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THE SCIENCE OF SCIENCE RHETORIC

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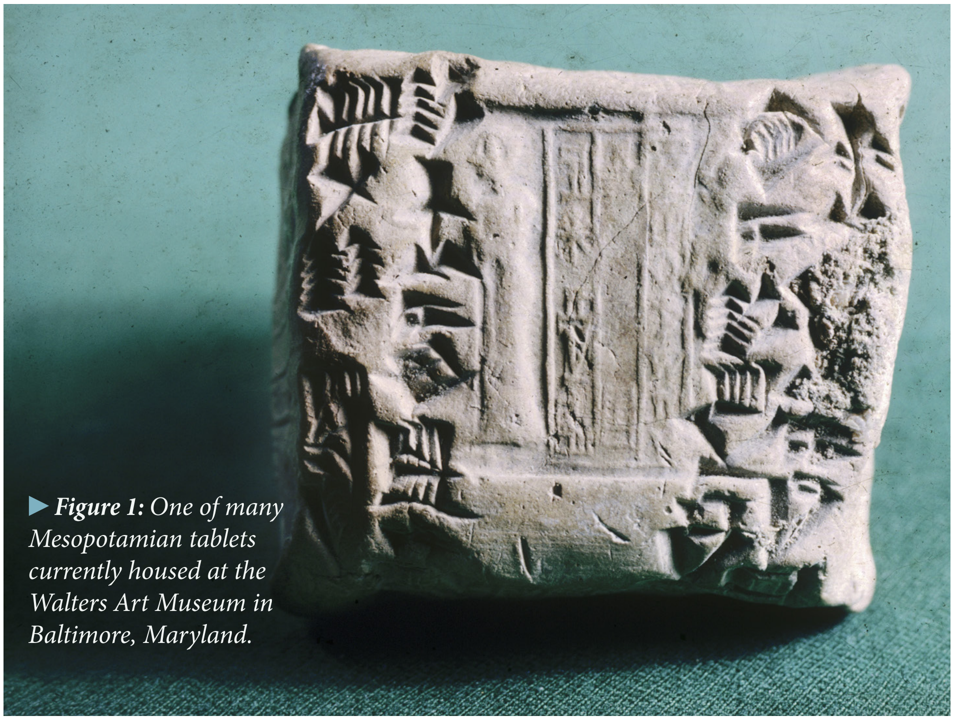
One of the earliest collections of writing samples in human history comes from what is often called the "birthplace of civilization": ancient Mesopotamia. Containing deep indentations carved into hardened clay, Mesopotamian tablets encapsulate a wealth of information ranging from the minutiae of daily life to elaborate myths such as the Epic of Gilgamesh. It should come as no surprise, then, that Mesopotamia is one of several starting points for rhetoric. Indeed, the oldest known letter of complaint originates from Mesopotamia and describes an argument between a copper ore merchant and an unhappy customer:

> You alone treat my messenger with contempt! […] Take cognizance that (from now on) I will not accept here any copper from you that is not of fine quality […] and I shall exercise against you my right of rejection because you have treated me with contempt.[1]

But how do we operationally define—or even define—rhetoric in a scientific setting? In natural science, operational definitions precisely delineate how quantities are measured. One operational definition of sleep, for instance, measures the pattern of EEG waveforms observed during a period of unconsciousness. The primary issue that arises in creating an operational definition of rhetoric, however, is that of scope. Rhetoric is typically thought of as the art of persuasion. Formal rhetoricians seek to convince, persuade, and at times manipulate their audience into accepting a particular argument. On the other hand, persuasion is not necessarily confined to such oratorical discourse. The trope of a boy pulling a girl's hair in school, a paper published in a



▶ ***Figure 1:*** *One of many Mesopotamian tablets currently housed at the Walters Art Museum in Baltimore, Maryland.*

scientific journal, and heated debates over political events in Facebook comments are all modern examples of persuasion that do not necessarily take the form of speech. Forms of rhetoric have, of course, already been defined in academic literature. A research review in *Discourse Processes* compiled several definitions of "argumentation" as based on making a concept more accessible, justifying an uncertain position, or improving an audience's understanding of an idea.[2] But for now, let's focus on exploring the parts of rhetoric that try to change psychological cognition with the aim of conveying certain ideas.

IN SEARCH OF QUANTIFICATION

The study of rhetoric from a cognitive neuroscience perspective is most frequently operationalized using functional magnetic resonance imaging (fMRI). The basic premise of fMRI is that the activation of neuronal circuits is accompanied by greater flow of oxygenated blood to those areas. Because oxygenated blood has different magnetic properties than deoxygenated blood, fMRI machines can detect activated brain regions in real time.[3]

Since the invention of fMRI in 1990, researchers have used the technique to map a variety of brain structures to their corresponding functions, although many of these remain incompletely characterized. In a study at the University of Michigan, researchers used fMRI to examine parts of the brain associated with processing of self-relevant messages (messages that are perceived as relevant to one's self) and smoking cessation messages. The scientists hypothesized that since personalized treatment plans increase rates of successfully quitting smoking, these plans should activate neural regions associated with smoking-cessation and self-relevant messages. Furthermore, the researchers collected fMRI data to predict whether a smoker given a treatment plan would successfully quit based on their level of brain activity. Four months later, the researchers were successful: greater activity in the dorsomedial prefrontal cortex and precuneus predicted smoking abstinence (Fig. 2).[4] Further research regarding cognition may use similar techniques in order to identify parts of the brain that are more susceptible to good arguments.

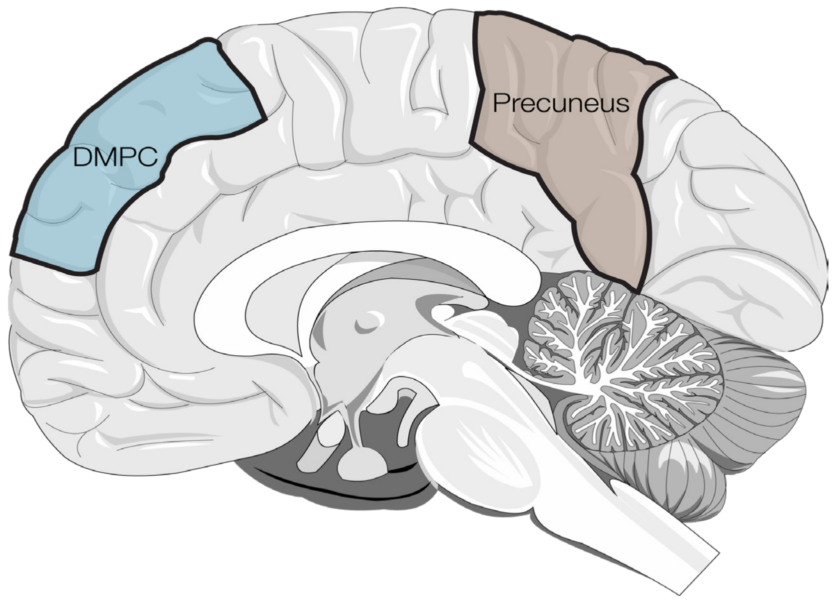


Figure 2: *Activity in the dorsomedial prefrontal cortex (DMPC) and precuneus predicts success rate of tailored smoking cessation plans in smokers. The DMPC is responsible for higher-order cognitive functions such as planning, processing information, and many others.[11] The precuneus plays roles in retrieval of episodic memory, self-processing, and self-consciousness.[12]*

ANTI-VACCINATION

One argument that has become prominent in today's mainstream discourse is that of vaccination. Although most approve of vaccination, a minority of people claim that vaccines are harmful and refuse to vaccinate. This refusal has had major repercussions. According to a recent report released by the World Health Organization, there have been over 40,000 cases of measles in Europe this year—a two-fold increase from last-year, and an eight-fold increase from 2016.[5] This reemergence has been ascribed to an increase in the number of parents who advocate for anti-vaccination, a belief that initially arose based on invalidated research that erroneously claimed that vaccines could cause autism.[6] The drastic increase of late in vaccine-preventable diseases demonstrates that greater efforts are required to shift anti-vaccination attitudes. But how can scientists accomplish such a feat?

One reason that parents refuse vaccination is because they believe that vaccines have the potential to harm their children.[7] Consequently, strategies geared toward countering this belief have focused on rationalizing the safety of vaccines by, for instance, providing scientific explanations of their ingredients. Unfortunately, these attempts are often futile, due in no small part to the psychological phenomenon of confirmation bias.[8] In short, people who hold strong beliefs will often inflate the importance of evidence supporting their views and ignore evidence contrary to these views. Confirmation bias often drives how people

"According to a report released by the World Health Organization, there have been over 40,000 cases of measles in Europe this year—a two-fold increase from last-year, and an eight-fold increase from 2016."

perpetuate stereotypes, form opinions, and make decisions. Fortunately, scientists have tested other methods. Rather than trying to refute anti-vaccination claims, researchers have tried replacing those beliefs with new information about the health risks of not vaccinating. They found that out of several arguments, arguments that informed subjects of the risk of disease caused subjects to favor vaccination the most.[9] The anti-vaccination mindset is not necessarily as set in stone as it may appear.

Further research, however, is still required to create effective strategies that can counter attitudes on anti-vaccination. A recent study of over 5,000 people discovered that anti-vaccination attitudes were high among those who exhibited individualistic or hierarchical worldviews among other beliefs, while other demographics such as education or income level had little correlation with anti-vaccination attitudes.[10] Methods and arguments for correcting anti-vaccination attitudes could target some of these other belief systems. Research on anti-vaccination attitudes also contributes to efforts of understanding people who are unfazed by evidence-based refutations, such as climate-change deniers or Flat Earth theorists. So although anti-vaccination is a mounting problem, society is not completely defenseless in countering its effects.

THE RHETORIC OF SCIENCE

The results of the above studies call into question certain approaches that members of the scientific community may follow in argumentation and discourse—in other words, the rhetoric of science. Scientists often laud science for its precise, unemotional rationality, and its conception as an objective and universal language by which people the world over can discuss observations of the surrounding world. When people express polarized political beliefs through primarily pathos-based arguments on Facebook, many people claim that their closed discourse induces the formation of echo chambers that are unconducive to fair rhetoric. Yet, when academics communicate verbose ideas inaccessible to the general public using the language of logos, isn't a separate echo chamber formed, one that resonates with remarks floating through the halls of academic ivory towers? The type of conversation that happens in Facebook groups and scientific journals may be distinctly different in their content, but they are not quite so in their form.

It should come as no surprise that the credibility and argumentation of scientists in public discourse is disputed. Scientists may take pride in their objectivity, but this language that is restricted to academics contributes to a rhetoric that strives to be primarily based on logic alone. Good argumentation employs a variety of rhetorical modes of persuasion. Evidently, replacing the fear of vaccines with a more intense fear of disease risk conveyed using scientific reliability changed attitudes more effectively than any solely science-based argument could. And in this era replete with crisis and uncertainty, scientists must remember that although science plays a key role in everyday discourse, it is merely one component among many anyone should use when communicating with the rest of the world.

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