ACE: A Model of the Cognitive Strategies of a Contemporary Artist

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Abstract

Building on the analysis of Leclerc and Gosselin (2004), we present a partial but nonetheless substantial computer-based model of some of the processes involved in a contemporary visual artist's practice. This model is based on fieldwork data and its purpose is the modeling of the tasks, goals, and operations involved in a real-world artistic practice. The project is being conducted within the *artistic creativity as situated problem solving* framework; we thus view creativity both as a problem-solving process and a situated process.

Keywords: creativity; problem solving; situated cognition; computer model; field study; visual arts.

Introduction

This project consists of a field study of the real-life practice of a well-known Canadian visual artist, Isabelle Hayeur. The project was conducted over a three-year period and is ongoing at the moment of writing. The goal of the project is to uncover and describe the problems facing a contemporary artist in the context of a real-life practice and to describe sets of processes or strategies applied by the artist to face these problems or tasks related to her artistic practice. See Leclerc and Gosselin (2004) for a first qualitative analysis of this data – an analysis based on human problem solving theory (Klahr & Simon, 1999; Newell & Simon, 1972). This project has been conducted in two phases. In the first phase of the project, over a twelve-month period, from May 2003 to April 2004, we conducted a field study of this artist's practice; in the second – ongoing – phase, started in May 2004, we have been modeling the gathered data. Our project is thus a field study – an ethnographic type of study – that has the uncommon goal of building a computer-based model of real-life artistic problem-solving processes[1].

Recently, Klahr and Simon (1999) have suggested that by using the concepts and vocabulary of human problem-solving theory (Newell & Simon, 1972) "we may be able … to converge toward a common account of discovery in many areas of human endeavor", including the arts (p. 524). Much work has already been done to understand processes of scientific discovery with this approach (e.g., Klahr, 2000; Kulkarni & Simon, 1988). But, with few exceptions (e.g., Weisberg, 1993), little has been done to study artistic creativity from this perspective. In fact, most of the computational models of creativity, in recent years, have been of the creativity involved in the process of scientific discovery (e.g., Kulkarni & Simon, 1988; Langley, Simon, Bradshaw, & Zytkow, 1987; Schunn & Anderson, 1998).

In recent years, research on creativity has also converged on ideas and models similar to those found in situated and distributed approaches to cognition (e.g., Csikszentmihalyi's systems model of creativity, 1999). This is why our project is conducted within the *artistic creativity as situated problem solving* framework (Leclerc & Gosselin, 2004). We are considering the problem-solving processes involved in artistic creativity to be situated, thus reflecting, and responding to, the environmental, social, cultural and economic conditions (Nersessian, 2004; see also Clancey, 1997; Hutchins, 1995; Norman, 1993; Thagard, 1999). The most significant element concerning the situated aspect of the project is its use of field methods and corresponding emphasis on ecological validity.

Methodology

Isabelle Hayeur: Contemporary Visual Artist

Isabelle Hayeur[2] (IH) is a successful professional Canadian visual artist[3]. She works mainly with digital photography and video; her work has been shown in solo and group exhibitions nationally and internationally. A great part of her work involves producing large-scale photomontages; these often show idyllic-looking landscapes… idyllic, but not quite; her images often evoke a feeling of strangeness in the viewer. She also works with video, Net art and does *in situ* – site-specific – projects.

Data Collection and Analysis

A detailed account of data collection and qualitative analysis is provided in Leclerc and Gosselin (2004). Briefly stated, multiple data types, from multiple sources, have been collected, on-site, to allow the modeling of a distributed set of cognitive activities (Clancey, 2001). These included: interviews, photographs of work space and tools, recording of activity at the computer, and extensive field notes. All data was digitally recorded and archived (except for the

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[1] The study might be said to be interested in problem finding as well as in problem solving. Problems faced by artists in real-life practice are not 'presented problems' (compared to those given to subjects in the context of laboratory experiments, for example); those problems are rather discovered or taken on by the artist in the course of the artistic practice. Problem finding – as well as problem solving – has been found to be an important part of artistic creativity (e.g., Getzels & Csikszentmihalyi, 1976).

[2] Her work, artist's statement and resume can be found on her Web site: isabelle-hayeur.com

[3] IH is considered a *professional artist* according to Quebec's law on the *Professional status of artists in the visual arts, arts and crafts and literature, and their contracts with promoters* (R.S.Q., S-32.01).

field notes); total data volume amounts to about 30 gigabytes. The ACE model, presented in this paper, is based mainly on the interview data and field notes.

Interview Data and Analysis Eight semi-structured interviews were conducted over a six-month period, from May to October 2003, at the artist's studio (Leclerc & Gosselin, 2003). The interview technique was inspired by traditional protocol analysis methodology (Ericsson & Simon, 1993) and aimed at eliciting descriptive information about the subject's artistic activities. Interviews were 30 to 60 minutes long; these were digitally recorded and transcribed verbatim. They were then organized, stored, and analyzed using the Atlas.ti computer package. The analysis consisted of coding the interviews in terms of the *problem spaces*, *goals*, *operators* (i.e., using the concepts of human problem-solving theory, Newell & Simon, 1972) and, from the coded interviews, extracting a set of 70 rules pertaining to the diverse problem spaces – problems, tasks, and so on – involved in this artist's work and practice.

Four additional two-hour interviews were conducted with the artist, over a two-month period, from October to December 2004, in order to complete the model. In this second round of interviews, we considered the artist to be a *domain expert* (an expert of her own practice; e.g., McGraw & Harbison-Briggs, 1989; Meyer & Booker, 1991). These additional expert interviews allowed us to: (1) fill gaps in the model, (2) and do a first validation of the model.

Search Spaces in IH's Creative Processes

Human problem-solving theory models usually distinguish sets of problem spaces, or search spaces, in which a problem solver operates in order to resolve a particular problem or accomplish a task (for example, the two-space model of scientific discovery, first proposed by Klahr & Dunbar, 1988; this model presents scientific discovery as a process involving dual search in an Hypothesis space and an Experiment space). We previously came to the conclusion that IH's artistic processes were operating in two main problem spaces, an Artistic practice space (A) and a Career space (C), and a third, secondary one, the Economic space (E) (Leclerc & Gosselin, 2004). Our model's name, ACE, comes from the letters standing for these three search spaces. How IH resolves the problems of being an artist, of producing art works and of attaining a certain level of professional success all happens in these, A, C, E spaces. The combined size of these search spaces is vast (compared, for example, to the cognitive space involved in a typical cognitive psychology experiment). Thus, such a model cannot be fine-grained; what matters most to us is the ecological validity of the model and its ability to give us a bird's eye view of the problem-solving processes involved in a real-life artistic practice.

Production Systems as Cognitive Models of Artistic Creativity

The model presented here was implemented as a *production system*. Production systems have their origin in Emil Post's (1943) study of the properties of systems based on rules (Jackson, 1999); these systems have been adopted early on by cognitive scientists to model language, memory, and problem solving (e.g., Anderson, 1976; Chomsky, 1957; Newell & Simon, 1965). These have also served more recently to model scientific discovery processes (e.g., Kulkarni & Simon, 1988; Schunn & Anderson, 1998). According to Anderson and Lebiere (1998), "[production systems] are the only modeling formalism capable of spanning a broad range of tasks, dealing with complex cognition, in complete detail, and with a high degree of accuracy" (p. 3).

The production system outlined in this article was implemented using Jess[4] (version 6.1p6), a general-purpose rule engine, a Java-implemented version of CLIPS, itself a descendant of the OPS family of production rule languages and related languages; OPS5 was the language most often used to model cognitive processes by the first generation of cognitive scientists (Herbert Simon, Allen Newell, and others). The Jess language, like its ancestors, has a syntax very close to LISP, a language traditionally used in AI and in many models of human cognition.

We chose to model IH's artistic processes in terms of four main entity types or variables: (1) agents, (2) goals, (3) knowledge, and (4) environment. Goals and knowledge are typical categories involved in knowledge-based, or production, systems (see Jackson, 1999). Even though our main focus is on one individual, we want to allow for the explicit modeling of 'outside' processes, i.e. other agents and their respective environments; this relates to the situated, or distributed, part of our approach. Each rule in the model, therefore, involves either agents – the main one being IH, goals and knowledge of these agents, or various states of the environment. The ACE model is a forward-chaining production system[5]; the current version consists of a set of 70 rules.

Results

ACE: A Sample Run

To illustrate the model's behavior, we have chosen initial conditions – a state of the world, so to speak – typical of those encountered during our time working with the artist. Some of these initial conditions are *stable* variables in the subject, conditions observed to be present for the entire duration of the research project. Part of the initial conditions also consist of variables that may change from one simulation run to the other. These represent *changing* conditions in IH's own state, the state of her goals and knowledge, and in the state of her environment (these may also include the changing state of other agents). Among the twenty initial conditions for this run, every stable condition, and some of the most significant changing conditions, are shown in Table 1.

[4] Jess (trial version or licensing for either academic or commercial use) is available online from Sandia National Laboratories at: http://herzberg.ca.sandia.gov/jess/

[5] The model, and related information, are available at: mapageweb.umontreal.ca/gosselif/ACE.html

Table 1: Initial conditions of the simulation run

All stable conditions
(agent (name IH) (status artist)) (goal (agent IH) (task being-an-artist-doing-that-my-entire-life)) (goal (agent IH) (task art-must-remain-a-calling-remain-research)) (goal (agent IH) (task taking-my-work-as-an-artist-seriously)) (goal (agent IH) (task living-conditions--food-and-house)) (goal (agent IH) (task having-success-as-an-artist))
Some changing conditions
(agent (name IH) (variable artistic-production-unpaid)) (agent (name IH) (variable photographic-production)) (agent (name IH) (variable very-active-professional-life)) (goal (agent Isabelle) (task sending-projects-to-arts-centers)) (knowledge (agent IH) (variable what-I-have-to-do-to-be-an-artist)) (environment (agent Isabelle) (variable high-cost-of-printing-large-scale-photographs))

The above facts state, in first-order predicate logic, that IH's status is that of an artist, that her goal is to be an artist her entire life, that for her art must remain a calling, that her artistic production is initially unpaid for, that she has a photographic production, has a very active professional life, and so on. For the computer simulation, these facts are put in working memory at the start of the simulation, may change during the simulation, and they serve to activate the *production rules* that constitute the model of IH's artistic process; in turn, these rules may change the content of working memory – the facts – as the simulation unfolds.

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DISSEMINATION --- making-a-project-move-forward-and-completing-it – [CA]
MAKING-A-PROJECT-MOVE-FORWARD --- putting-time-into-the-project – [A]
PUTTING-TIME-INTO-THE-PROJECT--- starting-to-work-again-on-the-project – [A]
COMPLETING-THE-PROJECT --- setting-aside-time-for-working-on-the-project – [A]
…

DOING-THE-ARTIST-WORK-SERIOUSLY --- doing-my-work-as-an-artist-full-time – [A]
DOING-MY-WORK-FULL-TIME --- having-time-for-my-artistic-work – [A]
MAKING-TIME-FOR-ARTISTIC-PRACTICE-AND-CAREER --- putting-all-my-time-in-artistic
  -work-and-artist's-dossiers – [AC]
NOT-STOPPING-MY-ARTISTIC-WORK --- avoiding-a-return-to-the-job-market – [AE]
AVOIDING-A-RETURN-THE-THE-JOB-MARKET --- promotional-activities-making-my-work
  -known – [C]
…

BEING-AN-ARTIST-MY-ENTIRE-LIFE --- doing-what-I-have-to-do – [AC]
DOING-WHAT-I-HAVE-TO-DO --- doing-what-makes-a-difference-in-an-artist's-career – [C]
DOING-A-DIFFERENCE-IN-MY-CAREER --- taking-care-of-everything-related-to-the-career
  -side-of-the-artistic-life – [C]
…

PAYING-FOR-ONE'S-ARTISTIC-PRODUCTION --- the-artist-must-pay-for-own-artistic
  -production – [AE]
PAYING-FOR-ARTISTIC-PRODUCTION --- taking-small-jobs-in-your-domain – [EA]
PAYING-FOR-ARTISTIC-PRODUCTION --- selling-art-works – [EA]
…
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Figure 1: A sample run of the ACE model. Letters in square brackets (e.g., [AC]), following the name of a rule, indicate in which of the three search spaces (A, C, E) the rule operates.

Shown in Figure 1 is a list of the main rules fired in the course of the simulation, starting from the initial conditions (see Table 1). Displayed here are 'threads' of activity simulating interweaved threads of activity in IH's life and art-related activities. Each thread begins with a top-level goal; in this run, there are four top-level goals: (1) disseminating the artistic work, (2) doing the artist work seriously, (3) being an artist one's entire life, (4) paying for one's artistic production.

One thread in Figure 1, for example, begins with the rule "DOING-THE-ARTIST-WORK-SERIOUSLY---doing-my-artistic-work-full-time" (see Figure 2); this rule states that if IH wants to do the artist's work seriously, she must do this work full-time, and not come out or stop doing her artistic work. In order to achieve its goal, this rule calls on the next rule in the thread, "DOING-MY-ARTISTIC-WORK-FULL-TIME---having-time-for-my-artistic-work". The same goes on for every rule that follows in the thread; each one is activated in turn, until the initial goal is reached. As we can see, each thread constitutes an operator – a set of rules – working to achieve particular goals.

```
(defrule DOING-THE-ARTIST-WORK-SERIOUSLY---doing-my-work-as-an-artist-full-time-[A]
        (goal (agent Isabelle) (task doing-the-artist-work-seriously))
        (not (goal (agent Isabelle) (task accepting-full-time-job-outside-of-my-artistic-work)))
        =>
        (assert (goal (agent Isabelle) (task not-stoping-my-artistic-work)))
        (assert (goal (agent Isabelle) (task being-in-my-artistic-work-full-time))))

(defrule DOING-MY-ARTISTIC-WORK-FULL-TIME---having-time-for-my-artistic-work-[A]
        (goal (agent Isabelle) (task being-in-my-artistic-work-full-time))
        =>
        (assert (goal(agent Isabelle) (task having-time-for-my-artistic-work))))

(defrule TIME-FOR-ARTISTIC-PRACTICE-AND-CAREER---putting-all-my-time-in-artistic-work-and-dossiers-[AC]
        (goal (agent Isabelle) (task having-time-for-my-artistic-work))
        (not (agent (name Isabelle) (variable bread-and-butter-job)))
        =>
        (assert (goal (agent Isabelle) (task putting-all-my-time-artistic-work-and-dossiers))))

(defrule TIME-FOR-ARTISTIC-PRACTICE---working-less-and-having-less-expensive-lifestyle-[AE]
        (goal (agent Isabelle) (task having-time-for-my-artistic-work))
        =>
        (assert (goal (agent Isabelle) (task not-having-an-expensive-lifestyle)))
        (assert (goal (agent Isabelle) (task working-less-at-bread-and-butter-jobs))))

(defrule NOT-STOPPING-MY-ARTISTIC-WORK---avoiding-a-return-to-the-job-market-[AE]
        (goal (agent Isabelle) (task not-stoping-my-artistic-work))
        =>
        (assert (goal (agent Isabelle) (task avoiding-a-return-to-the-job-market))))

(defrule AVOIDING-A-RETURN-TO-THE-JOB-MARKET---promotion-activities-making-my-work-known-[C]
        (goal (agent Isabelle) (task avoiding-a-return-to-the-job-market))
        =>
        (assert (goal (agent Isabelle) (task making-my-name-be-known))))
```

Figure 2: An operator's description.
"Doing the artist work seriously"

Threads like this one, and those displayed in Figure 1, give us an understanding of some of the most important goals, strategies and activities occupying the artist, given the initial conditions set for this run of the model. We see how each thread involves the application of a certain set of rules – or, operators – to reach these high-level goals.

Analysis of the ACE Model

Simulation runs of the ACE model, as shown in Figures 1 and 2, provide us with a first means of identifying the problem-solving processes involved in IH's art-related activities. But, further analyses are needed to understand exactly (1) what problems are solved by the artist in the context of her practice, and (2) by what sets of strategies. Because of the difficulty that comes with attempting to analyze the complex behavior that results from the interaction of 70 rules, with the naked eye, we turned to cluster analysis for a deeper understanding.

Cluster analysis is an exploratory analysis technique, or set of techniques, designed to solve classification problems; essentially, it allows the discovery and grouping of related objects. In order to understand the structure behind the ACE model's – and the artist's – behavior, we conducted two types of hierarchical cluster analyses (HCAs): (1) one on *rules* fired during a simulation run, and (2) one on *sets of rules* fired during multiple runs of the ACE model. The HCAs and other statistical analyses reported here were performed with the Statistics Toolbox for MATLAB version 6.5.

Cluster Analysis of IH's Rules of Practice

We performed a first HCA on *rules* fired during a simulation run of ACE; initial conditions were kept identical to those used previously (see Table 1; these initial conditions are a set of conditions typical of IH usual artistic life and practice). Euclidean distance (ED) was calculated to measure distances between rules fired. Rules fired closer in time, during the simulation, were considered closer in terms of ED. Unweighted pair group method with arithmetic mean (UPGMA) clustering was performed.[6] As a result, a dendrogram (i.e., hierarchical binary cluster tree) was produced, visually representing the clusters of rules found (see Figure 3). To evaluate goodness of fit of the UPGMA dendrogram and original distance matrix, a cophenetic correlation coefficient was calculated (r = 0.82; a value of 0.8, or above, indicates a low-level of distortion, and is considered good [Romesburg, 1984; see also Everitt, Landau, & Leese, 2001]). Thus, the dendrogram in Figure 3 can be considered an adequate representation of the relationships among rules of the ACE model.

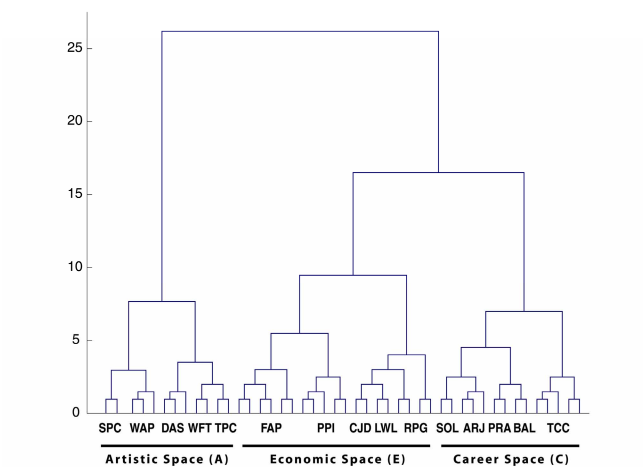

Figure 3: Operators of the A-C-E search spaces

[6] Using other distance measures and clustering algorithms we obtained very similar results; it appears that the analyses reported here are robust.

Operators from IH's Artistic Practice This first HCA serves to analyze the rule structure of the ACE model, and thus reveals the goal and operator structure used by IH in the course of her practice. The resulting dendrogram (see Figure 3), allows us to see which rules of practice work together, form clusters, and thus act as operators working to achieve specific, artistic, goals. It also allows us to see clear relationships between subsets of rules.

Following this cluster analysis of ACE, we can outline the following operators IH uses to solve 'problems' – or, reach goals – in the three search spaces of her artistic practice:

- Artistic space:
  - [SPC] Sending art projects to art centers, galleries.
  - [WAP] Working on art projects; making time for working on projects.
  - [DAS] Doing my work as an artist seriously.
  - [WFT] Working full-time as an artist (i.e., artistic work and career-related activities).
  - [TFC] Making time for art practice and career.
- Economic space:
  - [FAP] Financing one's artistic production.
  - [PPI] Producing, printing, photographic images.
  - [CJD] Choosing 'bread-and-butter' jobs related to one's artistic domain.
  - [LWL] Living with less; 'bread-and-butter' jobs must not replace time for artistic work.
  - [RPG] Being represented by a private gallery; selling one's work.
- Career space:
  - [SOL] Simplifying one's life (i.e., living with less, less time working at 'bread-and-butter' jobs).
  - [ARJ] Avoiding a return to the job market.
  - [PRA] Promotion-related activities (i.e., making oneself and one's work known).
  - [BAL] Being an artist my entire life; doing what I know I have to do to be an artist.
  - [TCC] Taking care of career side (of artist's life).

The dendrogram – set of strategies used – may recombine according to the (1) external conditions (i.e., environmental variables) and to the (2) state variables (i.e., IH's goals and other variables). For example, if we change the initial state to include these facts: (1) represented by a private gallery, (2) private gallery is an excellent one, and (3) production medium is low-cost, then, a major branch of the dendrogram disappears, the E branch, simply because the operators needed to achieve E goals are no longer needed.

Cluster Analysis of Randomly Generated Sets of Rules of Artistic Practice

We performed a second HCA on the *sets of rules* fired during 30 simulation runs of the ACE model[7]; each run was the result of a randomly generated set of six, present or absent, 'stable' initial conditions (see first section of Table

[7] After the first 10 simulation runs, the analysis was already converging on the set of clusters represented in Figure 4.

1, “Stable conditions”). ED was calculated to measure distances between these *sets of rules* (i.e., for each of the 30 runs, a vector was recorded, representing the entire set of rules of the model, and whether each rule had fired or not during this run). Similar runs – vectors of rules fired – were at a closer distance, and thus represented similar general artistic strategies, or attitudes. UPGMA clustering was performed. As a result, a dendrogram was produced (see Figure 4). To evaluate goodness of fit of the UPGMA dendrogram and original distance matrix, a cophenetic correlation coefficient was calculated ($r = 0.94$). Thus, the dendrogram in Figure 4 is an adequate representation of the relationships among sets of active rules generated by random runs of the ACE model.

Classes of Cognitive Strategies of Artistic Practice This second HCA allows us to better comprehend IH’s general artistic strategy by examining its boundaries[8]. The resulting dendrogram allows us to observe what would happen to the ACE model’s behavior if we modified its initial conditions. And, afterward, comparing the clusters of strategies, thus generated, with IH’s usual strategy will give us further insight into what makes her own strategy successful.

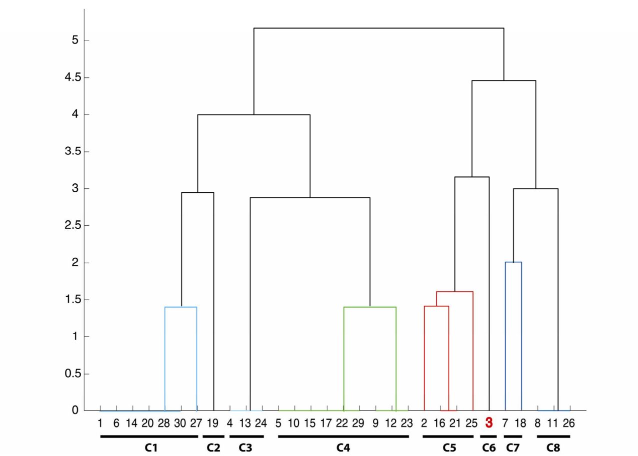

Figure 4: Sets of possible strategies for an arts practice

The clustering of the 30 generated sets of active rules, starting from 30 randomly generated sets of initial ‘stable’ conditions, is shown in Figure 4. Of these 30 randomly generated sets of ‘stable’ conditions, one took the form of the binary array [1 1 1 1 1 1], meaning that every initial stable condition was set to ON; this set is identical to IH’s stable conditions (Table 1). Thus, it represent IH’s own artistic strategy (i.e., use of operators, given the initial conditions of the simulation); in Figure 4, this artistic strategy is represented by cluster 6 (i.e., C6). In fact, this strategy is the set of rules we have seen in the previous simulation run of ACE (Figures 1, 2, 3). Now, knowing that IH’s general artistic strategy is represented by C6, we might ask: What are the other *possible* strategies? What are their relationships to C6?

Looking at Figure 4, we notice two main strategy clusters. The first one includes C1, C2, C3, C4; the second one, C5, C6, C7, C8 (and, thus, includes IH’s strategy). C1, C2, C3, C4 are the furthest from C6, compared to C5, C7, C8. Why?

C1 and C2 have in common the first and fourth initial ‘stable’ conditions (from Table 1, the *absence* of: (agent (name X) (status artist)); and, the *presence* of: (goal (agent X) (task taking-my-work-as-an-artist-seriously))). Both assert that their simulated – ACE – agent does *not* have the status of artist. Thus, they do not have to pay for their own production, be productive, and so on, as IH must. The case is the same for strategies C3 and C4. We might say that these four strategy types represent strategies that might be used by ‘aspiring artists’; these strategies use some of the operators of IH’s own strategy, but are also lacking many (i.e., those related to financing one’s own production).

What about strategies closer to IH’s strategy? Unlike C1-C2-C3-C4, both C5-C6 and C7-C8 have in common the asserted fact of having the status of artist (i.e., from Table 1: (agent (name X) (status artist))). In the simulation, the runs that later formed clusters C5-C6-C7-C8 (i.e., runs 2, 3, 7, 8, 11, 16, 18, 21, 25, 26) activated many of the E operators (e.g., FAP, PPI), but the runs forming C1-C2-C3-C4 never did. Thus, strategies closer to IH’s manage to efficiently achieve E goals – economic ones.

The closest strategies are those composed of the runs clustered under C5 (i.e., runs 2, 16, 21, 25). These runs, in addition to simulating agents having the status of artist, assert that these have as a goal taking their artistic work seriously (from Table 1: (goal (agent X) (task taking-my-work-as-an-artist-seriously))). What happens if you combine this artistic status with serious work? In runs 2, 16, 21, and 25, many operators are active in E; and, as a consequence of doing the work as an artist seriously, there is more activity in both the A and C spaces (e.g., the DAS, ARJ, PRA operators; these ensure that the agent does not stop working on his or her art, works at it full-time). These strategies, very close to IH's own, emphasize highly committed work, both on the artistic front and the career front.

This second HCA mainly emphasizes the importance and role of both IH’s status as a professional artist and of her high-level goal of doing her work as an artist seriously – and of what these initial conditions entail in IH’s general artistic strategy. To these all-important conditions, IH’s strategy also adds very significant high-level goals (see sections “ACE: A Sample Run” and “Cluster Analysis of IH’s Rules of Practice”): wanting to be an artist her entire life, learning and doing what she needs to in order to do that, wanting art to remain a calling, maintaining basic living conditions, and attaining success as an artist. These high-level goals – and related operators – distinguish her strategy from other variations seen here.

Conclusions

Previous analyses (Leclerc & Gosselin, 2004) had suggested three main search spaces, three problem-solving spaces, were involved in the artistic practice of professional artist Isabelle Hayeur. Now, a computer model, simulations and

[8] This HCA may also serve as a *Gedanken*, or thought experiment, suggesting possible general classes of artistic strategies; these different strategies – sets of operators and artistic goals – would then suggest different types of artistic strategies.

cluster analyses of the model's behavior further suggest the role played by these search spaces in this artist's real-life artistic practice. Further work will need to be done, both with other artists and other research methods, in order to validate this three-space model of artistic creation. If validated, this model could prove useful for the study of artistic creation and practice-related processes in a similar way as Klahr and Dunbar's (1988) dual-space model is for the study of discovery processes in science.

We are currently planning on extending the model to include the "image-generation space", the problem-solving space involved in the image-production activity of the artist (part of A, but at a finer resolution than the rules presented here). Further work will also involve expanding and validating the model; this will include testing the predictions of the model as these relate to the artist's behavior.

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