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# Applied Artificial Intelligence

## 09 - Creative AI

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Karlsruhe Institute of Technology

TUM School of Management

# Real or AI generated?



[1]



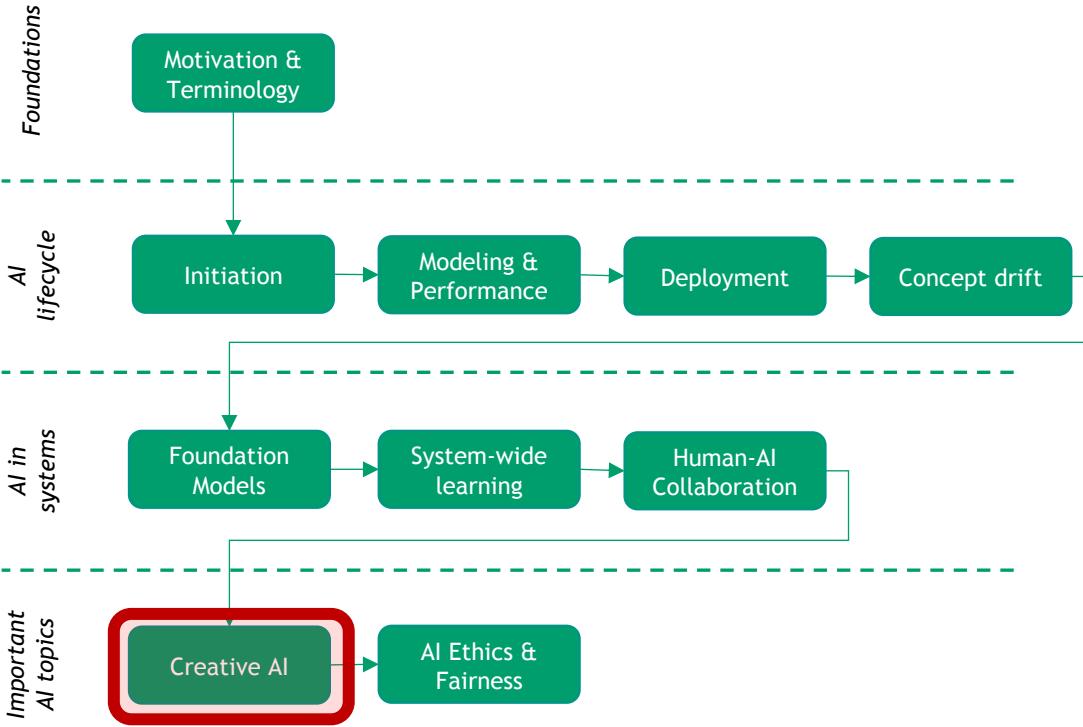
[2]



ING Group (2021) ([Image](#)) [1]  
Gatys et al. (2015). A Neural Algorithm of Artistic Style. Journal of Vision [2]

# Organizational

## The story of the lecture



# Objectives

What are the learning goals of this lecture?

## EXPLORE

Discover creativity with AI



## UNDERSTAND

Comprehend the phenomena creativity and how it can be differentiated



## INTENSIFY

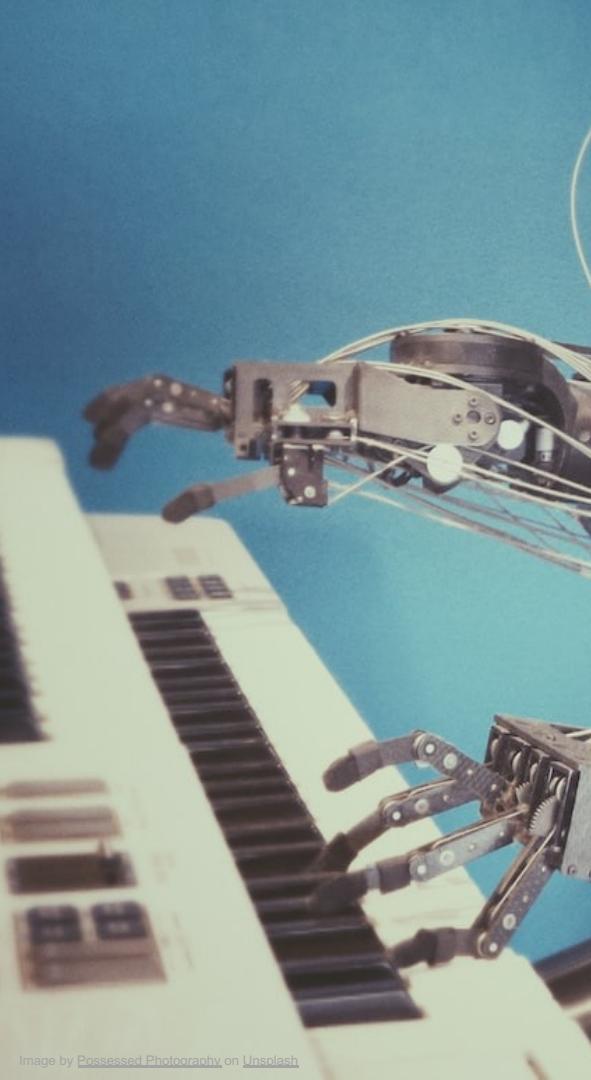
Gain knowledge which aspects of creativity could be covered by an AI



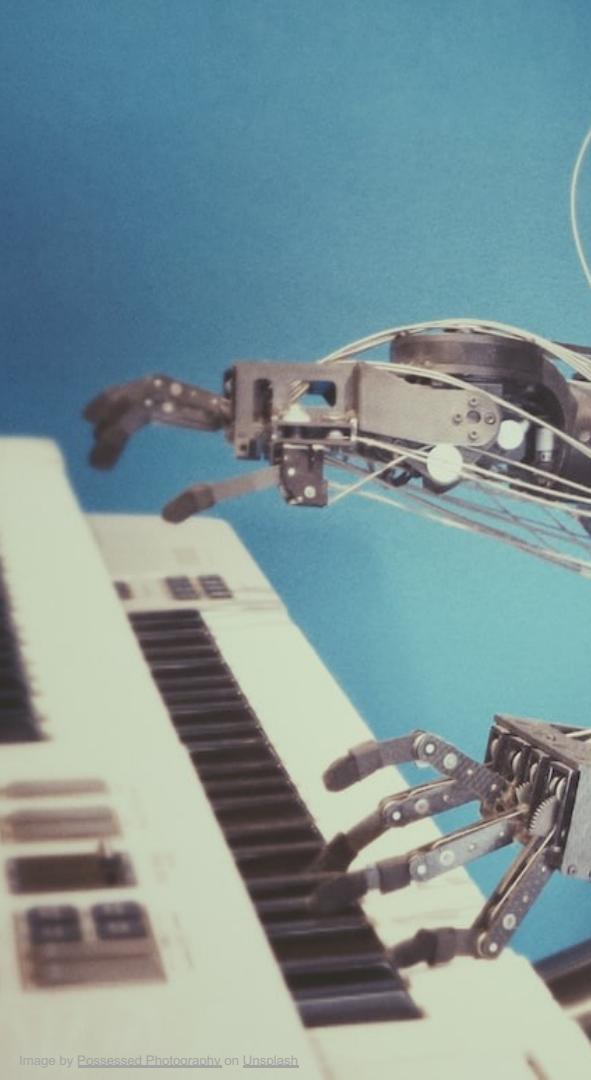
## APPLY

Be able to discuss recent examples for creative AI





- 1 What is Creativity?
- 2 Aspects of AI
- 3 Combination of AI and Creativity



1

What is Creativity?

2

Aspects of AI

3

Combination of AI and Creativity

## What is Creativity?

Capturing the complex term and process of “Creativity” is difficult as there exist numerous theoretical perspectives. We focus on the cognitive research approach.

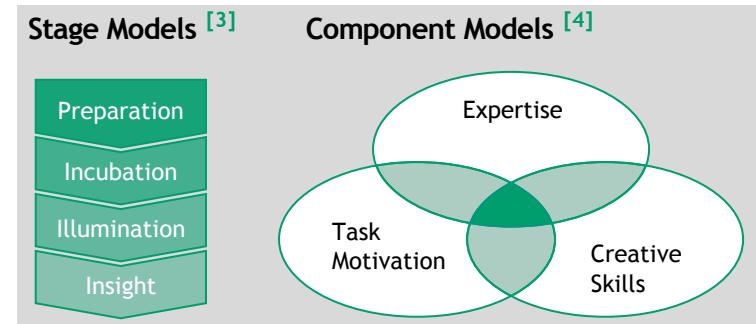
### What does creativity mean?

“ The creative work is a *novel* work that is accepted as *tenable* or *useful* or *satisfying* by a group in some point in time. By “*novel*” I mean the creative product did not exist previously in precisely the same form. [...] it is necessary to distinguish between *internal* and *external frames of reference*. (Stein 1953) [1]

Creative P's: Creative Product, Creative Process, Creative Person, Creative Potential [2]

#### Creative Process:

- unconscious  
(e.g. concepts like intuition or incubation)
- conscious  
(e.g. stage and/or component models)



Stein (1953). Creativity and culture. The journal of psychology. [1]

Runco (2014). Creativity: theories and themes: research, development, and practice. Elsevier Academic Press. [2]

Wallas (1926). The art of thought. Franklin Watts. [3]

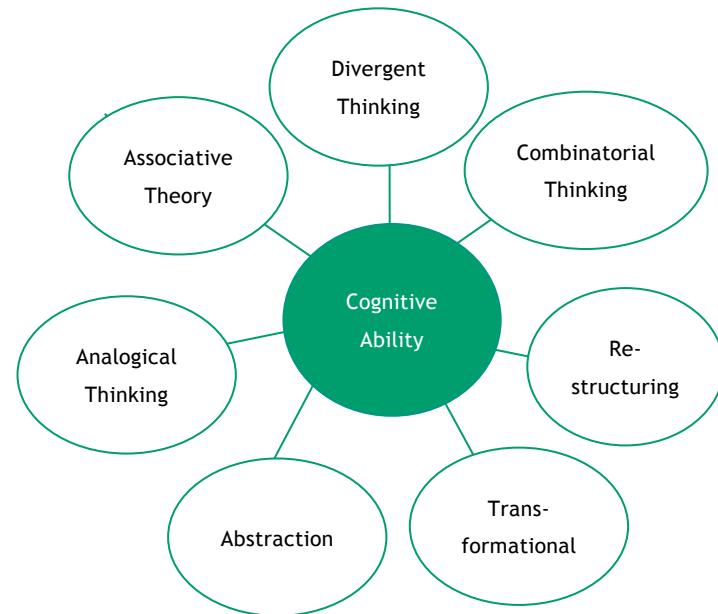
Amabile (2012). Componential theory of creativity. HBS Working Paper Series. [4]

# What is Creativity?

Various cognitive abilities can lead to creativity, enabling individuals, groups and crowds being able to be creative

## Necessary capabilities for creativity

-  Individual Creativity: through “creative personality” [1]
-  Dual Creativity: through team qualities [2]
-  Group Creativity: through team qualities [3]
-  Crowd Creativity: through collaboration [4]



Runco (2014). Creativity: theories and themes: research, development, and practice. Elsevier Academic Press. [1]

Rouse (2018). Where You End and I Begin: Understanding Intimate Co-creation. Academy of Management Review. [2]

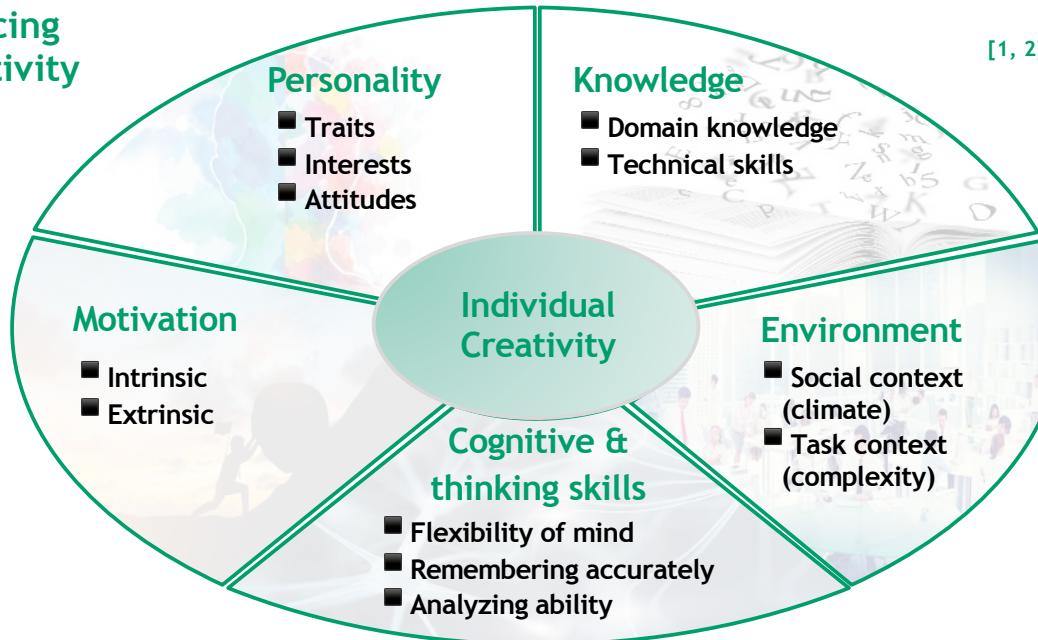
West (2002). Sparkling Fountains or Stagnant Ponds: An Integrative Model of Creativity and Innovation Implementation in Work Groups. Applied psychology. [3]

Yu and Nickerson (2011). Cooks or cobblers? Crowd creativity through combination. Proceedings of the SIGCHI conference on human factors in computing systems. [4]

## What is Creativity?

Factors influencing and that are necessary for individuals to be creative can be classified into the five categories named below

### Factors influencing individual creativity



[1, 2]

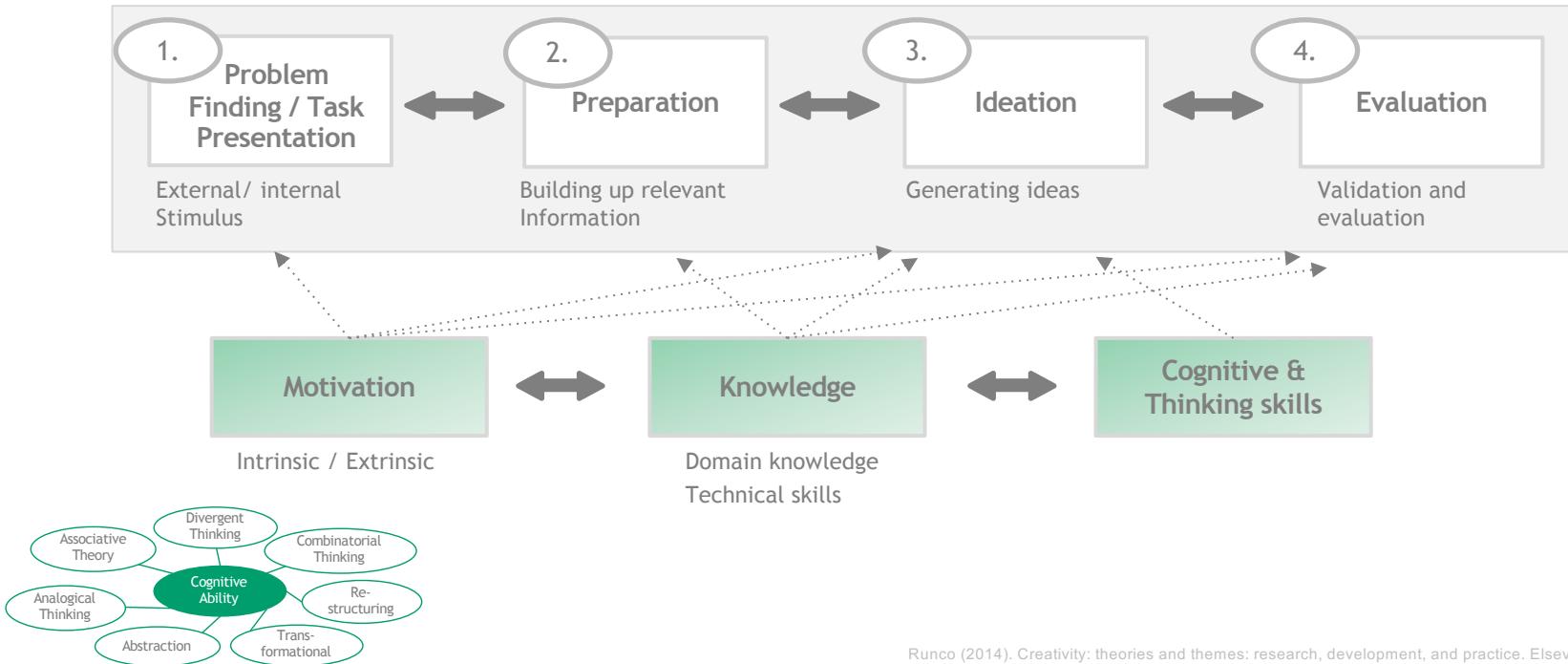
Anderson (2014). Innovation and creativity in organizations: A state-of-the-science review, prospective commentary, and guiding framework. Journal of Management. [1]  
Amabile (2012). Componential theory of creativity. HBS Working Paper Series. [2]

# What is Creativity?

The process by which people develop creative work can be summarized in four general steps influenced by motivation knowledge

## Necessary capabilities for creativity

[1, 2]



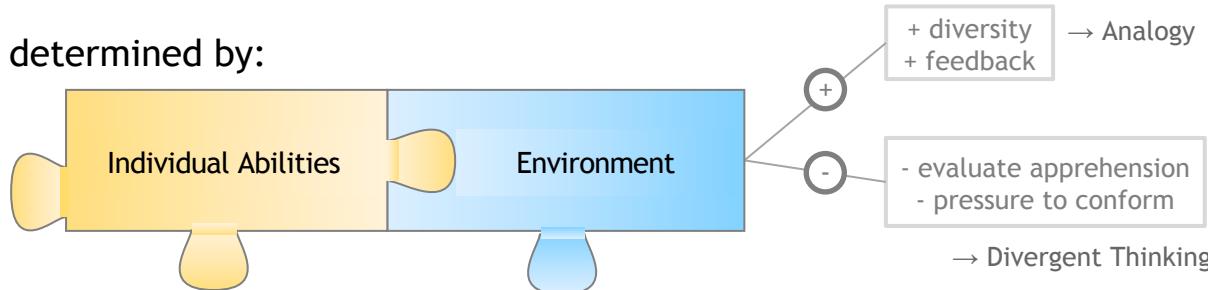
Runco (2014). Creativity: theories and themes: research, development, and practice. Elsevier Academic Press. [1]  
Amabile (2012). Componential theory of creativity. HBS Working Paper Series. [2]

## What is Creativity?

The process dual creativity changes, as individual abilities are combined and the overall environment changes

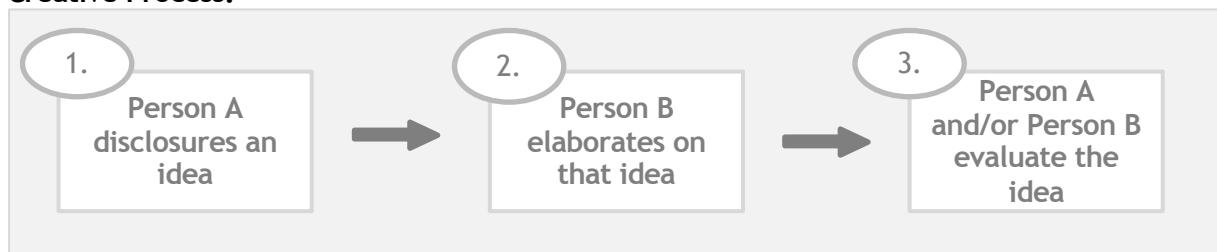
### Dual Creativity<sup>[1]</sup>

Creativity is determined by:



Only two individuals → greater intimacy → psychologically safe environment (mutual trust, affection)

Creative Process:



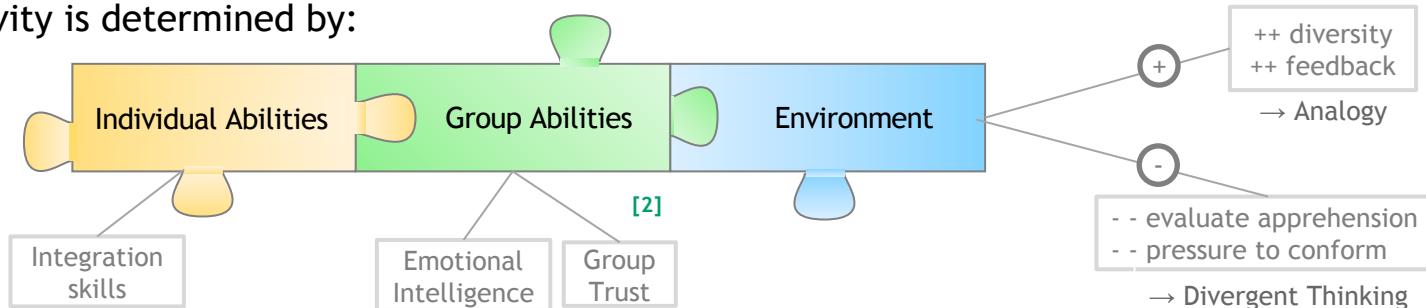
**Intimate co-creation:**  
evaluation not reflective  
of a person or a  
relationship - only about  
the idea

## What is Creativity?

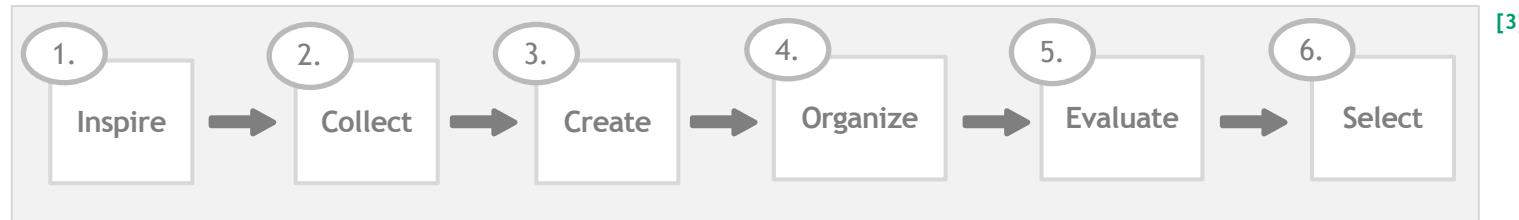
The process of more than two individuals being creative and the influences (additional to individual and dual creativity) are summarized

### Group Creativity [1]

Creativity is determined by:



Creative Process:



West (2002). Sparkling Fountains or Stagnant Ponds: An Integrative Model of Creativity and Innovation Implementation in Work Groups. Applied psychology. [1]

Barczack (2010). Antecedents of team creativity: An examination of team emotional intelligence, team trust and collaborative culture. Creativity and innovation management. [2]

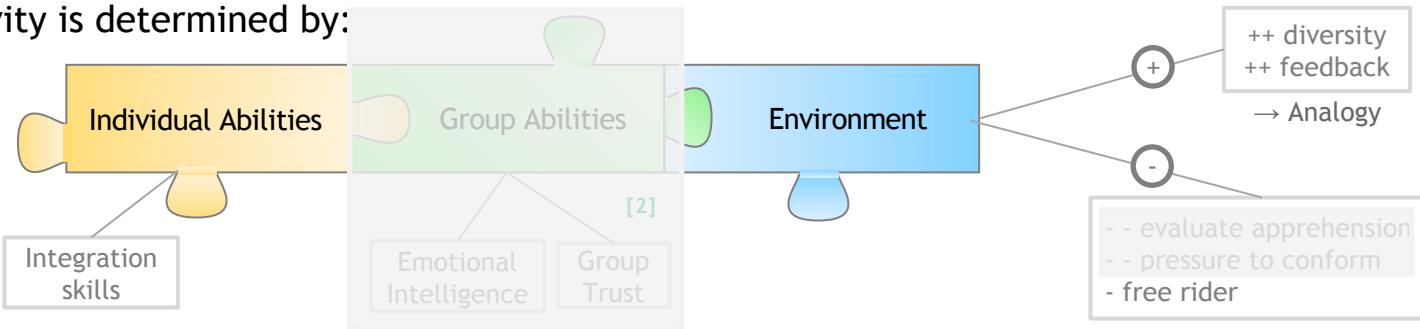
Voigt & Bergener (2013). Comprehensive Support for Creativity-Intensive Processes - An Explanatory Information System Design Theory. Business & Information Systems Engineering. [3]

# What is Creativity?

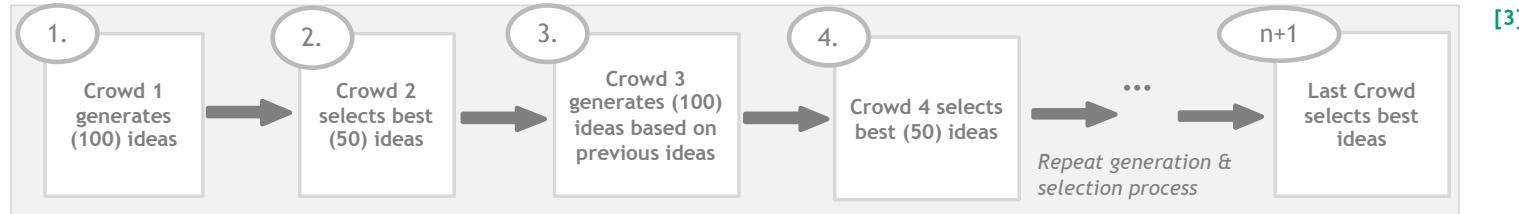
The process of more than 50 individuals being creative and the influences are summarized

## Crowd Creativity<sup>[1]</sup>

Creativity is determined by:



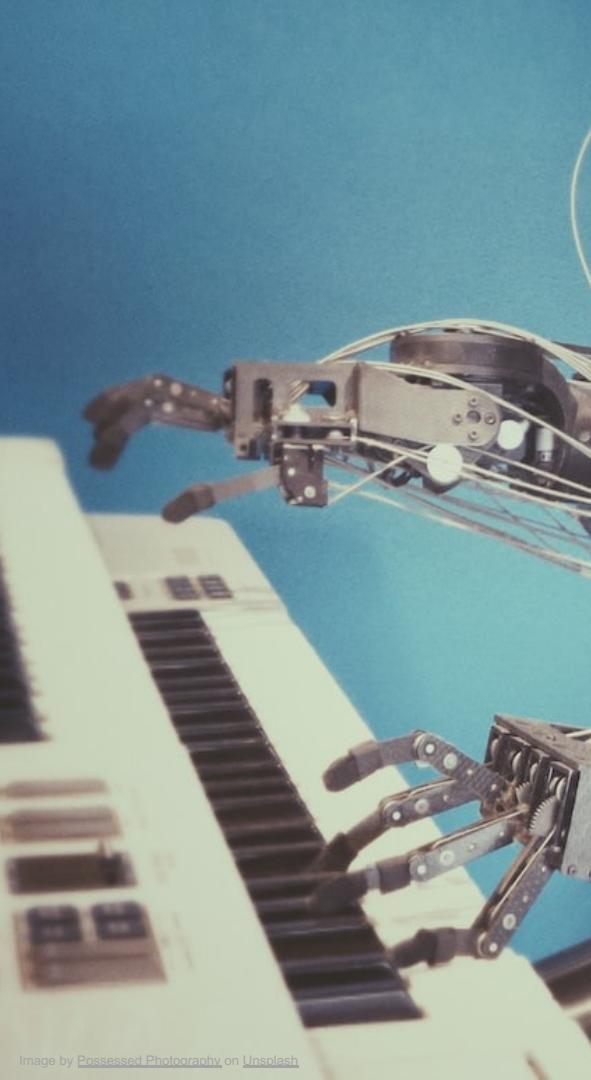
Creative Process:



West (2002). Sparkling Fountains or Stagnant Ponds: An Integrative Model of Creativity and Innovation Implementation in Work Groups. Applied psychology. [1]

Barczack (2010). Antecedents of team creativity: An examination of team emotional intelligence, team trust and collaborative culture. Creativity and innovation management. [2]

Voigt & Bergener (2013). Comprehensive Support for Creativity-intensive Processes - An Explanatory Information System Design Theory. Business & Information Systems Engineering. [3]



- 1 What is Creativity?
- 2 Aspects of AI
- 3 Combination of AI and Creativity

## Aspects of AI

Problem-solving derives solutions for a goal, knowledge creates the basis of decision making and uncertainty deals with unsure outcomes

### Aspects of Artificial Intelligence (1/2)<sup>[1]</sup>

Problem-solving	Knowledge	Uncertainty
A <b>goal</b> is defined for which the agent starts searching a <b>solution</b>  Additional <b>constraints</b> are introduced  In Reinforcement Learning: Adversarial search delivers <b>action depending</b> on prior <b>state</b>	<b>Knowledge</b> can be used as a basis for decision-making  Propositional logic stores <b>true or false information</b> of the world/domain - first-order logic allows additional connections	<b>Uncertainty</b> cannot be prevented in a <b>real-world</b> scenario  Probabilistic reasoning can be addressed with <b>Bayesian networks</b> (state dependencies with probabilities)  Multiple uncertainty approximations exist for Artificial Neural Networks (e.g., Monte Carlo Dropout).

## Aspects of AI

Learning describes the structured process of an AI gathering knowledge, while communicating thrives the AI's interaction with an environment

### Aspects of Artificial Intelligence (2/2)<sup>[1]</sup>

#### Learning

**Supervised** ( $\exists$  train- & test-set) vs. **unsupervised**

**Learning from examples:** linear/logistic regression, **neural networks**, SVMs, boosting, nonparametric models (e.g., k-NN), etc.

Learning can also take **knowledge** into account (remember the discussion on updating models)

**Reinforcement** learning lets agents discover an unknown environment through rewarding the outcome of their decisions

#### Communicating

**Natural Language Processing (NLP).** Text classification, semantic interpretation through machine translation, speech recognition

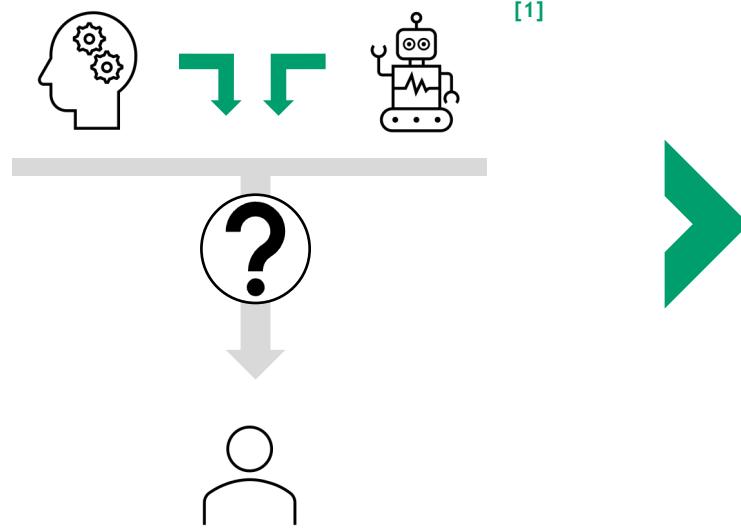
**Image processing** (geometric and physical aspects)  
- can be extended to process 3D image

**Robotics** utilize sensors to detect localization and recognize objects - decisions are done probabilistic based on knowledge

## Aspects of AI

Strong AI can act unmistakably humanly and weak AI can support certain tasks intelligently

### Strong and weak AI - the Turing test



#### Strong AI

Artificial Intelligence  
that can completely  
replace or mimic human  
behavior  
→ passes Turing test



[2]

#### Weak AI / Narrow AI

Artificial Intelligence  
that can execute certain  
tasks intelligently  
→ does not pass Turing test



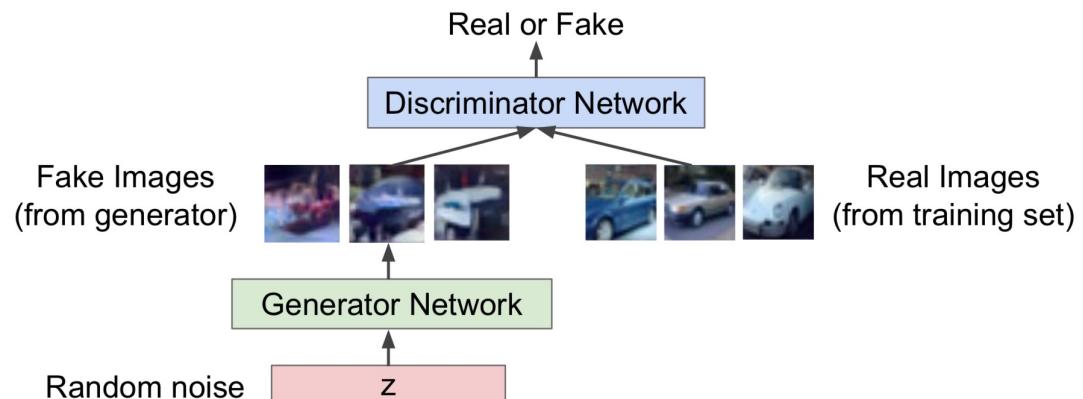
Turing (1948). Intelligent Machinery. [1]  
Kurzweil (2005). The singularity is near. Ethics and emerging technologies. [2]

## Aspects of AI

Generative Adversarial Nets is an AI concept that can be leveraged for creativity tasks

### Generative Adversarial Network (GAN) <sup>[1, 2]</sup>

- A generating network can create impressions which a discriminating network assesses
- The generating network is the creative part whilst the discriminating is the realistic one
- This means that two intelligent entities cooperate
- One scenario could be the training of truth and fakes

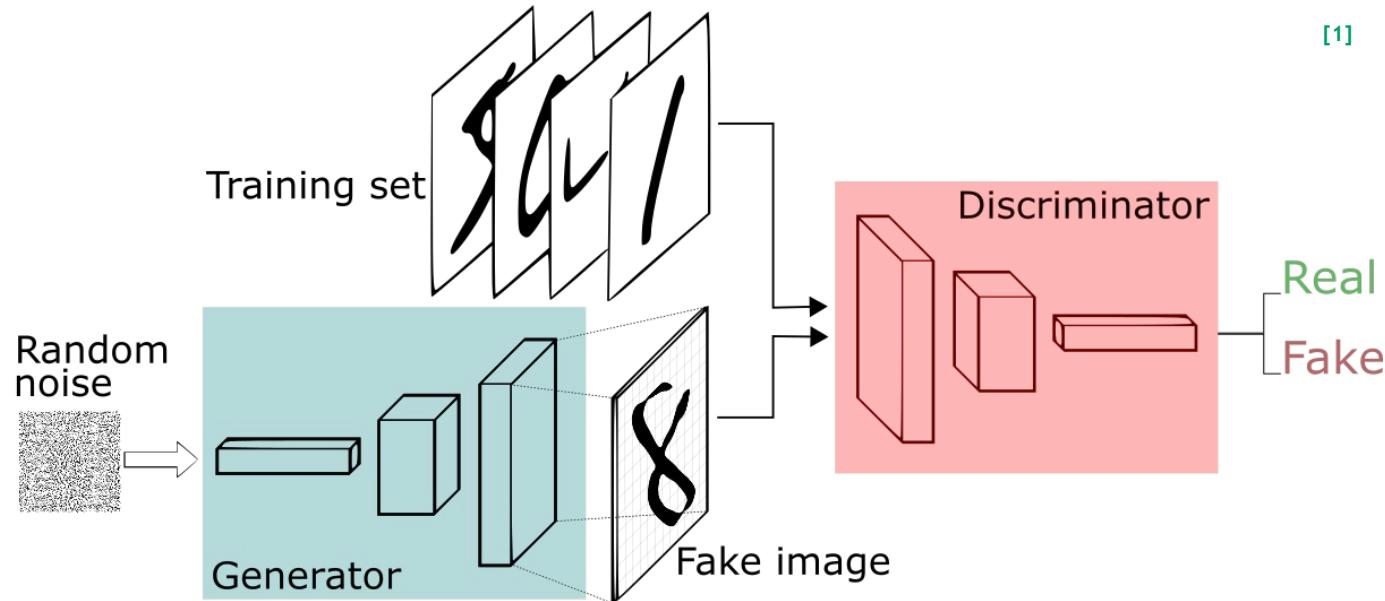


Zhang et al. (2018). Self-Attention Generative Adversarial Networks. Proceedings of the 36th International Conference on Machine Learning [1]  
Goodfellow et al. (2014). Generative Adversarial Nets. Advances in neural information processing systems. [2]

## Aspects of AI

Generative Adversarial Nets is an AI concept that can be leveraged for creativity tasks

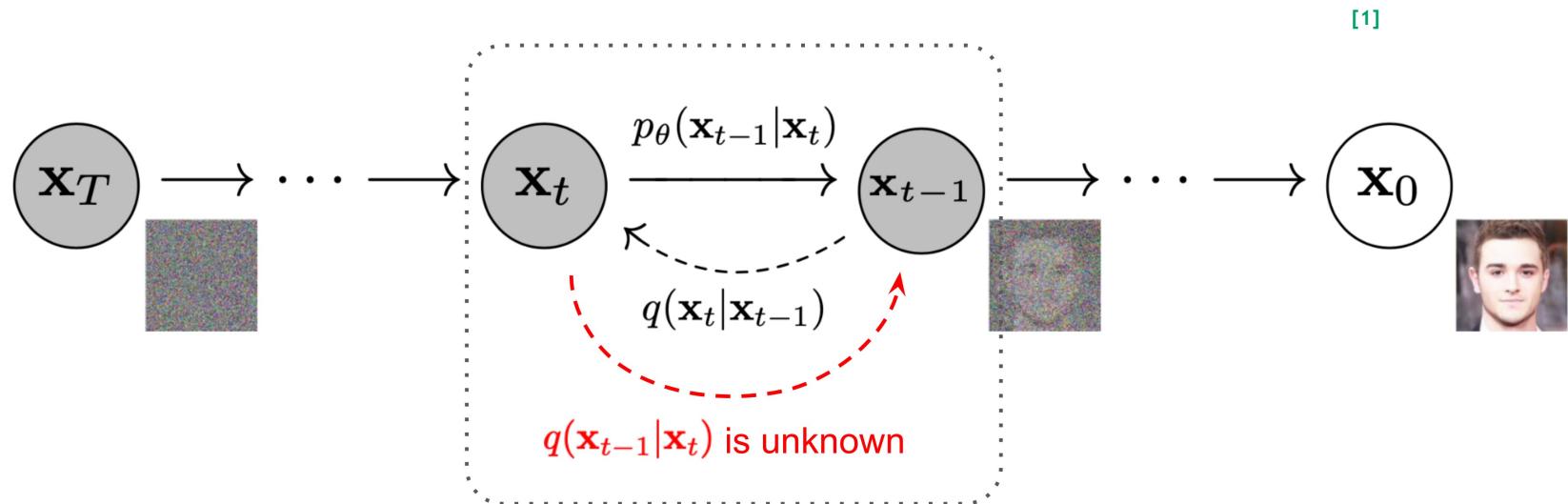
### Generative Adversarial Network



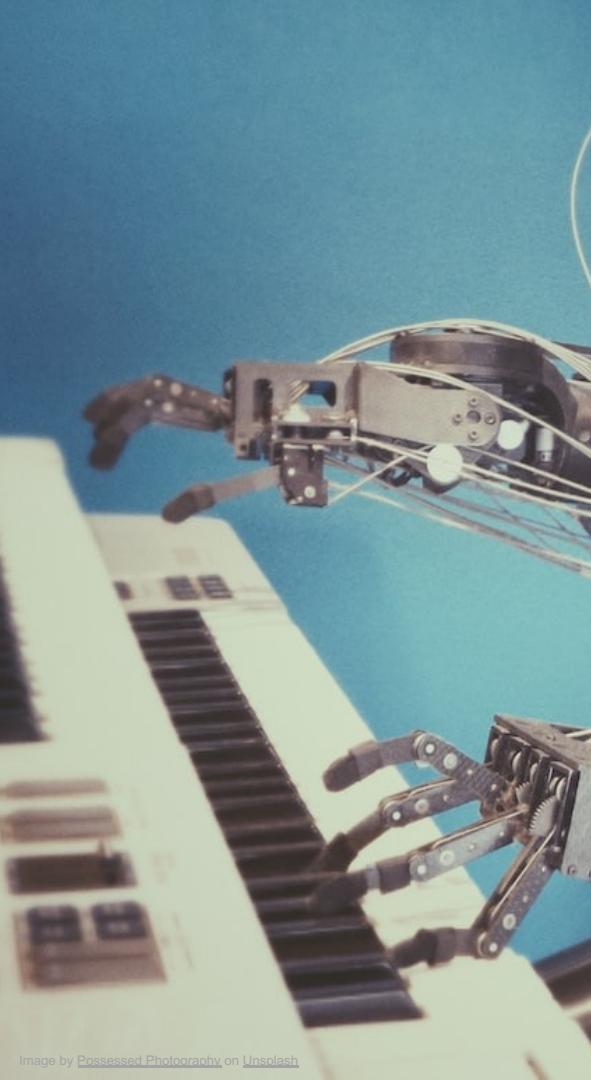
## Aspects of AI

Diffusion Models make use of gaussian noise

### Denoising Diffusion Probabilistic Models (DDPMs)



Ho et al. (2020). Denoising Diffusion Probabilistic Models. Advances in neural information processing systems. Advances in neural information processing systems. [1]



- 1 What is Creativity?
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- 3 Combination of AI and Creativity

# Combination of AI and Creativity

Computational creativity occurs in various forms.

## What does computational creativity mean?

“

The philosophy, science and engineering of computational systems which, by taking on particular *responsibilities*, exhibit behaviours that *unbiased* observers would deem to be creative.

S. Colton, W.A. Wiggins (2012) [1]

	GAMES [games, design, player]	VISUAL [image, painting, collage]	EVALUATION [evaluating creativity systems, participants]
lexical	LINGUISTIC [poems, story, words]	COMPUTATIONAL CREATIVITY	CONCEPTUAL [analogy, mapping, associations]
recipes	poetry	narrative	MUSICAL [music, improvisation, composition]
			conc. blending
			associations/ analogies

Colton and Wiggins (2012). Computational creativity: The final frontier?. ECAI.[1]  
Pollak et al. (2018). Computational Creativity in Slovenia. Informatica. [2]

# Combination of AI and Creativity

There is a discussion whether the creative process has to be taken into account to assess an artefact that was created by AI.

## How can computational creativity be assessed?

### 3 different approaches<sup>[1]</sup>

J. Koza

- Focus on the creative **process**, evaluating how well the system mimics human

G. Ritchie

- Ignore the process behind the artifact, look at the **output**
- Key properties: quality and novelty

S. Colton

- “The Creativity Tripod”

- 
- Skill
  - Imagination
  - Appreciation of the creative medium

## Combination of AI and Creativity

In the following there are examples presented of how AI and creativity interact

### Example 1 - The next Rembrandt

[1]

- Gathering information from existing Rembrandt paintings
- Creating a new painting based on the learned features



ING Group (2021) ([Image](#)) [1]

# Combination of AI and Creativity

In the following there are examples presented of how AI and creativity interact

## Example 1 - The next Rembrandt

Gathering data

To distill the artistic DNA of Rembrandt, an extensive database of his paintings was built and analyzed, pixel by pixel

Determining the subject

Data from Rembrandt's body of work showed the way to the subject of the new painting

Generating the features

A software system including facial recognition algorithms was designed to understand Rembrandt's style and generate new features

Bring it to life

Once the 2D image was complete, a height map was created to mimic the brushstrokes used by Rembrandt



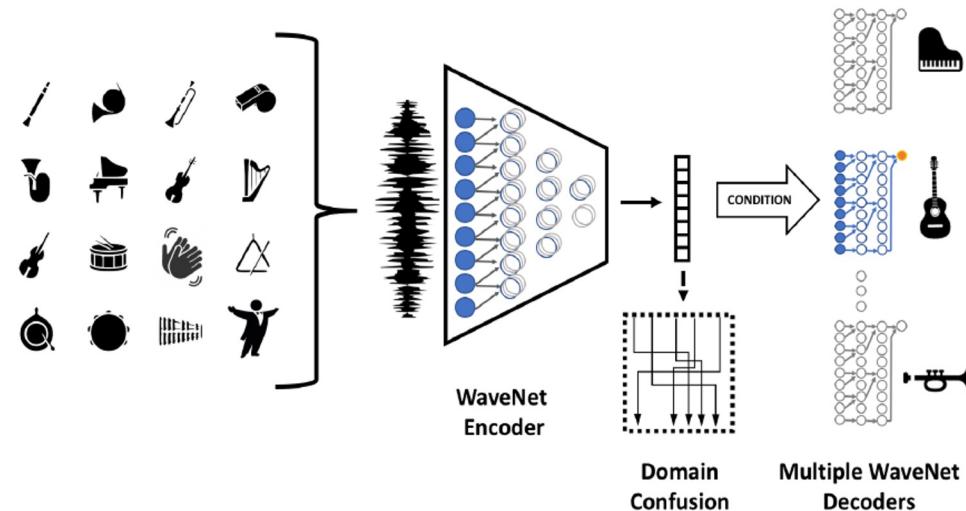
Source: ING Group (2021) (Video) [1]

# Combination of AI and Creativity

In the following there are examples presented of how AI and creativity interact

## Example 2 - Universal Music Translation Network <sup>[1]</sup>

- Music passed into a learning machine that extracts the style of music as well as rhythmic or harmonic specialties
- After that a new style can be applied to a specific rhythm (e.g., Haydn can sound like Mozart)

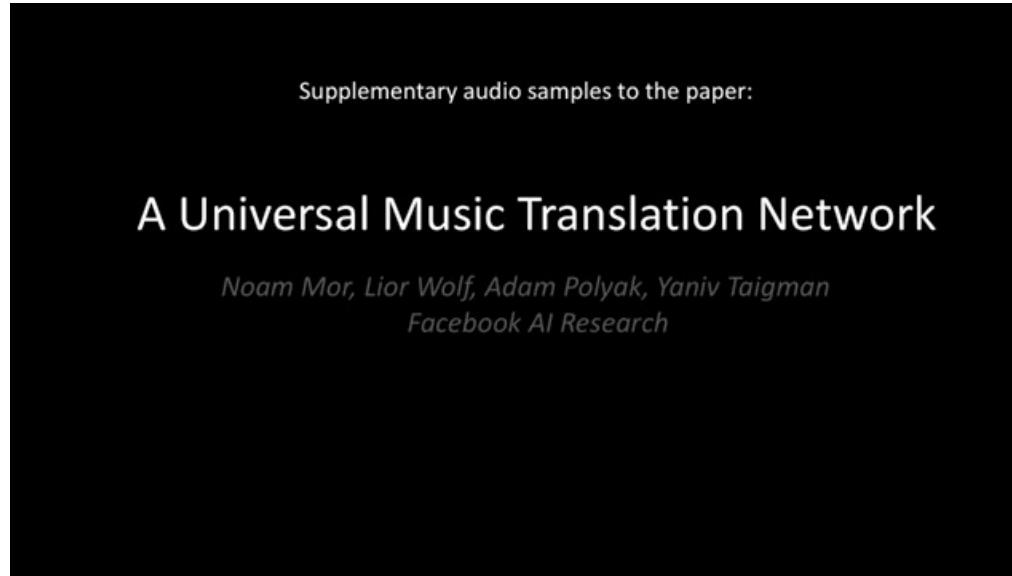


Mor et al. (2018). A Universal Music Translation Network. International Conference on Learning Representations. ([Video](#)) [1]

## Combination of AI and Creativity

In the following there are examples presented of how AI and creativity interact

### Example 2 - Universal Music Translation Network (2018)<sup>[1]</sup>



Mor et al. (2018). A Universal Music Translation Network. International Conference on Learning Representations. ([Video](#)) [1]

## Combination of AI and Creativity

In the following there are examples presented of how AI and creativity interact

### Example 3 - GETMusic (2023) <sup>[1]</sup>



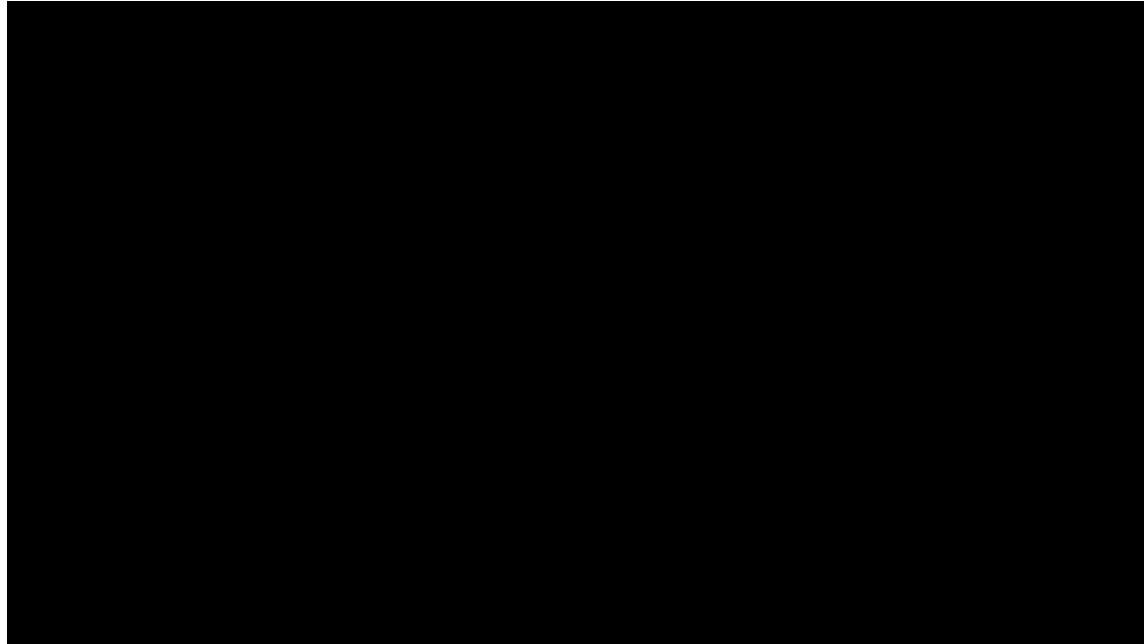
Generating all tracks  
from scratch 2

Lv et al. (2023) GETMusic: Generating Music Tracks with a Unified Representation and Diffusion Framework. Arxiv. ([Video](#)) [1]

## Combination of AI and Creativity

With Google AI duets a user is enabled to play music in a duet with the computer

### Example 4 - Google AI duets <sup>[1]</sup>



There are more  
[AI Experiments at Google](#)

[Google AI Experiments](#) | [Video](#) [1]

# Combination of AI and Creativity

## Creating your own music with generative AI

### Example 5 - Suno AI <sup>[1]</sup>

The screenshot shows the Suno AI web interface. On the left, there's a sidebar with navigation links: Home, Create, Library, Explore, and Search. Below these are sections for Credits (40 Credits), Subscribe, and a 'What's New?' section with 20 items. The main workspace has two tabs: 'Lyrics' (selected) and 'Instrumental'. In the 'Lyrics' tab, there's a text input field with placeholder text: 'Enter your own lyrics or describe a song and click Write About...'. Below it is a 'Surprise Me' button and a character count indicator (0 / 1250). Underneath is a 'Style of Music' section with a text input field for 'Enter style of music' and a list of genres: acoustic guitar, grunge, lo-fi, dreamy. A character count indicator (0 / 120) is shown next to the list. The 'Create' button is at the bottom of this section. To the right of the workspace, a dark panel displays a generated song preview titled 'City Lights'. It includes the genre 'electronic, drum and bass, psychedelic', the creator 'AbstractPreludes7142', and the date '1 October 2024 at 11:49'. The lyrics are presented in three parts: [Verse 1], [Verse 2], and [Chorus]. The [Verse 1] lyrics are:

[Verse 1]  
City lights they shine so bright  
In the dark they feel like day  
Neon signs and crowded night  
A symphony in shades of gray

The [Verse 2] lyrics are:

[Verse 2]  
Cars are rushing down the street  
People laughing in the heat  
Music plays a steady beat  
Where the light and people meet

The [Chorus] lyrics are:

[Chorus]  
City lights keep calling me  
In the shadows I feel free  
Dancing through the urban sea  
In the night we find our key

The [Verse 3] lyrics are:

[Verse 3]  
Buildings reaching for the sky  
Dreams are painting every line  
In the hustle we can fly  
Our stories merge and intertwine

The [Bridge] lyrics are:

[Bridge]  
Find a moment in the rush  
In the noise a gentle hush



[Suno AI](#) [1]

# Combination of AI and Creativity

Transferring the style of a Van Gogh image to another raw image using Convolutional Nets to support content representations

Example 6 - Another painting example <sup>[1]</sup>

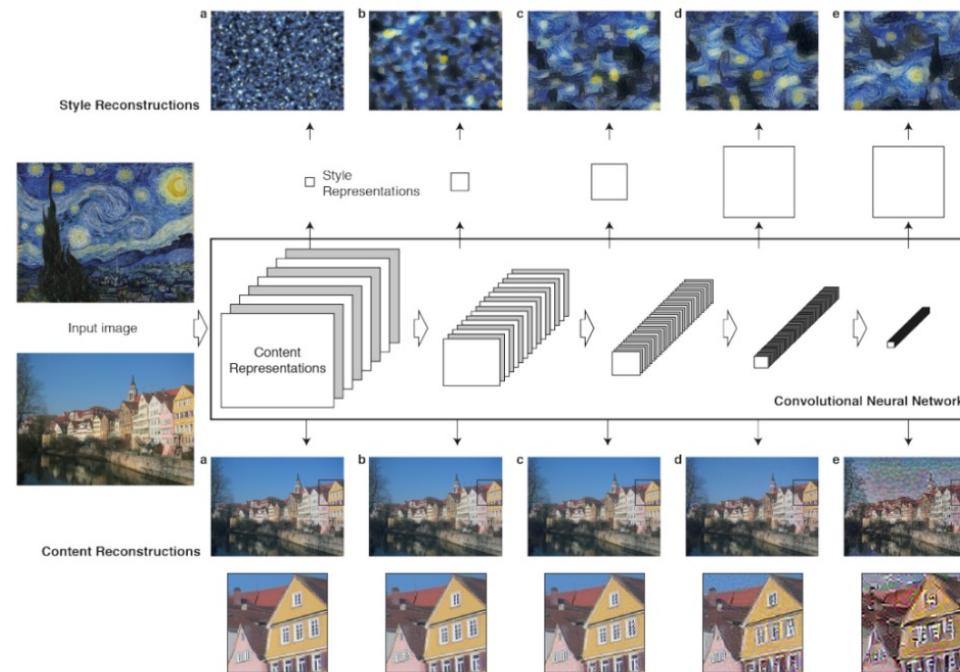


Gatys et al. (2015). A Neural Algorithm of Artistic Style. Journal of Vision [1]

# Combination of AI and Creativity

Transferring the style of a Van Gogh image to another raw image using Convolutional Nets to support content representations

## Example 6 - Another painting example [1]



Gatys et al. (2015). A Neural Algorithm of Artistic Style. Journal of Vision [1]

## Combination of AI and Creativity

Transferring the style of a Van Gogh image to another raw image using Convolutional Nets to support content representations

### Example 6 - Another painting example <sup>[1]</sup>



Xu et al. (2017), AttnGAN: Fine-Grained Text to Image Generation with Attentional Generative Adversarial Networks. Proceedings of the IEEE conference on computer vision and pattern recognition. [1]

# Combination of AI and Creativity

A Generative Adversarial Network is combined with a text classifier to create detailed images from a text description

## Example 7 - Creating images from text with GANs <sup>[1]</sup>

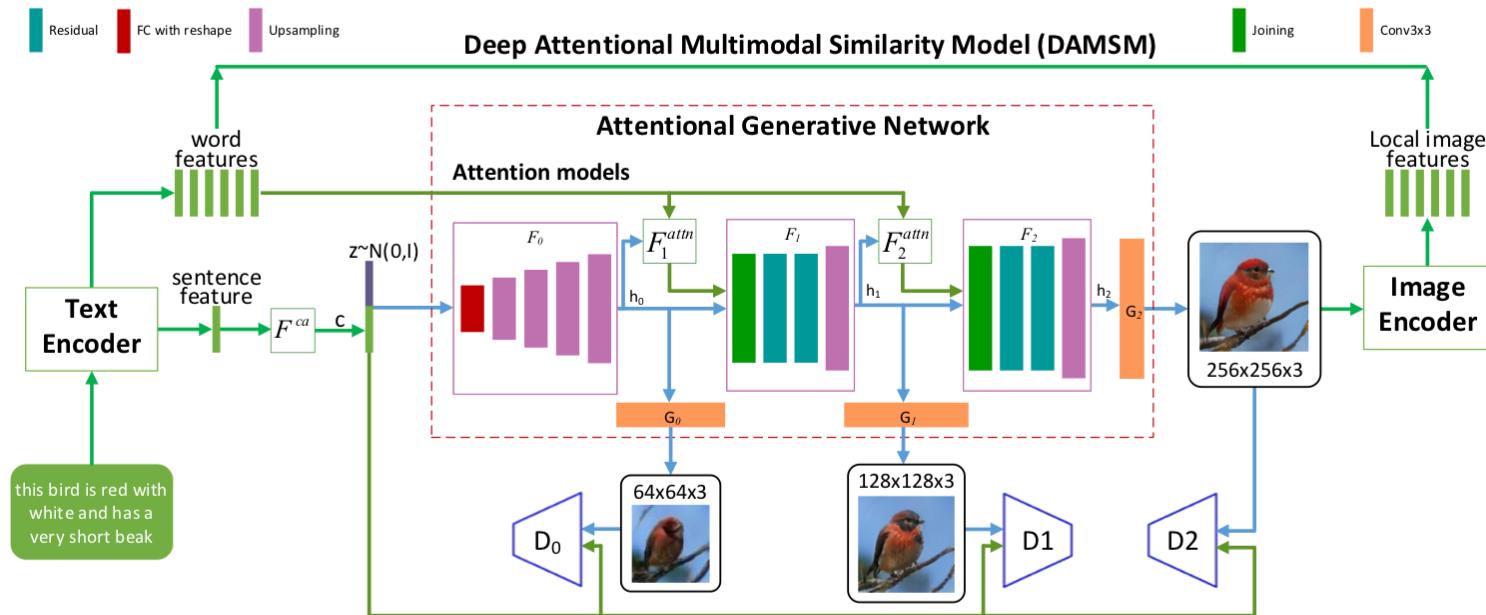


- At first the **text** is encoded to retrieve information from it with the help of a semantic vector of text descriptions
- Then an **image is created** utilizing already learned image details with a Convolutional Neural Network to map the image to the semantic vector
- In the last step the generated image is rated with an **image-text matching score**

# Combination of AI and Creativity

A Generative Adversarial Network is combined with a text classifier to create detailed images from a text description

## Example 7 - Creating images from text with GANs <sup>[1]</sup>



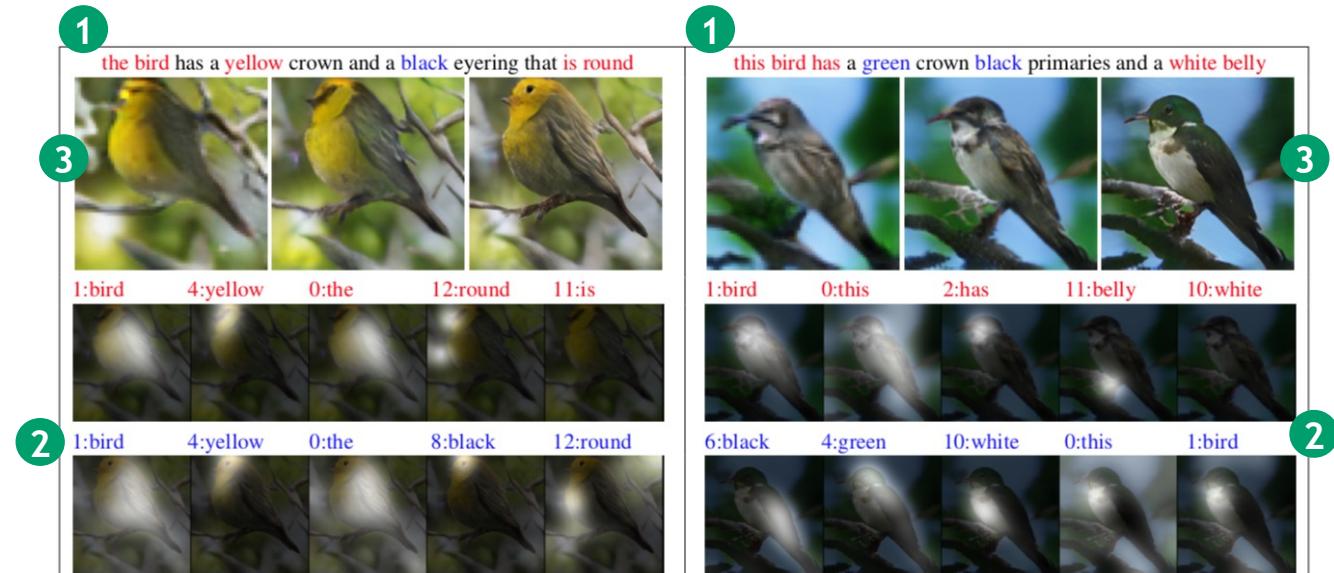
Xu et al. (2017), AttnGAN: Fine-Grained Text to Image Generation with Attentional Generative Adversarial Networks. Proceedings of the IEEE conference on computer vision and pattern recognition. [1]

# Combination of AI and Creativity

A Generative Adversarial Network is combined with a text classifier to create detailed images from a text description

## Example 7 - Creating images from text with GANs<sup>[1]</sup>

Here again, birds are created from a  
1 description with the  
feature representation  
below and the result  
above 2 3

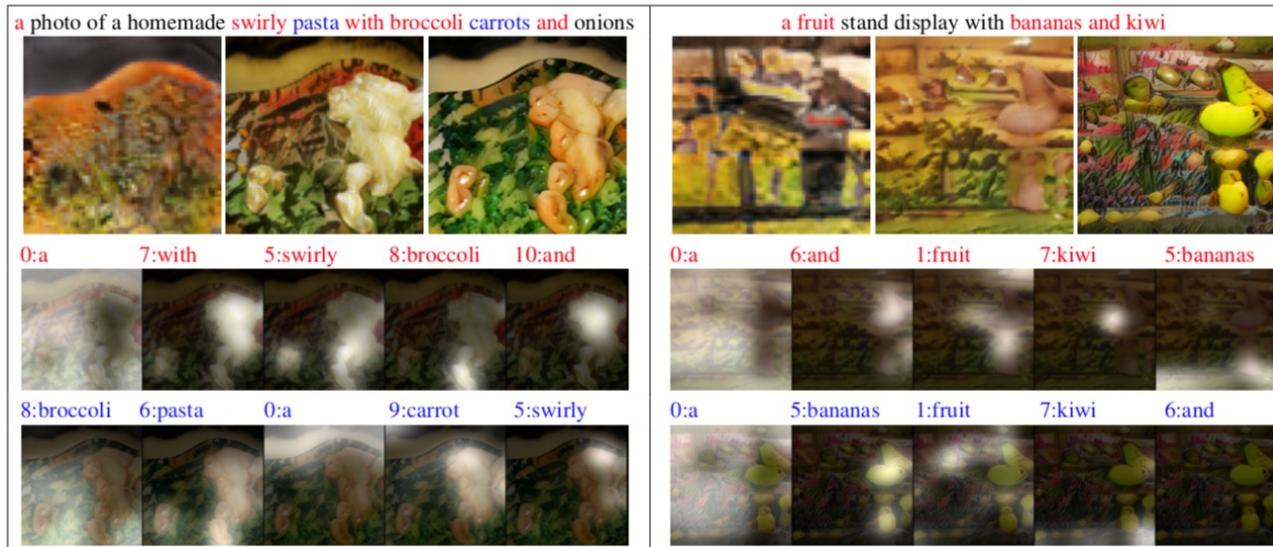


# Combination of AI and Creativity

A Generative Adversarial Network is combined with a text classifier to create detailed images from a text description

## Example 7 - Creating images from text with GANs <sup>[1]</sup>

It's working not only for birds...



Xu et al. (2017), AttnGAN: Fine-Grained Text to Image Generation with Attentional Generative Adversarial Networks. Proceedings of the IEEE conference on computer vision and pattern recognition. [1]

# Combination of AI and Creativity

By combining GANs with interpolation with transfer learning,  
pictures can be transformed entirely

## Example 8 - Photo editing: Style changes with GANs<sup>[1]</sup>



Figure 2: Schematic of the "layer swapping" interpolation scheme described in Section 2. Each block represents a resolution level in StyleGAN, the final interpolated model is composed of blocks taken from each of the input models depending on the resolution (not all blocks are shown for brevity).

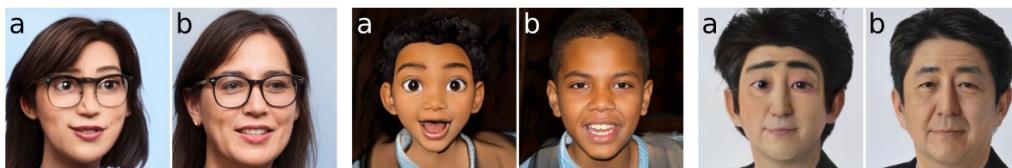
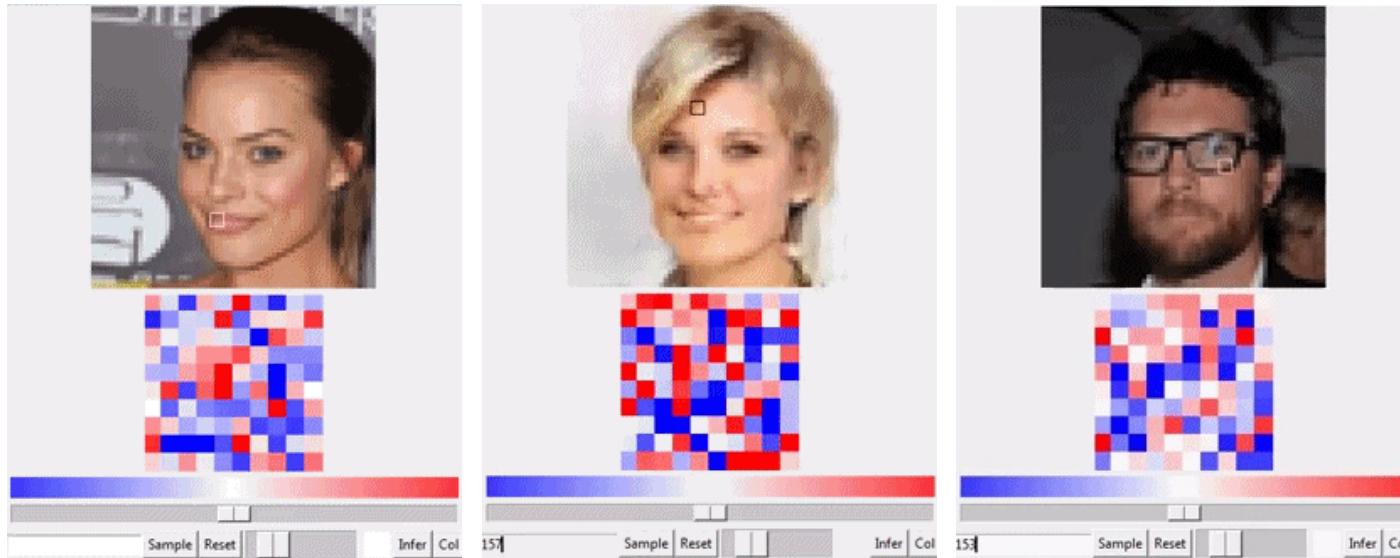


Figure 3: The interpolated model (a) produces images with the structural characteristics of a cartoon, but with photo-realistic rendering. When comparing the same latent vector input to the original FFHQ model (b) the identity appears largely preserved thus the interpolated model gives a "cartoonification" effect. The right most pair shows a result after encoding an image of Shinzo Abe.

## Combination of AI and Creativity

By training GANs to have the ability of generating close-to-reality faces, they can also be edited...

Example 8 - Photo editing: Adjusting facial features with GANs<sup>[1]</sup>

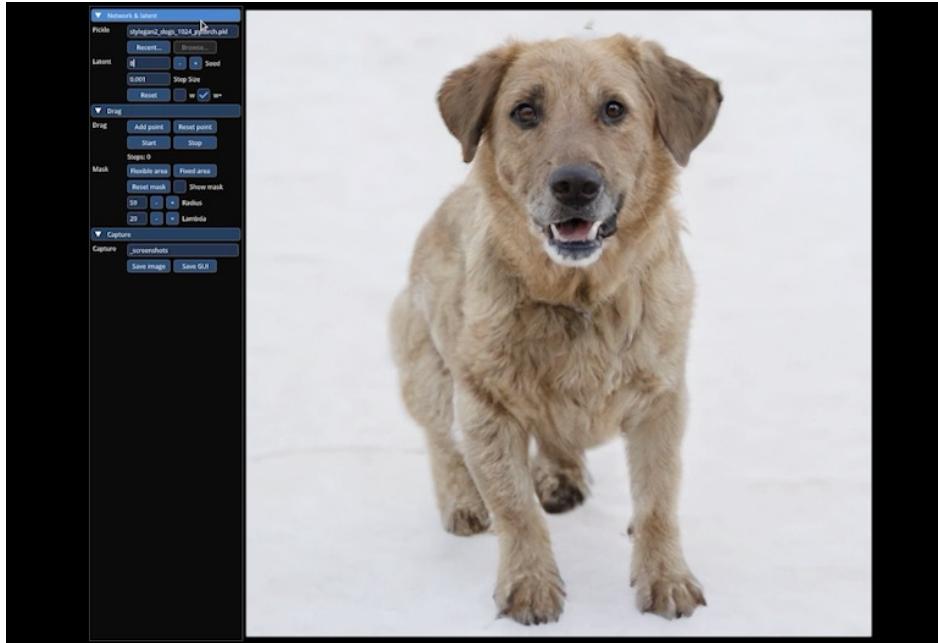


Brock et al. (2017), Neural Photo Editing with Introspective Adversarial Networks. International Conference on Learning Representations. ([Video](#)) [1]

# Combination of AI and Creativity

By training GANs to have the ability of generating close-to-reality faces, they can also be edited...

## Example 8 - Photo editing: Adjusting images with GANs<sup>[1]</sup>



Pan et al. (2023), Drag Your GAN: Interactive Point-based Manipulation on the Generative Image Manifold. ACM SIGGRAPH 2023 Conference Proceedings. ([Video](#)) [1]

**Combination of AI and Creativity**  
.... or completely generated from scratch.

**Example 9 - Generating faces artificially with GANs** <sup>[1]</sup>



<https://thispersondoesnotexist.com/>, based on Keras et al (2020). Analyzing and Improving the Image Quality of StyleGAN. Proceedings of the IEEE/CVF conference on computer vision and pattern recognition [1]

# Combination of AI and Creativity

Novel tools like DALL-E & Midjourney perfect these applications

Example 10 - Generating entire images based on text artificially with Diffusion Models



[1]



[2]

Dall-E

Midjourney

Karmaker (2022), [The Business Standard](#) [1]  
TBS Report (2023), [The Business Standard](#) [2]

## Combination of AI and Creativity

...and application within “Deep Fakes” might have troubling implications.

Example 11 - Generating entire videos based on text artificially with Diffusion Models <sup>[1]</sup>



BRIANMONARCH ([Video](#)) [1]

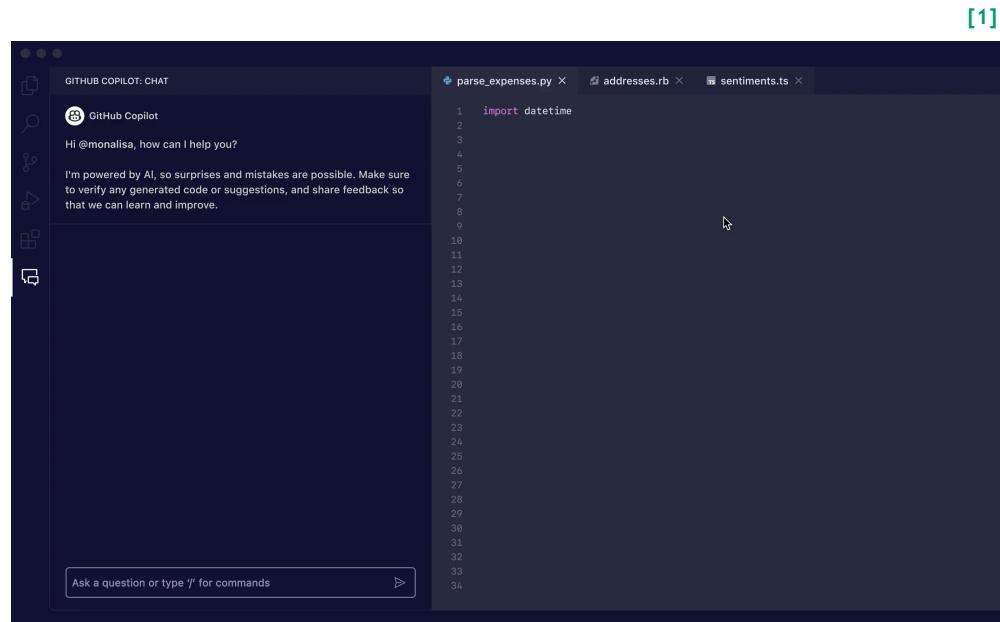
# Combination of AI and Creativity

What can we observe across these examples?

- In the past, AI was mostly used to become *more efficient*.
- Now, we see more and more examples where AI can *inspire*, e.g.
  - [Notion AI](#)
  - [Github Copilot](#)
  - ...

## What can Notion AI do?

- Let it tackle that first draft — Ask Notion AI to handle your first draft about a topic and get ideas that you can mold into something great.
- Spur ideas and creativity — Notion AI can instantly give you a list of ideas about anything, surfacing ideas as a jumping-off point for your own creativity.
- Act as a hawk-eyed editor — Whether it's spelling, grammar, or even translation, Notion AI catches mistakes and even translates whole posts.
- Summarize meetings and documents — Instead of sifting through a garble of notes, let Notion AI pull out the most important points and action items.

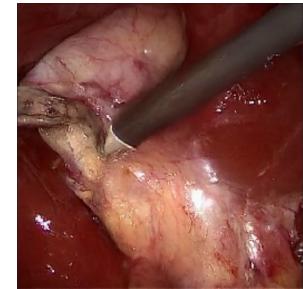
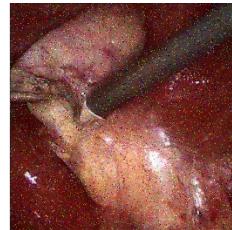


The screenshot shows a dark-themed GitHub Copilot interface. On the left, there's a sidebar with icons for file navigation and search. The main area has a header 'GITHUB COPILOT: CHAT' and a profile icon for 'GitHub Copilot'. Below that, a message says 'Hi @monalisa, how can I help you?'. A note below it reads: 'I'm powered by AI, so surprises and mistakes are possible. Make sure to verify any generated code or suggestions, and share feedback so that we can learn and improve.' At the bottom, there's a text input field with the placeholder 'Ask a question or type "j" for commands' and a send button. To the right of the chat window, there are three tabs: 'parse\_expenses.py', 'addresses.rb', and 'sentiments.ts'. The 'parse\_expenses.py' tab is active, showing a code snippet with line numbers from 1 to 34. The code starts with 'import datetime'. The status bar at the bottom right shows '[1]'.

# Examples from our Research

Can Generative AI be a valuable assistant in surgical training?

*"grasper retract  
gallbladder  
and hook dissect  
cystic duct"*



*"hook dissect  
cystic artery"*



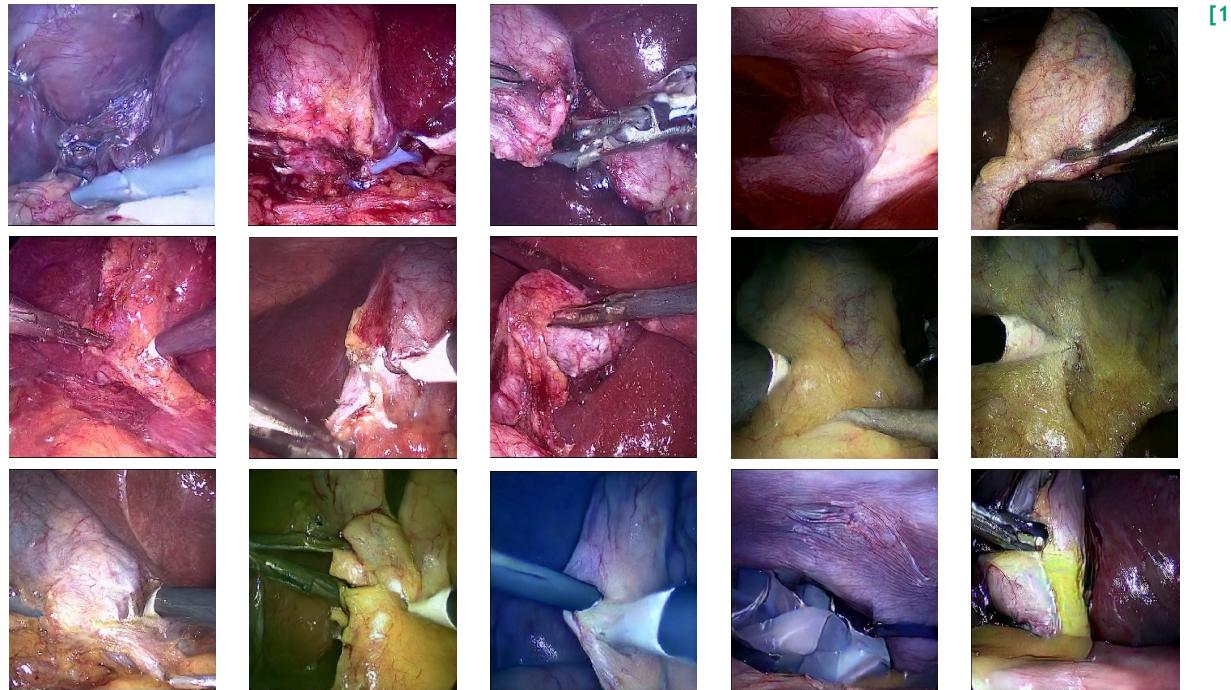
**Text Conditioning**



**Synthetic Image**

# Examples from our Research

Can Generative AI be a valuable assistant in surgical training?



## Examples from our Research

Can Generative AI be a valuable assistant in surgical training?

Condition surgical videos solely by text and surgical tool position...



10 tool positions



10 tool positions

# Discussion

How “creative“ is AI actually?

... in generating “art”?

... in judging “art”?

... in being innovative?