POST-QUESTIONNAIRE**

1. What did you use as the predominant cue for finding an answer to the questions asked?

   _____

2. When unsure about the answer to the question, what most influenced your decision?

   _____

3. Did you make any assumptions when finding an answer to the questions asked?
   *Please circle one:* Yes No If yes, what were some assumptions you made?

   _____

4. Did anything stand out to you in the images?
   *Please circle one:* Yes No If yes, what in particular stood out to you?

   _____

5. Were there any distractions in the images?
   *Please circle one:* Yes No If yes, what were the distractions?

   _____

6. In the images, did the environment in which the people were in play a role in your answers?
   *Please circle one:* Yes No Comments:

7. In the images, did the persons' race play a role in your answers?
   *Please circle one:* Yes No Comments:

8. In the images, did the persons' age play a role in your answers?
   *Please circle one:* Yes No Comments:

9. In the images, did the persons' culture play a role in your answers?
   *Please circle one:* Yes No Comments:

10. In the images, did the persons' name play a in your answers?
    *Please circle one:* Yes No Comments:

11. In the images, did the persons' religion play a role in your answers?
    *Please circle one:* Yes No Comments:

# APPENDIX C: Stimuli Set

| Picture | Audio | Other Question | Self Question | Culture | Gender | Phrase | Correct Other Resp. |
|---|---|---|---|---|---|---|---|
| **Main Topic: Individualism vs. Collectivism** | | | | | | | |
| Sub Topic: Assume Responsibility | | | | | | | |
|  | Sergei notices a pollution violation in the steel mill where he is employed. | Is Sergei likely to take the blame for the violation? | Would you be likely to take the blame for the violation? | Russia | Male | Pos | Yes |
|  | Akiyo notices a bookkeeping error that his company has been making for the last 5 years. | Is Akiyo likely to say the error was his fault? | Would you be likely to say the error was your fault? | Japan | Male | Neg | Yes |
|  | Chun, a manger for a manufacturing company, has noticed that lead is being put into children's toys. | Is Chun likely to admit to the violation? | Would you be likely to admit to the violation? | China | Female | Pos | Yes |
|  | Valentina realizes that she sent a large product shipment to the wrong customer. | Will Valentina let her supervisor assume responsibility for the error? | Would you let your supervisor assume responsibility for the error? | Russia | Female | Neg | No |
| **Main Topic: Individualism vs. Collectivism** | | | | | | | |
| Sub Topic: Let Others Share | | | | | | | |
|  | Petrova's family farm yielded a quality crop following a severe drought. | Is Petrova likely to distribute the crop with disadvantaged farmers? | Would you distribute the crop to disadvantaged farmers? | Russia | Female | Pos | Yes |
|  | Akimi received a bonus for her family for completing a recent project? | Will Akimi choose to spend all of the bonus on herself? | Would you choose to spend all of the bonus on yourself? | Japan | Female | Neg | No |
|  | Etsuo, a Japanese fisherman, has just ended a season with a small yield. | Is Etsuo likely to share his meager earnings with his extended family? | Would you share your meager earnings with your extended family? | Japan | Male | Pos | Yes |
|  | Cheng, after trying for years, finally won 1,000 yen in a Chinese lottery. | Will Cheng purchase gifts for friends? | Would you purchase gifts for friends? | China | Male | Pos | Yes |

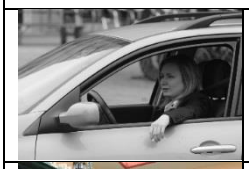
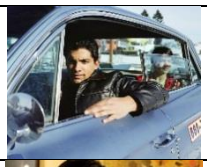
| Picture | Audio | Other Question | Self Question | Culture | Gender | Phrase | Correct Other Resp. |
|---|---|---|---|---|---|---|---|
| **Main Topic: Individualism vs. Collectivism** | | | | | | | |
| Sub Topic: Sacrifice | | | | | | | |
|  | Mitsuo's work is crucial to the success of the construction company he works for. | Will Mitsuo relocate to ensure the successful construction of a skyrise? | Would you relocate to ensure the successful construction of a skyrise? | Japan | Male | Pos | Yes |
|  | Fu has been an elite member of the Chinese Republican Army for several years. | Will Fu reject a classified position that would prevent him from having a family? | Would you reject a classified position that would prevent you from having a family? | China | Male | Neg | No |
|  | Fang enjoys going to the Tianjin University, but her family is struggling to harvest this year's crop. | Will Fang likely quit attending the University to return home? | Would you quit attending the university to return home? | China | Female | Pos | Yes |
|  | Anya is training to become a cosmonaut, but her mother is struggling to care for her ailing father. | Is Anya likely to continue her training to become a cosmonaut? | Would you likely continue your training to become a cosmonaut? | Russia | Female | Neg | No |
| **Main Topic: Individualism vs. Collectivism** | | | | | | | |
| Sub Topic: Value of Group Success/ Well-Being | | | | | | | |
|  | Dimitri's schooling is beginning to negatively impact his employer's productivity. | Will Dimitri likely stop his education? | Would you likely stop your education? | Russia | Male | Pos | Yes |
|  | Alexi and his close friends have recently become radicalized by an Eastern bloc militia. | Will he lose interest in his career in favor of the militia's agenda? | Would you lose interest in your career in favor of the militia's agenda? | Russia | Male | Pos | Yes |
|  | Chiya, a key employee at an accounting firm, just received a job offer from a larger firm. | Will she accept the offer, even if her current firm will suffer? | Would you accept the offer, even if the current firm would suffer? | Japan | Female | Neg | No |
|  | Tai, a Chinese engineer, notices a design flaw one week before a project is due. | Is Tai likely to ignore the flaw and let her group continue working on the problem? | Would you ignore the flaw and let your group continue working on the problem? | China | Female | Neg | No |

| Picture | Audio | Other Question | Self Question | Culture | Gender | Phrase | Correct Other Resp. |
|---|---|---|---|---|---|---|---|
| **Main Topic: Individualism vs. Collectivism** | | | | | | | |
| Sub Topic: Importance of Group Inclusion | | | | | | | |
|  | Youka has recently been invited to join an elite academic society in Tokyo. | Will Youka lie about her job to fit in with the group? | Would you lie about your job in order to fit in with the group. | Japan | Female | Pos | Yes |
|  | Hua has just transferred departments within her current investment company. | Will Hua speak candidly of her past co-workers to win friends? | Would you speak candidly of your past co-workers to win friends? | China | Female | Pos | Yes |
|  | Hao dislikes Indian food, but all of his coworkers eat at the local Indian restaurant during the week. | Is Hao likely to get lunch at another restaurant instead of where his coworkers eat? | Would you get lunch at another restaurant instead of eating with your co-workers? | China | Male | Neg | No |
|  | Andrei lives in a small farming village and has just received a job offer in Moscow. | Is Andrei likely to accept the offer and leave his family and friends behind? | Would you accept the offer and leave your friends and family behind? | Russia | Male | Neg | No |
| **Main Topic: Masculinity vs. Femininity** | | | | | | | |
| Sub Topic: Meeting efficient when run by men | | | | | | | |
|  | Yin attends several corporate meetings on a weekly basis for her research position. | Is Yin likely to feel the meetings she leads are most productive? | Would you be likely to think the meetings she leads are the most productive? | China | Female | Neg | No |
|  | Tung is an assertive and ambitious employee at his factory where he manages finances. | Does Tung think that meetings are better when he leads them instead of his female counterpart? | Would you feel the meetings are better when he leads them instead of his female counterpart | China | Male | Pos | Yes |
|  | Alejandro is a drug manufacturer in Mexico city, and travels a lot for business. | Will Alejandro let his female employee lead the weekly meetings while he is away? | Would you let your female employee lead the weekly meetings? | Mexico | Male | Neg | No |
|  | Katsu really enjoys volunteering at her local dog shelter every weekend. | Does Katsu consider the weekly meeting at the shelter effective when run by the female director? | Would you consider the weekly meeting effective when run by the female director? | Japan | Female | Neg | No |

| Picture | Audio | Other Question | Self Question | Culture | Gender | Phrase | Correct Other Resp. |
|---|---|---|---|---|---|---|---|
| **Main Topic: Masculinity vs. Femininity** | | | | | | | |
| Sub Topic: Men Solve Problems with Logic vs. Intuition | | | | | | | |
|  | Yoshimi is having unexplainable mechanical issues with his new automobile. | Will Yoshimi pursue troubleshooting steps to fix the issue? | Would you pursue troubleshooting steps to fix the issue? | Japan | Male | Pos | Yes |
|  | Cho is having trouble determining the cause of a problem with her cell phone. | Will Cho keep using the phone until the pattern of symptoms points to the cause? | Would you keep using the phone until the symptoms point to the cause? | Japan | Female | Pos | No |
|  | Jie is a cyber-engineer for the Chinese Government who spends most of his time combating hacking. | Will Jie likely use his instinct as his dominant problem solving strategy? | Would you likely use your instinct as the dominant problem solving strategy? | China | Male | Neg | No |
|  | Amaya is facing constant problems managing and keeping up with her finances. | Is Amaya likely to write a computer algorithm to help resolve the problem? | Would you write a computer algorithm to help resolve the problem? | Mexico | Female | Neg | No |
| **Main Topic: Masculinity vs. Femininity** | | | | | | | |
| Sub Topic: Men Solve Problems with Dominant Approach | | | | | | | |
|  | Ignacio has been having several task and interpersonal issues with a new co-worker. | Is Ignacio likely to confront the co-worker? | Would you be likely to confront the co-worker? | Mexico | Male | Pos | Yes |
|  | Carlotta has been getting a poor reputation because her community director is spreading rumors. | Will Carlotta seek to discredit these rumors by creating some of her own? | Would you seek to discredit rumors by creating some of your own? | Mexico | Female | Pos | Yes |
|  | Xing has not been sleeping very well due to a noisy and rude neighbor. | Will he likely seek the help of others to help him with the neighbor? | Would you seek the help of others to help him with the neighbor? | China | Male | Neg | No |
|  | Etsuko is struggling to advance in her career as a paralegal assistant in Osaka. | Will Etsuko discuss it with her boss and ask for a promotion? | Would you discuss it with your boss and ask for a promotion? | Japan | Female | Neg | No |

| Picture | Audio | Other Question | Self Question | Culture | Gender | Phrase | Correct Other Resp. |
|---|---|---|---|---|---|---|---|
| **Main Topic: Masculinity vs. Femininity** | | | | | | | |
| Sub Topic: Pick Men As Leaders | | | | | | | |
|  | Jiao is employed as a seamstress in a sewing factory in a large Beijing district. | Is she likely to apply as a shift-leader? | Would you be likely to apply as a shift-leader? | China | Female | Neg | No |
|  | Regina is very unsatisfied with her local civic leadership in Nogales, Mexico. | Does Regina search for a male candidate instead of running herself? | Would you search for a male candidate instead of running yourself? | Mexico | Female | Pos | Yes |
|  | Shen is asked to provide feedback on two candidates for shift manager at his factory. | Is Shen likely to provide better feedback about a male candidate? | Would you be likely to provide better feedback about a male candidate? | China | Male | Pos | Yes |
|  | Hiro is competing for a manager position against a female with equal experience. | Does Hiro likely believe that he is a better candidate than the female candidate? | Would you believe that he would be a better candidate than the female candidate? | Japan | Male | Pos | Yes |
| **Main Topic: Uncertainty Avoidance** | | | | | | | |
| Sub Topic: Prefer Unstructured Situations | | | | | | | |
|  | Eduardo has begun negotiating and acting as a mediator for quarreling native tribes. | Is Eduardo satisfied in dealing with this chaotic situation? | Would you be satisfied in dealing with this chaotic situation? | Mexico | Male | Pos | Yes |
|  | Ernesta was just hired as a server. On her first day of training, she is instructed to observe other servers. | Is Ernesta likely to ask the other servers about the job throughout the day? | Would you ask the other servers about the job throughout the day? | Mexico | Female | Neg | No |
|  | Diedrich is traveling to a new region in Southern Germany for a festival. | Will Diedrich attempt to drive to his destination without getting directions? | Would you attempt to drive to your destination without getting directions? | Germany | Male | Neg | Yes |
|  | Masako has just begun learning and practicing the ancient craft of Okimono. | Will Masako take a hands on approach and forgo the lessons in her textbook? | Would you take a hands on approach and forgo the lessons in the textbook? | Japan | Female | Pos | Yes |

| Picture | Audio | Other Question | Self Question | Culture | Gender | Phrase | Correct Other Resp. |
|---|---|---|---|---|---|---|---|
| **Main Topic: Uncertainty Avoidance** | | | | | | | |
| Sub Topic: Prefer Broad Guidelines | | | | | | | |
|  | Curt works on a mass assembly line that does not regularly observe safety standards. | Is Curt likely to search for new employment? | Would you be likely to search for new employment? | Germany | Male | Neg | No |
|  | Freida was not given clear instructions for her new job at the local power plant in Munich | Is Freida likely to ask her supervisor for additional task instructions? | Would you be likely to ask your supervisor for additional task instructions? | Germany | Female | Pos | No |
|  | Daniela, a seamstress in Jalisco, received an order, but no measurements were given except length. | Is Daniela likely to sew the garments despite being given unclear instructions? | Would you sew the garments despite being given unclear instructions? | Mexico | Female | Neg | Yes |
|  | Toshiro's manager had to leave the office early, and left him to finish a proposal without sufficient information. | Is Toshiro likely to consult his coworkers to gather the information to complete the proposal? | Would you consult your coworkers to gather the information to complete the proposal? | Japan | Male | Pos | No |
| **Main Topic: Uncertainty Avoidance** | | | | | | | |
| Sub Topic: Not Stressed When Outcomes Cannot be Predicted | | | | | | | |
|  | Huang is scientist who is heavily invested in a risky research and development project. | Does Huang second guess being over-stretched financially? | Would you second guess being over-stretched financially? | Japan | Male | Neg | No |
|  | Ishi was given a vague diagnosis of her abdominal pain by her doctor. | Will Ishi worry about the diagnosis to the point of pursuing a second opinion? | Would you worry about the diagnosis to the point of pursuing a second opinion? | Japan | Female | Pos | No |
|  | Luis was informed that there will be layoffs next month at the textile factory where he works. | Is Luis likely to go on about his work and life as usual, despite the warning of layoffs? | Would you go on about your work and life as usual, despite the warning of layoffs? | Mexico | Male | Neg | Yes |
|  | Olga learned that the sausage she served her family last week may have been part of a contamination recall. | Is Olga likely to pursue additional info. about the recalled meat and its effects on her family? | Would you pursue additional info. about the recalled meat and its effects on your family? | Germany | Female | Pos | No |

| Picture | Audio | Other Question | Self Question | Culture | Gender | Phrase | Correct Other Resp. |
|---|---|---|---|---|---|---|---|
| **Main Topic: Uncertainty Avoidance** | | | | | | | |
| Sub Topic: Take Risks When Outcomes Cannot Be Predicted? | | | | | | | |
|  | Helga is thinking about buying a home in Hamburg, but is new to home buying and renovation. | Will Helga demand an inspection before buying a property? | Would you demand an inspection before buying a property? | Germany | Female | Neg | No |
|  | Ullrich's friend asks him if he wants to buy stock in a startup technology company in Munich. | Is Ullrich likely to buy stock in the startup without extensively researching the company first? | Would you buy stock in the startup without extensively researching the company first? | Germany | Male | Pos | Yes |
|  | Garcia has just been offered a slightly higher paying job several towns away. | Is Garcia likely to accept the job offer without learning the details? | Would you accept the job offer without learning the details? | Mexico | Male | Pos | No |
|  | Hatsumi works for an auto maker with a program for employees to purchase refurbished vehicles. | Is Hatsumi likely to purchase a new automobile from her company instead of a refurbished one? | Would you be likely to purchase a new automobile from your company instead of a refurbished one? | Japan | Female | Neg | Yes |
| **Main Topic: Uncertainty Avoidance** | | | | | | | |
| Sub Topic: Rules Should Not Be Broken for Mere Pragmatic Reasons | | | | | | | |
|  | Javier has an unfair opportunity to see his test score before other students. | Will Javier look at his scores early? | Would you look at your scores early? | Mexico | Male | Neg | No |
|  | Akio must wait to begin the exam until all students receive the test booklet. | Will Akio begin the test early? | Would you begin the test early? | Japan | Male | Neg | No |
|  | Consuela is about to put money down for a home purchase in Juarez Mexico. | Will she likely make a low bid and run the risk of being outbid? | Would you make a low bid and run the risk of being outbid? | Mexico | Female | Pos | Yes |
|  | Brigetta knows that a co-worker is planning a surprise party for someone in the office. | Will Brigetta snoop around to figure out the details of the party? | Would you snoop around to figure out the details of the party? | Germany | Female | Pos | No |

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