MAE386 Week 1 Notebook Answers

Course: Ideation, Thought Media, and Mathematics
Week: 1
Reading: *Catching Unicorns* (CU), Introduction (pp. 3-12)
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Question 1: Engrams and Exograms

Part A: Define both terms and explain Donald's view of the advantages of exograms

According to Merlin Donald's work (referenced in footnote 2 on p. 4 of CU), **engrams** are biological memory traces stored internally within the brain, while **exograms** are external memory storage systems—persistent symbolic representations stored outside the brain on physical media such as clay tablets, paper, or digital devices.

Donald's characterization emphasizes that exograms represent a revolutionary shift from purely biological memory to non-biological memory systems. The key advantages of exograms that Donald identifies include:

1. **Persistence**: Unlike speech or internal memory, exograms remain stationary on their medium over time, allowing us to "sit and stare at the idea as we think about it and develop it" (p. 247). This persistence enables extended contemplation and analysis.

2. **Shareability**: Exograms can be shared across space and time, allowing ideas to be communicated to others who are not physically present and preserved for future generations.

3. **Memory Extension**: Exograms extend our working memory capacity. As CU explains, our working memory has low storage capacity for unrelated symbolic information (p. 277). Exographics allows us to store information externally rather than trying to maintain it in our limited biological memory systems.

4. **Enables Complex Discovery**: Most importantly, exograms enable us to discover ideas that would be impossible to discover using only engrams. The book provides the example of calculating 8,497 × 8,672—virtually impossible without exographics, but easily achievable with it (p. 87-89).

Part B: Additional advantages of exograms

Beyond Donald's characterization, exograms offer several additional advantages:

- **Searchability**: With modern technologies like search engines, we can quickly locate specific information within vast exographic records, something impossible with purely internal memory.

- **Editability**: Exograms can be revised, corrected, and refined over time, allowing ideas to evolve and improve.

- **Collaboration**: Multiple individuals can work with the same exographic representations simultaneously, enabling collaborative ideation.
- **Precision**: Exograms allow for exact reproduction of symbolic sequences, reducing errors that might occur in oral transmission or memory recall.
- **Scalability**: Exograms can store vastly more information than any individual's biological memory capacity.

Part C: Relative efforts required to form and store engrams vs exograms

Both engrams and exograms require effort, but the nature and distribution of that effort differs significantly:

Engrams:

- Require repeated rehearsal and mental effort to encode information into long-term memory
- The effort is primarily cognitive and occurs during the encoding process
- Once encoded, maintenance may require periodic reinforcement
- Some engrams form automatically through experience (procedural memory)

Exograms:

- Require physical effort to inscribe symbols on a medium (writing, typing, etc.)
- Require learning the symbolic system (literacy, mathematical notation, etc.)
- The effort is distributed: initial learning of the system, then ongoing physical inscription
- However, once created, exograms persist without ongoing effort, unlike engrams which may decay

The book notes that learning exographics "takes considerable effort" (p. 260), but this investment pays off by enabling discovery of ideas that would otherwise be impossible.

Part D: Are there engrams that cannot be stored as exograms?

Yes, there are several types of engrams that cannot be fully captured as exograms:

1. **Tacit Knowledge**: Skills and knowledge that are difficult to articulate explicitly, such as how to ride a bicycle or recognize a face. These are embodied and procedural.
2. **Emotional Memories**: The subjective, qualitative experience of emotions associated with memories cannot be fully captured in symbolic form.
3. **Procedural Skills**: Muscle memory and motor skills (like playing a musical instrument by feel) are stored as engrams but cannot be fully represented as exograms.
4. **Sensory Qualia**: The subjective experience of sensations (what it "feels like" to see red) cannot be fully communicated through symbols.
5. **Contextual and Episodic Details**: While we can describe events in exographic form, the rich, multi-sensory context of lived experience cannot be fully captured.

However, CU emphasizes that for abstract concepts and symbolic reasoning—the domain of the e-Class—exograms are not only possible but necessary.

Part E: Relative speeds of recall for engrams and exograms

Engrams:

- Can be recalled very quickly when well-encoded (milliseconds to seconds)
- However, recall speed depends on how well the information was encoded and how recently it was accessed
- Some engrams may be difficult to access or may have decayed over time

Exograms:

- Initial access requires locating the exographic record (which can be fast with modern search technologies)
- Once located, reading and processing the information takes time
- However, exograms never "forget" or decay—the information remains exactly as recorded
- Modern technologies (search engines, databases) have dramatically increased the speed of accessing exographic information

The key difference is that engrams offer faster recall for well-remembered information, but exograms offer reliability and permanence that engrams cannot match.

Part F: Is it still necessary to require students to form engrams in the age of Google/ChatGPT?

Yes, it is still necessary for students to form engrams, though the nature of what should be internalized has evolved. Here's why:

1. **Foundation for Understanding**: Basic engrams provide the conceptual framework necessary to understand and use exographic information. For example, a mathematics student must understand what differentiation *means* before they can effectively use ChatGPT to solve differentiation problems.

2. **Efficiency**: Having certain concepts as engrams allows for faster problem-solving. If you must look up every basic operation, your problem-solving becomes inefficient.

3. **Critical Evaluation**: To evaluate the accuracy of information from Google or ChatGPT, you need sufficient engram knowledge to recognize errors or inconsistencies.

4. **Creative Application**: Applying knowledge creatively often requires internalized understanding (engrams) that can be flexibly combined and applied in novel ways.

5. **Working Memory Integration**: Engrams allow information to be held in working memory and manipulated mentally, which is essential for complex reasoning.

However, the book's argument suggests we should reconsider *which* engrams are essential. Rather than memorizing vast amounts of factual information (which can be accessed via exograms), students should internalize:

- Fundamental concepts and principles
- Methods of inquiry and problem-solving
- How to effectively use exographic tools
- Critical thinking skills

The Apollo 13 example (p. 263) illustrates this: Lovell needed to know *how* to do arithmetic (an engram), but he used exographics to perform the actual calculation.

Question 2: Is a spoken word also a symbol?

Yes, a spoken word is also a symbol. CU explicitly states: "By the same reasoning, speech is also symbolic" (p. 49).

The argument follows from the definition of a symbol: a culturally-agreed representation that stands for something else, where the connection between the symbol and its referent is arbitrary rather than inherent.

Evidence that spoken words are symbols:

1. **Arbitrary Connection**: Just as the written word "apple" has no inherent connection to the fruit, the spoken word "apple" has no inherent connection either. As CU notes, "our ancestors could just as easily have called it an 'elppa'" (p. 48).

2. **Cultural Agreement**: Spoken words, like written words, have meaning only through cultural agreement. The book explains: "if you say 'I have a dream' to a listener, you are pushing modulated sound at the listener and, fantastically, these arbitrary symbols have a culturally agreed meaning" (p. 52).

3. **Symbolic Function**: Spoken words represent ideas, concepts, and referents—they stand for something other than themselves, which is the defining characteristic of symbols.

4. **Abstract Representation**: Spoken words can represent abstract concepts (like "unicorn") just as written words can, demonstrating their symbolic nature.

The key distinction between spoken and written symbols is not their symbolic nature (both are symbols), but rather:

- **Persistence**: Written symbols persist on a medium; spoken symbols disappear almost immediately
- **Medium**: Written symbols are visual; spoken symbols are auditory
- **Function**: Written symbols (exographics) enable discovery of certain ideas that spoken symbols cannot, due to their persistence and ability to bring abstract concepts into the visual field

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Question 3: Four characteristics of techno-literate culture

According to CU (pp. 5-6), a techno-literate culture is characterized by four essential features:

1. **Basic Literacy in the Population**: Most of the population has some minimal level of literacy, including the ability to read, write, and do arithmetic. This foundational skill enables participation in the broader culture.

2. **Innovators**: The culture includes a relatively small set of individuals who are able to discover ideas that push the culture forward. These are the people working at the frontiers of the Ideasphere, discovering new e-Class ideas.

3. **Socioeconomic Structures**: The culture has evolved socioeconomic structures and behavioral characteristics that enable large populations of strangers to coexist in relative harmony. These structures include cities, governments, laws, regulations, markets, media, prisons, corporations, and religions. These allow for decentralized coordination of large groups.

4. **Substantial Education System**: There is a substantial education system in place that teaches basic literacy and, for some, the advanced knowledge required to arrive at new ideas. This system prepares individuals to participate in and contribute to the techno-literate culture.

The book emphasizes that "techno-literate culture is a tectonic shift from our lifeways as hunter-gatherers" (p. 61), representing a fundamental transformation in how humans organize themselves and discover ideas.

Is the CAF (Canadian Armed Forces) a techno-literate culture?

The Canadian Armed Forces (CAF) exhibits characteristics of a techno-literate culture, though it is a specialized subculture within the broader Canadian techno-literate society:

1. **Basic Literacy**: CAF members must be literate to operate complex equipment, follow procedures, and communicate effectively. Literacy is a requirement for service.

2. **Innovators**: The CAF includes research and development units, engineers, and specialists who discover new ideas related to defense technology, tactics, and strategy.

3. **Socioeconomic Structures**: The CAF has a hierarchical command structure, regulations, procedures, and systems that enable large numbers of personnel to coordinate effectively—essential characteristics of techno-literate organization.

4. **Education System**: The CAF operates extensive training and education systems, from basic training to advanced technical schools and professional military education.

However, the CAF is better understood as a component *of* a techno-literate culture rather than a techno-literate culture itself, as it depends on the broader Canadian techno-literate society for recruitment, technology, and support.

Question 4: Why is cooperation so important to Homo sapiens?

Cooperation is crucial to Homo sapiens for several interconnected reasons:

Self-Domestication and Large Groups

The book references the theory that humans have "self-domesticated" (p. 211, footnote 6), similar to how we domesticated animals through selective breeding. This self-domestication selected for traits promoting cooperation and reduced aggression, enabling us to live in large anonymous groups—something that would be impossible for our closest relatives. As Sarah Hrdy's thought experiment illustrates (p. 75), if chimpanzees were placed in the same situation as humans boarding an airplane, the result would be "mayhem" rather than orderly cooperation.

Enables Complex Cultural Achievements

Cooperation allows us to achieve things impossible for individuals alone. CU provides striking examples:

- **Apollo Moon Landing**: Required 300,000 people working together for almost a decade (p. 72)
- **iPhone Development**: Required 200 people working for 3 years (p. 72)

These achievements demonstrate that our "most important trait might be our collaborative ability" (p. 71).

Cultural Learning and Transmission

Cooperation enables social learning, which is "crucial for a species that thrives on culture and cultural change" (p. 79). Unlike bees, whose culture is genetically wired, human children must learn their culture. This learning requires cooperation between teachers and learners, parents and children, and across generations.

Networked Imaginations

The book's thesis emphasizes "networked imaginations" (p. 42) as key to our cultural advance. Cooperation enables these networks, allowing ideas to be shared, built upon, and refined collectively. The "exographic record of this problem solving" (p. 77) in libraries and archives represents the accumulated cooperative efforts of countless individuals.

Survival and Adaptation

From an evolutionary perspective, cooperation likely provided survival advantages. Working together enabled our ancestors to:

- Hunt larger game
- Defend against predators
- Share knowledge about food sources and dangers
- Care for the young and elderly

This cooperative capacity, combined with exographics, enabled the transition from small hunter-gatherer groups (30-50 people) to massive modern cities (like Tokyo with 37 million people) (p. 42).

Question 5: Counter-example showing not all ideas can be discovered without exographics

The statement "All ideas discoverable by the human mind can be discovered without exographics" is false. CU provides compelling counter-examples:

Example 1: Arithmetic Problem

Consider the multiplication problem **8,497 × 8,672**. As the book explains (pp. 82-89), if you attempt this calculation "with your hands neatly folded" (without exographics), "virtually all of us would find this 'no-hands' problem impossible."

The difficulty arises because:

- Our working memory cannot hold all the intermediate results needed for the calculation
- We must remember partial products while calculating new ones
- The cognitive load exceeds our biological memory capacity

However, "with exographics, it's easy. In fact, it's so easy that children learn to do it in grade school" (p. 89).

This demonstrates that the idea represented by the answer (73,685,984) **cannot be discovered** without exographics for virtually all humans.

Example 2: Einstein's Special Relativity

A more serious example is Einstein's discovery of special relativity (pp. 15, 90). Einstein was famous for his thought experiments, and he imagined a scenario with a train, a passenger, and an observer. However, "it's at this point that he had to fall back to the mathematics of the experiment which he was able to work through with pen and paper."

Crucially, "He freely admitted that his mathematics skills were poor, so there was no way that he could just sit and think through the mathematics" (p. 90). The complexity of the mathematics required exographics. The book concludes: "Einstein required exographics to discover special relativity."

Why These Counter-Examples Work

These examples prove the statement false because:

1. **They are ideas**: Both represent discoverable ideas (a mathematical result, a physical theory)
2. **They require exographics**: Neither can be discovered using only unaided biological memory
3. **They are demonstrably discoverable**: We know these ideas exist because they have been discovered—but only with exographics

The book terms the false belief that all ideas can be discovered without external tools the **"neurocentrism fallacy"** (p. 291), emphasizing that "some of the ideas we discover require us to use tools we operate with our hands."

Question 6: Why multiplication is an abstract object

Multiplication is an abstract object because it has **no real-world referent**—it exists only as a concept in our minds, not as a physical thing we can observe or touch.

Definition of Abstract Objects

CU explains that "we refer to concepts without a real-world referent as abstract objects" (from the question). The number 23 is given as an example of an abstract object, while a baseball is a concrete object (something we can physically interact with).

Why Multiplication is Abstract

1. **No Physical Existence**: You cannot point to "multiplication" in the physical world. You can point to three groups of four apples (which equals twelve apples), but "multiplication" itself—the operation, the concept—exists only as an idea.

2. **Exists Only in Minds**: As CU explains about numbers: "Numbers exist only in our minds, but wood and hammers and nails are things we can reach out and touch" (p. 96). Multiplication, like numbers, is a mental construct.

3. **Requires Symbolic Representation**: To work with multiplication, we must represent it symbolically using exographics (the × symbol, or written notation). The book explains: "To make 23 real, we can use exographics to inscribe a representation of it on a visual medium" (p. 96). The same is true of multiplication—we use symbols like "×" or "·" or write "multiply" to represent this abstract concept.

4. **Conceptual Relationship**: Multiplication represents a relationship or operation between quantities, not a thing itself. It describes *how* to combine quantities, not *what* those quantities are.

Contrast with Concrete Objects

A baseball is concrete because:

- It has physical properties (size, weight, texture)
- It exists independently of human thought
- It can be observed, touched, and manipulated directly

Multiplication is abstract because:

- It has no physical properties
- It exists only as a human mental construct
- It can only be worked with through symbolic representation (exographics)

This is why exographics is so crucial: it allows us to bring abstract concepts like multiplication "into our visual fields" where "we can begin to use them to fashion new ideas" (p. 96), making these "unicorns of our minds" as real as physical objects for the purposes of ideation.

References

Hurley, Bill, and David Hurley. *Catching Unicorns: The Exographic Revolution and the Rise of Techno-Literate Culture*. Wild Road Books, 2026.

Donald, Merlin. "The Exographic Revolution: Neuropsychological Sequelae." In *The New Brain Sciences: Perils and Prospects*, edited by Dai Rees and Steven Rose, 157–178. Cambridge: Cambridge University Press, 2004.