Julian Rohrhuber

Algorithms in Anthropology

Introduction

The project *Virtual Gamelan Graz* proposes that the practical experiment with sound synthesis opens new theoretical perspectives for the understanding of gamelan music. Instead of using notational systems simply as a device for procuring and storing musical information, appropriate systems allow researchers and musicians to reason about musical rules by making them explicit and experimentally test them. Not restricted to a passive collection of facts, thus knowledge (both emic and etic) becomes embedded within a context that reproduces certain aspects of the music and may be part and not only result of an active process of investigating, of listening, adjustment, and reappraisal. In the paper "Listening to theory. An introduction to the Virtual Gamelan Graz framework" by Rohrhuber and Schütz (in this volume), we discuss this method in closer detail. Here, I propose to take a broader perspective and ask in how far such a strategy is justified within anthropological methodology in general. In such a context, computational methods should not be reduced to technical details of something that could be thought and specified without algorithmic means. Since we are dealing, strictly speaking, with formal rule systems, with sets of instructions, the question can be specified: How to formulate a concept of *algorithm* from within anthropology? And if so, how does this conception relate to a more formal notion, as well as to the practical needs of modeling within this field? Consequently, in the following, the algorithm is considered in two aspects: in the position of a possible subject of research on the one hand (as musicologists, for instance, we are interested in the logic immanent in the art of gamelan music), and in the position of a research methodology (modeling gamelan music practice, we need to implement a logic that makes up this model) on the other.

Let's consider the terminology from a historical point of view first. The term *algorithm*, as derived by Europeans from the name of the Persian scholar Abu Abdullah Muhammad ibn Mūsā al-Khwārizmī ('From Khwārizmī' was born around 780 CE in today's Uzbekistan), originally referred to methods that allow the manipulation of Indo-Arabic numerals and formulas through a series of rearrangements of place holders. Such mathematical operations can be traced back over long periods of Asian history (Srinivasiengar 1967, Grattan-Guinness 1999). Similar to the rules for using an *abacus* which allows solving difficult calculations by simple shifting patterns of beads, an algorithm removes complications. This is reflected in terminology: The act of *al jabr*, the origin of today's term *algebra*, at the time meant the physician's act of 'setting a patient's limb,' as well as rearranging and thus 'balancing' a mathematical equation so that it can be solved more easily.[1] Algebraic reasoning, in other words, dealt with the technology of restructuring, of taking apart and putting together; it is an act of *calculation* only insofar as it teaches the operation of 'setting the equation's variables.' Like a grammar of action, it is rather a reflection upon possible operations.

While in their original reception in 13th century Europe, algorithmic techniques were confined to variables that refer to numbers and polynomials, over the following centuries, the field of algebra widened considerably. Attempting to set down a general technique of scientific thinking, in the Europe of the seventeenth and eighteenth century, scholars brought the mental act of reformulation and logical reckoning ever closer to algorithmic methods; further generalization followed, and operating with entirely abstract entities became so commonplace that today, an algorithm may refer to any set of rules for manipulating symbolic structures. More precisely, in this context, an algorithm can be thought of as very simple and unambiguous steps which, as a whole, function in a more complex way than their individual simplicity may suggest (Dietrich 1999:11-12).

Earlier attempts to unify two realms – formal language and rule based action – date back at least to the Renaissance, but over the course of the twentieth century, they became relevant to various fields such as telecommunication, factory automatization and warfare. Today's omnipresence of programmed devices makes the algorithmic a prominent, and yet at the same time hidden, constituent of our material culture. Moreover, computer programs serve as *models* for social and economic organization, and various art genres reapply the idea of algorithmic action to human performance. Above this, many artifacts imply calculations or, from a more general point of view, they may have been produced by or

1 For a detailed discussion of the history of al jabr, see Gandz 1926, Saliba 1972, Oaks/Alkhateeb 2007.

allow the application of rules.[2] Not to forget, the original algorithmic technique of *al-jabr* has its modern revenant: An algorithm is what refers to the decision trees used in diagnostics and emergency medicine today.

Clearly, the algorithm is a cultural technique that has been transcribed many times and has thus attained a somewhat multiple identity. Or, on the contrary, it is only because it appears to be so essential to current technological developments, that the algorithm becomes a meaningful concept for a rereading of some older, but also certain current practices. Maybe, for instance, musical improvisation appears only to be a case of rule based, algorithmic action because computer languages and music machines have commonly been used within European music culture. While keeping this unavoidable methodological caveat in mind, it is noticeable that in various forms of algorithmic techniques, a peculiar intermediacy between mental and physical acts and a strong affinity toward a reflective attitude by means of mechanisms can be observed. From one point of view, their mechanisms may be seen as an externalization of reasoning. From the other, one can consider them as acting patterns setting cognitive constraints. Addressing the frontier between thinking and acting, the algorithm is necessarily an ambiguous term. Here, I will sketch out a brief account of this concept from a perspective of cultural anthropology, against the background of a discourse on the interaction between cognition and material culture.

It is worthwhile to ask to what extent algorithms are justified not only as a subject, but also a method within cultural anthropology. All kinds of statistical and algorithmic techniques have found their way into its toolbox,[3] though the algorithms themselves usually make up a rather implicit part of concept formation. In ethnomusicology and social anthropology, computer experiments have become more common over the last two decades.[4] Contextualizing computer

---

2 Within theory of mathematics education, for instance, it has been suggested that in a modern society, “Formerly explicit mathematics […] has become ‘embodied’, ‘crystallized’ or ‘frozen’ in objects of all kinds.” (Chevallard 1989:2)

3 Many of these programs have been adopted as tools for fieldwork. See for instance Bharwani 2006, or Michael D. Fischer’s *Kinship Editor* (http://era.anthropology.ac.uk/Era_Resources/Era/Kinship/index.html).

4 Fischer and Zeitlyn even diagnose a new phase in the use of computers within cultural anthropology: “We are now entering the third phase of computer use, interactive and non-repetitive, integrated as a part of an overall activity, rather than an independent process. This is necessary for the research environment in the knowledge rich disciplines, where the principle mode of

programming as a *cultural technique*, from a metatheoretical point of view we may describe experimental forms of programming as an epistemological interaction situated between cultures of algorithmic thinking, rather than a simulative model for the reproduction and demonstration of behavior. We can expect this to apply only to some limited domains, so that we will first have to determine where it is justified to speak of algorithms in a more specific sense.

Algorithms as Artifacts

Within the cultures of computer science, the term *algorithm* has a very definite place; its formal description is considered largely unproblematic, although multiple models do exist (Knuth 1980). Nonetheless, there are at least two ambiguities that can be recovered, touching foundational questions of computer science. One of them concerns the question whether an algorithm is a technique, just like a mechanical device, or whether it is a mathematical entity, devoid of any concrete physical dependencies. This question has been crucial to several juridical disputes, in which the patentability of such techniques has been at stake.[5] The difficulty to decide this problem could be considered a symptom for the algorithm being not restricted to formal sciences as such, but rather to relate to a more general distinction between knowledge (governed by copyright and fair use) and technology (governed by patents and trade). The second ambiguity is central to foundational discourses in computability and complexity theory and to theory of formal languages. Here, the algorithm is treated as an abstract, timeless solution to a specific problem, such as the calculation of a certain number or series of symbols. All the same, the notion of timelessness is challenged, either by attributing a limitation to the concept or by extending the algorithm to explicitly allow for the passage of time and the occurrence of external intervention within its operation. These ambiguities are related to the question of how the descriptive aspect of the algorithm relates to its result. They tend to become evident where computer programs cannot be reduced to a tool for a purpose. While from an 'applied' point of view, a program that behaves unexpectedly is a

analysis concentrates on the interconnections between different sources of information, rather than on the modeling of a particular limited knowledge domain." (Fischer/Zeitlyn 2003:10)

5 For instance, see Newell 1986, which is a response to Chisum 1986.

disturbance to be removed, it is a much-studied property of algorithms whether they actually lead to a solution of a problem, or whether they stray away, become circular, or fail in other ways. Not only its productive result, but the basic (physical or mental) motion it describes, is of interest.[6] In experimenting with a synthesis of gamelan music, for instance, the perceptual aspects of time passing, of interaction within different parts of the system and even the basic temporal quality of sound are essential and cannot be eluded. Interaction must therefore be thought as to be integral to the rule based sound synthesis processes.

Consequently, algorithms, as we use the term here, are part of interaction processes, just as the steps of a mathematical deduction are part of the mathematician's reasoning, or the recipe of the cooking procedure. In a sense, this situatedness is a consequence of basic formal properties. While this understanding is maybe the broadest, it allows us to regard the narrower definitions by other theorists in the light of cultural sciences. For instance, one often takes algorithms to be *definite* (unambiguous) and *effective* (simple to follow) (Dietrich 1999:11-12). In other words, they are a way to render something unambiguous, as well as to create a context in which its rules become easy to follow. This is no general property though, it depends on the given situation; this dependency can even be considered necessary for all foundational mathematical ideas, so that for algorithms it is unavoidable "because being unambiguous and simple are rela-

6 Drawing from research on distributed, parallel systems, one may follow Wegener and Goldin and posit an opposition between systems of interacting objects and algorithmic procedures. According to this understanding, an interaction "contract" is valid over time, and thus is part of continuing transactions, whereas algorithms have to be considered timeless, already existing solutions to problems. "Procedures and objects both determine a contract between providers and clients of a resource, but objects provide richer services to clients that cannot be expressed by algorithmically specified procedures. Algorithms are like sales contracts, guaranteeing an output for every input, while objects are like marriage contracts, describing ongoing contracts for services over time. […] The folk wisdom that marriage contracts cannot be reduced to sales contracts is computationally expressed by interaction not being reducible to algorithms." (Wegener/Goldin 1999:10). Such differences can be important to computer science because in a system that is incompletely specified, and that receives its specification while it is applied, the interaction that happens over time may (or may not) be considered to 'express more' than a system that is complete from the beginning. Wegener and Goldin need this distinction within their argument on computability. From a historical perspective though, we do not need to follow this terminology, as long as we keep in mind that the temporality and determination of formal systems is – with good reason – an old dispute in philosophy and mathematics. Kleene, for instance, preferred the term *decision procedure* for algorithms that halt. Generally it is undecidable whether a given set of instructions will halt in a given situation, so that if this property defines what an algorithm is and what isn't, the term itself becomes undecidable. (Kleene 1952).

tive, context-dependent terms."(ibid:11). It is useful to keep this idea of a key-lock principle for the further discussion: It will become relevant when we try to consider in more general terms what makes up the specific agency of algorithmic structures.

Following very simple rules may lead to complex behavior that, as a whole, is almost impossible to understand – this phenomenon has been influential to European thinking over the last century. Considering fields like cybernetics, chaos theory, and dynamical systems theory, it stands to reason that, together with the development of computers, the algorithm has become a cultural artifact that is the emblem of control and of intractable diversion at the same time. Yet of course, a fascination with the particularities of unfolding rule systems is not at all confined to urban computer culture. To reflect the relations between schemes and consequential actions can be considered to be a rather basic human need, and it must be assumed that such a reflection is important for the transmission of knowledge about actions, for their synchronization, as well as for their modification. It is not necessary to subsume such a reflection under the term *algorithm*, and without doubt, in each case, there are specific terms for such types of reasoning. It may serve as a useful concept that allows us to converge reasoning and action on a more general level however; this is if we understand it in the broad sense, namely as a specification of an action, determining rules that are dependent on circumstance and that can be applied in certain, possibly varying order. In this respect, algorithms are a typical case of *operation chains* (*chaînes opératoires*) that anthropologists try to infer from Paleolithic artifacts (Bar-Yosef et al. 1992). The stages of labor without which it would have been be impossible to invent, create or use such a utensil can be seen as vital part of its identity. Within French anthropology, this concept has been extended (Leroi-Gourhan 1993). According to this reasoning, we may infer not only stages of labor from artifacts, but may also ask in how far they embody and replace action patterns of an earlier era. In his critique of a unidirectional view on operation chains, Schüttpelz discusses another important aspect: It is not enough to consider a one-way inscription of an action scheme into accumulating material circumstances such as things or living environment, but also the reverse process in which they are re- and misappropriated, and form the background of a new formation of action (Schüttpelz 2006). An artifact has to be understood as a hybrid between its social context and its materiality, and operation chains are neither separable from material culture nor are they simply invested into the matter of the artifacts they bring about.

This well-studied interaction allows us to discuss the algorithm in the context of a broader discourse on cultural techniques. First, the algorithm *results* in an operation chain; an algorithmic rule consists in elements that prescribe discrete operational steps – these steps concern a specific environment or device in which they take place (for instance when we see it as a way to use an abacus for arithmetic). On the other hand, an algorithm has its own operational history, too – it is an invention and it is modified frequently, so that we can let it take the position of the artifact and bring its own enchainment into focus. Such an understanding appears when rules are not only applied, but are being negotiated and modified, for instance when they fail or where they are underspecified and in constant development (Schüttpelz 2006:6, Latour 1999). This reflection or recursion cannot be taken for granted; instead, if an algorithm becomes evident, we usually have to suspect some kind of noise or disturbance (*Störung*) that inhibits its transparent functioning and stages its law while diffusing the instrumental relation (Schüttpelz 2004).

Accounting for an underlying discourse of rule systems, the dichotomy between tool/labor and art/reasoning on the other becomes indistinct. This is because the cognitive chain that has led to an action pattern is itself embedded in the pattern. On a more basic level, we can conclude for now that one can always take the perspective of an algorithm's eventual *result* or of the *effect* it has for working conditions, ceremonial action, or musical performance. In many cases these aspects are difficult to separate: Mechanisms are ambivalent in the sense that they direct and constrain human action just in the same way as they help to fulfill a goal. This explains why the enactment of schemata may appear as a tool or a method, while on the other hand its ability to structure time and social situations brings it closer to performative art. Such an ambiguity is typical for a medium in a more literal sense: it is just as much a mediator or means as it is an environment or setting.

We may conclude that by abstracting agency into general rules and patterns, the algorithm is something that we *suspect* 'behind' operation chains. It is not the chain itself that is taken for the agent, but the constellation of exigencies that motivates the chain. This may be considered some causal and/or social structure, motivations, intentions, or formal procedures, but it may well be an entirely imaginary cause. But on the other hand, being a 'medium of operation chains' in this sense, the algorithm is usually coupled to some other medium: It may be written down as a formula or as a description, it can be depicted in some other way, or it can simply be talked about; but an observer may also infer algorithms from certain actions or from an artifact, and speculate in how far these actions directly embody a reflective aspect. Here we touch on the difficult question in how far we may, from an analytical point of view, discriminate between explicit and implicit representation, and, as far as agency is concerned, find out where we are confronted with a representation at all. Whereas in the rather narrow understanding, algorithms are part of written language, or even restricted to a certain type of mathematical or logical writing system, clearly there are various ways to communicate about rules or plans of action. In recent times, historians of mathematics have begun to take into account forms of representation that diverge from the established path; in a broader sense of formal language, poetry, music, dance and visual art are possible candidates for systems of mathematical knowledge, or implicit mathematical reasoning. For instance one may try to infer the development of numeracy from such media of reasoning and their relation to cognition,[7] or one may suggest a specific mathematical reasoning implied in music.[8] The material culture relevant in enabling or supporting mathematical cognition has become worthy of attention in the history and theory of science.[9]

These research efforts make it plausible to attribute methods of formal reasoning or of calculation to all kinds of situations. The algorithmic assemblage from elements of actions is especially interesting in this context, as it combines embodied acts and physical objects to form a situated cognitive process. It seems that this specific kind of agency that may be attributed to the participants of such situations may be worth a closer look. In the following, I will suggest a specific

7 Also within pedagogics, the physical embodiment of mathematical concepts has gained attention, so that material culture has become a subject of interest. See for instance Powell/Frankenstein 1997. In a way, these more recent developments could be considered a response to the structuralist conceptions, where within anthropology and linguistics, the influence of generative grammars and graph theory was especially prominent, while over time, research has been taking into account a wider field of mathematical ideas.

8 An example in musicology is Brenner 1997.

9 Damerow, for instance, makes this point: “In particular, the level of development of arithmetical thought in the various cultural epochs is not being defined by the actual results of arithmetical thought, but by the arithmetical means and external representations of mental models that were available for the ontogenetic development of arithmetic abilities, so that these could in principle evolve.” (Damerow 2007:23).

interpretation of the algorithm as an artifact, and artifacts as traces of the application of algorithms.

Abstractions of Agency

In his work on agency, the British social anthropologist Alfred Gell shows in how far artworks have the tendency to become inferential puzzles: While getting enmeshed in it, the observer becomes fascinated in the specific causation that supposedly brought the work into being. In this *abductive reasoning*, the traces of action lead to the supposition of general rules or motivations (Gell 1998). Generally, this involvement results in an intricate network of agency between various things and persons participating in the artistic social situation. There are certain things (in Gell's anthropology of art these are the artworks) that have the effect on observers to make them start construct plausible reasons for these objects' existence. These reasons may well lay beyond immediate causation and, in principle, can include any kind of inner logic that allows to account for the appearance. Often, something is necessary to disturb the habituated associative activity and trigger the search for alternative causes in a more complicated field of possibilities.

So while an artifact may draw an observer toward assuming such an underlying rule system, it may at the same time be extremely difficult to understand. Gell gives some examples for such artifacts that provoke, as we may term it, an algorithmic interpretation while at the same time resisting to be read as the product of a rule system. In many cases, such as some of the Tamil threshold designs (*kolam*), a relatively simple algorithm leads to a result that thwarts a simple decoding (Gell 1998:84-86). Looking at a *kolam*, we see a line of rice powder that appears to be simple and schematic; the underlying dot (*pulli*) pattern gives orientation; yet when one tries to reason about how it was made, it becomes opaque: The observer is caught between the attraction of its simplicity and its cognitive resistance. This 'stickiness' is what Gell refers to be a characteristic "subversive effect of viscosity on the body/world boundary."[10] The observer is

[10] Gell draws this illustration from Sartre's description of viscosity (Douglas 1966), which he gives the post-Maussian reading of "gifts as adhesive components of persons", and of decorations as mediators in the "creation of attachment between persons and things". (Gell 1998: 83)

held between the attraction of understanding and a baffling complexity. Thereby the artifact also produces an urge within the observer to overcome the cognitive resistance by becoming part of the artwork, and learn the underlying algorithms by acting them out.[11]

This can be found in music performances, too: because everything heard is the observable result of actions – be it voice, be it instruments played, it is their intractable combination that captivates observer and performer alike. In the case of 'improvisational' music cultures that use notation only as a general guideline and take situated decisions as central part of musical reality, observers may also assume with good reason that it is reasonably elementary situational rules, and not a memorized composition that orients the musicians' actions. Here, the aforementioned, more formal concepts of *definiteness* and *effectiveness* of algorithms apply surprisingly well: One has the impression that each step is simple and easy to follow. Moreover, it makes it easy to decide what to do next, presenting a situation where choice is reduced and, in handing over most responsibility to the mechanism, blindly enjoys the consequences of initial conditions. In such a way, algorithms deserve to be considered caricatures of causation, or *abstractions* of agency. Here, abstract agency is not understood to be removed from an assumed 'original' place, but rather as modifying the situation so that its elements become players in a game in which they wear the masks that allow them to appear simple and clear.

Despite this simplicity, for an observer who wonders about its origination, it is difficult to decide whether it is the artist's actions or the algorithm that has caused the artifact. In many respects it is a direct or indirect result of the rule system, so that its inner dynamics seem to be the sole origin of the former. On the other hand, the rule system can be seen as a tool or cultural technique that is just being applied by a human agent, who is then seen as the prime mover. In other words, the viscosity, or cognitive resistance also blurs the boundary between the human and automatic causation. According to most agency theories, this ambiguity is typical for artifacts, as well as for tools: action and passion, agency and patienthood tend to swap places, so that things take on the roles of persons (Gell 1998, Latour 1999).

---

11 It could be that it is the affect of such a "pleasurable frustration", that the audience and the researcher share when confronted with partly unknown causal texture. Maybe the complicated issue of participant observation becomes directly entwined with a basic function of art here.

We have to remember though, that agency is an *ascribed*, or as Gell puts it, *abducted* quality. Nevertheless this model does not suppose that it is the observer who brings herself into a receptive state of mind to aesthetically judge and ascribe properties to the artwork. It is the artwork itself that involves the observer, and forces her to hypothesize; it is attractive, exactly because it tends to involve the observer in a relation: By disturbing the *causal milieu*, the functioning of accustomed deduction patterns, it makes us wonder about causation, and speculate. Because algorithms are abstract, they can be ambiguous and polyvalent – we may never know for sure who and why. Faced with ambiguous agency, the situation becomes readable as a system of a latent artificial causality.[12] Usually, the algorithm that takes part in this situation is hidden, implicit in what could be called performance, habitus, or style. As a law that governs this medium of artificial causation and replaces other, more common laws, it is one of the agents in the situation. Yet the source of its attractiveness, the tension between its strictness and its intractability, causes a different kind of agency: It does not so much act on the appearance of the artwork, but, quite reversely, it becomes the source of a cognitive process in which the observer is drawn into the game (Gell 1998:86).[13]

From abductive reasoning results an interactivity which is not confined to the relation between an observer and an artifact, it rather encompasses a whole network of social and cognitive relations. Stickiness creates discourses and social formations, and the fact that we are confronted with small, but unsolvable problems, that we have acquired a taste for something, or that we share a competence, gives rise to a living environment, or a community of practice. 'Live style' can be seen as such a specific causal system. Also games and especially musical interaction have this specific discrete stickiness that characterizes a clear intuition of being 'inside,' of being situated. Here, the algorithmic is not hidden in the past and in a maze of traces, but it is in action, or enacted, like a role. The terminological closeness between agent and actor makes sense here: By acting differently, one experiences how contingent association is, and how equally

12 In another paper, we have looked into structures of artificial causality within networked computer music practice (Rohrhuber/de Campo 2004).

13. It is clear that this discussion need not to be confined to artworks at all. Algorithmic agency actually is clearly more generally related to reasoning, and it would be worth considering the suggestive character of scientific reasoning in this context.

attractive an alternative, parallactic, view can be. The instantaneous impression that a given situation is consistent comes with a rather great difficulty to explain why this is so. While in his earlier theories of enchantment (Gell 1999), Gell views the efficacy of the artwork as a function of an artist whose control over the material exceeds the percipient's, in further steps, he shows how the observer relation becomes more complex. One might be reminded of hysteria as a phenomenon in which the analyst's desire to speculate is mirrored by the analyzed person's desire to enrich this search with endless series of symptoms.[14] Since in this way, works of art are made to be read, and are refined to persist at the border of perception and cognition, involving the percipient, art functions by leaving a remainder (Certainly we may be able to find out more about the cultural determinations of cognition if we look into the specific techniques that navigate along the sticky border of perceptual complication). Moreover, we face an object (or situation) that is not silently waiting to be discovered, or a natural law that is only to be found, but we are confronted with an object that *addresses* our ability of understanding and our habituation of action, and intervenes in it. Art is algorithmic in the sense that it leads to ambiguous situations in which exploratory objects (Guardans 2008), become relevant for possible epistemic things (Rheinberger 1997). This leads us to the methodological question raised in the beginning: In how far can algorithms be a method for understanding art? Since the object's agency depends on the situation, it can be useful to approach this situation by slowly adding assumptions about the inner connections between different observations, and slowly build up something like a model of one's own assumptions. In the case of algorithmic situations, such a model does not have to be a collection of written statements; it can be an algorithm itself.

A program as perspicuous presentation

The activities that formerly had been transformed from labor to machines, and then increasingly made independent from mechanical devices, have developed into a peculiar kind of culture. Be it communication devices or simply per-

---

14 In this vein we may also read Searle's conception of computation, in which he posits that "nothing is intrinsically computational. Computation exists only relative to some agent or observer who imposes a computational interpretation on some phenomenon." (Searle 2002:Section IV)

sonal computers, today, algorithms are ubiquitous parts of daily life in many societies. Because of this significant impact, a large section of computer science has been oriented toward being an engineering discipline, and computational problems have been stated as technological problems. As a consequence, algorithms are mostly regarded as solutions to mathematical problems that can be materialized in the form of some technology, some application. On the other hand, the history of the computer has been accompanied by the idea that programs do not only solve problems (invisible once constructed), but they may form a continuous constituent of a human reasoning process, in which the programming is not a result that follows the formulation of a solution, but it is an active part in concept formation. Such conversational or interactive programming approaches then serve as a way of explicating models, sketching ideas, as archives of knowledge and of connecting formal schemata with concrete cultural data. This possibility has led to a shift in scientific culture: One may simulate phenomena or model causal relations by writing down algorithms in a computer language. Thus, one may test the consequences of one's own assumptions much more directly, because the program follows the description in a strictly defined way that is, to a degree, independent of other background assumptions. Translating assumptions in such a language removes them from their original domain and introduces distance, forcing to both clarify the underlying concepts as well as accept their formal consequences. In this programming is a little bit like the reflection that happens when one tries to teach someone a skill that one has acquired over a long period, maybe with the slight difference that computers are at least as patient as their user and tolerate methodological results fatalistically. In such a way, the computer algorithm is a mirror not so much of the process modeled, than of the network of assumptions made by the researcher.

In cognitive sciences, computation has been significant as a model of thinking – be it in the more direct form of thought as symbol processing (cognitivism), or more indirect approaches like connectionism or situated cognition.[15] Especially for the cultural sciences, but not exclusively so, I would like to propose a more reflective interpretation: Computation functions as a *mirror of the assumptions of the researcher*. Rather than making the system an image of the domain of research, it is an image of the consequences of statements made in the

[15] For a discussion of different conceptions of music cognition together with agency cf. Kim/Seifert 2007.

research, and a way of keeping the collection of data in an environment where it can be combined with other data. Whether a computational process can provide useful insights depends largely on the domain. Especially remembering the fact that programs are hardly able to simulate social embodied agency, we should not expect too much from such models; on the other hand, the anthropological accounts themselves are usually restricted to recordings (film, sound, photography) or to text, which is, by itself, equally disembodied. Actually it is exactly this type of reduction by the act of writing, filming, etc., that helps to gain orientation and allows a perspective that is involved and disengaged at the same time; and just as in anthropological field research a notebook may be the last refuge, for a physicist a model of the theory is indispensable. Thus, the medium of report becomes an observational tool just as well. It is exactly its poverty and its inability to total transparency that make it significant. As such, it provides a brittle bridge between the inner logic of the situation (or the inner workings of a theory in the second case, the local society in the first) and the logic of scientific description and knowledge accumulation.

This gap between different kinds of logic systems is considered to have led to the most fundamental confusions, notably in the discussion of magic, where the attribution of causality – central to scientific reasoning – became a problem. Wittgenstein gave a detailed account of this complication in his remarks on Frazer's *Golden Bough* (Wittgenstein 1979:8–9), in which he analyzes the researcher's hypothetical reasoning: "And all this points to some unknown law", is what he sees in the material Frazer has collected. He goes on:

> "I can set out this law in an hypothesis of development, [*or evolution?] or again, in analogy with the schema of a plant I can give it the schema of a religious ceremony, but I can also do it just by arranging the factual material so that we can easily pass from one part to another and have a clear view of it – showing it in a 'perspicuous' way. For us the conception of a perspicuous presentation is fundamental. It indicates the form in which we write of things, the way in which we see things. […] This perspicuous presentation makes possible that understanding which consists just in the fact that we 'see the connections'. Hence the importance of finding intermediate links. But in our case a hypothetical link is not meant to do anything except draw attention to the similarity, the connection, between the facts. As one might illustrate the internal relation of a circle to an ellipse by gradually transforming an ellipse into a circle, but not in order to assert that a given ellipse in fact, historically, came from a circle (hypothesis of development) but only to sharpen our eye to the formal connection. But equally I might see the hypothesis of development as nothing but a way of expressing a formal connection."

In these remarks, Wittgenstein essentially suggests that when faced with the inner logic of another culture, one is mistaken trying to interpret or translate it to find its presumed essence, but one may only lay out a transitory presentation of its internal relationships. The German anthropologist Fritz Kramer, who discusses the concept of perspicuous presentation in his essay “Booco” (Kramer 2005:302–306), follows Wittgenstein’s concept in so far as to generally doubt the value of explanations within cultural anthropology. Also a suggested autonomous schematic reinvention would go wrong; instead, he suggests that to comprehend the development of inventions and artistic practices, one needs to make them plausible from an emic perspective (Kramer 2005:379–391). Insofar as we share a certain background of cognitive and cultural experience, we may conceive, in its proper social and environmental situation, how practices interrelate.

Following this setting, I suggest to maintain the separation between a formal perspective and a developmental one, simply because formal presentations are *more obviously inadequate*, or at least they do not claim to be explanations. Within such a separation between developmental and formal association, in some specific domains, programs provide an interesting method of developing such hypotheses. They add to the perspicuousness of the presentation, because they do not only give a connective overview of causal relations, but, along with this, they form a stage on which these relations may become active and produce expected and unexpected consequences. They form a type of *immutable mobile* that does not so much circulate between distant regions and allow combining heterogeneous measurements, but forming a circulating montage of iterations between reasoning and acting – an *intractable mobile*.

Especially in cases where a sophisticated and maybe intractable rule system is expected, such as language and music, this type of method may be considered promising. Bernhard Bel and James Kippen, when trying to find out about the most general compositional rules of tabla improvisation, constructed phrases from a generative grammar with the aid of a computer program (Kippen/Bel 1992), learned to play them and presented them to their local interlocutor, whose approval or disapproval became the basis for modifications of the system, where the balance between generality and specificity is iteratively negotiated and may help to form a clearer conception of possible explanations by rule patterns. In this way, musicological reasoning extends its methodology by means of a formal system that demands an explicit formulation of assumptions, and that may actually generate consequential results. To give another example which attempts to serve such processes on a more general level, Latour and Teil proposed a system that uses the structural relations between terminologies to navigate between heterogeneous scientific discourses (Teil/Latour 1995). By identifying homological structures in the terminological network, this program is suggested as a participant in the research, neither providing solutions by itself nor being just a tool: According to its authors, this kind of expert system rather serves as a different way to reason about concept formation.

Specific domains demand much more specific approaches though, and one should not expect a system that could claim to provide a universal language which would resolve all ambiguities. As the history of programming languages show, the modeling of social phenomena, and the cultural context of formal sciences is deeply engrained into technology – we could hardly expect any neutral ground here anywhere. Here lies a methodological pitfall that is present when taking computer models as simulations for processes in general, but which is even more delicate when art and society are subjects of investigation: the fact that algorithms are automatic and dynamic. They *appear* to be untouched by intention, which makes them amenable to naturalization. The question whether and how cultural knowledge of action can be represented in a computer language at all must be posed on the background of an essential culturality of such systems. Thus it is not a question about how to describe an informal practice within a formal language, but rather how to include algorithms into the process of cross-cultural reasoning and concept formation. This is, as our own attempts demonstrate, by no means trivial or unproblematic. But it becomes clear that in such a process, it is unavoidable to re-formalize cultural practice in one or the other way, and to embed this ongoing labor in a conversational approach; since we may understand a computer program both as an instruction for an algorithmic process *and* an instruction how to understand this process, computer programs can be subsumed under the many different techniques of *operative writing* (Krämer 1993). This is a good reason for embracing the culturality of algorithmic procedures such as computer programming and make them part of other activities such as discussing, practicing, guessing, observing, suggesting, book keeping.

Now taking the special case of Bel's and Kippen's research on music into consideration, it may be admissible to take this process as a negotiation between two algorithmic cultures. First, the historical relation between arithmetical and rhythmic thinking results fairly immediately from the affiliation of metric synchronization and combinatorics. In a tradition such as North Indian tabla performance, that shows a high degree of improvisation and interaction, we know that the surface form of practice is mostly the result of a system that cannot be grasped simply by a collection of all variations. Rather, we encounter a rich and peculiar knowledge of algorithms that constitute artistic competence – in knowing how and when to actually perform them, the art is appreciated. On the other hand, regarding the researcher who makes use of computer programs, we are confronted with a knowledge of no less historical, or contingent nature – the generative grammars used in Bel's *Bol Processor* are a result of a long tradition of algorithmic and logic reasoning, and Chomsky mentions his concept to have a predecessor in Panini's Vedic linguistics (Chomsky 1969, Chattopadhyay/Chaudhuri 2001). The success of this project may be the result of its fortunate choice of formalism.

> "That the computer should be an ally in the revaluation of the concrete has a certain irony; in both the popular and technical cultures there has been a systematic construction of the computer as the ultimate embodiment of the abstract and formal. But the computer's intellectual personality has another side: Computers provide a context for the development of concrete thinking. When we look at particular cases of individuals programming computers, we see a concrete and personal approach to materials that runs into conflict with established ways of doing things within the computer culture. The practice of computing provides support for a pluralism that is denied by its social construction." (Turkle/Papert 1992: 161)

While mathematics and computer science justly tends to aim at universality, at the same time they are just as cultural (and universal) as North Indian tabla playing. Turkle and Papert take it to be an irony of fate that in the computer, the formal and the concrete become so intertwined as to reveal this. The specific culture implied in programming forbids the assumption that computer languages are, in themselves, of a higher degree of universality and thus could provide a neutral ground on which one may simply project empirical findings of a culture. Nevertheless, it is still to be seen in what domains different fields of culture share algorithmic knowledge as a common background, and in what ways the combination of reflection and enactment that algorithms provide can serve to stage a reflective epistemology that neither claims totality of knowledge nor absolute relativism.

References Cited

BAR-YOSEF, Ofer et al.
1992 "The Excavations in Kebara Cave, Mt. Carmel", in *Current Anthropology*, vol. 33(5):497-550.

BHARWANI, Sukaina
2006 "Understanding Complex Behaviour and Decision Making using Ethnographic Knowledge Elicitation Tools (KNets)", in *Social Science Computer Review* 24:1-29.

BRENNER, Klaus-Peter
1997 *Chipendani und Mbira: Musikinstrumente, nicht-begriffliche Mathematik und die Evolution der harmonischen Progressionen in der Musik der Shona in Zimbabwe*. Göttingen: Vandenhoeck & Ruprecht.

CHATTOPADHYAY, Suhrid Sankar / KALYAN CHAUDHURI
2001 "An event in Kolkata", in *Frontline*, 18(25), December 08-21.

CHEVALLARD, Yves
1989 "Implicit mathematics: Their impact on societal needs and demands", in: *The mathematics curriculum: Towards the year 2000.* Curtin University of Technology, 49-57.

CHISUM, Donald S.
1986 "*The patentability of algorithms*" Symposium cosponsored by University of Pittsburgh Law Review. University of Pittsburgh Press, 959–1022.

CHOMSKY, Noam
1969 *Aspects of the Theory of Syntax*, Cambridge: MIT Press.

DAMEROW, Peter
2007 "The Material Culture of Calculation", in: Uwe Gellert/Eva Jablonka (eds.): *Mathematisation and Demathematisation. Social, Philosophi-*

cal and Educational Ramifications. Rotterdam, Taipei: Sense Publishers, 19-56.

DIETRICH, Eric
1999 "Algorithm", in: Robert A. Wilson/Frank C. Keil (eds.): *The MIT Encyclopedia of the Cognitive Sciences* (Bradford Book). Cambridge: MIT Press, 11-12.

DOUGLAS, Mary,
1966 *Purity and Danger*. London: Routledge & K. Paul.

FISCHER, Michael D.
Kinship Editor: http://era.anthropology.ac.uk/Era_Resources/Era/Kinship/index.html (retrieved May, 20th, 2008)

FISCHER, Michael D./ ZEITLYN, David
2003 "Visual anthropology in the digital mirror: Computer-assisted visual anthropology", Tech. report, University of Kent at Canterbury, http://lucy.kent.ac.uk/csac/lucy/dz/layers_nggwun.html (retrieved March 2008).

GANDZ, Solomon
1926 "The Origin of the term 'Algebra'", in *American Mathematical Monthly*, 33(9):437-440.

GELL, Alfred
1998 *Art and Agency: An Anthropological Theory*. New York: Clarendon Press.
1999 "The Technology of Enchantment", in: Eric Hirsch (ed.): *The Art of Anthropology: Essays and Diagrams* (LSE monographs on social anthropology). Oxford: Berg Publishers, 159-186.

GRATTAN-GUINNESS, Ivor
1999 *The Norton History of the Mathematical Sciences* (Norton History of Science). Norton, New York: Mathematical Association of America (MAA).

GUARDANS, Ramon
2008 forthcoming in: Eckhard Fürlus/Siegfried Zielinski (eds.): *Variantologie 4*. Köln: Buchhandlung König.

KIM, Jin Hyun / SEIFERT, Uwe
2007 "Embodiment and Agency. Towards an Aesthetics of Interactive Performativity", in Georgaki Spyridis/Anagnostopoulou Kouroupetroglou (eds.): *Proceedings of the 2007 International Conference of Sound and Music Computing (SMC'07)*, 230-237.

KIPPEN, Jim / BEL, Bernard
1992 "Modelling music with grammars: Formal language representation in the bol processor", in Alan Marsden/Anthony Pople (eds.): *Computer Representations and Models in Music*. London, New York: Academic Press, 207–238.

KLEENE, Stephen C.
1952 *Introduction to Metamathematics*, New York:Van Nostrand.

KNUTH, Donald E.
1980 "Algorithms in Modern Mathematics and Computer science", Tech. Report STAN-CS-80-786, Stanford University, Department of Computer Science.

KRAMER, Fritz
2005 "Booco", in *Schriften zur Ethnologie*. Frankfurt: Suhrkamp, 302-306.

KRAMER, Fritz / REES, Tobias.
2005 "Gespräch IV: Übersichtliche Darstellung: Das Leben der südlichen Nuba", in: *Schriften zur Ethnologie*. Frankfurt: Suhrkamp, 379-391.

KRÄMER, Sybille
1993 "Operative Schriften als Geistestechnik. Zur Vorgeschichte der Informatik", in Peter Schefe (ed.): *Informatik und Philosophie*. Mannheim: BI-Wissenschaftsverlag, 69-84.

LATOUR, Bruno
1999 “Circulating Reference: Sampling the Soil in the Amazon Forest”, in Bruno Latour (ed.): *Pandora's Hope: Essays on the Reality* of *Science Studies*. Cambridge, London: Harvard University Press, 24-79.

LEROI-GOURHAN, André
1993 *Gesture and Speech.* Cambridge: MIT Press.

NEWELL Alan
1986 “Response: The models are broken, the models are broken!”, in *University of Pittsburgh Law Review*. Pittsburgh: University of Pittsburgh Press, 1023-1035.

OAKS, Jeffrey A. / ALKHATEEB, Haitham M.
2007 “Simplifying equations in Arabic algebra”, in *Historia Mathematica* 34(1):45-61.

RHEINBERGER, Hans-Jörg
1997 *Toward a history of epistemic things: Synthesizing proteins in the test tube*. Stanford: Stanford University Press.

ROHRHUBER, Julian / DE CAMPO, Alberto
2004 “Waiting and uncertainty in computer music networks”, in *Proceedings of ICMC 2004: the 30th annual international computer music conference*, San Francisco: International Computer Music Association. Online Version at http://iem.at/projekte/publications/ paper/icmc04/icmc04 (retrieved June 26, 2008)

SALIBA, George A.
1972 “The meaning of al-jabr wa’l-muqābalah”, in *Centaurus*, 17(37):189-190.

SCHÜTTPELZ, Erhard
2004 “Die Spur der Störung” in Gisela Fehrmann/Erika Linz/Cornelia Epping-Jäger (eds.): *Spuren Lektüren. Praktiken des Symbolischen.*

Festschrift für Ludwig Jäger zum 60. Geburtstag. München: Fink, 121-132.

2006 „Die medienanthropologische Kehre der Kulturtechniken“ in: Lorenz Engell/Bernhard Siegert/Joseph Vogl (eds.): *Kulturgeschichte als Mediengeschichte (oder vice versa?)*. Weimar: Weimar Universitätsverlag.

SEARLE, John R.

2002 “The Problem of Consciousness” (Online-Publikation) http://users.ecs.soton.ac.uk/harnad/Papers/Py104/searle.prob.html (retrieved May 20, 2008)

SRINIVASIENGAR, C. N.

1967 *The History of Ancient Indian Mathematics.* Calcutta: World Press Private.

TEIL, Geneviève / LATOUR, Bruno

1995 “The Hume Machine: Can Association Networks do more than Formal Rules?” in *Stanford Electronic Humanities Review*, 4(2):47-65, online version at http://www.stanford.edu/group/SHR/4-2/text/teil-latour.html (retrieved June 26, 2008)

TURKLE, Sherry / PAPERT, Seymour

1992 “Epistemological pluralism and the revaluation of the concrete” in *Journal of Mathematical Behavior* 11(1):3-33.

WEGENER, Peter / GOLDIN, Dina

1999 “Mathematical models of interactive computing” in *Tech. Report CS-99-13*, 10.

WITTGENSTEIN, Ludwig

1979 *Remarks on Frazer’s Golden Bough.* Atlantic Highlands: Humanities Press.