Australian National University

Generating Art using evolutionary algorithms and artificial AI

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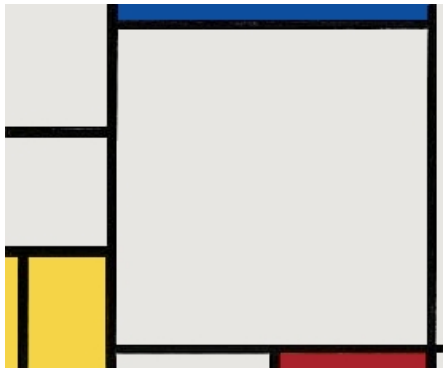
HCC **Human Centred Computing**

Piet Mondrian



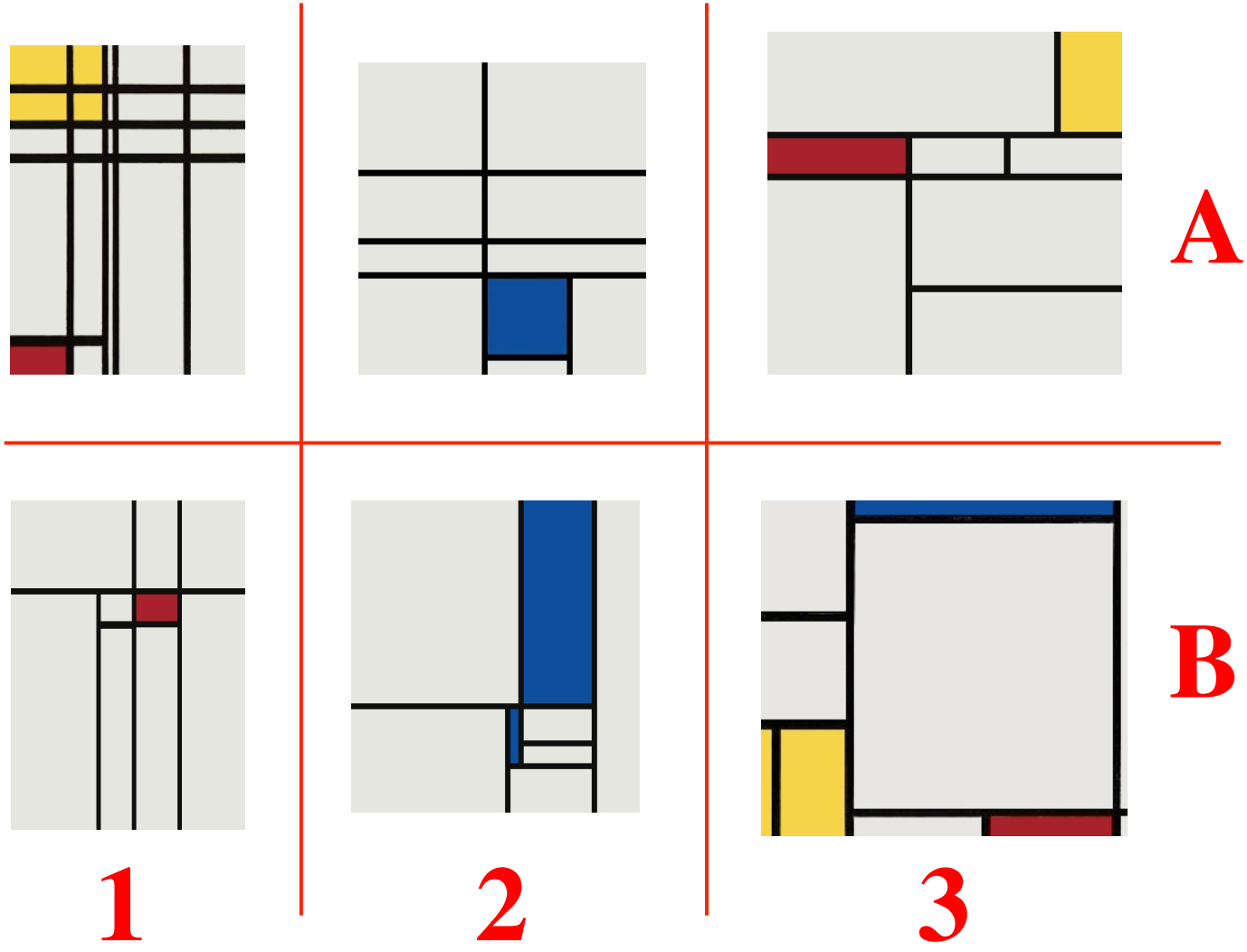
- b. 1872 Netherlands, d. 1944 New York
- Contributor to the De Stijl art movement
- Attempts at mathematical analysis of his compositions
  - E.g. some of Mondrian's compositions are triple connected, in that you can not separate the graph into two without cutting at least three lines. This applies to about half of Mondrian's work in the period 1918 – 1938

Art from artists? Mondrian's role

- Mondrian's work appears to be simple compositions
- Lee (2001): art students could not identify genuine Mondrian compositions
- But McManus (et al, 1993) found majority of subjects could distinguish between original and modified
- Wolach (2005) found subjects preferred Mondrian's line spacings
- BUT if they could chose own preference, then the preference for Mondrian spacings vanish
- => individual aesthetics?

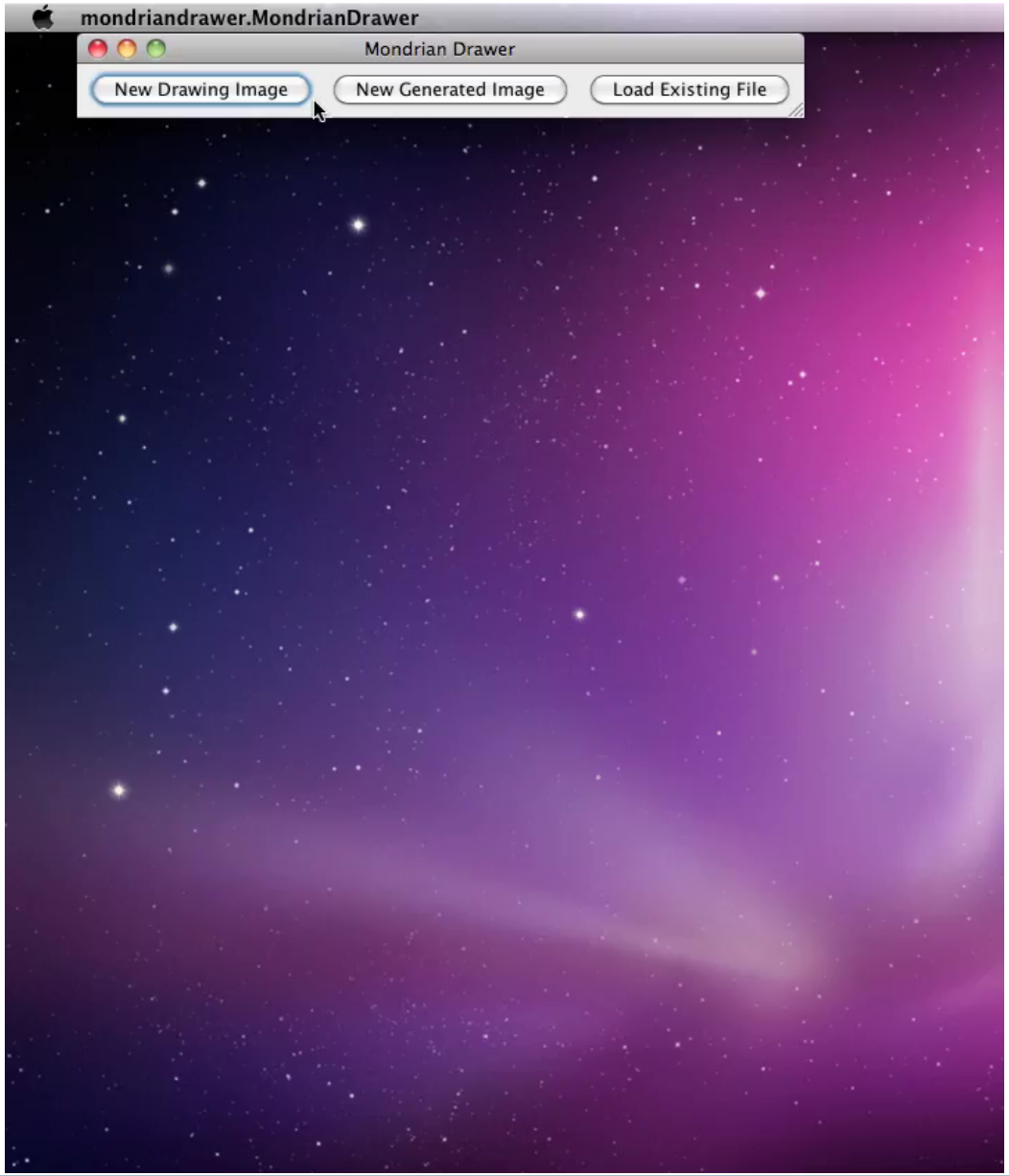
Which are really by Mondrian?

(OR, pick three which match some-how)



Drawing Mondrians

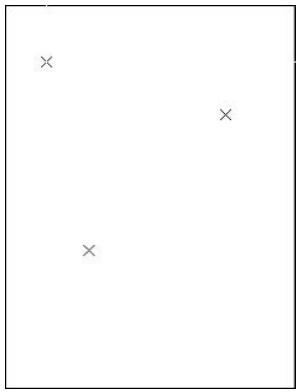
- Program can only draw valid images in Mondrian's style
- Clearly, I am the artist
  - But not very good at making nice images!



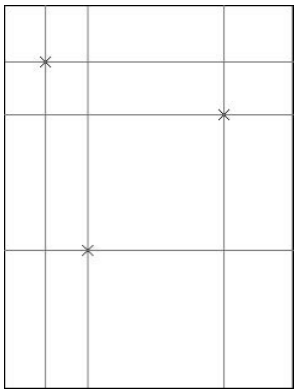
Constructing Mondrian-like images

1. Random initial points
2. Imaginary lines
3. Some imaginary lines selected
4. Skeleton filled in
5. Colour(s) added

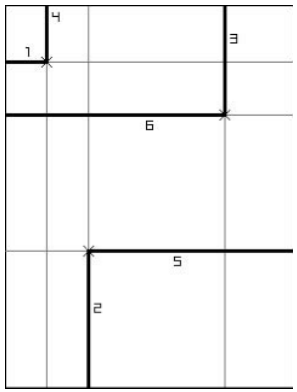
1.



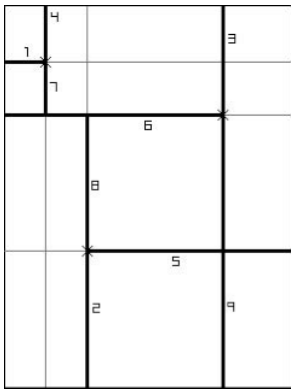
2.



3.



4.

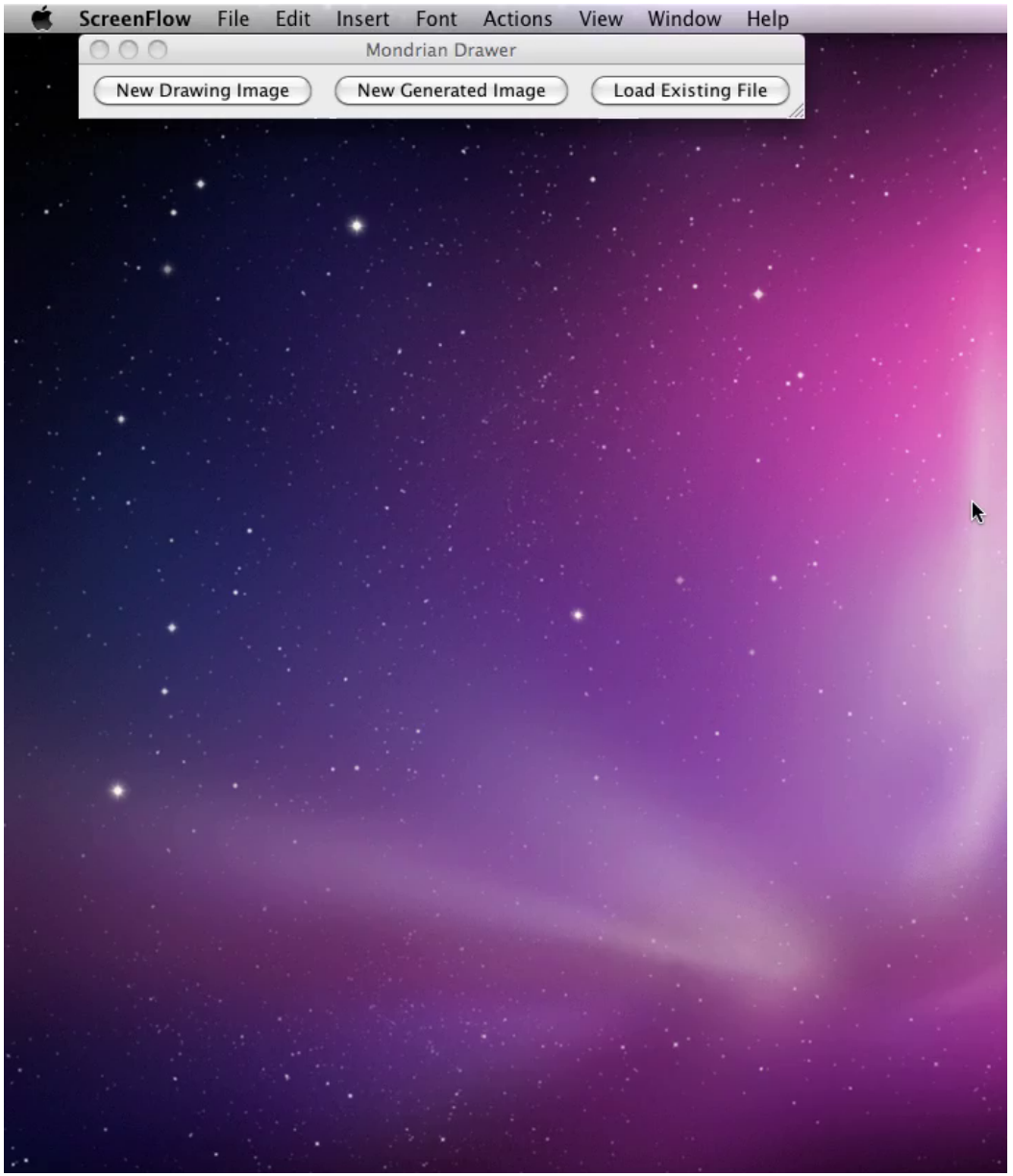


3. Some imaginary lines selected

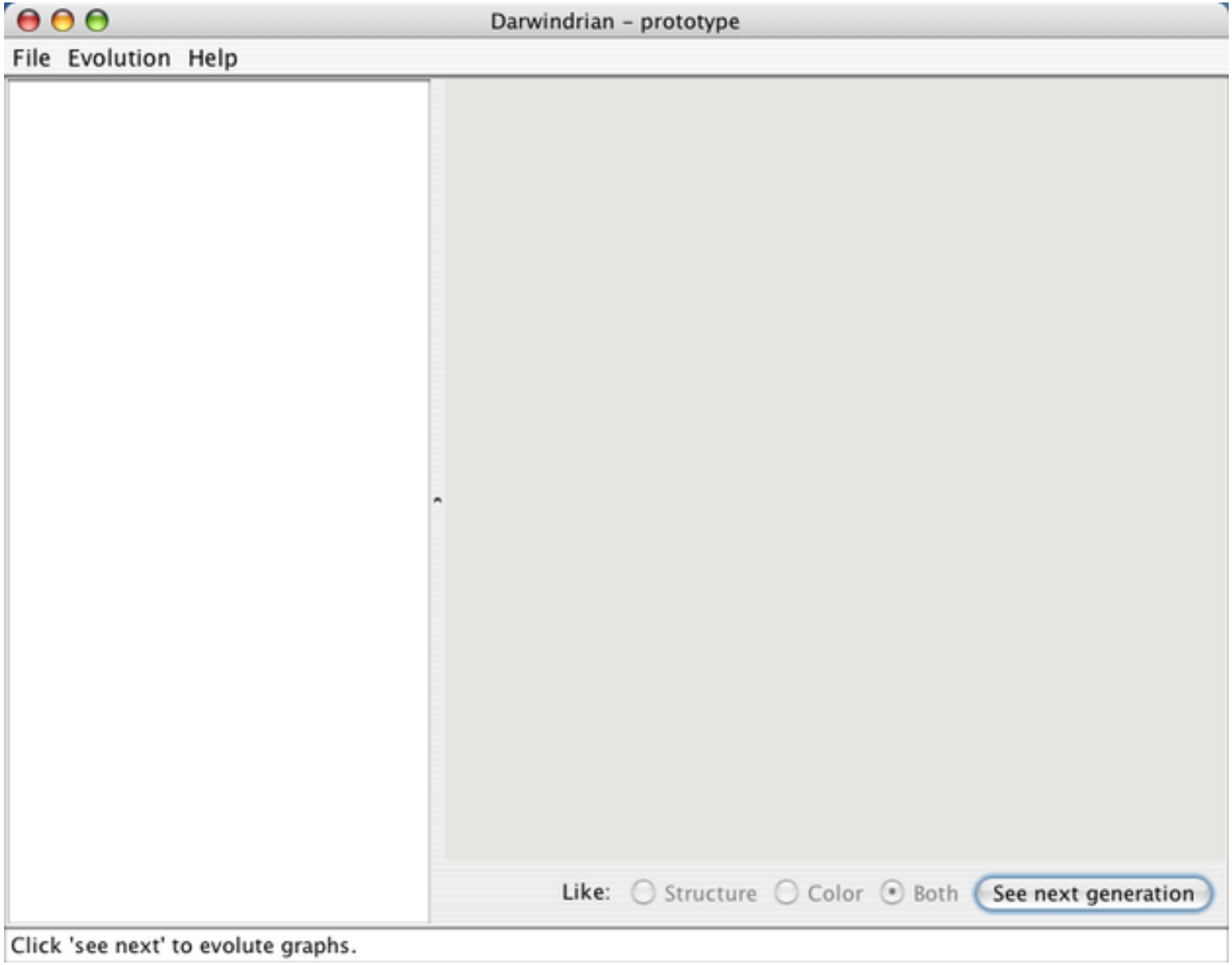
- Probabilistic! Each point has a probability that a new line will be added:
  - *initial point ≒ 100%:* a point without any lines
  - *right angle point ≒ 100%:* not allowed and must be eliminated by adding a line
  - *online point ≒ 30%*
  - *terminal point ≒ 90%:* a terminal point is rare, but does exist in Mondrian's works. So high probability that a terminal point will be eliminated
  - *cross point ≒ 0%:* already has enough lines (4)
  - *nodal point* ≒ 20%: has 3 lines already

Generating Mondrians

- Program can only generate valid Mondrians
- Clearly, I am a bit less the artist
  - I'm only chosing the image I like
  - Then I 'improve' it slightly
    - I'm still not so good at creating art!



Automatically – guided



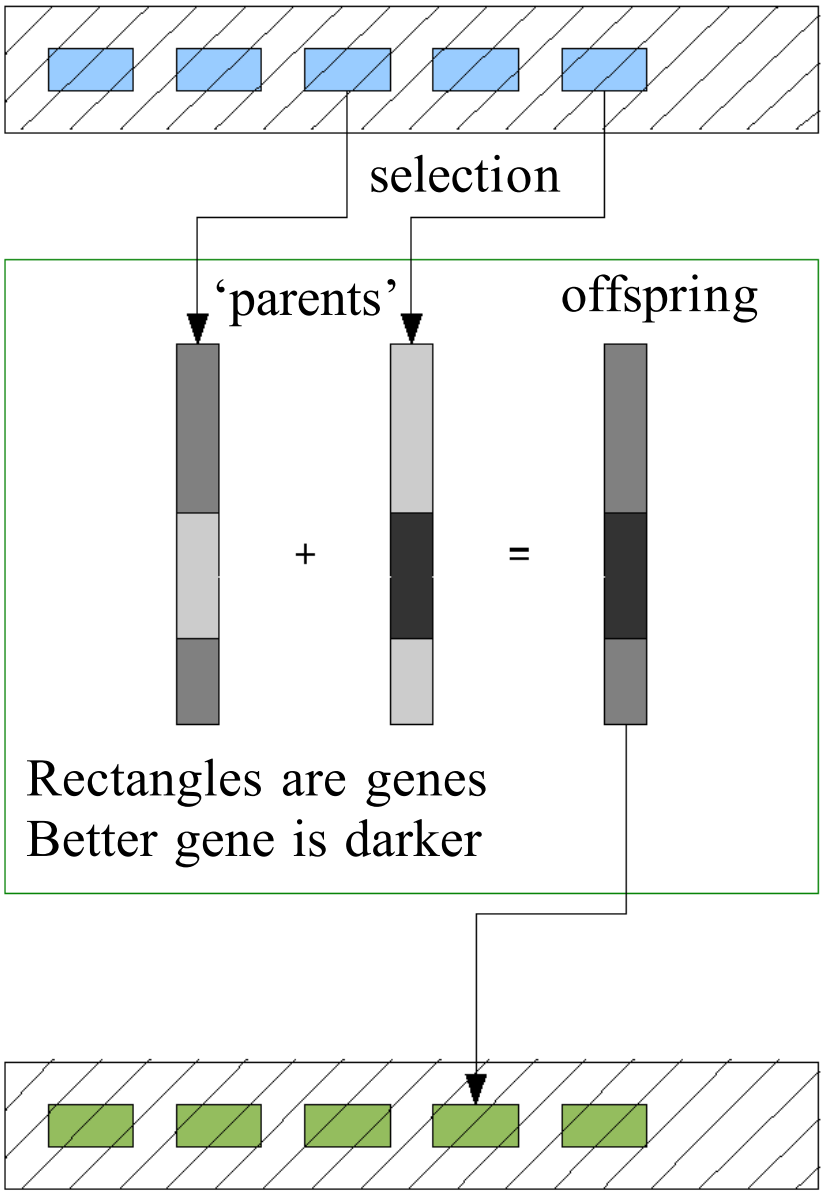
Generating Art / Artificial AI

- Evolutionary: make random changes to parts of solution, recombine parts, good parts collect together ⇒ improve over time
- AI = replace some behaviour of person;
- artificial AI = replace some computer (decision) behaviour by a person ☺
- We use a person to evaluate generated art.

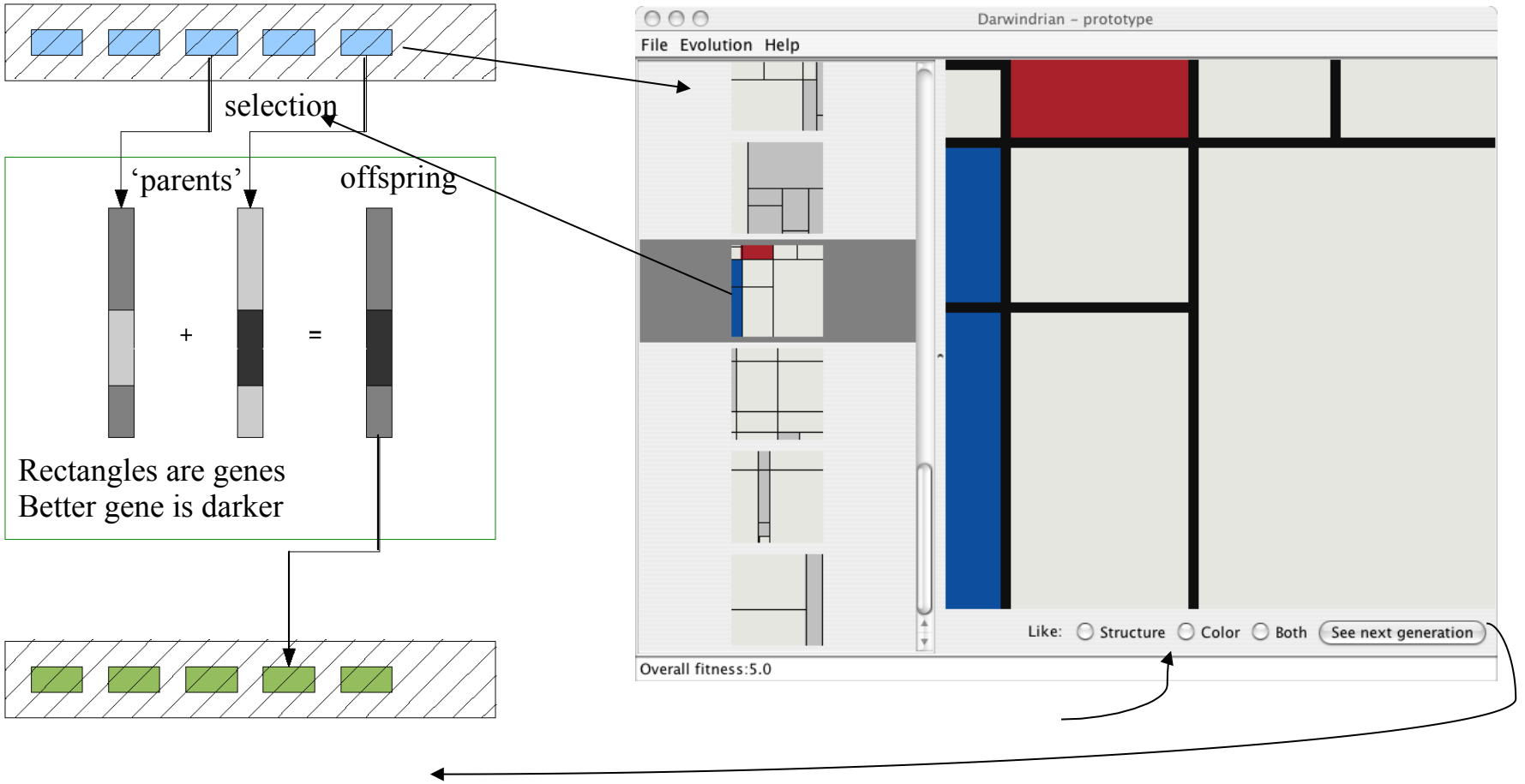
- Where is the creativity? Human or computer? (Does it matter?)

Evolutionary Algorithms

- are programs which solve ‘problems’ by simulating Darwinian selection among solutions
- Individuals are assessed for fitness and create ‘offspring’
- Over time, accumulate good components: better solutions
- Randomness in creating images = minor creativity (or at least an illusion of it)

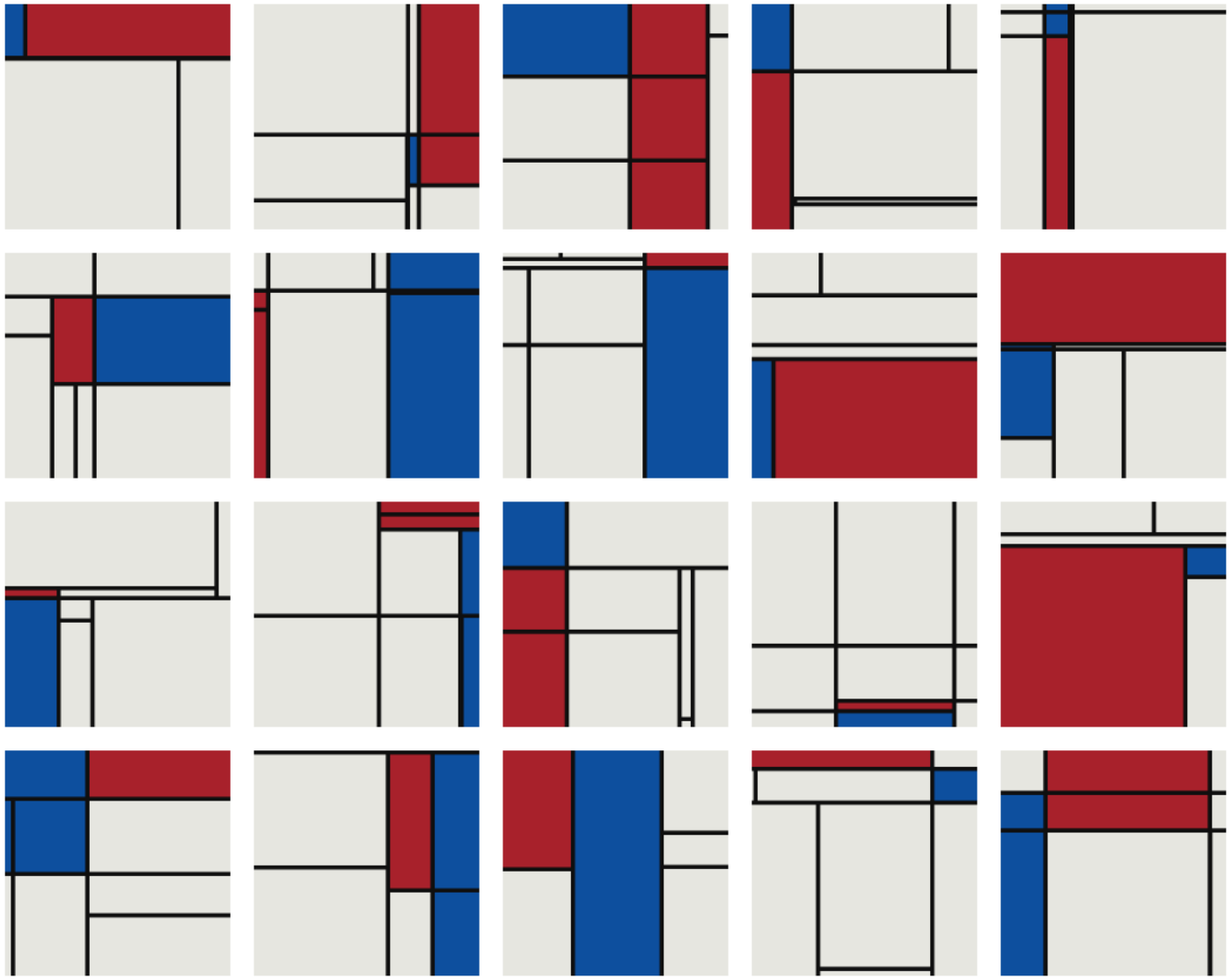


User interface & process



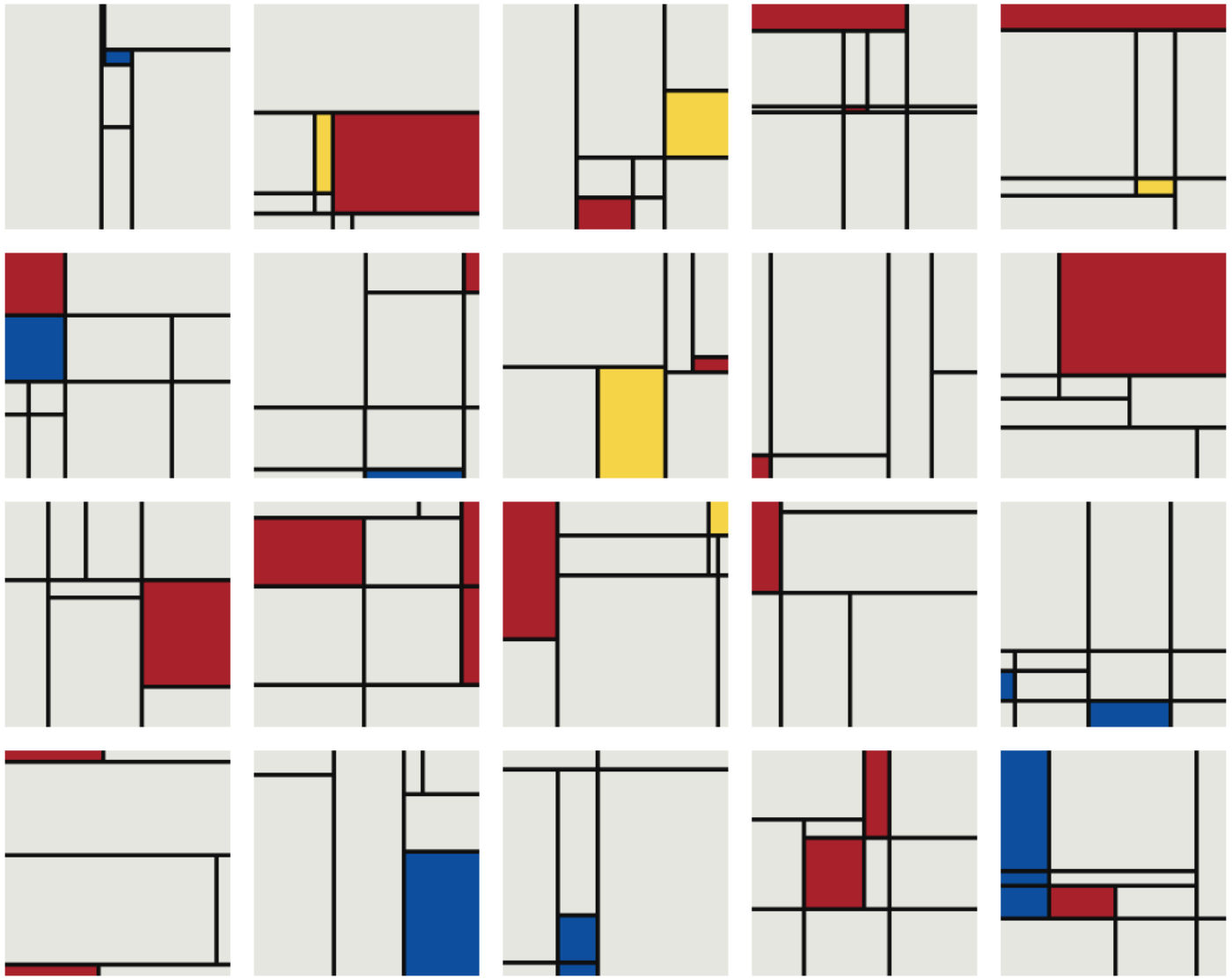
Results – subject Z

- 20 from 2000
- Red + Blue
- Mostly along edge



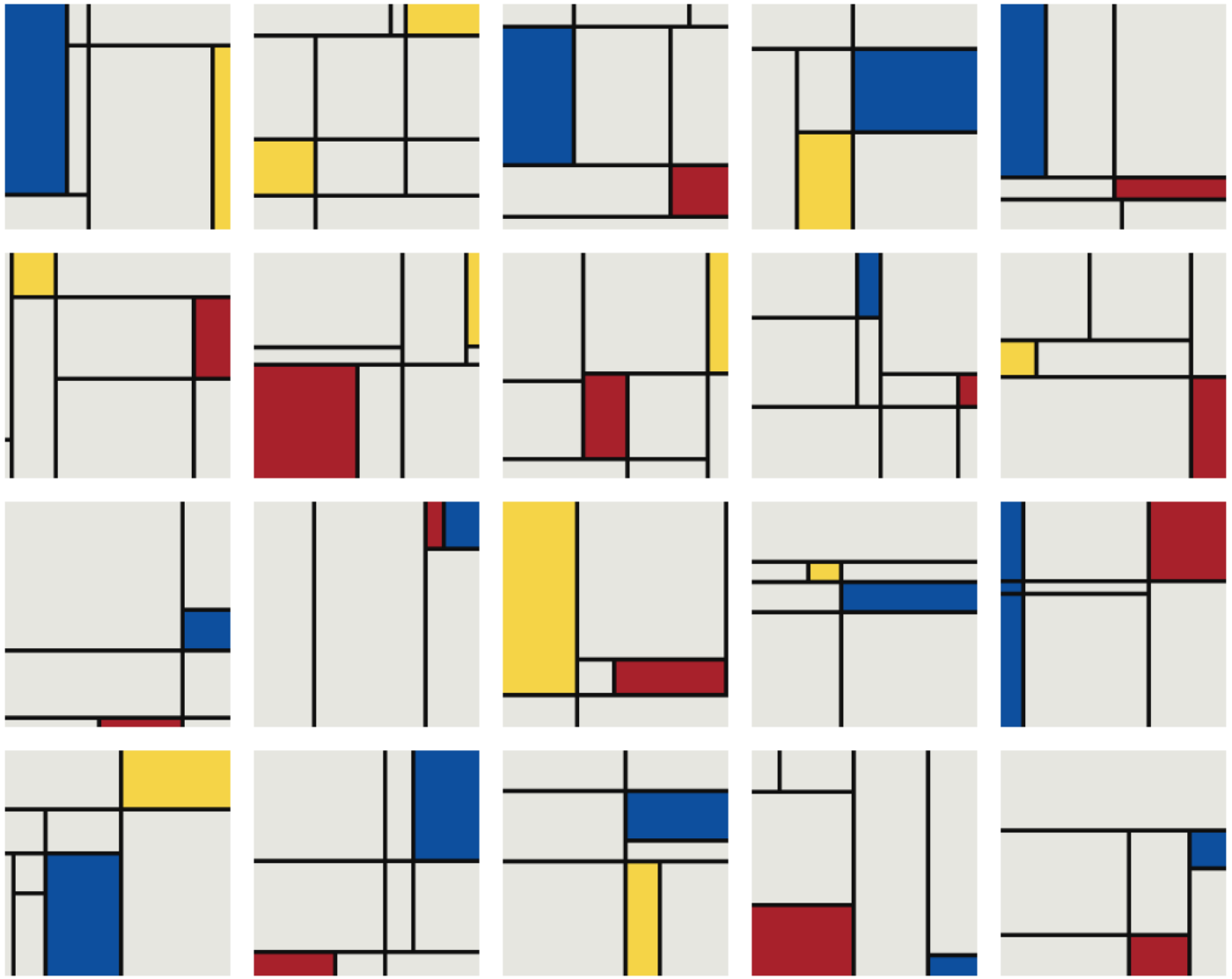
Results – subject J

- Small blocks
- Close to an edge
- ???



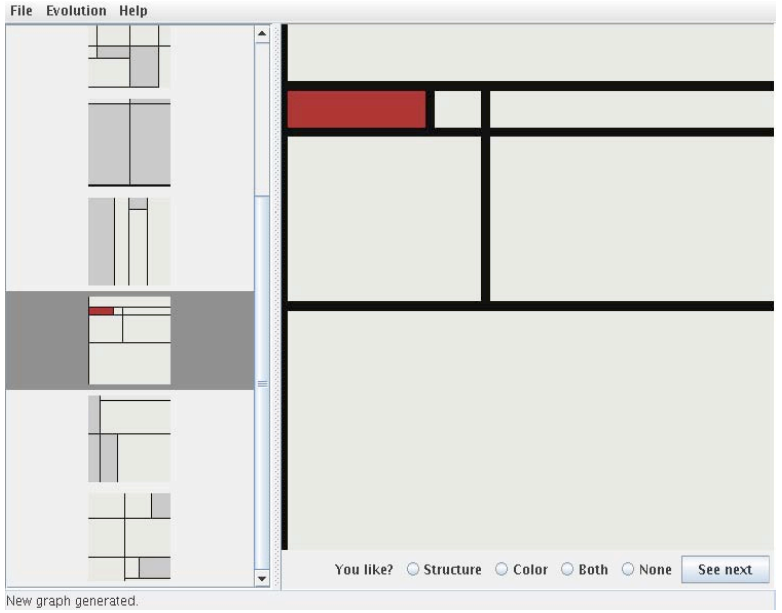
Results – subject T

- Medium sized blocks
- Some space between blocks
- Context!
- 10 Y
  13 R
  14 B



Implications, Applications

- Interested in finding out if we can capture some individual esthetics
  - Tom likes larger blocks of colour than Jian does
- Issues - extract enough info without exhausting (or boring) the user
  - x Would evolve 50 individuals, over 20 generations so user evaluates 1,000 images!



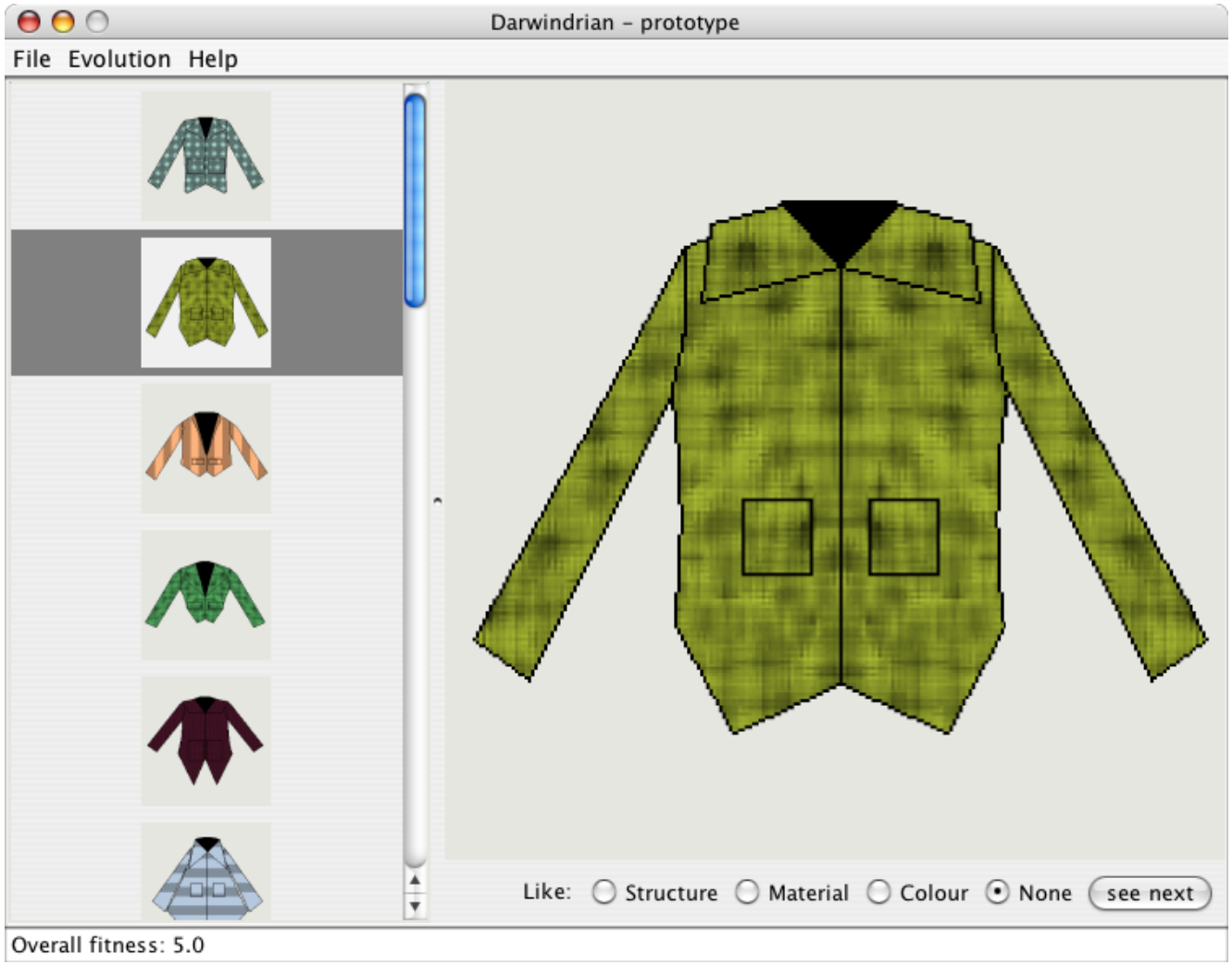
- ? Other areas with human only answers

Use in design (mockup)

GUI field structure:

would have many parts

for an expert, hide for laymen



Computer Evaluation of Art

- From literature: line spacing
- Our pre-processed vector image features: (28 total)
  - 2 Number of lines in image; Sum of their lengths
  - 3 Number of lines spanning entire image: horiz., vert. or in total
  - 4 Biggest/smallest distance between horizontal/vertical lines
  - 2 Length of smallest distance between lines vert./horiz.
  - 2 Smallest/biggest distance between lines either horiz. or vert.
  - 2 Smallest horiz./vert. distance to and edge
  - 4 Proportion of image which is red/yellow/blue/coloured
  - 5 Min dist. between r&y/r&b/y&b/2 cols/2 cols Manhattan dist.
  - 2 Length 2 colours touch; Longest contiguous coloured areas.
  - 2 Longest parallel non-touching coloured areas; Dist. between

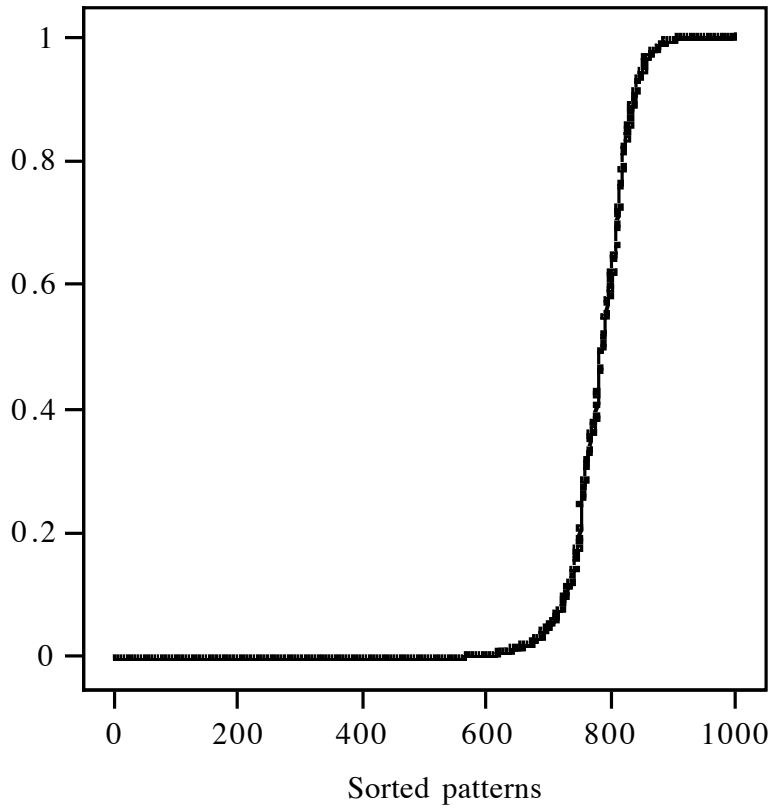
Experiment Design – Subjectivity (length time => esthetic training)

- Esthetic appreciation is an individual, subjective act
- Average esthetics – ? Mondrian's compositions
- Expt 1: 100 train + 44 test patterns
- Expt 2: initial 28 train + 12 test
  - Train a neural net: select 10 "like", 8 random, 2 "not like"
  - Repeat
  - I.e. 48 train, 32 test; -> 68 train, 52 test; -> 88 train, 72 test
  - Final 108 train, 92 test patterns
- Expt 1: 28 x 5 x 1 => tss 198.1 (28 x 50 x 50 x 1 => 190.3)
- Expt 2: 28 x 5 x 1 => tss 109.1

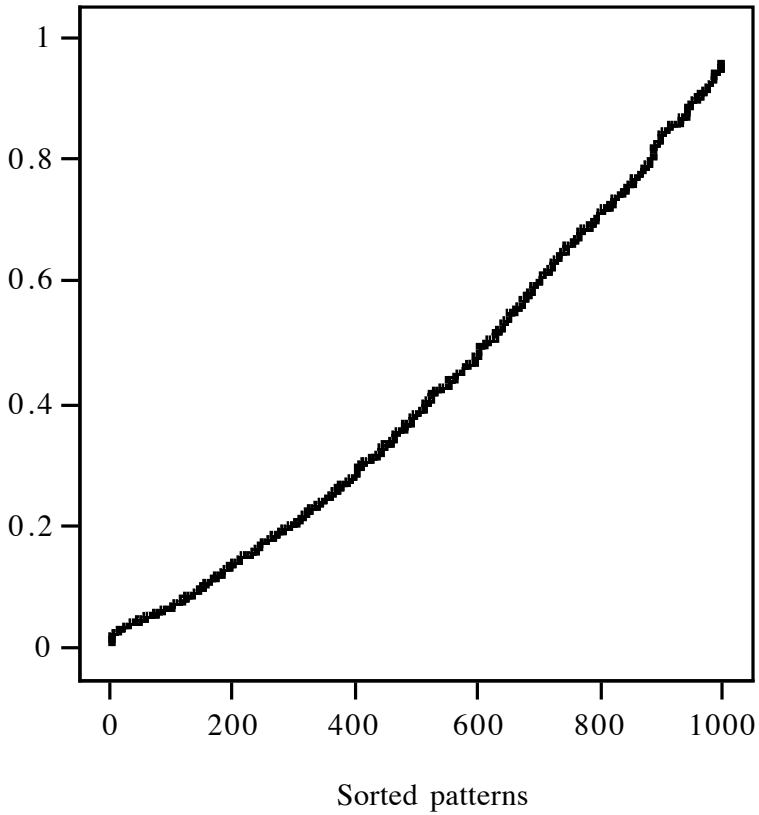
Predicted output validation set

- Difference between prediction profiles is profound

expt 1 – 'batch'



expt 2 – iterative



Significance of input parameters from 10% to 5% (total >50%)

- 19 = proportion of image which is coloured
- 9 = biggest horizontal distance between lines
- 24 = Manhattan distance between 2 colours
- 22 = min. Euclid. dist. bet. yellow & blue
- 17 = proportion of image which is yellow
- 15 = smallest vertical distance to an edge
- 20 = min. Euclid. dist. bet. yellow & red
- 25 = length 2 colours touch

Some comments

- Identified relationships which are not consciously available to users (e.g. subject T and yellow)
- Some ability to learn esthetic preferences
- Process of data set construction has profound effect (survives further sub-classification)

Further experiments

- NN expts described have GA individuals (GAi) which have _chance_ to be rated _if_ output shown to user
  - But, each individual could generate _many_ Mondrians …
  - Need further investigation of training on gene or result
- Chromosomal NN hybrid
  - Generate new random chromosomes for each generation
  - Select by NN trained on GAi's gene value
- Phenotype NN hybrid
  - Keep GAi pool, generate 1,000 possible Mondrians for each
  - Select by NN trained on Mondrian values (phenotype)

User experiment

- Participants
  - 16 experimental subjects, only 50 Mondrians rated
- User behaviours observed
  - Efficient selection: Rate every Mondrian – end experiment quickly (3rd or 4th generation)
    - Rarely rate a Mondrian as indifferent
  - Elite selection: Only rate Mondrians that are outstanding example of Liked / Disliked
    - This strategy often picked for first evaluation in experiments
  - Positive Elite selection: Only pick Liked Mondrians

User experiment results

- Objective results (number liked)

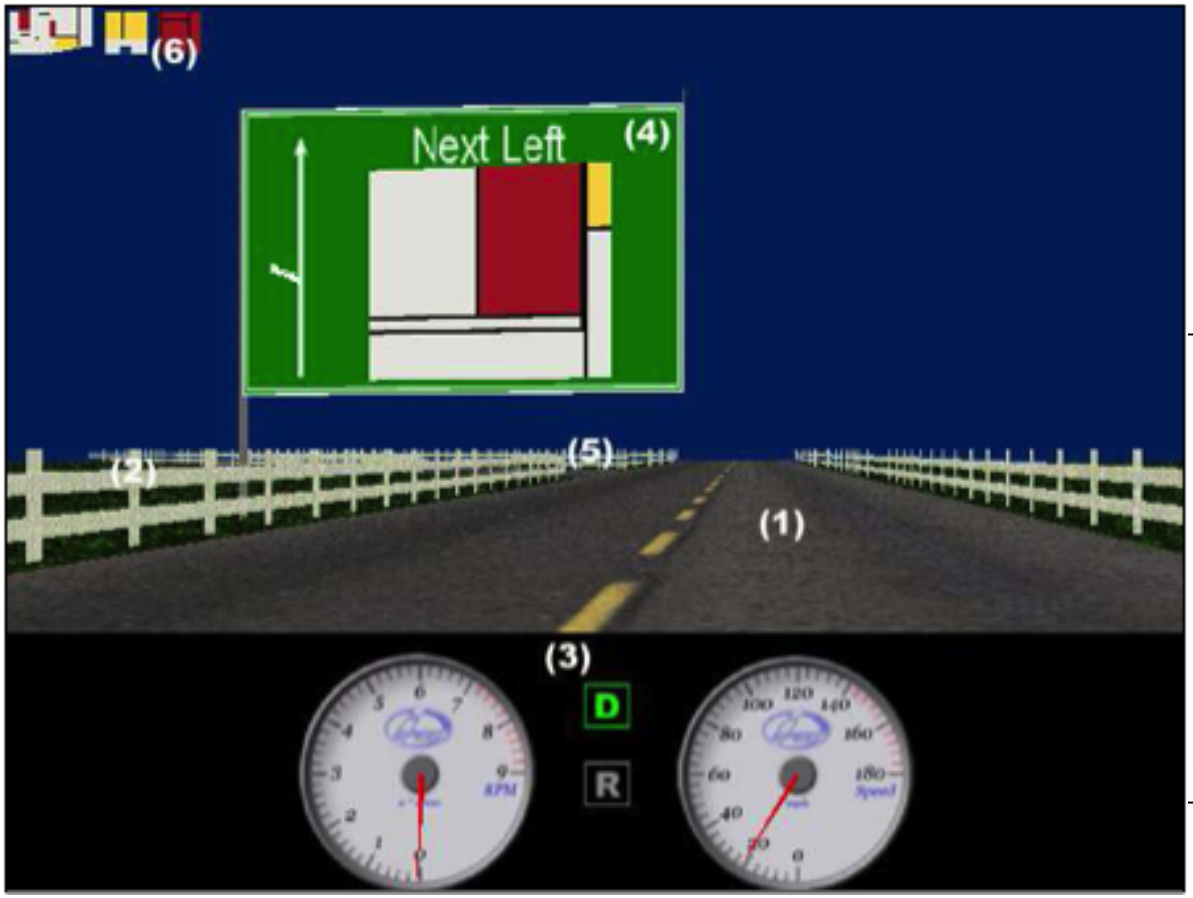
Measure	Algorithm	Mean	Std. Deviation	Std. Error	Minimum	Maximum
PosCount (number of liked pictures over test)	Original EA	24.2500	17.91049	6.33232	3.00	51.00
	Chromosomal NN	35.2500	14.42963	5.10165	16.00	53.00
	Phenotype NN	31.7500	8.97218	3.17214	19.00	42.00

- Subjective results (which liked most ⟹ peak fitness)

BestGenPercComp (averaged ratio of generations)	Original EA	.6057	.25967	.09815	.25	1.00
	Chromosomal NN	.5929	.31186	.11787	.25	1.00
	Phenotype NN	.7637	.13989	.04946	.60	1.00

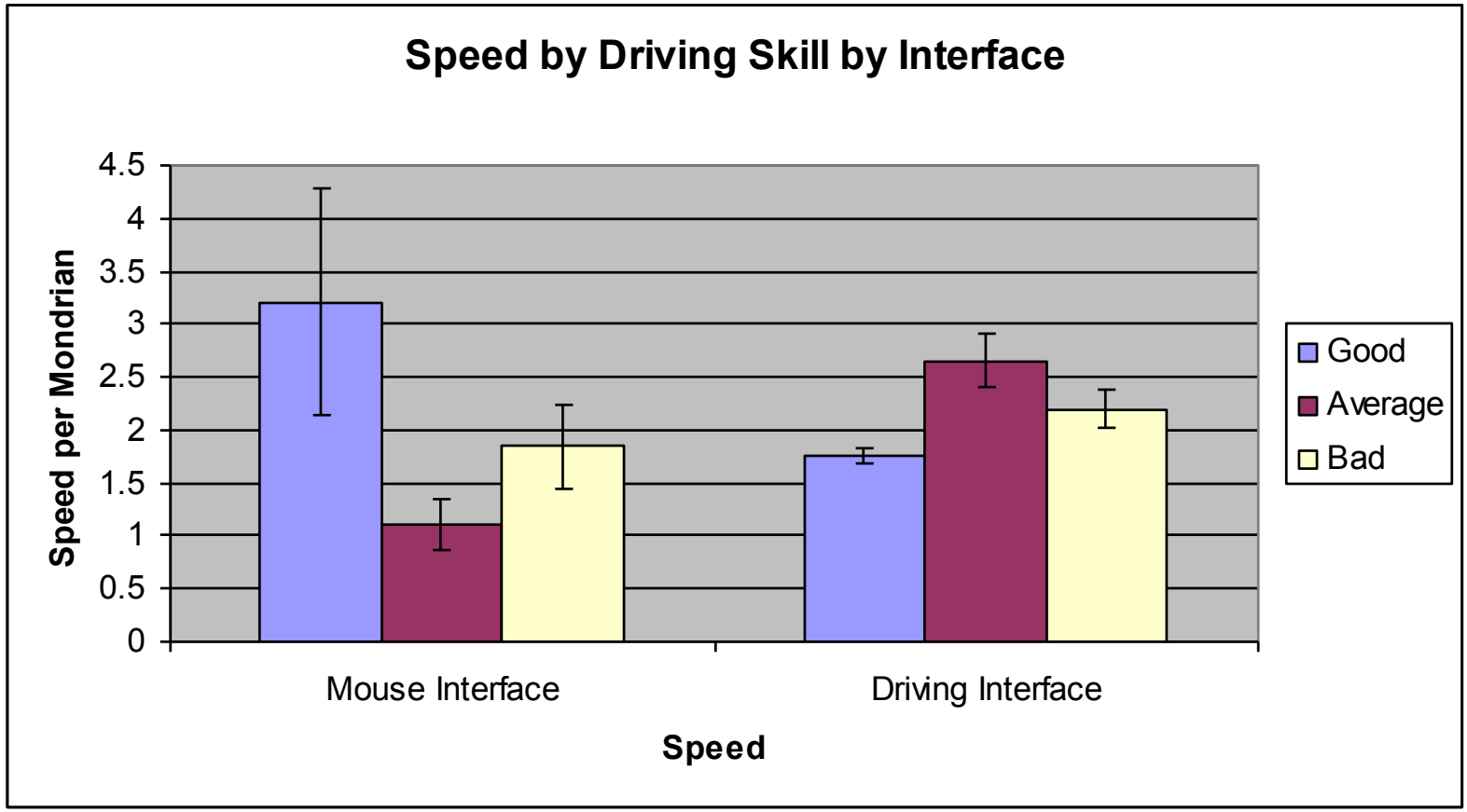
- Comment: Further work needed
  - E.g. redo 1st experiments on chromosomal / phenotype NNs

A different selection interface



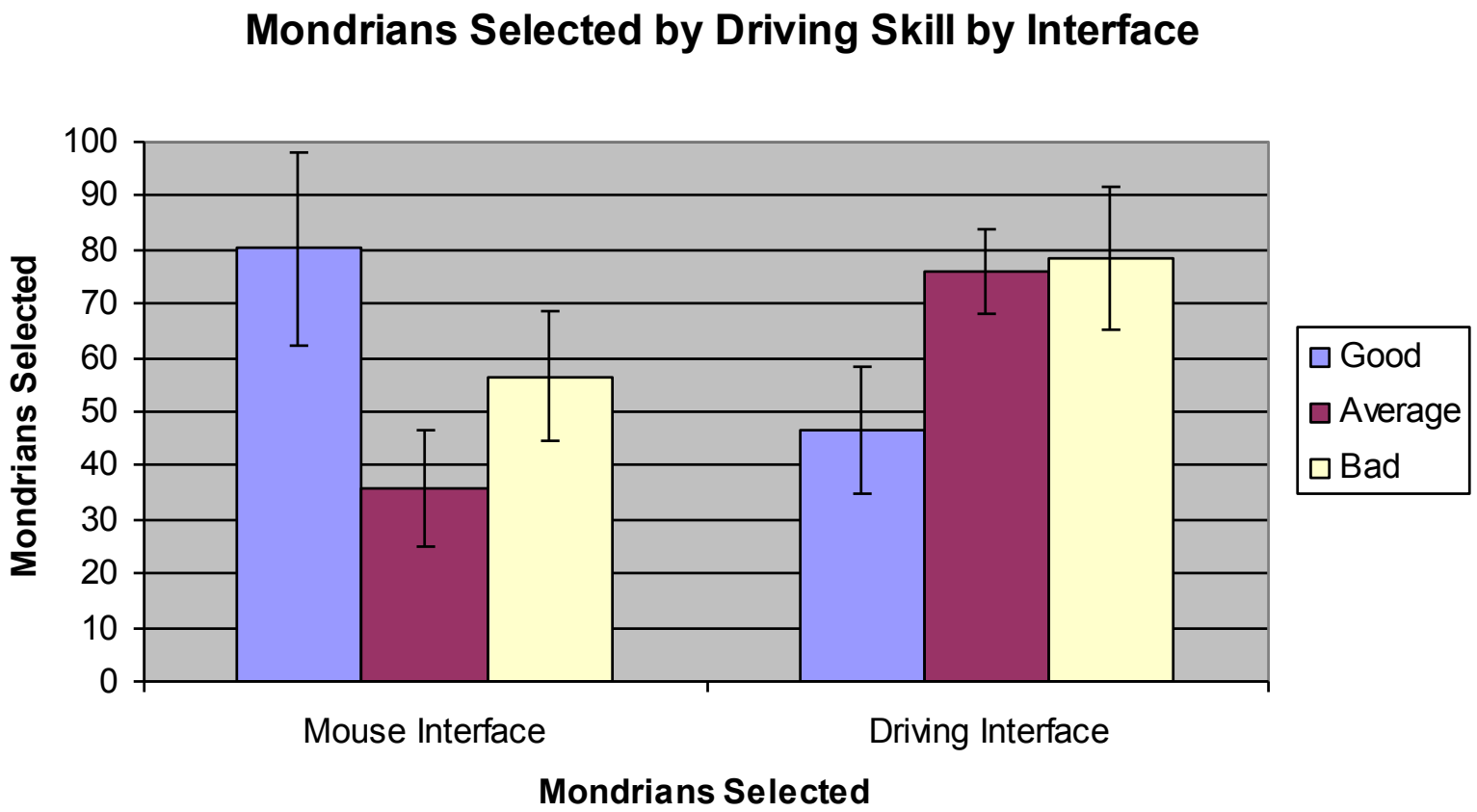
Driving Interface

Driving Skill Speed Results



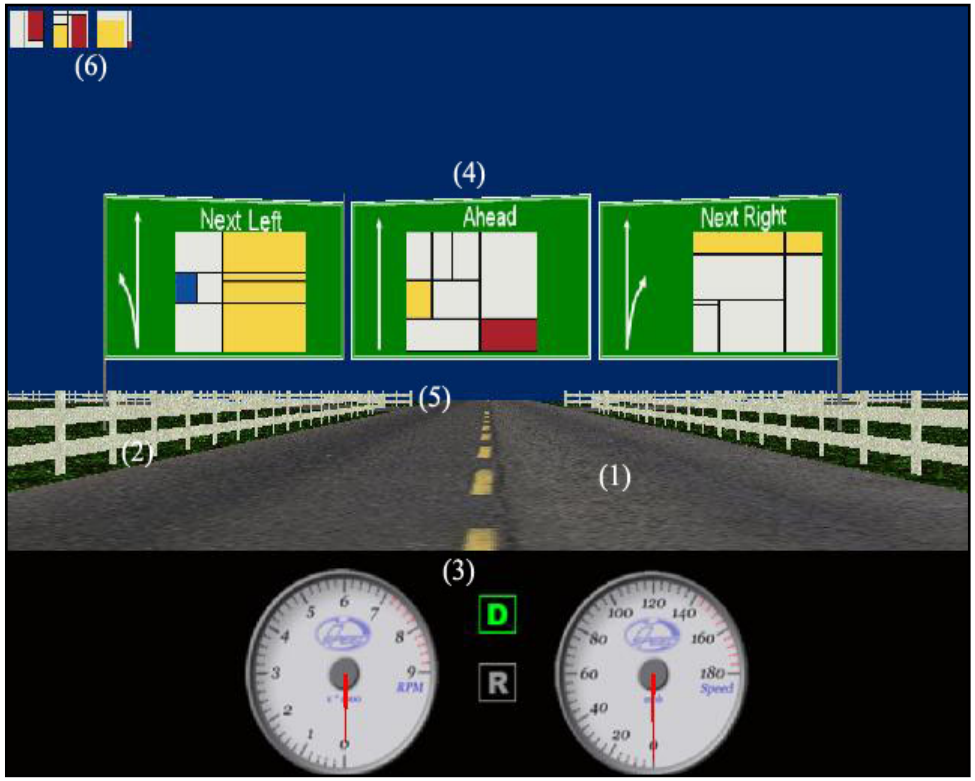
Good Drivers significantly faster on driving interface, slower on mouse. p-value 0.003.

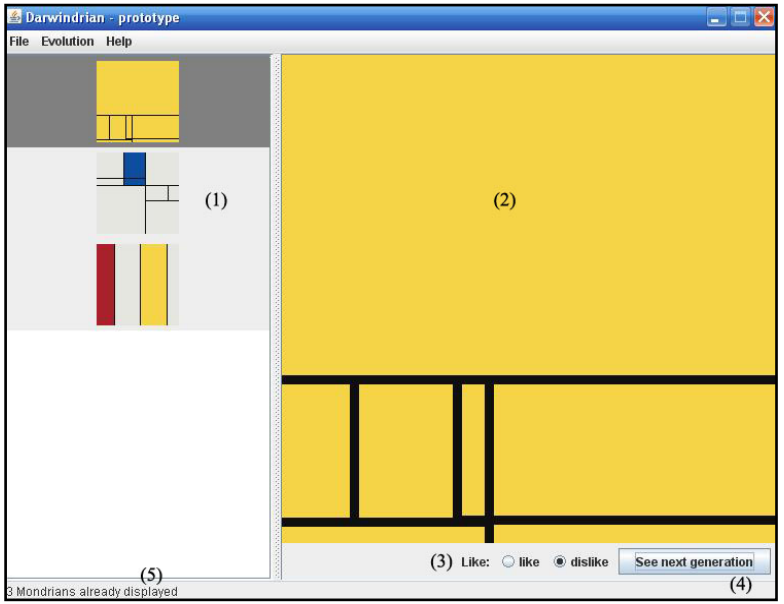
Selection of Mondrians Results



Less Mondrians selected by Good Drivers on Driving interface, more on Mouse. p-value 0.02.

Better interface comparison



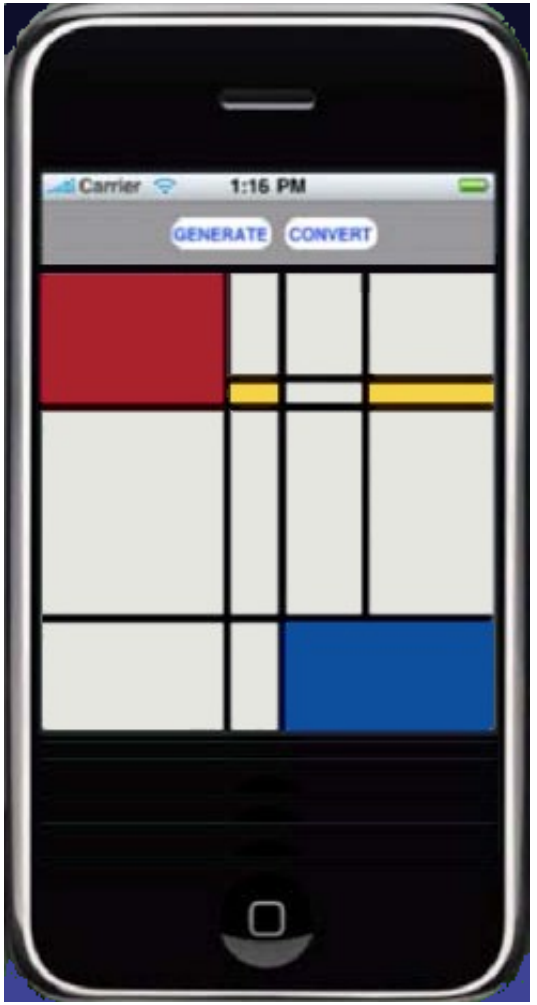


Driving Interface – select 3

- Driving interface is as fast and intuitive as mouse interface (Previous – driving interface is slow)

Mobile Mondrians

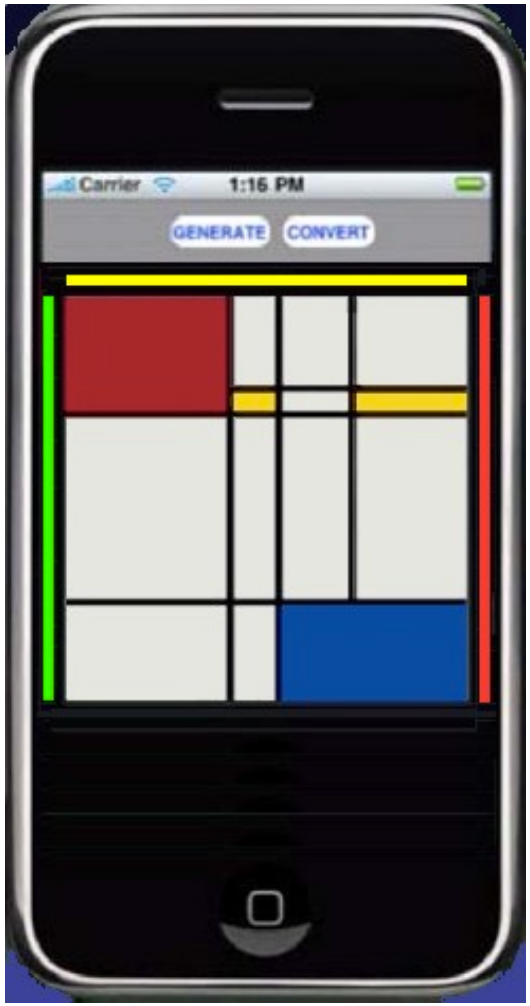
- iOS version for iPhone / iPod touch
- Plan: use dead time (walking) to repeated human interaction
- HCI experiment (about to start)
  - Hypothesis: while walking, gesture selection will be better than buttons
    - and while sitting buttons better
- Initial experiments to determine
  - Style of gesture for yes / no / don't care
  - How to differentiate hints from buttons



Potential mobile interfaces

- ? Use colour and button shape

Buttons



Gesture

Future work

- Try as a lay design tool (on the web?)
  - Need a suitable domain with an expert with time …
- Many conscious choices is tiring / can be boring
  - Use attention – with an eye gaze detector and EEG recorder or face expression recognition
- Improve driving interface
  - Select groups of images – e.g. destination selection
- Other novel interfaces