CS-E4002 – Special Course in Computer Science:

Seminar on Computational Creativity

Lecture 2: Introduction & Modelling Creativity

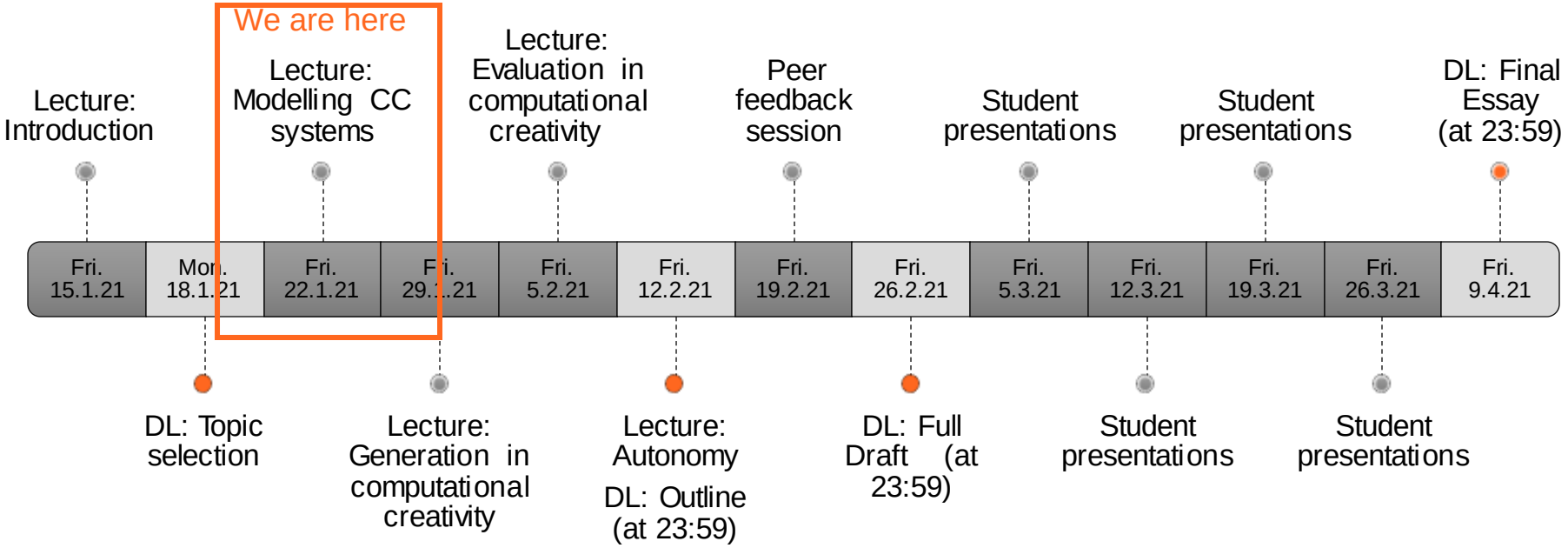
Anna Kantosalo, Christian Guckelsberger & Tapio Takala

Aalto University
School of Science

Agenda

- Revisiting the definition of computational creativity
- CC history and examples
- Csikszentmihalyi's Systems View of Creativity
- Liu's dual-Generate and Test model for creativity
- Wiggin's Creative Systems Framework
- Practical assignment
- Optional: Ventura's account of "How to Build a CC system"

Schedule


We are here
Lecture: Introduction
Lecture: Modelling CC systems
Lecture: Evaluation in computational creativity
Peer feedback session
Student presentations
Student presentations
DL: Final Essay (at 23:59)
Fri. 15.1.21
Mon. 18.1.21
Fri. 22.1.21
Fri. 29.1.21
Fri. 5.2.21
Fri. 12.2.21
Fri. 19.2.21
Fri. 26.2.21
Fri. 5.3.21
Fri. 12.3.21
Fri. 19.3.21
Fri. 26.3.21
Fri. 9.4.21
DL: Topic selection
Lecture: Generation in computational creativity
Lecture: Autonomy
DL: Outline (at 23:59)
DL: Full Draft (at 23:59)
Student presentations
Student presentations

Defining Computational Creativity

What is creativity?

Revisiting last week's themes

- Traditional perspectives to creativity
  - Rhodes 1961: 4Ps (perspectives on creativity)
  - Newell, Simon, Shaw, 1958: The Process of Creative Thinking
  - Different types of creativity (Boden, 1990):
    - P-Creativity and H-Creativity
    - Combinational, Exploratory, and Transformational

Defining Computational Creativity

CC is characterized by:

- Use of computational methods or artificial intelligence
- Goals:
  - Study and support of creative behaviors
  - Simulation of creative behavior
  - Engineering of creative systems

Why is computational creativity studied?

- To continue the study of creativity:
  - Simulation of creative behavior with computational means
- To extend artistic practice:
  - Development of new creative systems, methods and tools
- To advance artificial intelligence:
  - Creativity as a step towards general Artificial Intelligence

Why is computational creativity studied?

- Two perspectives (Veale, Cardoso and Pérez y Pérez, 2019):
  - Scientific: Use computational modelling and empirical studies to gain insights into the phenomenon of (human) creativity and the ultimate capabilities of creative people and machines
  - Engineering: Build working systems that embody these theoretical insights, usually to please and benefit people'
- Ideally, both are brought together in a ‘symbiotic relationship (...) wherein the artifacts that are produced also serve as empirical tests of the adequacy of scientific theories of creativity’ (p. 1).

History and Examples

A historical perspective

Early examples of computational creativity

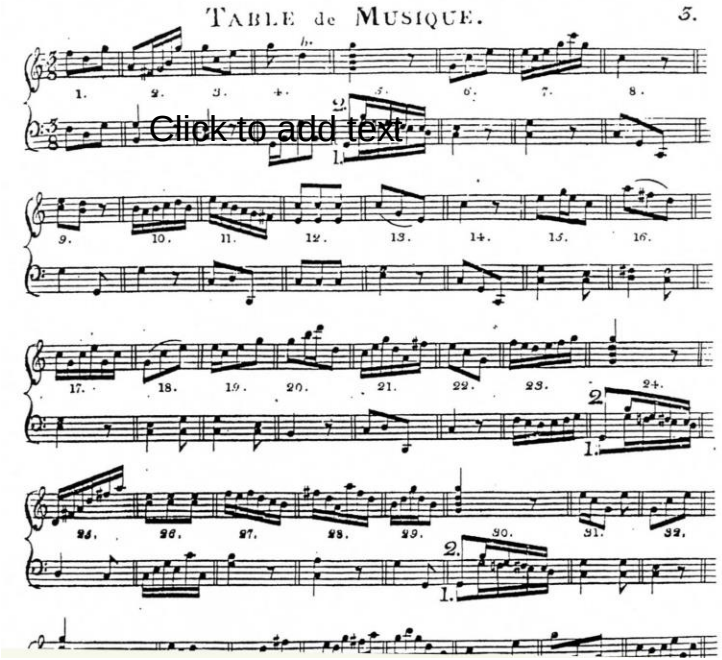
- Musikalisches Würfelspiel
  - An early example of algorithmic composition
  - Various artists, most famously Mozart (or his publisher) published a table of possible chord processions, which combined, would produce music in a distinctive style, such as Mozart's waltzes
  - To generate music anyone could cast a die to determine which processions to combine

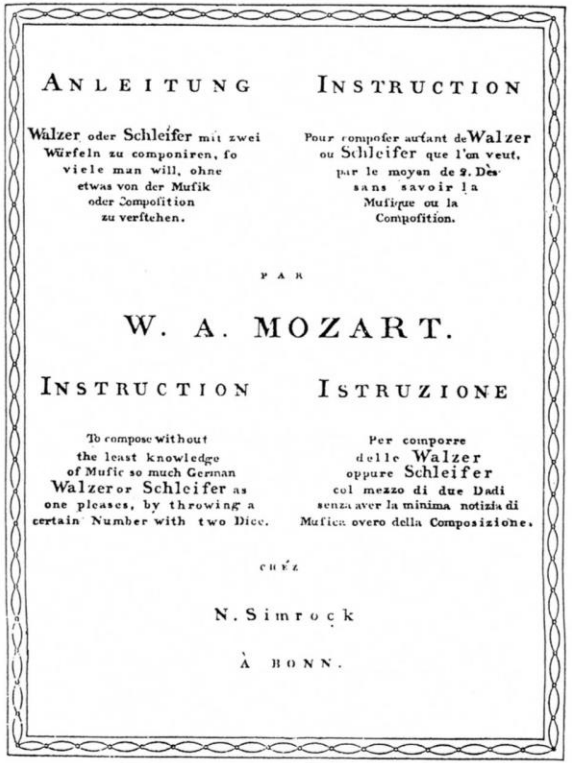
Musikalisches Würfelspiel

"To compose without the least knowledge of Music so much German Walzer Schleifer as one pleases, by throwing a certain Number with two Dice"

TABLE de CHIFFRES.

	A	B	C	D	E	F	G	H
2	96	22	141	41	105	122	11	30
3	32	6	128	63	146	46	134	81
4	69	95	158	13	153	55	110	24
5	40	17	113	85	161	2	159	100
6	148	74	163	45	80	97	36	107
7	104	157	27	167	154	68	118	91
8	152	60	171	53	99	133	21	127
9	119	84	114	50	140	86	169	94
10	98	142	42	156	75	129	62	123
11	3	87	165	61	135	47	147	33
12	54	130	10	103	28	37	106	16





Aalto University
School of Science

A historical perspective: music

- Illiac Suite, 1957 by Hiller & Issacson
  - Attributed as the first computer generated piece of music
  - A piece for a string quarted
  - A recording from a performance of the Illiac Suite from the Electro Museum in Moscow:

  https://www.youtube.com/watch?v=fojKZ1ymZlo

- In Finland: *"Kesän muistatko sen"* (Markku Nurminen, U Turku, 1967)
  - Popular tango tunes analyzed and randomly regenerated
  - https://yle.fi/aihe/artikkeli/2008/02/13/tietokoneet-savelsivat-tangoa-ja-soittelivat-polkkaa

- Similar work again: "Yö on rakkauden maa" (1999)
  - A computational average of Eurovision tunes 1961–1998. https://romanowski.fi/Rakkauden_maa/

A historical perspective

Early examples of computational creativity

- OULIPO (Ouvroir de littérature potentielle, workshop of potential literature)
  - A gathering of writers and mathematicians founded in the 1960s by Raymond Queneau and François Le Lionnais
  - Focus on algorithmic composition of poetry
  - Notable works
    - Cent Mille Milliards de Poemes – a poem in the style of the Musikalisches Würfelspiel
    - Constraint poetry, e.g. S+7 (Substituting every noun in an existing poem with another noun, found 7 nouns later in a dictionary)

A historical perspective

Early examples of computational creativity

- Cybernetic Serendipity (Jasia Reichardt, 1968)
  - 1st exhibition of cybernetic art in the Institute of Contemporary Arts, London, England; then travelling the US: Corcoran Annex, Washington, D.C.,Exploratorium, San Francisco.
  - Installations and computer-generated artefacts, e.g.
    - Computerized Haiku (Margaret Masterman and Robin McKinnon-Wood)
    - High-Entropy Essays (Prof. E. Mendoza)
    - Music Computer (Peter Zinovieff)

A historical perspective

Early examples of computational creativity

- https://archive.ica.art/whats-on/cybernetic-serendipity-documentation

A historical perspective

Establishing a systematic field of study

- Potential creativity of computers is already discussed by Ada Lovelace (Boden, 2017), and AI pioneers, such as Turing and Shannon (Colton & Wiggins, 2012)
- Creativity and randomness are the final element in the original Darthmouth workshop proposal (McCarthy et al. 2006, workshop held in 1956)
- Study of creativity from an AI perspective starts from mid 1990s (see. Cardoso, Veale & Wiggins, 2009)
    - Various workshops on computational creativity held in 1990s and 2000s
- First International Conference on Computational Creativity in 2010

What does computational creativity study?

Domains in CC research include (Loughrain & O'Neill, 2017):

- Logic
- Story
- Language
- Analogy
- Sound
- Design
- Maths
- Image
- Music
- Literature
- Concepts
- Humour
- Code
- Games
- ...

Examples

Computational humour:

What do you call a shout with a window?

- A computer scream.

The STANDUP system – Manurung et al. 2008

Examples

Stories:

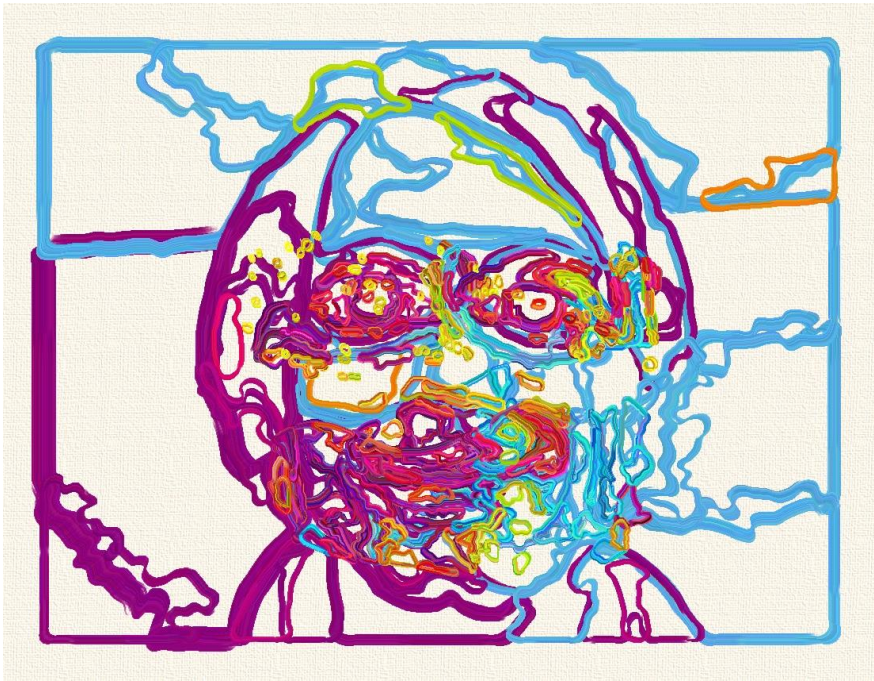
eagle knight went to the forest for a walk, suddenly the enemy appeared between the bushes and attacked the knight, the enemy ran away leaving the knight wounded, the princess decided to go to the forest for a walk, suddenly she found the wounded knight, she knew that it was her duty to help her people : the knight's life was at risk and she had to save him, the princess looked for some curative plants to heal the knight

MEXICA – Pérez y Pérez & Sharples, 2010

Examples: Images

AARON

http://geneticsandculture.com/genetics_culture/pages_genetics_culture/gc_w05/cohen_h.htm



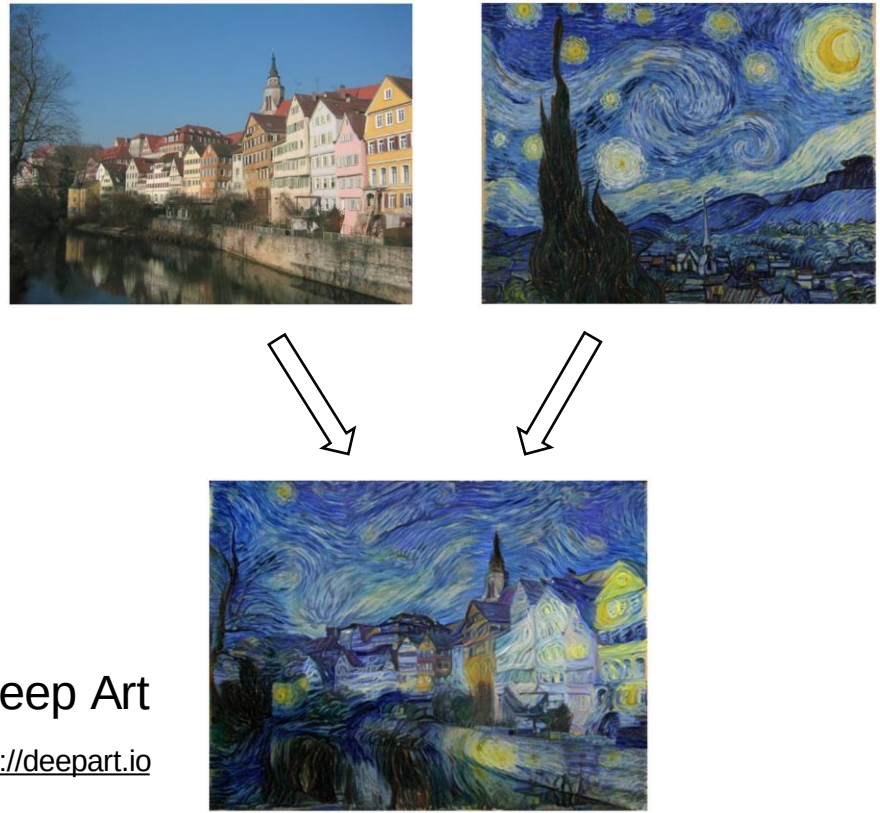
The Painting Fool

http://www.thepaintingfool.com/galleries/emotionally_aware/index.html

Examples: style transfer in music / images

Flow Machines

http://www.flow-machines.com/history/projects/odetojoy/

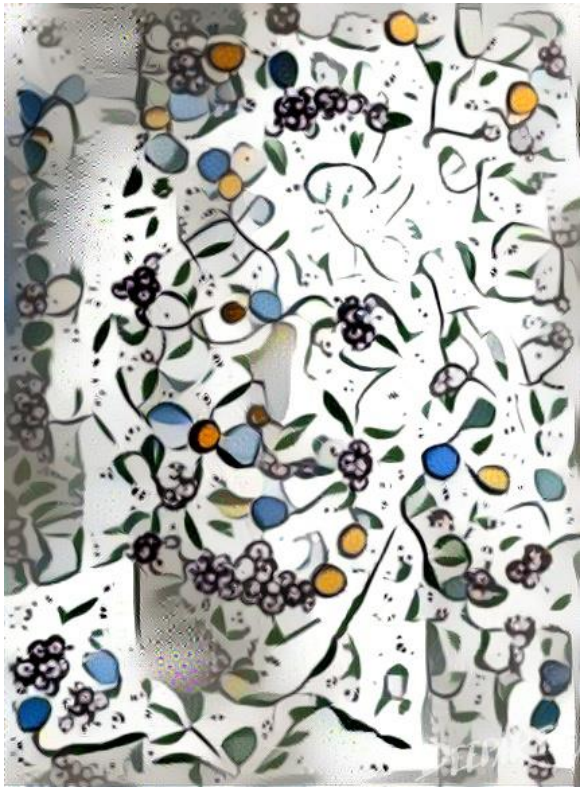


Deep Art

https://deepart.io

Aalto University
School of Science

Deep Art experiment



Aalto University
School of Science

Modelling Computational Creativity

Aalto University
School of Science

Why model (computational) creativity?

- To evaluate what is creative and to understand creativity as a phenomenon
- To facilitate creativity or to improve creative capacity
- To build creative systems

Three models for creativity

- **Csikszentmihalyi's Systems View of Creativity (Csikszentmihalyi, 1988)**
  - Defines creativity as a socio-cultural system
- **Liu's Dual Generate and Test model (Liu, 2000)**
  - Connects Csikszentmihalyi's view to classic generate-and-test ideas from AI and Cognitive Science
- **Wiggins' Creative Systems Framework (Wiggins, 2006a, 2006b)**
  - Describes creativity using the traditional AI paradigm of search

Three models for creativity

- Csikszentmihalyi's (1988) Systems View of Creativity
  - Defines creativity as a socio-cultural system
- Liu's (2000) Dual Generate and Test model
  - Connects Csikszentmihalyi's ideas to classic generate-and-test ideas from AI and Cognitive Science
- Wiggins' (2006, a, b) Creative Systems Framework
  - Describes creativity using the traditional AI paradigm of search

→ **We use these models to understand how CC systems are built**

Csikszentmihalyi's Systems View of Creativity

(Csikszentmihalyi, 1988)

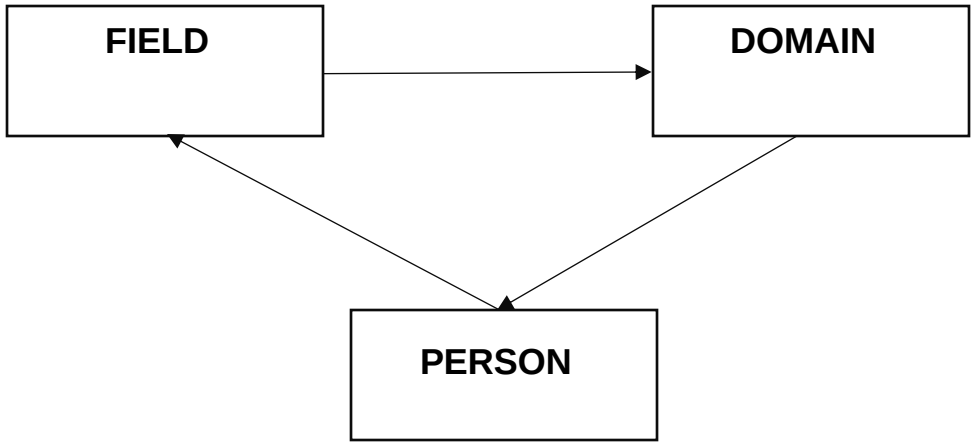
Systems view of Creativity

Motivations:

- **Where is creativity?**
- **Creativity cannot be studied by isolating individuals from their social and historical context**

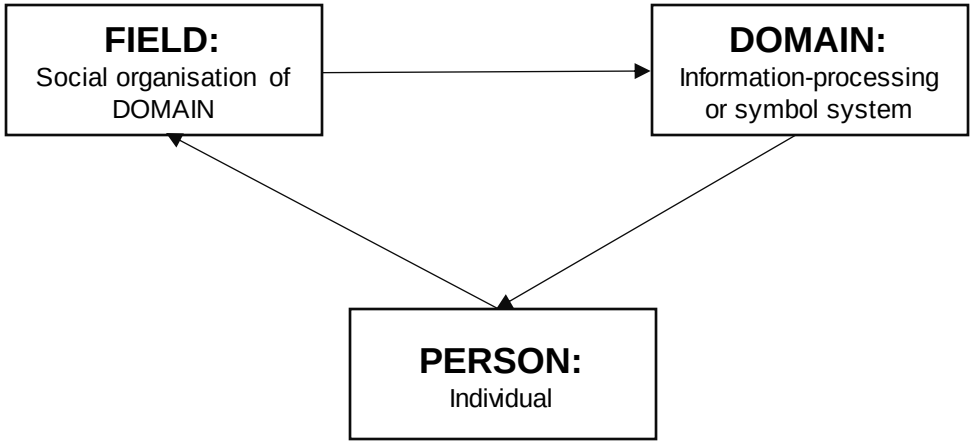
Systems view of Creativity

Creativity results from the interaction of three systems:

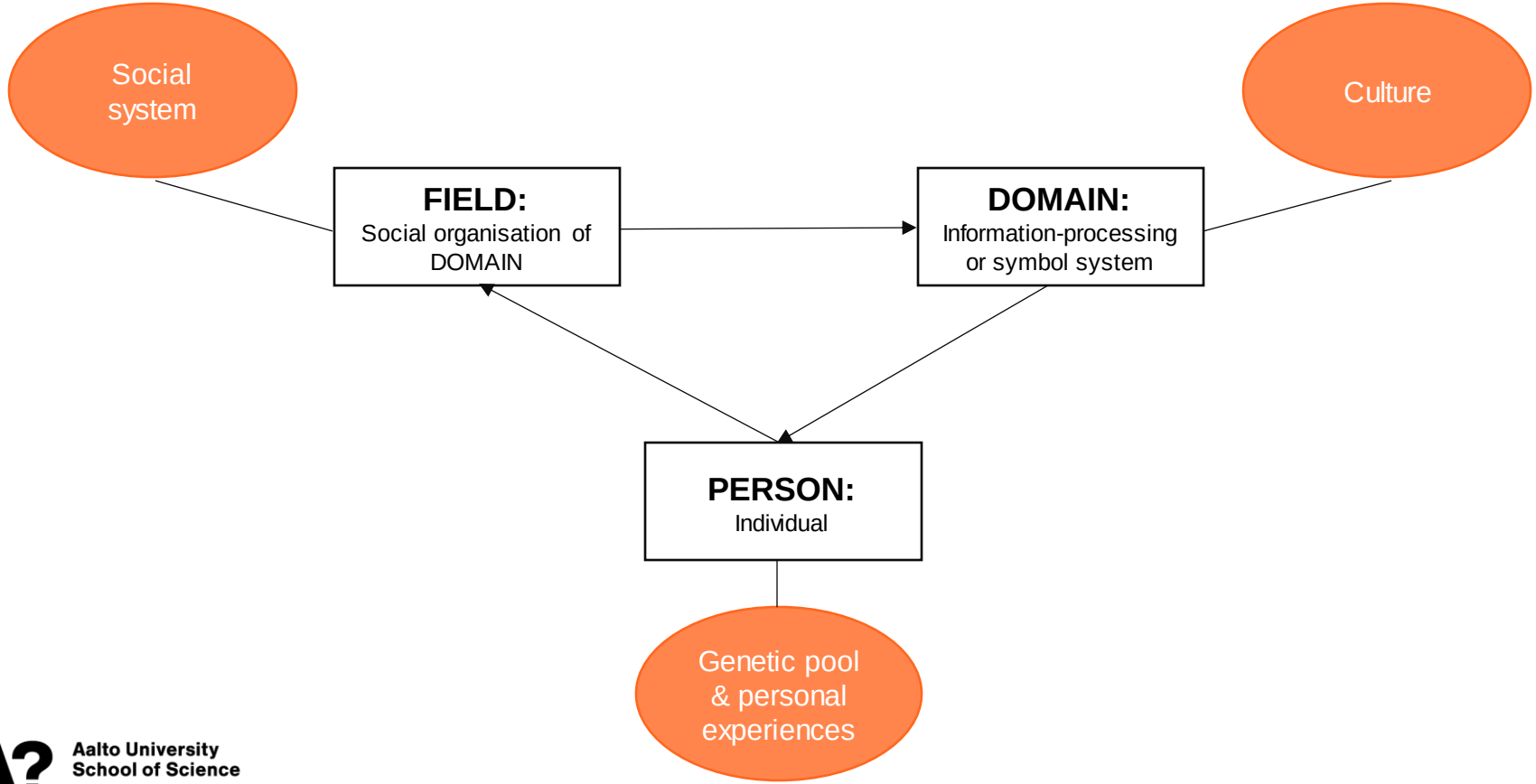


Systems view of Creativity

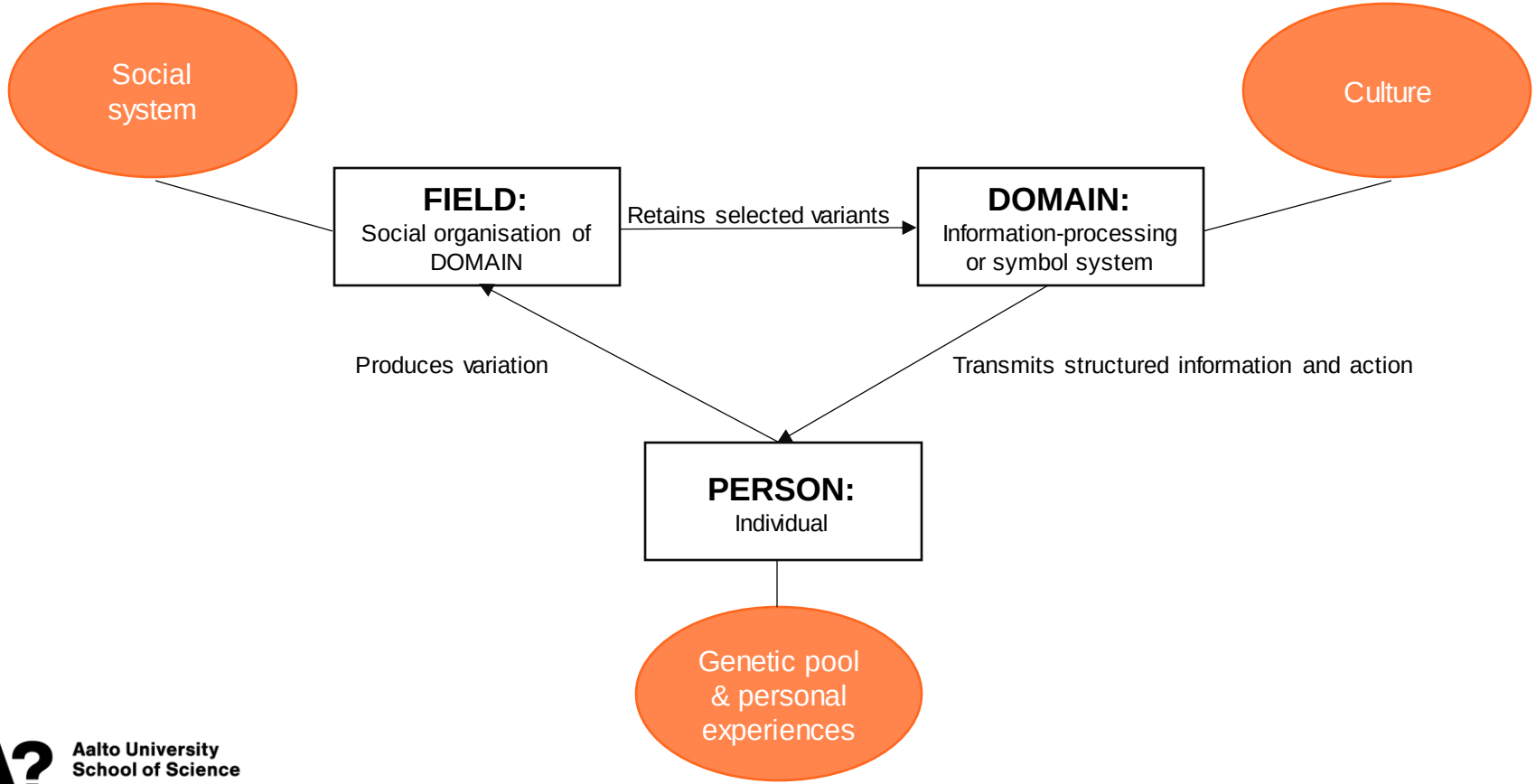
Creativity results from the interaction of three systems:



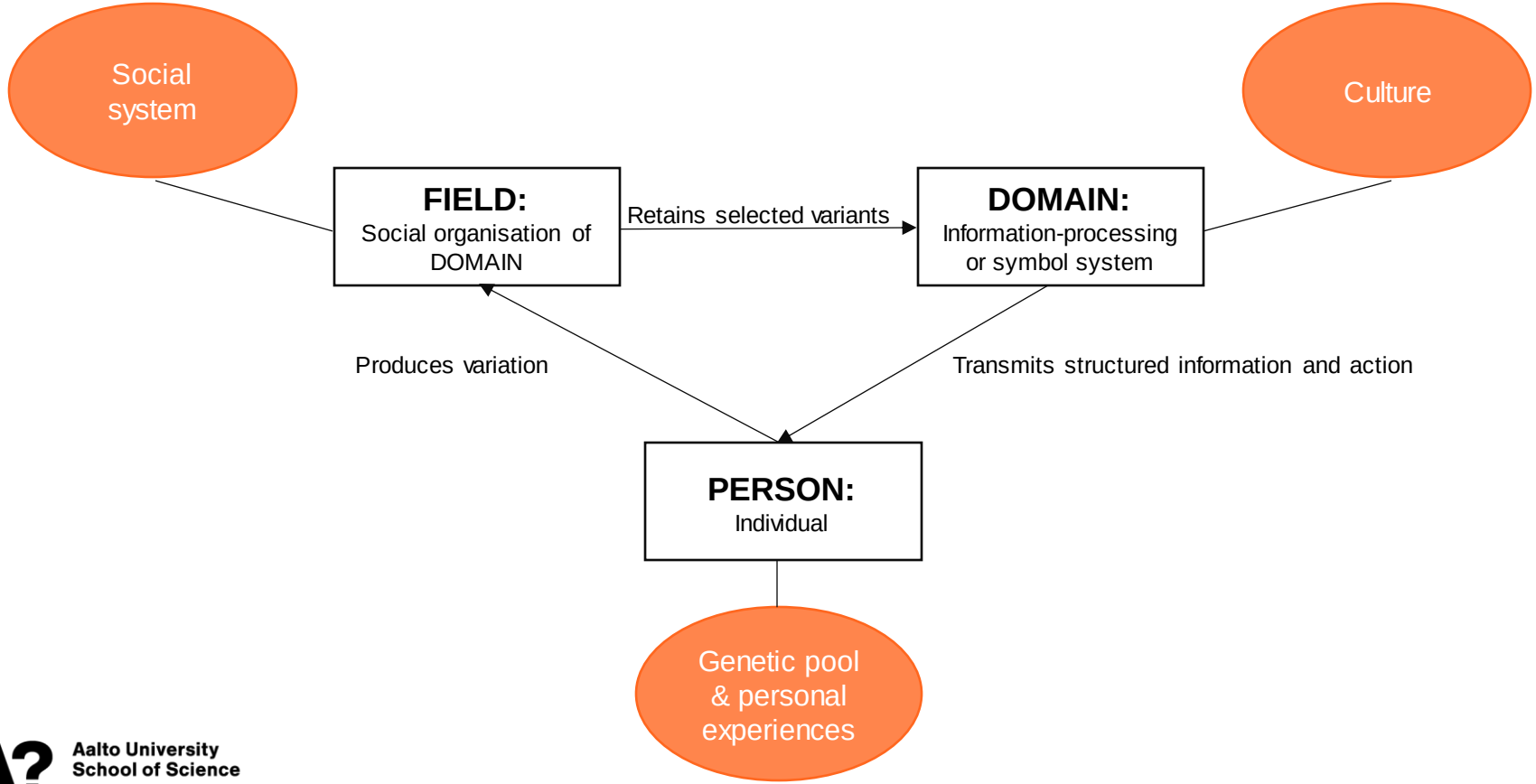
Systems view of Creativity



Systems view of Creativity



Systems view of Creativity

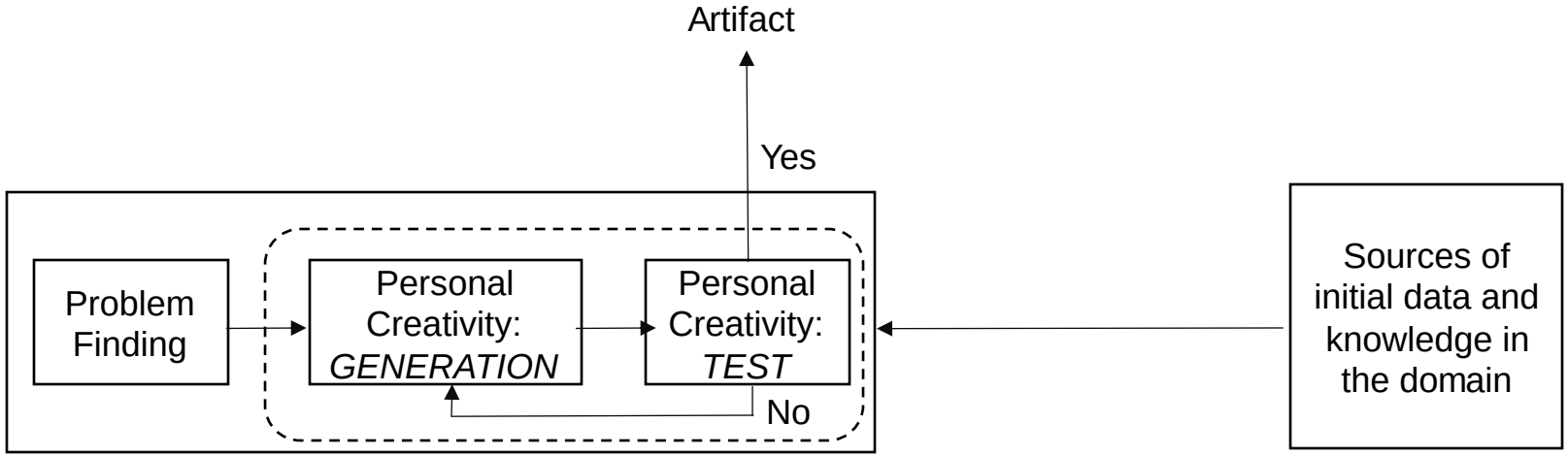


Liu's Dual-Generate and Test Model

(Liu, 2000)

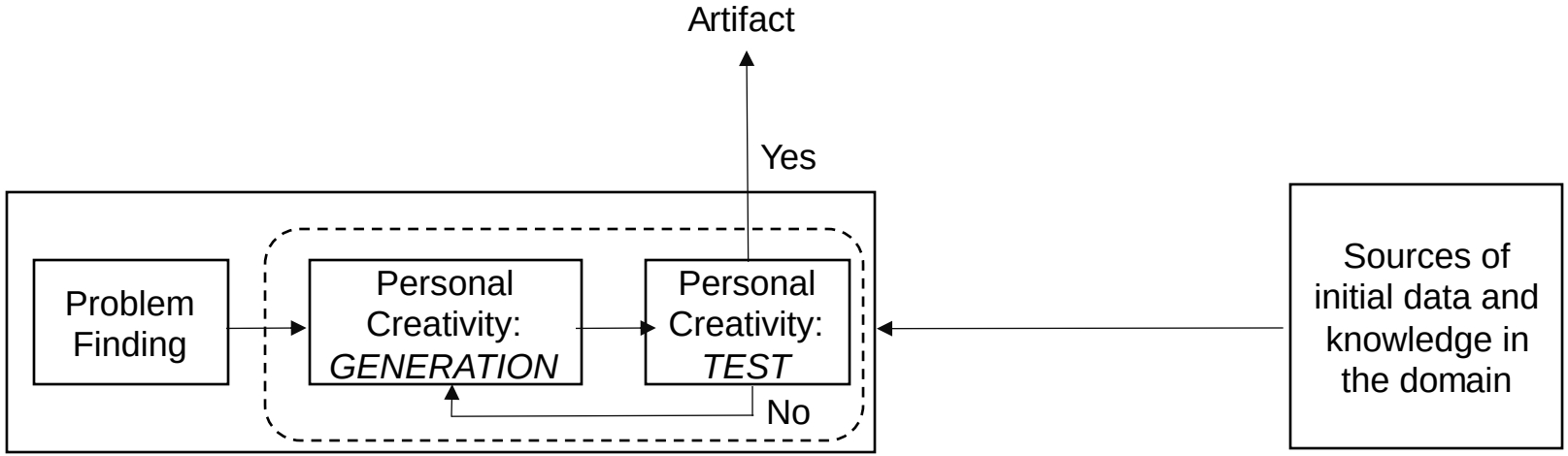
The Generate-And-Test Model

The generate-and-test model is popular in both AI and cognitive science

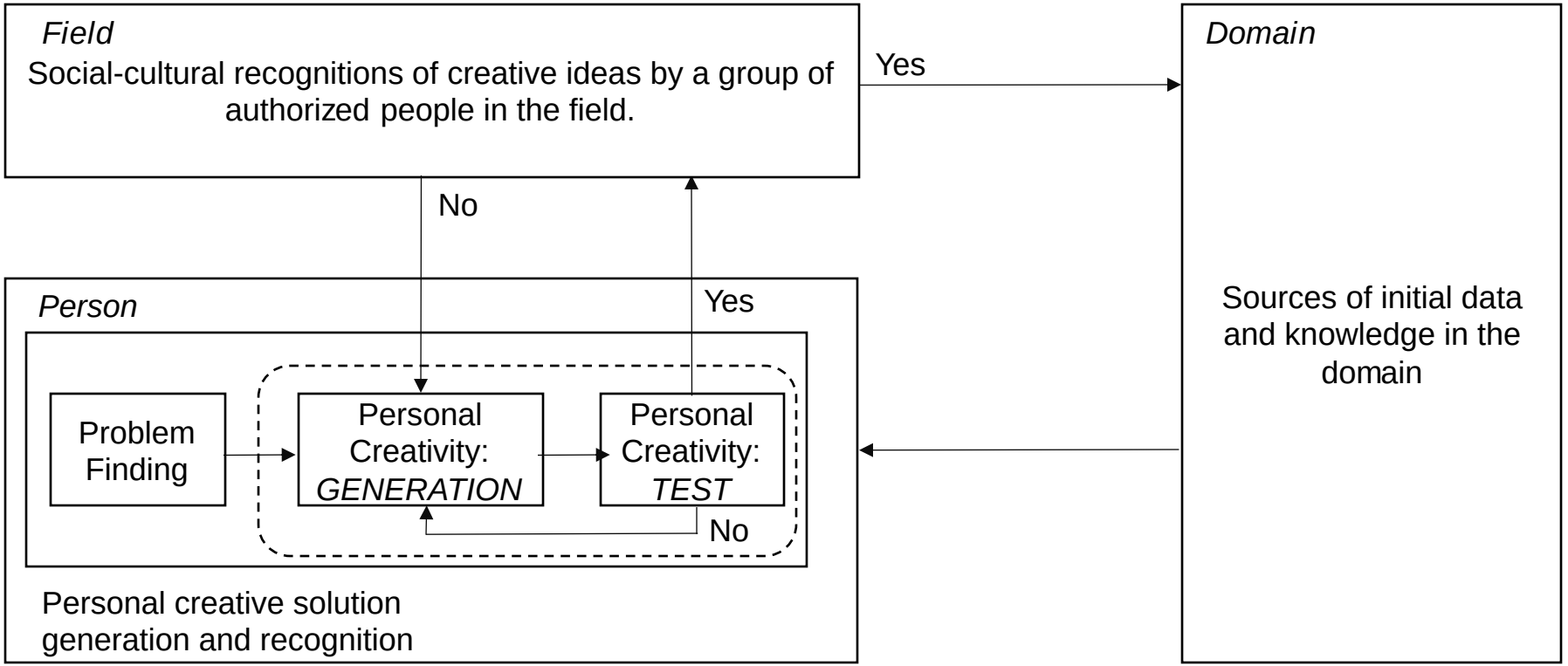


The Generate-And-Test Model

The generate-and-test model is popular in both AI and cognitive science



The Dual Generate-And-Test Model



Wiggins' Creative Systems Framework

(Wiggins, 2006, a, b)

The Creative Systems Framework

Background:

- A computational creativity focused general model for creativity
- Formulates Boden's theories about exploratory and transformational creativity in mathematical form
- Models creativity as a search in a "conceptual space"

The Creative Systems Framework

U – The universe of all possible concepts

C – Valid concepts

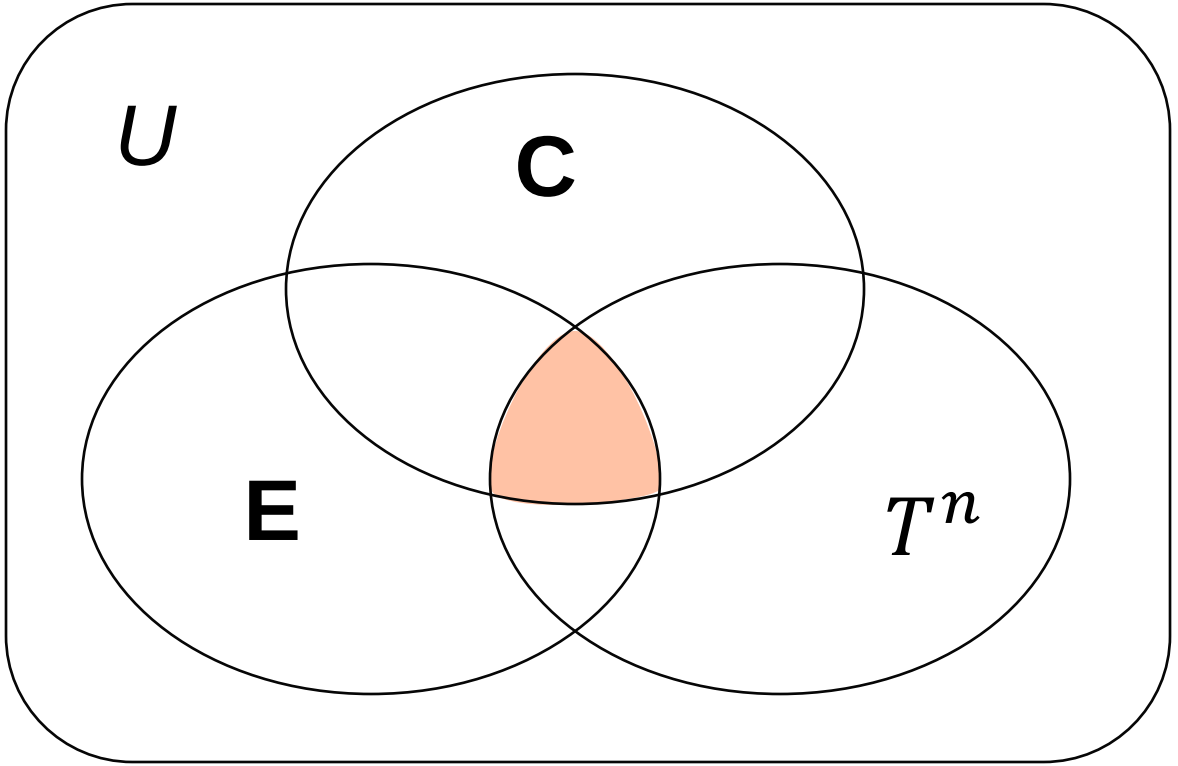
E – High quality concepts

T^n – Concepts reachable in n generative iterations

Full formalism in Wiggins 2006a,b

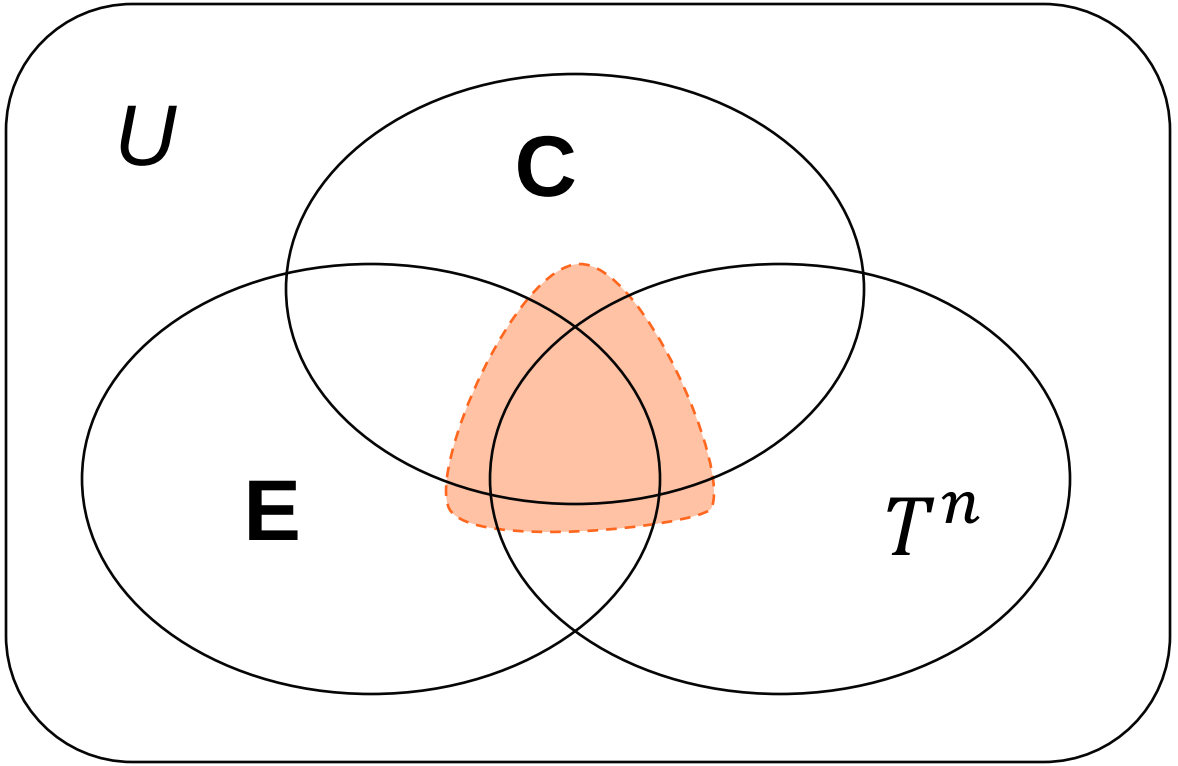
The Creative Systems Framework

Exploratory creativity happens in the intersection of these three sets:
U, E, and T^n



The Creative Systems Framework

Exploratory creativity happens in the intersection of these three sets:
U, E, and T^n
In transformational creativity we try to expand this intersection



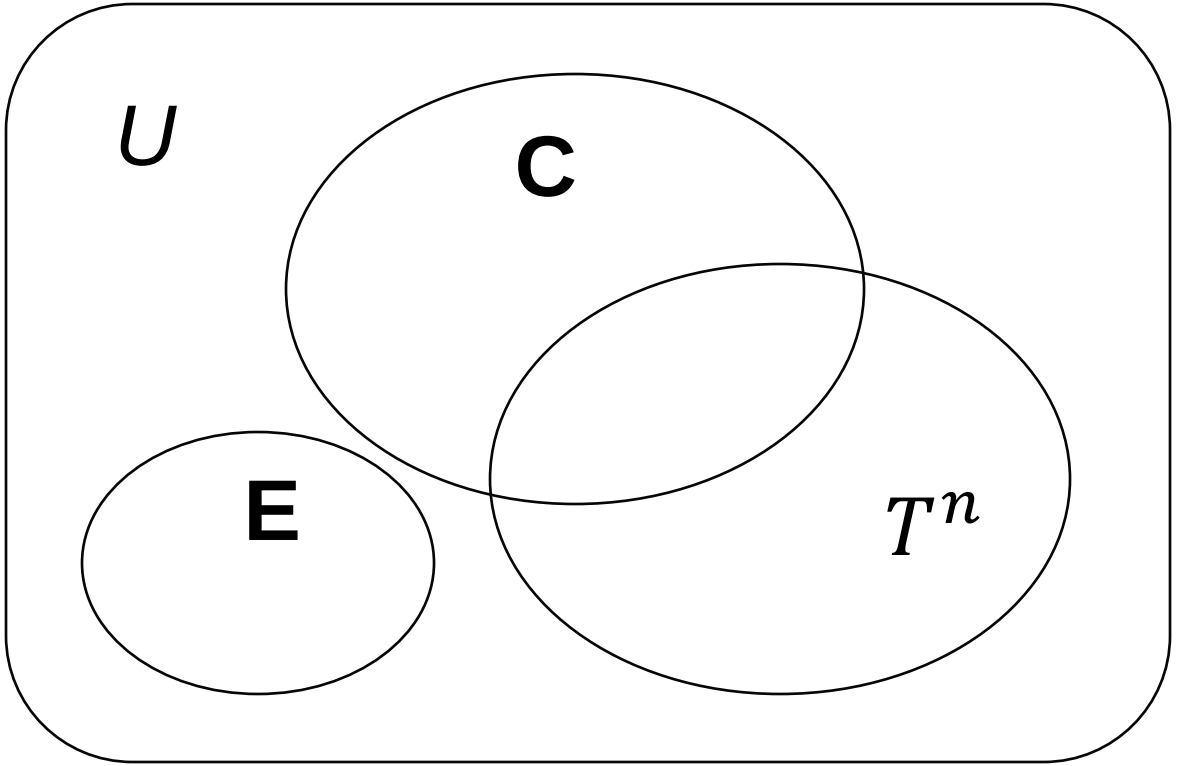
The Creative Systems Framework

With the model we can describe some interesting situations:

Uninspiration:
Hopeless: $\mathbf{E} = \emptyset$
Conceptual: $\mathbf{E} \cup \mathbf{C} = \emptyset$

Generative:

$$\mathbf{E} \cup \mathbf{T^n} = \emptyset$$

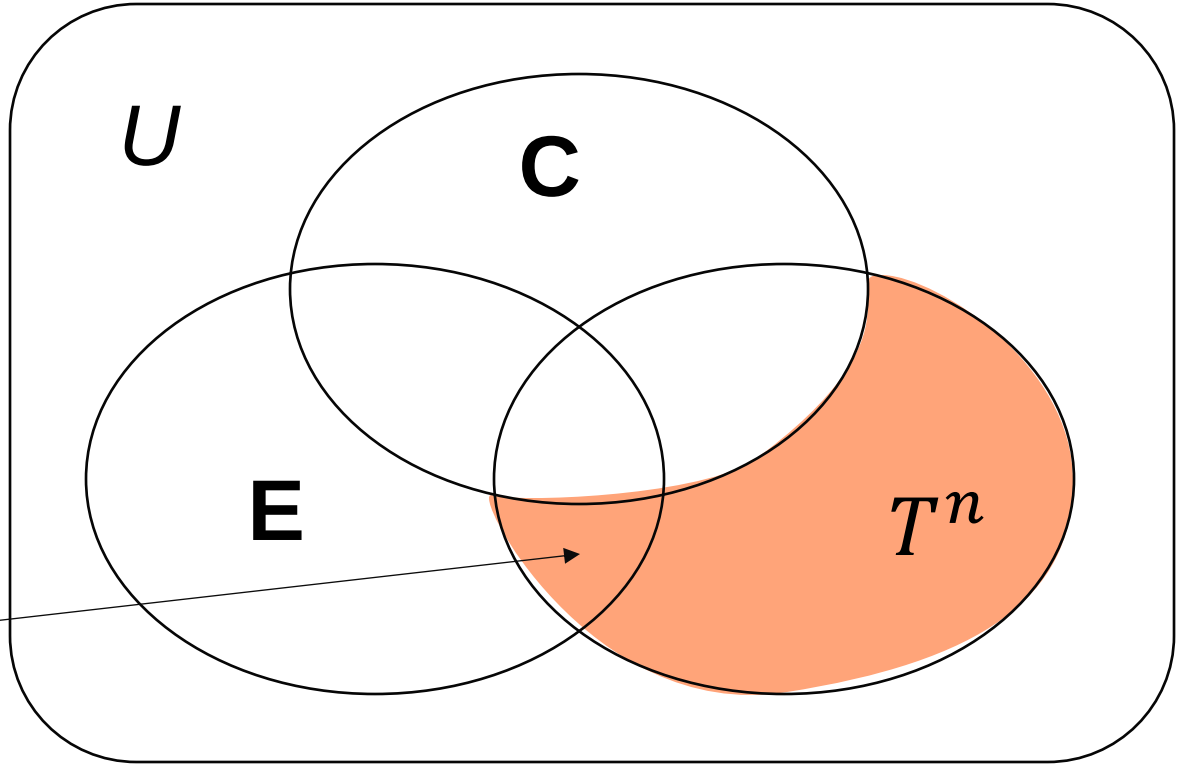


The Creative Systems Framework

With the model we can describe some interesting situations:

Aberration:
$Systm\ can't\ generate\ valid\ concepts$

In productive aberration



Let’s practice!

For the given domain sample, describe a creative agent by describing

a) **The conceptual space**

b) **The rules for valid concepts**

c) **The rules for evaluating concepts**

d) **The rules for traversing the conceptual space**

https://miro.com/app/board/o9J_lY55L1g=/

Building Computational Creativity Systems

Following Dan Ventura's suggestions (Ventura, 2017)

Aalto University
School of Science

Important characteristics for a CC System

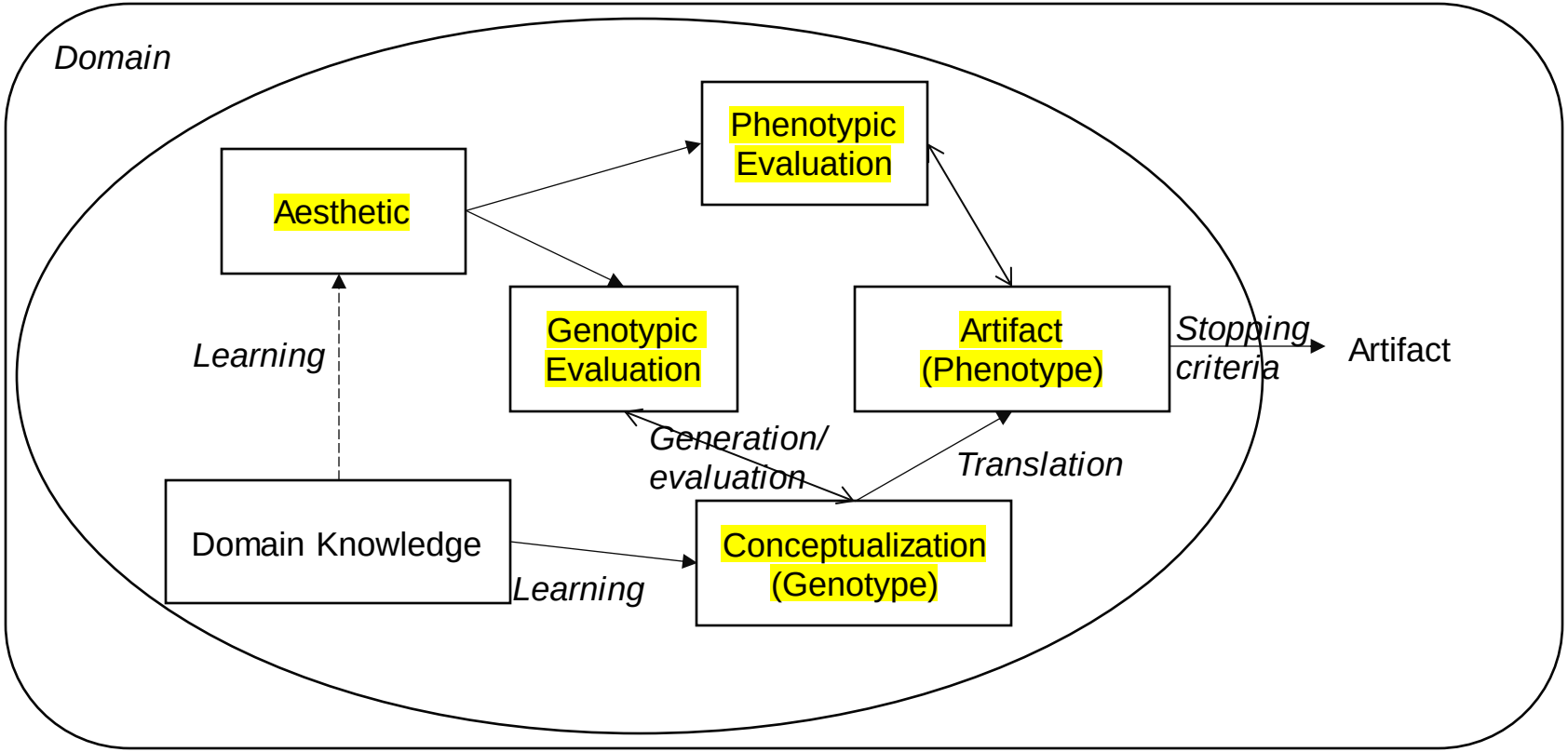
- **Novelty** – the quality of being new, original or unusual
- **Value** – the importance, worth, usefulness or aesthetic appeal of something
- **Intentionality** – the fact of being deliberative or purposive

See e.g. Runco and Jaeger's (2012) "Standard Definition of Creativity" for **Novelty** and **Value** components.

Important characteristics for a CC System

- **Novelty – the quality of being new, original or unusual**
- **Value – the importance, worth, or usefulness of something**
- ***Intentionality – the fact of being deliberative or purposive***

Parts of a CC system



Parts of a CC System

- **Domain**
  - All CC systems work in a domain
- **Representation**
  - Each system will have a domain appropriate external, phenotypic representation and an internal, genotypic representation, or artefact and concept representations
- **Knowledge Base**
  - Designers need to build knowledge bases and choose how information is represented in them

Parts of a CC System

- **Aesthetic**
  - Designers must choose abstract qualities of methods fit for the domain
- **Conceptualization**
  - Is a model facilitating the understanding and creation of artefacts in the domain
- **Generation**
  - The conceptualization must allow the system to generate artefact genotypes

Parts of a CC System

- **Genotypic Evaluator**
  - The system requires a way to evaluate the genotypes
- **Translation**
  - The system must be able to translate its internal, genotypic representations to phenotypic artefacts
- **Phenotypic Evaluator**
  - The artefacts must be evaluated again once the most successful genotypic presentations have been translated

How to use the models?

- Consider what are the most useful models for describing your essay topic
- Analyse the example systems using the models
- All models may not fit your work, or your work may not fit all parts of a specific model – it is also interesting which parts do not fit!

References

Boden, 2017 (non-peer reviewed) What is Creativity? In the Automated Designer http://www.bartdaems.com/the-automated-designer/margaret-a-boden-the-lovelace-questions

Boden, M. A. (1998). Creativity and artificial intelligence. *Artificial Intelligence*, *103*(1-2), 347-356.

Boden, M.A.,(1990) The Creative Mind, Abacus, London

Cardoso, Veale, & Wiggins, 2009: Cardoso, A., Veale, T., and Wiggins, G. A. Converging on the divergent: The history (and future) of the international joint workshops in computational creativity. AI Magazine 30, 3 (2009), 15–22.

Csikszentmihalyi, M. (1988). Society, culture, and person: A systems view of creativity. In *The nature of creativity, Sternberg, R. (eds.), Cambridge University Press*

Colton, S., & Wiggins, G. A. (2012, August). Computational creativity: The final frontier?. In *Ecai* (Vol. 12, pp. 21-26).

Liu, Y. T. (2000). Creativity or novelty?: Cognitive-computational versus social-cultural. *Design Studies*, *21*(3), 261-276.

Manurung, R., Ritchie, G., Pain, H., Waller, A., O'Mara, D. & Black, R. (2008) "The construction of a pun generator for language skills development." *Applied Artificial Intelligence* 22.9 : 841-869.

McCarthy, J., Minsky, M. L., Rochester, N., & Shannon, C. E. (2006). A proposal for the dartmouth summer research project on artificial intelligence, august 31, 1955. *AI magazine*, *27*(4), 12-12.

References

PÉrez Ý PÉrez, R. & Sharples, M. (2001) MEXICA: A computer model of a cognitive account of creative writing, Journal of Experimental & Theoretical Artificial Intelligence, 13:2, 119-139, DOI: 10.1080/09528130010029820

Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan*, *42*(7), 305-310.

Veale, T., Cardoso, F. A. & Pérez y Pérez, R. (2019). Systematizing Creativity: A Computational View. In T. Veale & F. A. Cardoso (Eds.), Computational Creativity (pp. 1–19). Springer.

Ventura, D. (2017). How to Build a CC System. In the Proceedings of the Eight International Conference on Computational Creativity (pp. 253-260).

Wallas (1926). The art of thought

Wiggins, G. A. (2006a). Searching for computational creativity. *New Generation Computing*, *24*(3), 209-222.

Wiggins, G. A. (2006b). A preliminary framework for description, analysis and comparison of creative systems. *Knowledge-Based Systems*, *19*(7), 449-458.