From Brainwave to Tradition—How to Detect Innovations in Tool Behavior

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ABSTRACT

This paper addresses problems in comparative innovation research and offers approaches to the systematic assessment of innovative potential based on the archaeological record. The problems involved in discussing differences in creativity and comparing the innovation rates of different groups, periods, and species are threefold: a) on the level of categorization, b) on the level of detection; and, c) on the level of preservation and resolution. Here, a qualitative and a quantitative scheme for categorizing innovations are proposed. For a detailed examination of innovations, the method of coding object behavior in cognigrams and effective chains is introduced. Finally, the problems of the preservation and detectability of the different categories within the archaeological record are discussed. In order to be able to address all aspects of the problem of identifying and specifying an innovation, the three problem levels are explained using a 21st century example. It is the aim of this paper to systematize the study of innovation and creativity based on the fragmentary remains of material culture that are available, and thus to increase objectivity in the evaluation of an imperfect data base.

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INTRODUCTION

In industrial societies innovation is a guiding theme. Creativity is highly valued and innovations stand for progress, economic prosperity, and modernity. The frequency of innovations is equated with the ability to adapt and thus thought to represent an important measure of the potential for success of a group (see, e.g., World International Property Organization 2009). This lopsided way of looking at and evaluating social communities often is transferred to historic and prehistoric groups, periods, and species. This view is problematic in itself (c.f. Mithen 1998: 2), and the data base underlying this assessment is patchy and rarely analyzed systematically. A social, chronological, or biological entity can be viewed as innovative or static depending on the focus of the beholder (cf. Kuhn and Stiner 1998: 147), the entities with which it is to be compared, or the part of the material record examined (cf. Kuhn and Stiner 1998: 144). An apparent lack of innovations in stone tool technology and a hand-axe tradition lasting more than one million years have been used to characterize the "primitiveness" of the Lower Paleolithic (e.g., Jelinek 1977: 15). Neanderthals have been regarded as mere imitators of the achievements of *Homo sapiens*, who were not able to invent graves, ornaments, bone tools, and foliate points out of their own culture, but relied on external prototypes (cf. d'Errico et al. 1998; Mellars 1999). In contrast, a creative explosion—often equated with a cultural revolution—has been associated with the Upper Paleolithic in Europe, and also with the earlier Middle Stone Age in Africa (e.g., Hoffecker 2005). The assumption that such a revolution occurred has been based on novelties in material culture, the innovative status of which is generally not discussed in detail and may be overemphasized.

To gain a more sensible view of innovative behavior in prehistory, two basic questions have to be considered. First, what sort of entity is under examination—a group, a period (e.g., Kuhn and Stiner 1998; Hoffecker 2005; Hovers and Belfer-Cohen 2006), a species, or even a genus (e.g., Lake 1998)? And are the entities under comparison of the same sort? Second, what is the nature of the innovations

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that have been introduced by this entity? Innovations differ in the extent of changes in the basic elements as well as in the effects. Not every innovation is based on an inspired invention. It may be a tiny variation or a far-reaching novelty in an existing solution to a specific problem, or even a completely new concept. The innovation may have little or tremendous effect by improving or facilitating the application of a solution, by broadening its material basis or the range of problems addressed. It is necessary to evaluate the group of behavioral novelties introduced within an entity under examination based not only on their conspicuousness or their effect, but by meticulous observation of the changes involved in all these different aspects.

The problems involved in discussing differences of creativity and comparing the innovation rates of different groups, periods, and species are threefold: a) on the level of categorization, b) on the level of detection; and, c) on the level of preservation and resolution (the latter are general issues in archaeological research, but with special relevance to the subject of innovation or creativity). Here, a scheme for categorizing innovations is proposed, followed by the introduction of a method to describe innovations in detail. Finally, the problems of preservation and detectability of the different categories within the archaeological record will be discussed. In order to be able to address all aspects of the problem of identifying and specifying an innovation, the three problem levels are explained using a 21st century example. It is the aim of this paper to systemize the study of innovation and creativity where only fragmentary remains of material culture are available and thus to increase objectivity in the evaluation of an imperfect data base.

PROBLEM A: CATEGORIZATION

Fundamental to any assessment of creativity and comparison of innovation frequency is the differentiation of invention from innovation given by Renfrew (1978: 90):

> "Invention is the discovery or achievement by an individual of a new process or form, whether deliberately or by chance. Innovation [...] implies the widespread adoption of a new process or form, and clearly it must be preceded by the relevant inventions whether by a short or by a long period."

Generally, the moment of invention cannot be identified in the archaeological record. If we are tracing a new aspect of behavior in prehistoric arteifacts, it is not the initial creative act that we find, but a durable and already widespread materialization of the basic idea (cf. Kuhn and Stiner 1998: 143–144). The differentiation between invention and innovation will be especially relevant in the discussion of preservation and detectability of innovation processes below.

Inventions are modifications of specific combinations of a problem—a question, desire, or need—and a solution that meets the need, answers the question, or satisfies the desire. In object behavior, a specific combination of a problem and its solution—a so-called problem-solution-concept—encompasses different aspects: the problem itself (the *function* of the solution), as well as the *material*, the *form*, the *technology of production*, and the *technology of use* of the solution. While inventions in the material, form, and technology of production of an item contribute to the solution of a given problem, variations in the function of a tool provide approaches to new problems. A new technology of use may improve a solution or tap into other problems. The first step in analyzing inventions and consequently innovations is to identify the new elements and categorize these as novelties in material, form, function, technology of production, or technology of use.

In a second step, these new elements have to be graded according to the nature and extent of novelty. Was the new element completely unknown before? Was it only unknown in this specific problem-solution-concept, but known from other contexts, and now transferred to the new context, and does it thus represent a sort of cultural exaptation (cf. Gould 1991; Gould and Vrba 1982)? Or is it only a minor variation of an element already known in this context? Inventions and consequently innovations can be characterized qualitatively by describing the novel elements. They can also be characterized quantitatively by giving the numbers of novel elements—the number of elements completely unknown before, the number of exaptations or elements transferred from other contexts, the number of variations—resulting in a code for the specific innovative potential. This formalized categorization easily allows a comparison of the extent of invention involved in different new behaviors.

A MODERN EXAMPLE

In spring 2007, J.B. was confronted with a problem—he was invited to take part in a special event, a designers' fair lasting for one day. He decided not to take the problem as well-known and to simply show his existing collection of ornaments. Instead, he chose to see the problem as a new challenge which deserved an uncommon problem-solution concept—ornaments that can be used only for one day. One of the solutions he found was a ring made of gelatine (Figure 1)[1]. But what is really novel in this example, how

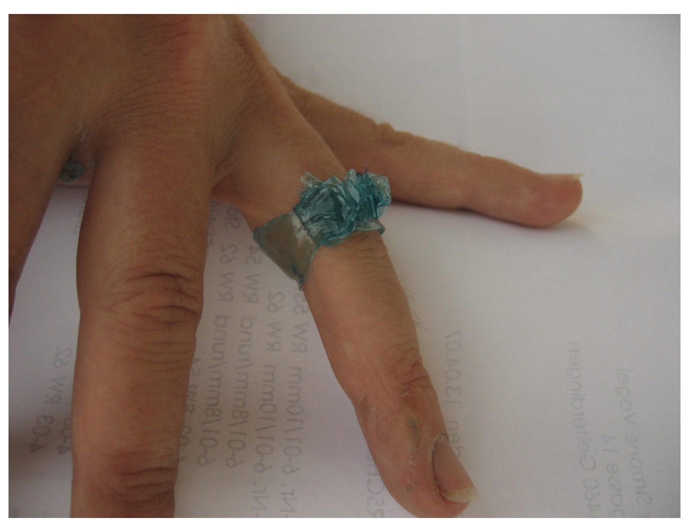

Figure 1. A gelatine ring.

can the innovation be categorized? The form of the solution—a band with a ring head and its function (ornamentation)—are standard in the jewellery context. The materials—gelatine and food coloring—are known from another context, cooking. They have been exapted for the use in the ornamental context. The technology of production, including soaking and coloring, is known from other contexts, while winding is a technology which is traditionally used in a jewellery context, e.g., with the winding of wire. The technology of use—only once—is generally known from other contexts but uncommon in jewellery.

The qualitative description of the innovation also can be expressed in quantitative terms as a specific code, a combination of the numbers of the different innovative categories of elements which were completely unknown before, exaptations, and variations: 0–3–0. In this example there are no elements that were completely unknown before, but three elements were exapted or transferred from other contexts—the material, the technology of production, and the technology of use. Mere variations of one of the elements are lacking. Such a variation could have been, for example, a different form of the ring head, such as a twisted ball instead of a folded square. In sum, the problem-solution-concept chosen is not completely new but new in this combination of aspects.

PROBLEM B: DETECTION OF INNOVATIONS

Without a systematic search for innovative elements, generally the only innovations that are recognized as such in the prehistoric record are those which catch one's eye. Simplifications of the material record can make the innovative elements identified seem more dramatic; a good example is the use of bone tools, sometimes assumed to begin with the Upper Paleolithic (Mithen 1996). In this period, a growing variety of different items made of bone, antler, or ivory can be found in Europe. Pooling all types of tools from this multifaceted period, that were made of these raw materials and were worked with specific techniques, often leads to a perception of this complex of innovations as a milestone in tool behavior, and even as reflecting a leap in cognitive evolution (Mithen 1996). Examined in detail, however, at least the material and some of the technology of production and use were already applied in earlier problem-solution-concepts reaching back to Lower and Middle Paleolithic times (e.g., Backwell and d'Errico 2001, 2008; Gaudzinski 1999). In addition, the increasing adoption of materials that were uncommon before did not at once produce numerous completely new problem-solution-concepts in the Aurignacian. Instead, bone, antler, and ivory were incorporated in the material canon to give a new approach to problems, most of which existed before. This process reached a climax in the Magdalenian. A milestone approach based on looking for the presence or absence of striking artifacts hinders the understanding of innovation processes. In order to detect innovations in material culture, changes in the different aspects of the innovation (material, form, function, technology of production and use, concept) have to be looked for in a systematic approach based on material and functional analyses, *chaînes opératoires*, cognigrams, and effective chains.

COGNIGRAM AND EFFECTIVE CHAIN: TOOLS FOR A SYSTEMATIC ANALYSIS

The comparison of different examples of tool behavior in order to assess differences in the sequences of actions involved in the manufacturing or use process is not new; nevertheless fatal errors are easily made by comparing apples with pears and by misinterpreting differences that are not clearly defined. For example, Joulian (1996) applied *chaînes opératoires* to compare Oldowan stone tools with the use of stone tools by chimpanzees to crack nuts and concluded that there is no big difference between the two, the manufacture of Oldowan tools being slightly less difficult than the use of stones to crack nuts. Two errors are basic to this assessment: a) a pear-and-apple-confusion; and, b) an unspecific identification of difference. First, in both cases the use of a hammer stone was seen as central to the behavior. This putative similarity, however, confuses a complete problem-solution-sequence (nut-cracking) with a partial sequence (manufacture of Oldowan tool without its use). Second, there are other differences between the two behaviors in addition to the mere number of actions needed to bring them to an adequate end. These become obvious by coding the behaviors in cognigrams and effective chains (Haidle 2009).

Cognigrams provide the possibility of analyzing and contrasting different forms of tool behavior—be it from hominins or from animals. As a basis for comparison, equivalent and self-contained study units need to be identified. Every unit comprises a behavioral process initiated by an internal or external stimulus (need, problem) and terminated by the positive or negative satisfaction of the need (the solution to the problem). Examples of such units are: a) the desire to feed on nuts in chimpanzees, opening nuts with the help of hammer and anvil, and the final satisfaction of eating nuts; or, b) the desire to feed on the meat of a carcass, cutting off meat with the help of a stone flake that has been produced by applying a hammer stone to a stone nodule, and the final satisfaction of eating meat. The complete study units are coded in cognigrams, which represent an enhancement of the *chaîne opératoire* methodology. In cognigrams, the various single-action steps, which are pooled in larger phases of action, are assigned to different attention foci (Figure 2). These include all separate, discrete elements of attention that take part in the sequence and include the acting subject, objects to be treated, locations, and actively operated tools. They may be active agents or passive elements. The different attention foci are initiated by the probable perceptions of needs and problems that start the actions. Additionally, the effects of one focus on another also are represented (Haidle 2010).

Effective chains are a simplified version of cognigrams. In this sort of diagram only the foci and the effects on each other are represented. Effective chains become a valuable tool in the comparison of complex and multifactorial behavior, especially if the behavioral process can be broken

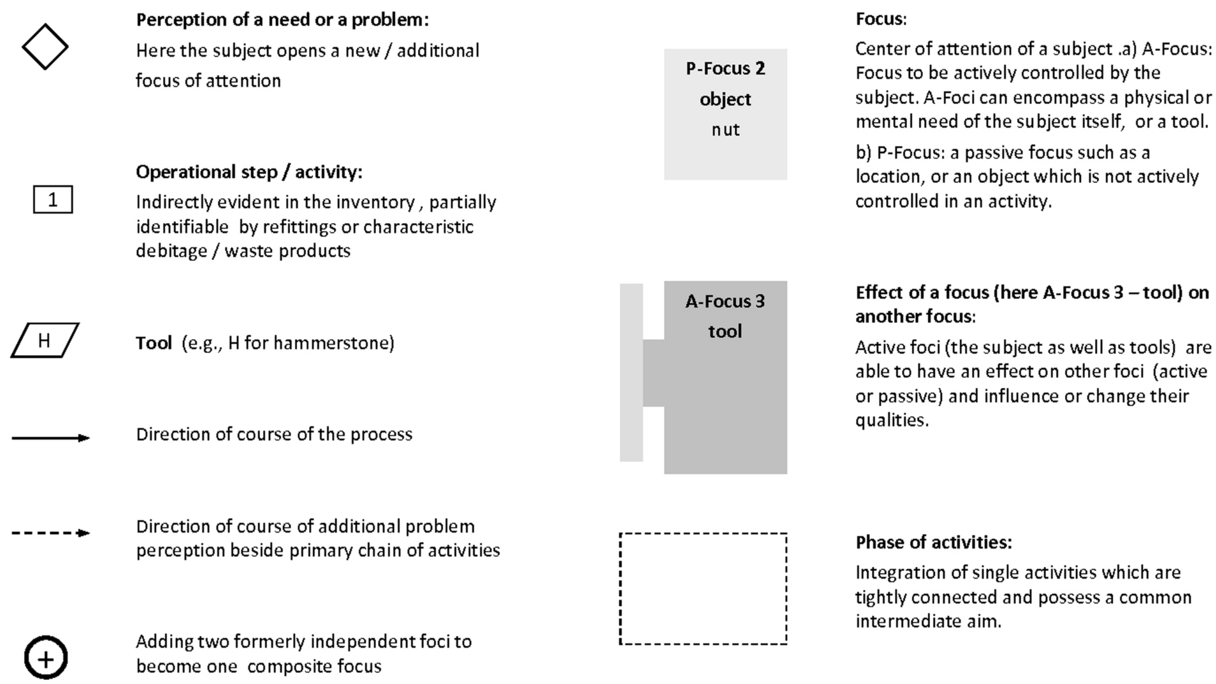

Figure 2. Elements of a cognigram.

down into several sub-processes. Effective chains provide an overview of all elements included in a process of tool behavior as well as how they are related to each other.

Comparing the cognigrams of nut-cracking by chimpanzees and of manufacture and use of an Oldowan tool reveals the differences between the two behaviors (Figures 3 and 4). The nut-cracking process requires only one tool—a hammer stone—to crack the nut. The subject handles only one focus of attention actively (the tool), while another, passive focus is important to open the nut—a specific location, a root, or a big stone used as an anvil (see Figure 3). The manufacture and use of an Oldowan stone tool does not require a specific location, but two tools have to be handled actively to attain the final goal of, for example, cutting meat (see Figure 4). The two tools—hammer stone and cutting tool—are not a simple tool set[2] applied one after the other on the same object, but are part of an extended effective chain (Figure 5 a, b); one (the hammer stone) is used to produce the other (the cutting tool) to achieve the final aim—to slice some meat.

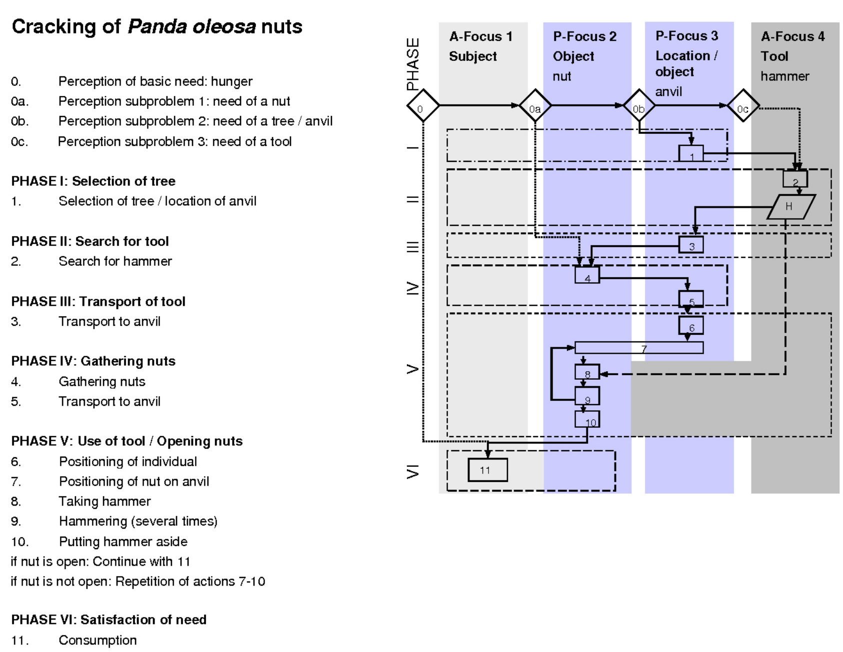

Figure 3. Cognigram of nut-cracking with stone hammer by chimpanzees.

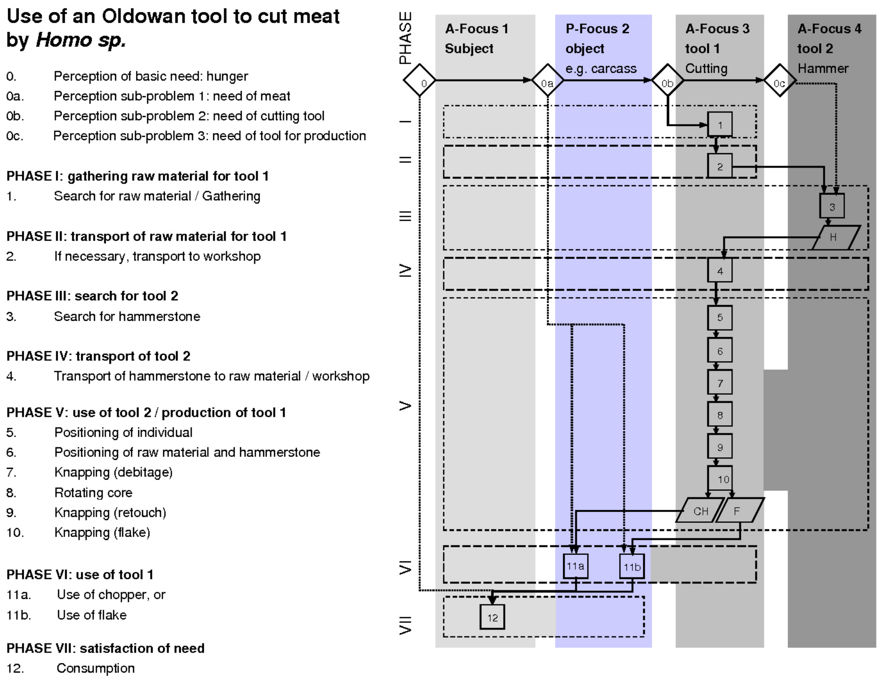

Figure 4. Cognigram of the manufacture and use of an Oldowan stone tool.

Both the cognigrams and the effective chains together point out what is really different between the two uses of a hammer stone, and can help in critically assessing which elements changed in an innovative process—the material, the form, the function, the technology of production, the technology of use, or the complete problem-solution-concept? Even coarse cognigrams and effective chains such as that of the gelatine ring (see Figure 5c; Figure 6), simplified by focusing only on the manufacture of the ring and not considering the production of the basic raw material (gelatine) and tools (scissors, food coloring), can help us to better understand the elements of a problem-solution-concept and to recognize new aspects of a behavior. The clear identification of the differences involved in novelties also can

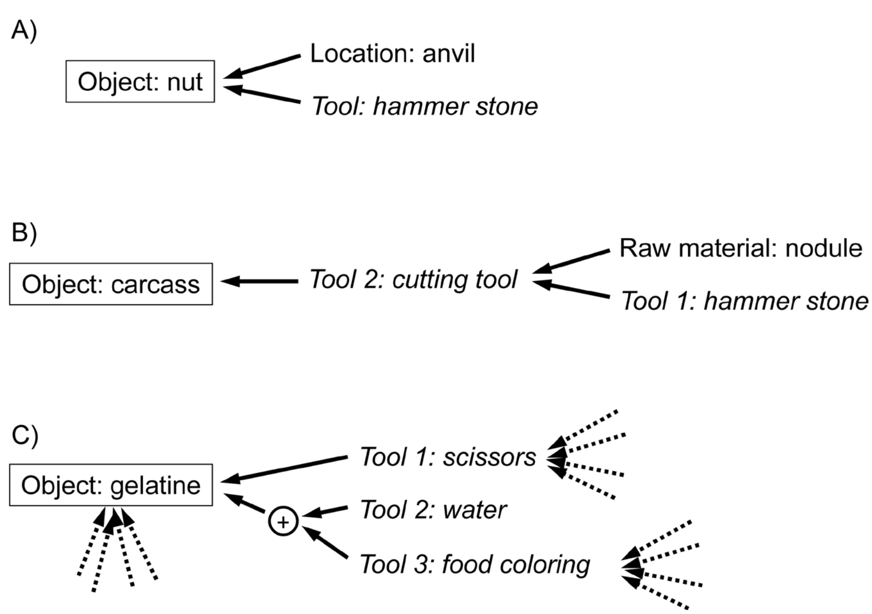

Figure 5. Effective chains of tools used: a) in nut-cracking by chimpanzees; b) in the manufacture and use of an Oldowan stone tool; and, c) in the manufacture of a gelatine ring. The effective chain of the gelatine ring is simplified by not describing the effective chains necessary to manufacture the gelatine, the scissors, and the food coloring.

Making a gelatine ring

0. Perception of basic need: ornament for one day
0a. Perception subproblem 1: need of a gelatine ring
0b. Perception subproblem 2: need of scissors
0c. Perception subproblem 3: need of water
0d. Perception subproblem 4: need of colour

PHASE I: Search for raw material
1. Search for raw material: gelatine

PHASE II: Search for cutting tool
2. Search for scissors

PHASE III: Manufacture of raw material stripes
3. Cutting gelatine stripes

PHASE IV: Search for coloring tool
4. Search for food coloring

PHASE V: Search for soaking tool
5. Search for water

PHASE VI: Color soaking tool
6. Add food coloring to water

PHASE VII: Manufacture of ring
7. Soak gelatine strip in colored water
8. Wind gelatine strip around finger
9. Twist ends of strips to form a ring head
10. Hold ring head until dry

PHASE VIII: Satisfaction of need
11. Wearing the ornament

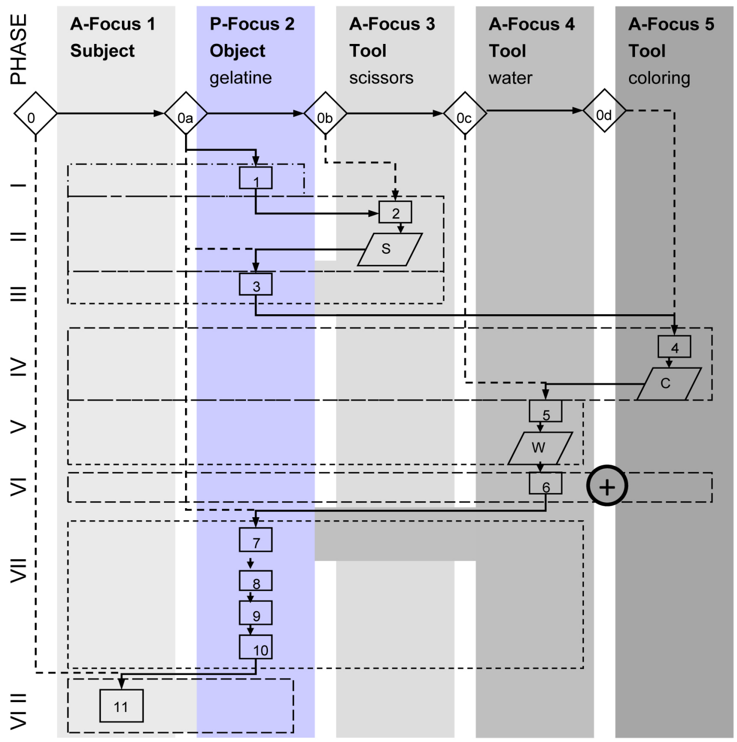

Figure 6. Cognigram of the manufacture of a gelatine ring. The cognigram is simplified by not describing the effective chain necessary to manufacture the gelatine, the scissors, and the food coloring.

help to answer the second basic question in assessing innovative processes: What is the nature of an innovation? How can it be characterized qualitatively and quantitatively?

PROBLEM C: PRESERVATION AND DETECTABILITY

As Renfrew (1978; see above) pointed out in his theoretical article on innovation, invention and innovation have to be regarded separately. This point is emphasized by Kuhn and Stiner (1998) in their approach to Middle Paleolithic creativity, and applied by Hovers and Belfer-Cohen (2006) in tracing modern behavior in the Middle Paleolithic record. An invention is the generation of a new idea; to become an innovation that idea has to be implemented or used repeatedly (Kuhn and Stiner 1998: 144). With regard to the archaeological record this differentiation has far-reaching implications:

> "We suggest that the archaeological finds reflect only those elements of human knowledge that have been accepted and incorporated into societal normative behaviours, stored and kept for repeated use through canonization and rituals. Instability of demographic systems and population crashes prevented the continuous accumulation of such knowledge in certain regions of the Old World, dictating that technological and symbolic innovations be "re-invented" time and again throughout the Middle Paleolithic period." (Hovers and Belfer-Cohen 2006: 295).

In an archaeological context innovations generally only become visible if the initial idea of a new aspect of behavior is broadly accepted by at least parts of the society and hence transformed into a tradition. Individual innovations which are not accepted and adopted by other group members remain singularities at best.

The early stages of a novel behavior from the first idea to a certain minimum extent of distribution can rarely be observed—be it in chimpanzee groups, in Stone Age technology, or in the boom towns of the 21st century. The visibility of an innovation from an external perspective depends first of all on its recognition as an innovation by the observer. The chance to observe an innovation process close to its origin is related to the frequency of use of the new problem-solution-concept. The more widespread the use of an innovation—be it within a community or, better, exceeding group boundaries—the more easily it can be detected.

> "..., given the coarse chronological 'grain' of most Palaeolithic records, in which the finest possible subdivision may represent tens or even hundreds of years, individual acts and even individual lifetimes are for all intents and purposes invisible. A singular act of innovation will appear to the archaeological observer as part of the 'normal' range of variation for a particular time period or place. A truly radical innovation, expressed as an entirely novel type of artifact or technique, may not be recognized as such, or, if it anticipates later procedures or artifact forms, might be passed off as an intrusion of more recent material into the older level" (Kuhn and Stiner 1998: 146).

Thus, while the early stages of a novel behavior can rarely be observed by archaeologists, primatologists, or anthropologists, the resolution of the archaeological record may make it particularly difficult to recognize innovation.

While an invention is an instant event (a brainwave), the innovation process takes considerable time—first the new idea, practice, or object has to become known to probable users, who then have to be persuaded that the novel item is a good idea before taking a decision of adopting it. There may be a significant time gap between the decision and the first implementation, and after this the "usefulness" of the novel behavior has to be confirmed before it will be integrated in the behavioral canon (cf. Rogers 1995, Chapter 5). Dispersal is fostered if the technology of production and use is already widely known or if the knowledge can be shared easily. The more exclusive the raw materials and skills required to make and use a new solution, the more is its distribution hindered. In general, these factors affect the distribution process in the above mentioned way. In some social circumstances, however, they may also have a converse effect. In sum, the rate of adoption depends on the relative advantage of a new idea, on the compatibility with social values, previously introduced ideas, and needs, on the complexity of the idea or practice, on the potential for personally experimenting with the novelty on a limited basis, and on the extent to which the results of an innovative behavior can be observed (cf. Rogers 1995, Chapter 6).

The frequency and spread of innovations is thus influenced by several, partly related cultural and social factors (Abrahamson and Rosenkopf 1997; Brown 1981; Dosi 1991; Haegerstrand 1967; Mahajan and Peterson 1985; Renfrew 1978; Rogers 1995) that not only vary in expression between different species of primates and hominins, but changed in qualitative terms in the course of human evolution (e.g., Hovers and Belfer-Cohen 2006). The available forms of communication, for example, determine the possibilities for the exchange of ideas through emulation, imitation, and especially teaching. Social organization with more or less influential agents, population density, and social tolerance for innovations affect the spread and the acceptance of new ideas. In groups with unique forms of human cooperation, the more solutions that are already available, the more easily variations can be found or invented—the cultural ratchet effect creates cumulative culture (Tennie et al. 2009; Tomasello 1999).

The dispersal of an innovation is influenced by both functional and social factors and varies with different forms of communication networks used to spread the novelty. The longer the lifespan of an innovation is—from an ephemeral occurrence to a long-lasting tradition—the higher is the probability that it will be recognized. However, the potential for observing innovation processes in prehistory as well as in animal behavior (e.g., Boesch 1995; Kawai 1965; Kummer and Goodall 1985; Reader and Laland 2003; van Schaik et al. 2006) is not only limited by a certain frequency of use needed to trace the innovation within the behavioral record, but is also restricted to the limited aspects of the total way of life about which we can learn through excavations and field projects.

The visibility of an innovation in the archaeological record depends, in addition to its recognition as an innovation, mainly on its state of preservation. Changes in the different aspects of innovation in object behavior discussed above are not all equally easy to observe, and may be misinterpreted if the preceding solutions are not equally well preserved:

- The *material* of a problem-solution-concept differs generally from very perishable to nearly indestructible and its preservation can vary as a result of chemical, physical, and biological conditions in the embedding matrix. Example: ornaments made from feathers, fur, or seeds compared to ornaments made from teeth, ivory, bone, and stone.
- The *form* of a problem-solution-concept can affect the likelihood of its preservation. Example: mortuary practices involving interment of the body in grave-pits with or without coffins compared to those involving placing the body in trees with open access by scavengers. In addition, there are typological problems in assessing change or continuity in the *form* of a problem-solution-concept. On the one hand, we do not know the broad or narrow nature of the formal definitions at the time of manufacture and use. On the other hand, the form of the tool could have changed through the use and maintenance sequence—the 'end product' in the archaeological record might not correspond to the original form intended by the maker, but may still have been regarded and used as the original tool, or may have changed its formal category. Additionally, current definitions might not be consistent between researchers or the same as past definitions.
- Subtle distinctions in the *function* of a problem-solution-concept are a common form of innovation in animal and modern human behavior which can barely be detected in the archaeological record. Example: probes used by chimpanzees to fish for termites, ants, and honey or to inspect unknown items.
- The *technology of production* of a problem-solution-concept is generally thought to be quite well un-

derstood in its coarse outline. Details about the sequence of activities and tools used, which are the most likely areas for innovations, are difficult to identify without direct observation of the process, which is clearly not possible for archaeological remains. Example: brush-sticks used by chimpanzees for termite fishing or as a digging tool. For several years the brush ends were thought to be produced by using a tool, because experiments failed to reproduce them by chewing with human teeth (Sugyiama 1985). Later direct observation, however, showed that chimpanzees were able to make brush ends used for termite fishing with their teeth (Sanz et al. 2004), while the brush ends of the digging tools were due to the raw material (Takemoto et al. 2005).

- The *technology of use* of a problem-solution-concept can rarely be revealed in detail; use wear analyses can only give hints and experiments can help to exclude possible options. The exact way in which a tool was handled remains unclear and small scale innovations are invisible. Example: different ways of using a probe by chimpanzees while dipping for driver ants on the ground or fishing for driver ants in trees (Yamamoto et al. 2008).
- Even a *complete problem-solution-concept* can be overlooked, if one of the aspects involved is necessarily of a nature that is barely preserved. Example: simple, chewed or folded leaf sponges used by chimpanzees to absorb liquids (Tonooka 2001).

The problems of preservation and detectability can be demonstrated in the modern example of jewellery for one day. In the initial stage the gelatine ring was nothing more than a brainwave. The mere idea was brought up and was then realized on one occasion to prove that it was practical. This novelty became an innovation when it was presented to the public and shared with at least some other people. The lifespan of an innovation depends on the extent and longevity of the adoption of the idea by the society—the perception, the use, and the transmission of the problem-solution-concept. In the case of the gelatine ring, not only was the duration of use of a single ring limited to one day, but so was the presentation and transmission, and consequently the perception. Crucial factors influencing the rate and scale of adoption are the means of communication used to spread the novelty, and its functional and /or social value. The gelatine ring was presented only by two people at a stand, with some banner ads to raise attention, so the transmission of the idea was limited to those people who passed the stand by chance and the few who found out about it from reports of people already attracted by the idea. The functional, material, and social value of the gelatine ring is low, and it was perceived mainly as a gag. Thus it did not become a must-have for people visiting the fair, but remained a niche product. Generally, dispersal is fostered if the technology of production and use is already widely known or if the knowledge can be shared easily. The more exclusive the raw materials and skills required to make and use a new solution, the more is its distribution hindered. In the case of the gelatine ring both the technology of production and the raw material were not exclusive and allowed a frequent replication. They were, however, not accepted as raising the preciousness of the ornament, which is an important means of making a distinction from ornaments for children's play. Even tiny cultural restrictions can further limit the success of an innovation, as the example shows[3]. Although around 50 gelatine rings were sold at the one-day-fair, the insufficient preservation prevents the future study of this innovation in the material record, beyond written and photo documentation.

CONCLUSIONS

In comparing innovative potential based on archaeological assemblages and living animal species, or studying its development in human evolution, several crucial points have to be considered. In a first step, the precise parameters of the study have to be assessed—the entity/entities examined (species, cultural group, time period) and the part of the material culture examined (a single item, a certain artifact group, or the complete record available). In general, the data base is highly fragmentary, be it due to selective preservation of artifacts or due to selective observations. To avoid a misleading 'milestone' approach signalling either cultural standstill or revolutionary trends, in a second step, innovations have to be detected systematically within the boundaries of the study, taking the incompleteness of the data base into consideration. In a third step, those innovations which have been discovered have to be critically assessed to identify the elements that are actually new. Only then can the impact of an innovation be evaluated, taking into account possible antecedents (cf. Tostevin 2003), the spatio-temporal distribution, the spread of the new aspects into other problem-solution-concepts, and the effect of the innovative elements. The innovative potential of a group, a period, or a species is not sufficiently expressed by one successful and flashy innovation, but depends on environmental (are there problems?), social (how does a group accept innovative behavior?), and cognitive factors (can problems be perceived and precisely formulated, can adequate solutions be thought of?). Not every innovation is an inspired invention. More frequent recognition of small innovations as well as more careful assessment of well-known innovations would help us to do justice to all different groups and to come to a more realistic appraisal of their innovative potential.

The approaches to comparative innovation research given in this paper allow some absolute assessments of innovative potential. The interpretative evaluation of the data gained, however, remains relative and focus-dependent:

> "It is equally important to recognize that the static nature of the Middle Palaeolithic is obvious only by comparison with later time periods. Compared with the first million or so years of the Lower Palaeolithic, the Mousterian seems like a veritable Renaissance, an interval of constant fomentation." (Kuhn and Stiner 1998: 147).

Most innovations do not turn the world inside out. Change and continuity are extremes which can rarely be observed in their pure form. Generally, they are two sides of a medal, and it depends on the perspective which side faces forwards. Appraisal is influenced by the aspect(s) on which the focus lies, as it is rare that all aspects of a problem-solution-concept are new. Furthermore, new concepts are mostly taken as alternative solutions to an existing concept and replace the old solution only slowly and gradually within a social group. The spread of an innovation can markedly vary between different groups. In addition to the extension of acceptance, the actual effects of novelties in behavior have to be evaluated. Innovations may provide benefits, but they may also represent neutral variation or, in some aspects, even be counterproductive. Change (variation, transformation) and continuity (permanence, stability) can take place at the same time; it depends on which levels of the involved group, the affected aspects, or the effect are examined.

ENDNOTES

[1]Help to spread the idea of a gelatine ring. Here is the production guideline "Ornament for one day—gelatine ring":

- You need a gelatine sheet, a pair of scissors, cold water, and food coloring if desired.
- Cut the gelatine sheets longitudinally with the scissors in ca. 1.5cm broad strips. Soak a strip in cold water (colored at will) until it is soft, slimy, and gluey. Wind it around the preferred finger on which you intend to wear the ring, and twine or fold the ends on top to close the ring and form an ornamental ring top. Fix the ring top for around 10 min while waiting until it becomes dry to the touch.

[2]A tool set is active in the simplified effective chain of the gelatine ring (see Figure 4c)—while food coloring and water build an effective chain, the scissors and the water are applied one after the other on the same object, gelatine, without influencing each other.

[3]Several problems in wearing a gelatine ring have been uttered by possible customers:

- Problem A—tradition "Don't play with food" (traditional/raw material problem)
- Problem B—BSE panic with animal waste products like gelatine (raw material problem)
- Problem C—cold and slimy in cold and rainy weather (functional problem)
- Problem D—not precious enough (social value problem)
- Problem E—(please fill in whatever other problem you see in wearing a gelatine ring and let us know!)

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