A Four-Strategy model of Creative Interaction with Musical Parameter Spaces

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This Talk

- Goals/Scope: Music Creation Systems & Parameter Space
- Creative Systems Framework & Technological Aberrations
- A slight redefinition of divergence/convergence (Axis 1).
- Dual Process Theory (Axis 2).
- EATR 4-strategy model of creative parameter navigation:
  - How the strategies traverse parameter space.
  - How they may interfere with each other.
  - What interfaces suit each one.
- If time: some experimental results.
Background/Goals

- 25 years as a guitarist + 20 years in the electronic music community.
- Frustrated with current knobs and sliders interfaces.
- Masters in DSP started PhD in DSP.
- Initial goal dimension reduction for musical interfaces… but
- Expressiveness, flow, usability? What are we trying to achieve?

Helping the musician-technology hybrid system to be more creative.
Interdisciplinary Scope

- CogSci
- HCI
- Research into Parameter Mappings
- Design & Evaluation of Music Creation Systems
- Comp. Creativity
Goal:
+ A simple model that characterises the most important aspects of both creativity and usability.
+ Can retrodict many disparate findings of DMI research.
+ Has a clear computational description.
+ Generates clear design and evaluation criteria that makes sense to musicians and music tech. developers.
Music Creation Systems

Instruments + Recording Studio

DMIs + DAW
Conceptual/Solution/Parameter Space

Parameter Space

INTERFACE

Conceptual Space

INTERFACE

Laptop with software interface

Human brain image
Creativity extends the conceptual space of a domain.
The Creative Systems Framework (Wiggins CSF)

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- Conceptual space traversal mechanism sometimes results in a concept that is not within the existing domain: an “aberration”.
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- Conceptual space traversal mechanism sometimes results in a concept that is not within the existing domain: an “aberration”.
- Sometimes this aberration proves valuable. The new concept is then included in the space.
- This is a frequent event in the use of music technology e.g. distortion, feedback, happy accidents. But seldom designed for!
Axis 1: Divergent/Convergent

Guilford (1967):

Divergent (multiple idea generation)

Convergent (single “correct” solution selection)

- Also has been described as evolutionary: ideas evolve by blind variation and selection (Campbell, Simonton).
- Geneplore: Generation and exploration (Finke).
- Individual creativity relies on being good at both these generative selective and evaluative aspects.
Convergence: Select Best Concepts

- Evaluation
- Selection
- Refinement

= Value

Conceptual Space
Divergence: Generate New Concepts

- Combination
- Transformation
- Analogy

= Novelty

Conceptual Space
Convergence

- Navigation of solution space is driven by increasing “value”.
- Similar to optimisation techniques (in continuous space requires gradient).

Divergence

- Temporary suspension of value maximisation for the sake of escaping local maxima.
One possible definition:

The art of overcoming “barriers” in conceptual space.

**Walls:** interim solutions seem like really bad ideas.

**Ceilings:** lack of tools/abstractions with which to traverse a given region.

Very different barriers: need different divergence techniques…?
Axis 2: Implicit/Explicit

Dual process theory of decision making.
### Dual process theory in a nutshell

<table>
<thead>
<tr>
<th>System 1 (Implicit)</th>
<th>System 2 (Explicit)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast &amp; Parallel</td>
<td>Slow &amp; Serial</td>
</tr>
<tr>
<td>Associative memory</td>
<td>Working memory</td>
</tr>
<tr>
<td>Intuitive &amp; Automatic</td>
<td>Requires conscious effort</td>
</tr>
<tr>
<td>Inflexible</td>
<td>Adaptable</td>
</tr>
<tr>
<td>Slow to train</td>
<td>“One shot” learning</td>
</tr>
<tr>
<td>Recognition based</td>
<td>“Analytic”</td>
</tr>
<tr>
<td>“Holistic”</td>
<td></td>
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</tbody>
</table>
Tri-process theory?

Implicit: TASS

- Perceptual
- Emotions
- Etc...
- Etc...
- Etc...

Explicit

- Reflective
- Algorithmic
- Supports

WM

HCI in a nutshell

- Working memory is precious: limited capacity and duration.
- Make use of “Affordances” (implicit processing of potential uses).
- Don’t mess up learned stuff!
Hunt, Wanderley et al. 1999

- Found that multi-dimensional controllers + complex mappings were better than one-to-one mappings for expressive DMIs.

- "holistic" thinking rather than "analytic" thinking.

  "The human operator, once familiar with the system, is free to perform other cognitive activities whilst operating the system."

Like what...?

What if…?

- What if dual process models apply to creative thought as well as just “reasoning”?
- What if both systems can carry out convergent and divergent strategies?
The EATR model

Fast System

Tacit

Slow System

Analytic
The EATR model

Divergent

Exploratory

Reflective

Fast System

SLOW SYSTEM

Tacit

Analytic

Convergent
Exploratory (Divergent-Implicit)
Random sojourns through solution space.

- Exploratory: perturb the system and see what happens. E.g. Blind Variation, Generate & Test.
- Unconscious recombination “spreading activation”.

Interaction and Mapping strategy:

fast access to possibilities combinations and transformations, low dimensional & undemanding to use, predictability not important, fast evaluation important.
Divergent-Implicit
Random sojourns through parameter space.

+ Cognitively/computationally undemanding.
+ Requires no learning (but exploration leads to learning)
+ Novelty generating: chance of “aberrations” emerging.
+ Breaks through “walls”.
+ Enjoyable!

- Extremely inefficient!
- Not as effective for skill acquisition as “deliberate practice”
- “mere” novelty, not transformational creativity.
TACIT (Convergent-Implicit)

An implicitly learned mapping between goal, parameter values and gesture

- Tacit knowledge, recognition based processing.
- Practiced complex motor control.
- Automatic selection of previous best (local) solutions.
- Instinctive, automatic behaviour.
- Fast evaluations: “sense of rightness”

Convergent-Implicit

An implicitly learned mapping between goal, parameter values and gesture

+ Fast
+ Parallel
+ Low working memory use
+ Enables higher level conscious control: expressiveness, improvisation etc.

- Requires large amounts of practice
- Inflexible (uncreative?)
- Implicit skills tend to be non-transferable
ANALYTIC (Convergent-Explicit)

Step by step setting of individual parameters to “correct” values.

- Algorithmic, methodical steps to achieve a known goal.
- Splitting into serial sub-tasks, if-then planning.
- Critical thinking: comparative evaluations.
- “Honing” the details.

- Mapping strategy: Separate controls for perceptually distinct attributes. Independent. Predictable (Linear, continuous etc.).
Convergent-Explicit
Step by step setting of individual parameters to “correct” values.

+ Efficient navigation of huge parameter spaces.
+ By far the dominant UI approach.
+ Skills are often transferable
- Serial one-at-a-time adjustments
- Uses working memory
- Goal not always known: more trial and error than design approach would suggest.
- May encourage excessive optimisation of local optima, missing vital remote-associations due to narrowed attention.
- May inhibit reflective thought?
Divergent-Explicit

Generating meta-concepts. Transforming the constraints/value function

- Meta-level concept forming.
- Intentional changing of the rules or constraints.
- Problem finding / Question asking.
- Reflective Introspection.
- Essential for “transformational creativity” (Boden 1990, Wiggins 2006)

Divergent-Explicit

Generating meta-concepts. Transforming the constraints/value function

+ Novelty generation, but with greater (eventual) likelihood of value generation.

+ Breaks through “ceilings”.

+ Metacognition informs and directs other processes, switching to the optimal strategy for a given situation.

- Cognitively demanding, can be interfered with by analytic processes and narrowed attention.

- Difficult to research (hard to model, evaluate or replicate)!
VALUE CHANGE?

Sometimes deliberate divergent approaches are necessary to extract the automatic responses from local minima.

A new value system is the most creative of all?
### Processing Efficiency with dimensionality

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<th></th>
<th>Exploratory</th>
<th>Analytic</th>
<th>Tacit</th>
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<tbody>
<tr>
<td>Pre-specified Solution</td>
<td>$O(c^D)$</td>
<td>$O(D)$</td>
<td>$O(c)$</td>
</tr>
<tr>
<td>Discovery time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Speed</td>
<td>$O(c)$</td>
<td>$O(D)$</td>
<td>$O(c^D)$ ?</td>
</tr>
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$D = \text{number of parameters/degrees of freedom}$

$c = \text{constant}$
The EATR model

Divergent

Exploratory

Fast System

Habit

Reflective

Slow System

Tacit

Convergent

Analytic
The EATR model

Divergent

Fast System

Exploratory

Tacit

Narrowed Attention

Reflective

Analytic

Convergent

Slow System
The EATR model

- Divergent
  - Exploratory
  - Reflective

- Convergent
  - Tacit
  - Analytic

Fast System

Slow System

Explicit Monitoring
The EATR model

Divergent

Exploratory

Reflective

Fast System

Slow System

Changing the space

Tacit

Analytic

Convergent
Stages of Skill Acquisition (Anderson)

- **Cognitive Stage**
  Learner develops goals and organises a solution.

- **Associative Stage**
  Recognize solutions without thinking through.

- **Autonomous stage**
  Solution achieved with no conscious effort.

Acquisition of cognitive skill. Anderson, John R. 1982
Stages of Learning a Synthesis Parameter Space

- Exploration
- Rules & Heuristics
- Automaticity

- Cognitive
- Associative
- Autonomous
3D Controller: Exploratory paths

User 2, test 1
3D Controller: Analytic paths

User 2, test 28
3D Controller: Tacit paths

User 2, test 658
Multi-D controllers improve more with practice

Before

After 3 hrs practice
Towards A Design Framework for Music Creation Systems

There are 12 strategy transitions that need to be considered!

Some examples:

- Discoveries in exploratory mode need to easily be made editable analytically. Likewise gestures.
- Gestural skill needs to be re-used at recurrent levels of abstraction.
- Ideas previously optimised need to be transformed and recombined easily without losing their value.
- “Think about the entire parameter space. E.g. if it is very redundant or fragile then exploratory strategies will not work.
- The 4 modes could actually be provided as interface modes.
Hypothesis

- Multi-D controllers suit fast automatic processing.
- Interfaces that use less of the explicit system leave more room for reflective cognition.
- Reflective cognition essential for transformational creativity.

Therefore well learned multi-dimensional interfaces should enhance transformational creativity, analytic ones may be inhibiting it!
Thanks!

Some other papers:
