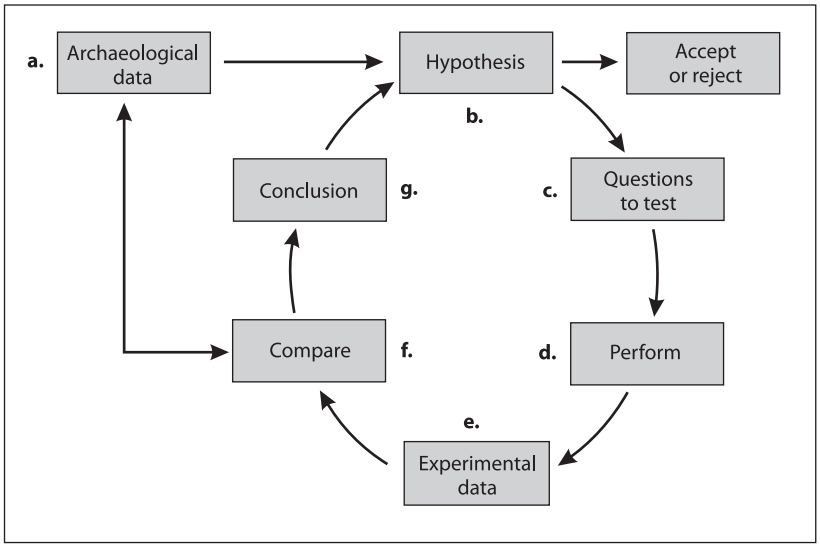

Fig. 1 Circle of Experimental Research. ■

Scientific experiments: a possibility? Presenting a general cyclical script for experiments in archaeology

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• **The article proposes a 12 step arrangement of archaeological experiments to obtain results usable for archaeological reasoning.**

Introduction

The theory behind experimental archaeology has been the subject of many articles (*Malina 1983; Mathieu 2002; Reynolds 1998, 1999; Richter 1992*). A distinction between different types of experiments and their correlated value for scientific reasoning is developing and being acknowledged more and more. However, a clear methodology and a framework for a general "archaeological experimental script" are still lacking. Up until now, many enthusiastic people have carried out experiments, but the majority of them lack archaeological hypotheses and feedback. In this article I would like to present a framework for experiments that makes it possible to give all archaeological experiments a place in scientific knowledge building.

A methodology for experiments is needed because the current value of experiments in archaeology is easily ridiculed. Using nature as a laboratory, slaughtering animals and/or cutting down trees using stone tools does not appear to be very scientific and

does not seem to lead to scientifically valuable results. However, when experiments are carried out to test hypotheses that are based on archaeological data, it is certainly possible to obtain results that can be used in archaeological reasoning. A general scientific cyclical setup has to be followed. The setup presented here is a symbiosis of models presented earlier by, among others, Reynolds, Richter and myself.

Invariable processes

The most important idea behind experimentation in science in general is the assumption that processes can be replicated and will always follow the same natural laws. For experiments in historical sciences this assumption is extended to the idea that processes also do not change over time. Each cause will have the same consequence, whether performed in the present or in the past. In archaeology one tries to reconstruct human life based on the results of these processes, that is, through understanding archaeologically recovered material culture. Using the principle of analogy, one can try to replicate the archaeological data by replicating the assumed behavioural and archaeological processes. In an ideal situation one should be able to gain knowledge on technological, functional and sociological aspects of past societies by replicating processes and material culture in experiments.

However, this assumption also leads immediately to some very basic questions: What about the uniqueness of each society or, even, of each individual? What about the influence of climate or economic means of support? Which factors are dominant in these matters?

Although these are questions that should not be underestimated or put aside too easily, for now, in this article, they will be held aside for this discussion. It is here assumed that technological and functional processes in general do not relate to cultural, economic or climatologic circumstances. [(1)]

Analogies

If data, resulting from experiments, is used in archaeological reasoning we speak of the use of analogy. Using analogies is a common scientific approach. It implies the possibility to apply the characteristics of one entity (source) to another entity (object), based on the similarities between the two entities. In the case of experimental archaeology, the object is to gain more knowledge of the way archaeological material culture functioned in the past. The archaeological data we have is static: artifacts and features/patterns. What we want to reconstruct is the dynamic processes that took place in the past and produced the static archaeological data. To gain more information about those dynamic processes we need an analogy. This is delivered by experimental research. The experimental results are the equivalent of the static archaeological data and the process that creates them (the experiment) is the equivalent of the dynamic processes.

[(1)] Although, of course one of these factors could be the subject of experimentation. In that case the suggestions presented here are still to be taken into consideration.

Uniformity and Non-ambiguity

Two other terms that define the use and the validity of the analogy are uniformity and non-ambiguity. An analogy is uniform when the process in the past and the one in the present are identical.

An analogy is unambiguous when there are no possible alternative explanations for the occurrence of similarities between source and object. It should therefore be impossible that the same archaeological data is caused by different actions. In the ideal hypothetical case, both aspects, uniformity and non-ambiguity, are present.

A concrete example would be the following: cutting down a tree should create exactly the same traces in the present as in the past and there should be no other activity that could create the same kind of traces. Clearly, the aspect of non-ambiguity is hard to prove in modern scientific reasoning.

Since the ideal situation is not present in most analogies, they should be regarded as testable hypotheses, or models, instead of as factual proof. The systematic and empirical testing of analogies (hypotheses/models) should involve a procedure that searches for the necessary similarities between the source and the object. Although this makes reasoning based on experiments more or less an interpretation, one should be able to distinguish between strong or weak analogies (hypotheses/models). A strong analogy should be tested over and over and still be regarded a possibility.

Since it is probable that not all processes that were relevant in the past are still active today, it is generally accepted that it is not possible to reconstruct a complete picture of the past. However, the enlargement of one's frame of reference is vital to be able to give at least an impression of the processes our ancestors were subject to.

Therein lays the justification for the use of analogical reasoning. Since it is impossible to know the past, archaeologists should search for research laboratories where the transformation from dynamic processes to archaeological material culture can be studied. This can either be in ethno-archaeological or experimental research settings. The belief in uniformity is vital to accept this strategy. Furthermore, experimental archaeology is, in this point of view, a necessity for archaeological research! Although sceptics will always say that ethno-archaeology and experimental archaeology cannot provide us with certainties or facts, it is often forgotten that this is impossible in science in general, and especially in the historical sciences. Experimental archaeology provides us with the possibility to see relationships between material culture and human actions (and non-human processes as well).

Levels of statement

Research strategies in experimental archaeology can be distinguished by their level of interpretation and therefore, by their scientific value.

Three main levels can be distinguished:

1. Interpretations based on intuition: Either the researcher or a "skilled specialist" follows their intuition and makes an interpretation such as: "It seems to be logical that…"
2. Interpretations based on semi-experimental results: The researcher bases his or her interpretations on either a single test or on data gathered in other experiments or general research.
3. Interpretations based on scientifically experimental results: Based on archaeological data, a hypothesis is formulated and tested. All factors that might influence the results are considered and multiple tests lead eventually to an interpretation about the archaeological process.

In many cases it is not possible to make a distinction between the different levels. In the ideal situation, experiments are carried out in several stages, each time resulting in interpretations based on a more improved level. In general, it can be said that an experiment begins by consulting either one's own or a specialist's intuition. After that, the performance of generalized or hypotheses-forming experiments leads to semi-experimental interpretations. In the final stage a series of repeated hypotheses-testing experiments lead to interpretations on the level of scientific experiments.

Hypothesis forming / testing

In her article of 1992, Richter makes a distinction between hypothesis-forming and hypothesis-testing experiments. An experiment forms a hypothesis when it follows a general approach. There is no specific question in advance – by carrying out the experiment one or more questions should arise. On the other hand, an experiment is considered to be hypothesis-testing when the goal is to either verify or falsify a specific assumption. In my opinion only a testing experiment can be regarded as scientific, since it is impossible to control all, or at least most, variables when there is no specific question. Even when there is such a question it appears to be very hard to control experimentation. To be able to identify variables, several tests need to precede a testing experiment. Therefore, hypotheses-forming experiments should be regarded as a kind of pre-test in which one tries to gain control over all factors that play a role in the final experiment. It also provides the opportunity to become skilled in the specific matter which is necessary to perform the experiment on the suitable level. In this way hypotheses-forming experiments are part of the preparation phase of experimentation. It is in this specific fact that their value lies. Most experiments carried out nowadays fit into this phase of the process. Many experiments do not involve specific questions: one tries to smelt iron or to make clothes. Most of the time, this consumes so much time that the testing experiment that could lead to scientific statements is not carried out. Furthermore, when such experiments are carried out their end results are only seldom compared to archaeological data. This last step is vital to make the analogy complete. Only

in a very few number of cases do experiments follow the cyclical script presented by Reynolds (*1998, 1999*) and that is necessary for scientific reasoning based on analogies. (**Fig. 1**)

Working-script for experiments

In the past few years among members of the VAEE (Dutch association for experimental and educational archaeology) a working-script for archaeological experiments has developed in order to create a shared system that could be used as a basis for scientific experimentation. The working-script consists of twelve steps which are shown in **Fig. 2**. Most steps follow a logical sequence common to experiments carried out in the natural sciences; others need some additional information. In the following, the proposal for a script will be clarified by means of an example.

1. Define archaeological problem
2. Hypothesis-testing or –forming
3. Structure: - static or dynamic
- single- or multiple
4. Conditions: - interpretation level
- influential variables
5. Check design and realization
6. Preparation documentation
7. Perform the test and document
8. Feedback or comparison
9. Ascertain analogy: - uniformity
- non-ambiguity
10. Conclusion
11. Report
12. Repeat test

Fig. 2 Working-script for experiments. ■

Comparable excavations of early farmers show a specific tool type in flint artifacts that are assumed to be involved in the cutting of siliceous plants (**Step 1**). This hypothesis will be tested using experimental research (**Step 2**). The artifact will be replicated several times and each one will be used to cut a different type of raw material, including siliceous plants. The structure of the experiment (**Step 3**) will therefore be multiple, because several raw materials will be tested during one experiment. The structure will also be static which means that no changes will be made during the tests, even if the tool does not prove to be useful for a certain predefined task. In a dynamic structure one could choose to leave one test out, for instance, when the desired results are already achieved (which is of course very dangerous!!). One of the most important steps is the definition of the conditions influencing the test (**Step 4**). Who should perform the test? Which variables can be defined and how can they be controlled? What is the level of measurement? In the example, attention should be paid to the replication of the tools, the experience of the user in using flint artifacts, the suitability of the raw materials to the early farmers' context, etc.

The level of measurement will be controlled by the application of the method of use wear analysis: a method that can verify the traces that occur on the experimental pieces as well as the archaeological pieces.

As a kind of mid-evaluation, after this stage the design of the test should be checked (**Step 5**) and preparation for the documentation of the test and its results (**Step 6**) should be made. After that, the test can be carried out (**Step 7**). When each tool is used to cut a different kind of raw material, use wear analysis should be applied on both the experimental and the archaeological pieces in order to find similarities (**Step 8**). Since different raw materials are cut, it should be possible to ascertain the correct analogy between experiment and archaeology (**Step 9**). If the traces on the experimental tools used on siliceous plants best resemble the traces on the archaeological tools while the other tools do not, uniformity is reached. However, it is not possible to determine whether the results are completely unambiguous. In theory, the same use patterns could result from other tasks and/or use on other raw materials. For now, one can conclude that the tools were probably used on siliceous plants (**Step 10**), with the possibility that other actions and use on other raw materials may have also resulted in the same kind of traces. The final steps should involve a report (**Step 11**) and, as in any experiment, the repetition of the tests (**Step 12**) in order to make the analogy stronger.

Concluding remarks

The presented cyclical working-script is an idealized setup for the performance of archaeological experiments. I do not want to state that experiments not following these steps cannot have scientific value. I hope to have made clear that all experiments can, in the opinion of the author, eventually add information to archaeological knowledge. However, it should also be clear that experiments lacking certain steps (e.g. feedback to archaeological data or control over conditions) are to be placed in a longer trajectory of gaining knowledge, eventually leading to an ideal experiment that follows the presented script, by which archaeological hypotheses can be tested. In my opinion, in this way, experimental archaeology is what it should be: a tool to gain more knowledge of the past.

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Summary

Wissenschaftliche Experimente: Eine Möglichkeit? Überlegungen für ein generelles zyklisches „Drehbuch" für Experimente in der Archäologie

Viele Forscher bestreiten die wissenschaftliche Relevanz von archäologischen Experimenten. Denn es erscheint unmöglich, Hypothesen, die die urgeschichtliche Zeit betreffen, zu überprüfen.

Wie dem auch sei, wenn Experimente auf der Basis von archäologischen Daten durchgeführt werden, ist es mit Sicherheit möglich, Resultate zu erhalten, die in archäologischen Schlussfolgerungen ihren Eingang finden sollten. Es sollte dabei aber einem generellen, wissenschaftlichen und zyklischem Versuchsaufbau gefolgt werden. In diesem Artikel wird ein zwölfstufiger Aufbau vorgeschlagen.

Am Beginn eines Experiments steht die Fragestellung, die aus archäologischen Daten abgeleitet ist. Diese Frage führt zu einer Hypothese, die in einer beobachtet-kontrollierten Situation – nach diversen, vorbereitenden Schritten - getestet wird. Am Ende werden die Ergebnisse des Experiments mit den originalen archäologischen Daten verglichen. Anschließend wird der Test wiederholt, um zu verifizieren, ob die gleichen Resultate gewonnen werden können oder ob eine neue Hypothese zu überprüfen ist falls die erzielten Ergebnisse nicht mit den Ausgangsdaten übereinstimmen sollten.

Obwohl, nach Ansicht des Verfassers, alle Experimente ihren eigenen Wert für die Archäologie oder die archäologische Pädagogik besitzen, sind jedoch nur solche von wissenschaftlichem Wert, die dem vorgeschlagenen Versuchsaufbau folgen. Alle anderen Experimente sollten als Vorschläge bzw. Anregungen für weitere Untersuchungen angesehen werden.

Expérimentations scientifiques: est-ce possible? Proposition ďun scénario cyclique général pour les expérimentations en archéologie

Un bon nombre de savants ne considère pas les expérimentations en archéologie comme scientifiques. Expérimenter les hypothèses touchant la préhistoire leur semble impossible. En fait, si les expérimentations sortent des données archéologiques, on peut certainement atteindre à des résultats susceptibles ďêtre utilisés à ľargumentation archéologique. Il faut respecter une approche cyclique scientifique générale. Dans cet article, on expose un procédé articulé en 12 phases. Tout ďabord, une question s'impose qui dérive des donnnées archéologiques. A partir de cette question, on émet une hypothèse qu'on expérimente dans les conditions contrôlées, au bout de quelques pas de préparation. Le résultat de ľexpérimentation est comparé aux données archéologiques de départ. On répète ensuite ľensemble des travaux ou pour confirmer qu'on peut obtenir les mêmes résultats à plusieurs reprises, ou, si les résultats ne coïncident pas avec les données archéologiques, pour expérimenter une nouvelle hypothèse.

Bien que, ďaprès ľauteur, toutes les expérimentations enrichissent ľarchéologie ou bien la popularisation de celle-ci, seules les expérimentations qui suivent le scénario proposé aient une valeur scientifique. Les autres peuvent être tenues pour une préparation des recherches suivantes.