

Mathematical Description of the Creative Process

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Goal and Purpose of Talk

To better understand the successes and failures of the creative process

- 1) Usually, only instances of success of the process are related. You can usually say what happened when it worked. And, now, why one may have failed.
- 2) One would also like to teach this process and help others to access the creative problem-solving process.
- 3) A nice example where nonlinear dynamics language makes sense.

Starting point

- Will be looking at the solving of “hard” problems – where a frontal direct (analytical) approach is not likely to succeed.
- These problems require a process that several (including Poincaré) have described:
 - 1) **Preparation** – deep immersion into the problem
 - 2) **Incubation** – sleeping & waking focus on the problem
 - 3) **Illumination** – realization that “a solution” may have been found. In a dream, upon waking, or popping into your head.
 - 4) **Verification** – testing of the proposed solution.

Early Work in this area

- Poincaré (1915) The Foundations of Science.
- Wallas (1926) The Art of Thought.
- Hadamard (1945) The Psychology of Invention in the Mathematical Field.
- Beveridge (1951) The Art of Scientific Investigation.

(See Merrill (2007) for a more complete discussion)

None of these proposed a mathematical (conceptual) description until Arthur Koestler (1964) The Act of Creation

Arthur Koestler

- Born in Budapest, educated in Austria, 43 years in Great Britain as a political commentator who wrote novels, essays, memoirs and biographies, and lectured widely.
- He had a very controversial personal life (see wikipedia)
- The Act of Creation was started in 1949 and published 15 years later (in my mind a long time).



1905-1983

Koestler's basic idea

“I have coined the term ‘bisociation’ in order to make a distinction between the routine [linear] skills of thinking on a single ‘plane,’ as it were, and the creative act, which, as I shall try to show, always operated on more than one plane. The former may be called single-minded, the latter a double-minded, transitory state of unstable equilibrium where the balance of emotion and thought is disturbed.”

Arthur Koestler, The Act of Creation, p. 34-35

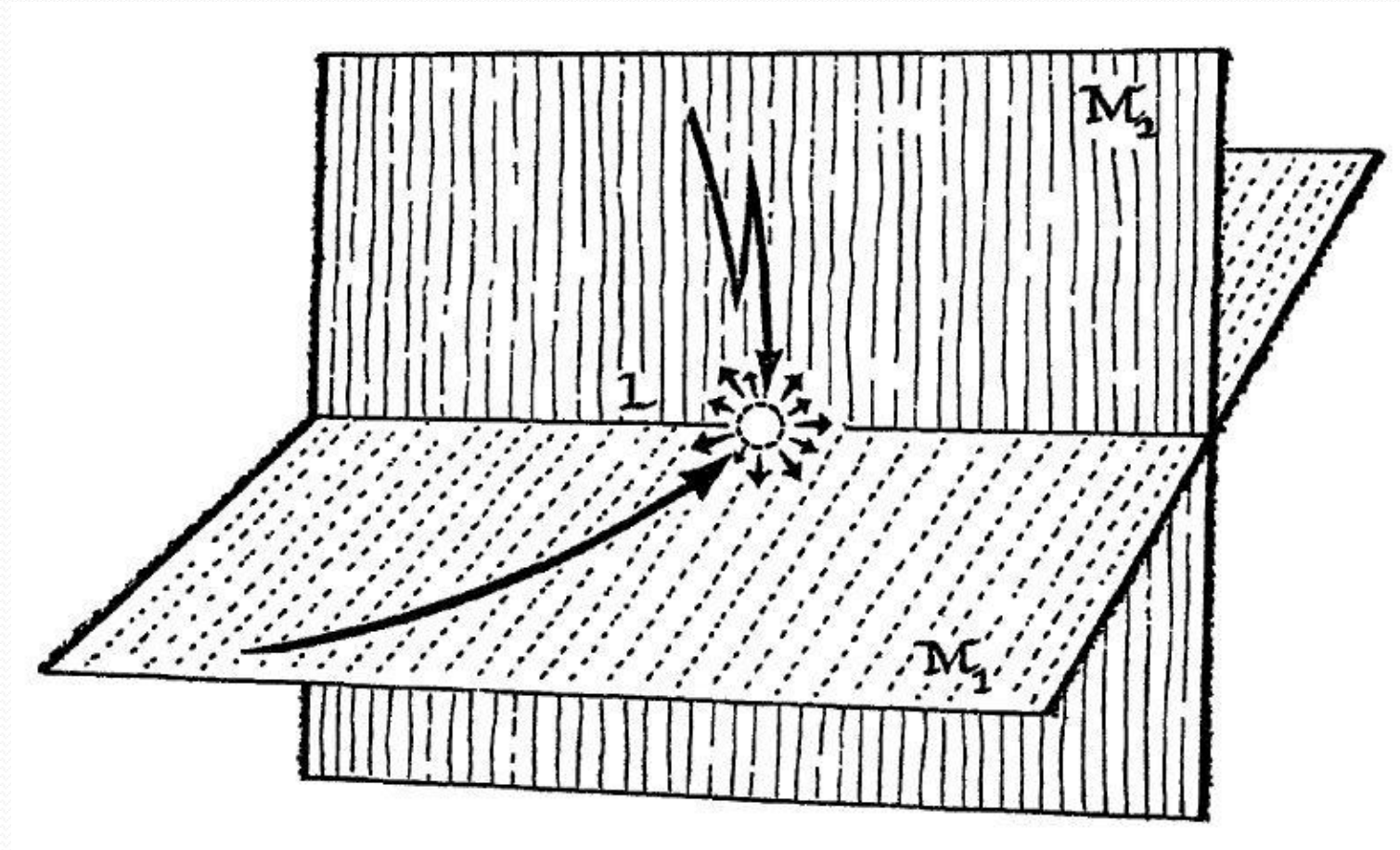
Importance of “Dreaming”

- Dreaming is when the “codes of disciplined reasoning” are suspended. There are no rules of logical contradiction, spelling, pronunciation. (Daydreams, flights of thought, and dreams in sleep)
- Ordered, disciplined thought demands that one follows a set of rules to help one stay in a single frame of reference – to “stay focused”
- In a dream, one can shift from one matrix to another – often keeping both in mind at once – “we constantly bisociate in a passive way” – contradictions are ok.
- Koestler gives many examples where jokes are effective because of this bisociation. Analogies are other ways in which useful ways of thinking (matrices) can be created.

Examples of Bisociation in jokes

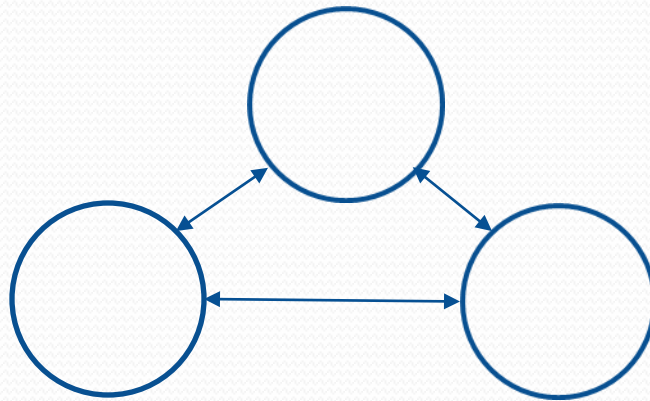
- Atheists don't solve exponential equations because they don't believe in higher powers.
- Some people's noses and feet are built backwards: their feet smell and their noses run.
- When the cannibal showed up late to the conference luncheon, they gave him the cold shoulder.

Bisociation – two frames of reference resulting in humor

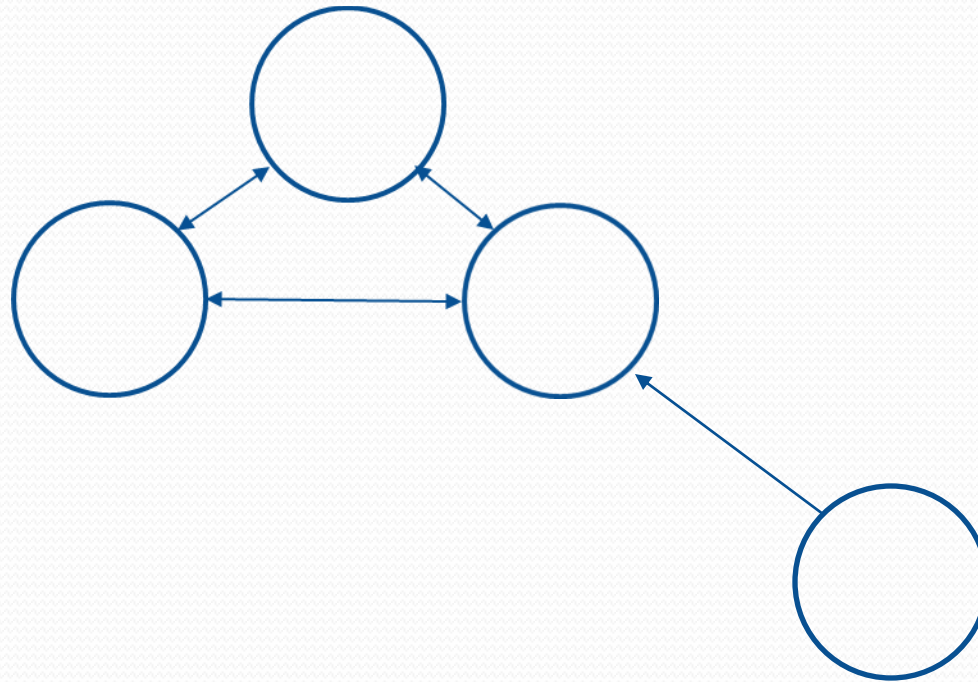


A conceptual model

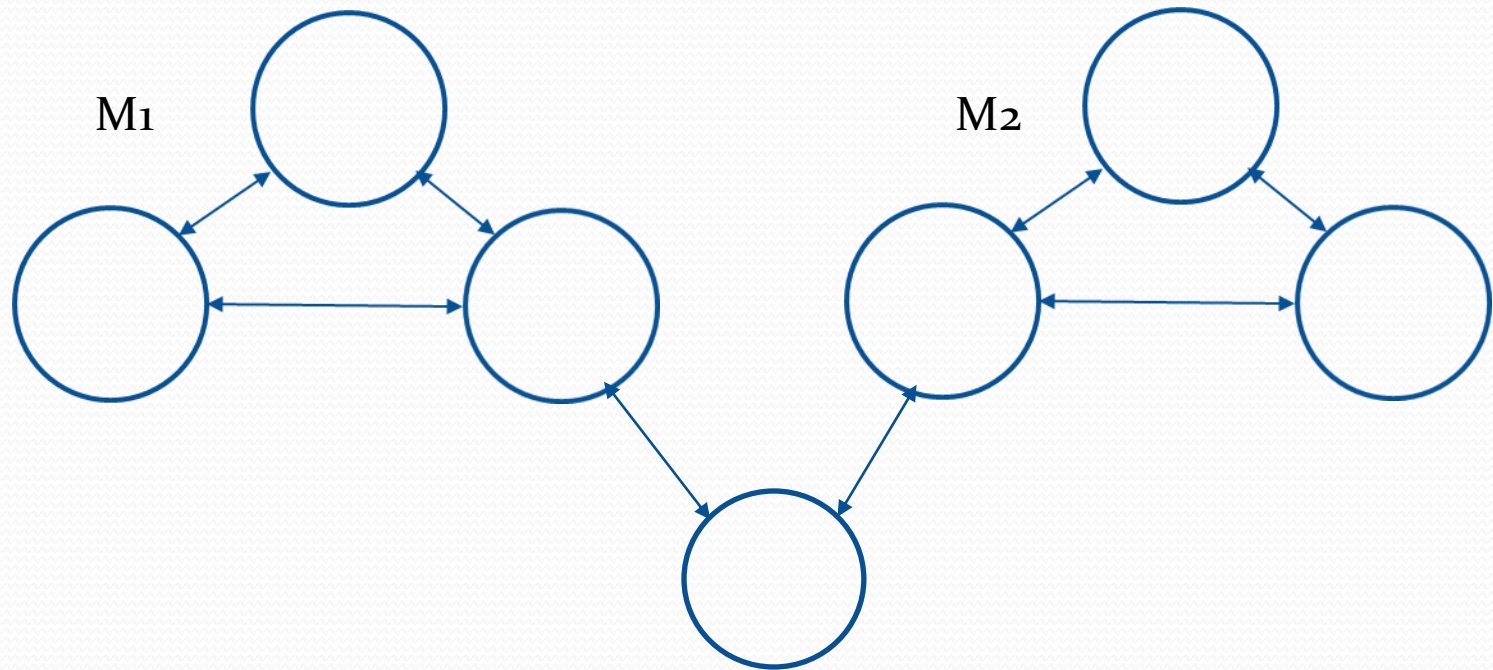
- Building a model to put the words into mathematical form.
- Provides a way to explore the ideas presented.
- We will associate a frame of reference (“matrix”) as an ergodic Markov chain. In this situation, the frame is stable in one cannot escape the chain (collection of states).



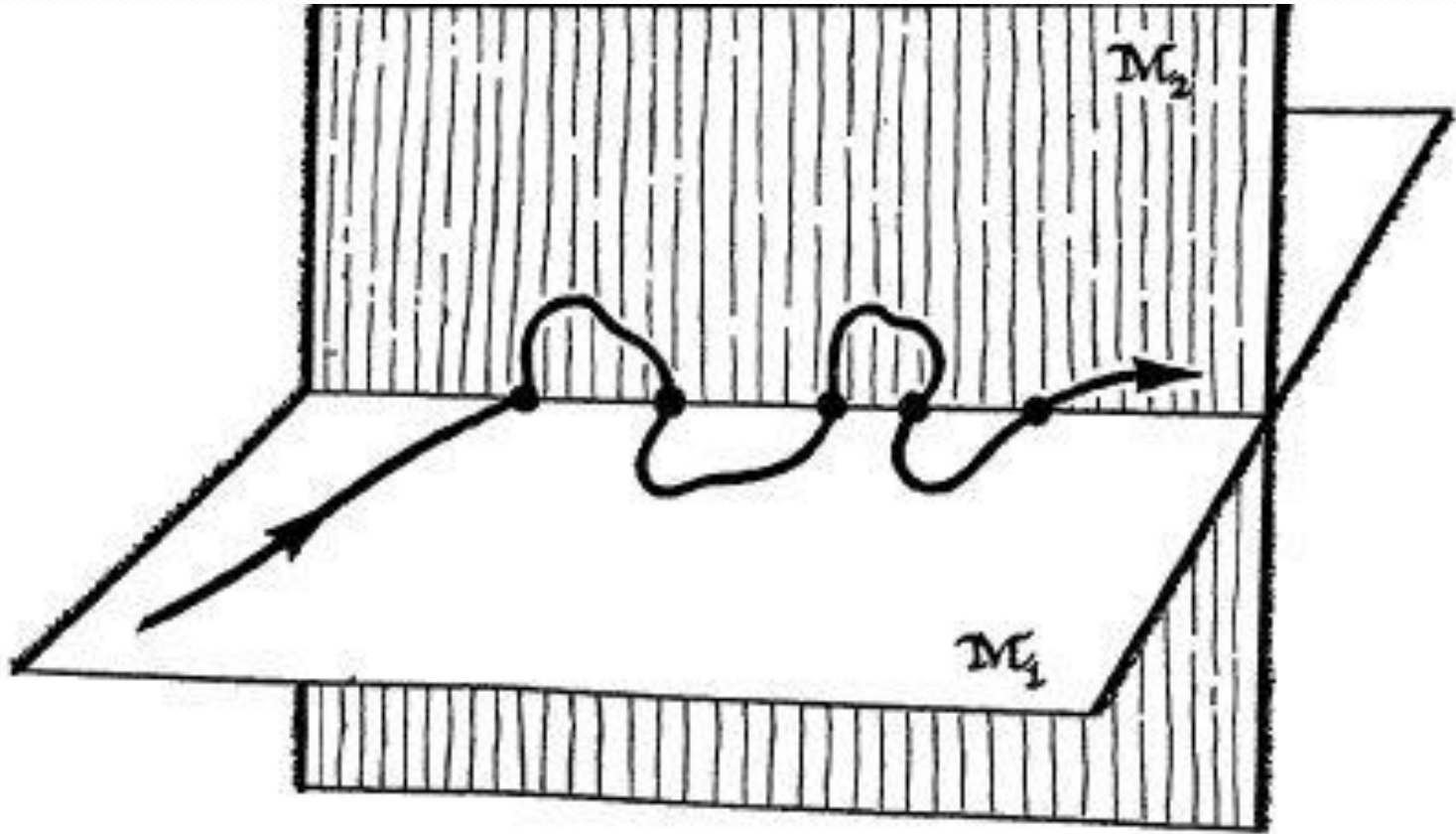
Ergodic chain with a transient state



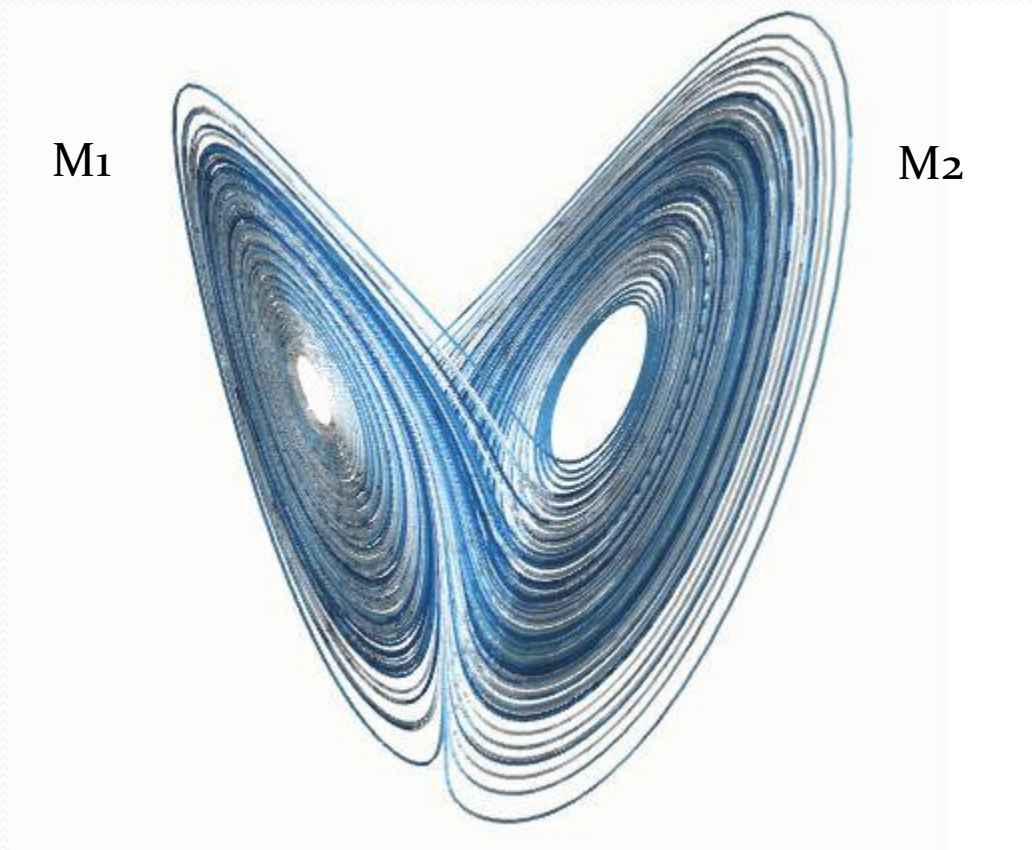
Two subchains and an extra connecting state



Thinking oscillating between frames of reference (“matrices”)



Bisociation in the Lorenz system



The role of the “transient” state

- The model suggests that a state that communicates with both frames of reference is important. In humor, that could be a word with two meanings or a pun.
- In solving hard problems one popular approach is the idea of TRIZ, theory of inventive problem solving (see wiki). One idea here is to identify the contradiction present in the ability to solve a hard problem. For instance, “how can the best quality product cost the least?” The result of this process can be seen as defining the two different frames of thought or the “matrix of contradictions”. They do not, however have a way to generate the key connection.

Analogy building

- Analogies are frames having important properties in common.
- The analogy often does not carry the same level of complexity as the system of interest.
- Often the problem can be solved in some form in the analogous situation.
- Bouncing back and forth between the system of study and the analogy can mimic this process of bisociation.
- Literature for use of analogies in problem solving includes Gick & Holyoak, 1980 (and the 1615 papers that have referenced them) and Novik & Holyoak, 1991, but emphasize “analytical” problem solving and not the creativity needed to solve hard problems.

Summary

- In addition to the well-known preparation for solving hard problems, building an analogy helps the process.
- In dreams, connections between the frames of reference are more easily bridged.
- Even if a connection is made in a dream, bringing that potential solution into the conscious world still involves a step back into a single frame of reference (requires practice in several of the steps).
- The conceptual model involving nonlinear dynamics terminology makes useful sense in this setting.

References

- Gick, M.L. and K.J. Holyoak (1980), Analogical problem solving, *Cognitive Psychol.* **12**, 306-355.
- Koestler, A. (1964), The Act of Creation, Macmillan.
- Merrill, S.J. (2007), To again feel the creative voice, *Int. J. Sci. & Math. Ed*, **5**: 145-164.
- Novick, L.R. and K.J. Holyoak (1991), Mathematical problem solving by analogy, *J. Exp. Psychol.* **17**, 398-415.