



The Potter's Wheel

Valentine Roux, Daniela Corbetta

► **To cite this version:**

Valentine Roux, Daniela Corbetta. The Potter's Wheel: Craft Specialization and Technical Competence. Oxford & IBH Publishing, pp.145, 1989. <hal-00439770>

HAL Id: hal-00439770

<https://hal.archives-ouvertes.fr/hal-00439770>

Submitted on 18 Dec 2009

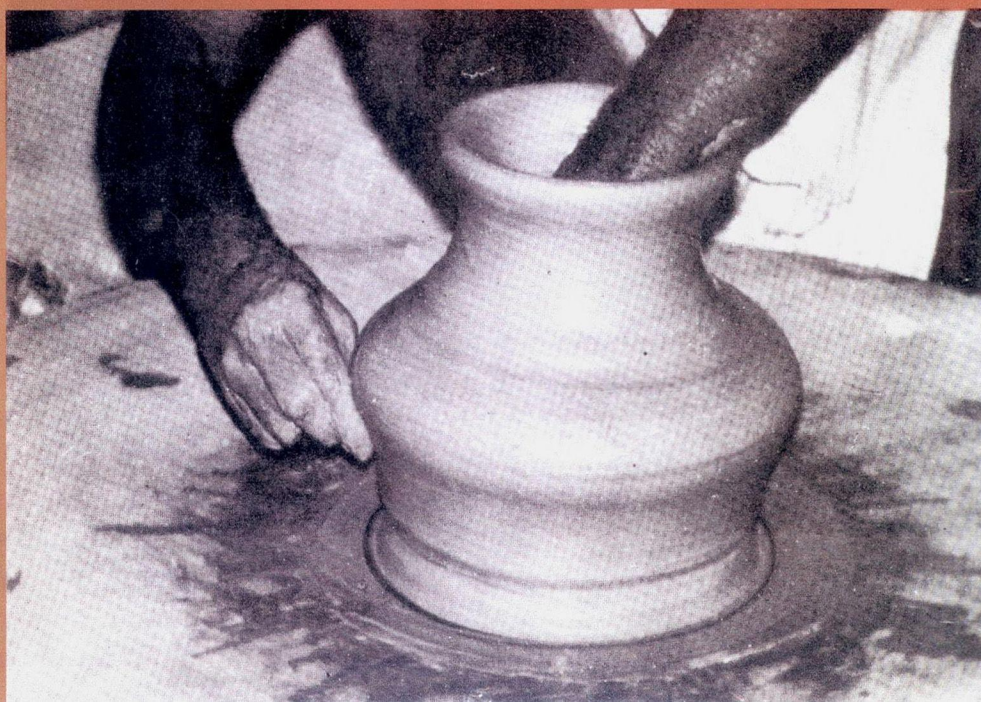
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THE POTTER'S WHEEL

CRAFT SPECIALIZATION
AND TECHNICAL COMPETENCE

Valentine Roux
in collaboration with
Daniela Corbetta



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Valentine Roux



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Foreword

Since archaeology exists, prehistorians and protohistorians have turned towards ethnography in an attempt to understand better the material vestiges discovered in excavations.

Most of the time, imperfectly mastered, this confrontation has experienced varied success and has often been rightly criticized. Born in the context of the New Archaeology of the sixties ethnoarchaeology aimed at providing new insights, permitting us lastly to get out of the stalemate and to build up a theory of the past-present confrontation.

In spite of numerous studies, most archaeologists are not convinced by the results. It is worthwhile to analyse the causes of this situation because the study proposed by Valentine Roux and Danièla Corbetta shows, in an exemplary fashion, the ways to follow in order to get out of the stalemate.

Given the current state of research, ethnoarchaeology must cope with three types of difficulty:

1) The analysis of the present ought to lead to positive propositions regarding the significance of the vestiges of material culture. Going through ethnoarchaeological literature, one notes that most of the studies come out with negative statements. Material vestiges are, by their very nature, ambiguous and their significance is eminently variable; most of the interpretations offered by archaeologists are not justified or are at least not the only ones possible.

These cautionary notes are naturally salutatory to the extent that prudence is advocated. However, it is somewhat curious to observe a development of this contesting current even though the new archaeology claims to show the way to reconstitute the past taking into account all the cultural aspects which have disappeared.

However, it is neither possible, nor desirable for a discipline to be based solely on negative statements and on invitations for caution. Although the way to resolve the stalemate is still to be found out.

2) Ethnoarchaeology must search for generalizable propositions; the transcultural constitutes its field of action. While confronting the present, the investigator must in fact avoid two dangers which, like Charybde and Scylla, threaten to drown him.

Concentrating solely on the transcultural can give rise to platitudes on human behaviour which are devoid of heuristic interest. By avoiding this approach, only local cultural particularisms are highlighted. Their actual field of application is never known and is probably limited.

This difficulty is well known. Some scholars thought of getting out of the impasse by adopting an intermediary position and by developing middle-range theories neither too general nor too specific. But can one really maintain such a delicate balance on the razor's edge without falling to side or the other? To our mind, this question still remains to be answered.

Ethnoarchaeological thought indeed has never been concerned with defining in terms of time and space the field of application of the enunciated propositions.

3) Most of the statements of ethnoarchaeology are what we tend to call regularities. The latter can be expressed in three different ways : mathematical correlations between two continuous or discontinuous variables, typologies associating intrinsic characteristics (nature or shape of objects) with extrinsic characteristics (localisation, temporal attribution, function of the object) and finally discursive propositions of the type if P_i then $P_i + 1$.

In most cases, these regularities are not understood as nothing is known about the "reasons" founding the empirical reality highlighted, even if the proposed constructions witness a power of efficient prediction on reality.

We think that it is only by understanding the mechanisms responsible for the observed regularities that it shall be possible to determine once the fields of application of the proposed transcultural rules.

While we were asking ourselves these questions, we got to know of the present work. It was for us a veritable revelation as it offered partial response to the questions asked.

We would like here to demonstrate how this work differs from many previous ethnoarchaeological works and why we think it opens the way to the emergence of a real science of reference for archaeology.

1) Our first point might seem banal; it is not however negligible. By choosing to study the relationship which exists between the wheel-throwing technique and craft specialization, Valentine Roux and Danièla Corbetta are placed explicitly at the heart of a fundamental archaeological problem, namely that of criteria allowing the description and explanation of the urbanization process in the Near and Middle East.

The objective of the research is thus defined on the basis of archaeological questions. A real critical analysis of archaeological discourse developed by Valentine Roux in other publications, precedes the ethnoarchaeological enquiry and specifies the stakes involved.

Confronted with the difficulties of interpreting vestiges, archaeologists have always turned intuitively to ethnography. However, they have not always explicitly formulated the problems to be solved. The present study is one step ahead; it finds its origin in a "logician" analysis of the archaeological discourse itself and a fundamental criticism of the latter. This criticism enables the authors to lay down the limited objective of the study : to demonstrate that use of the wheel necessarily implies a certain craft specialization.

It is also through the examination of archaeological reality and its confrontation with the present that the central hypothesis of the adopted procedure was "discovered". The temporal evolution of ceramic shapes at sites

in the process of urbanization is not without analogy to the evolution of shapes obtained at the time of learning wheel-thrown ceramics. Such an analogy is not based on any identity between phylogenesis and ontogenesis but on the constraints associated with a progressive mastery over the work of a specific material.

2) Finding its origin in a discourse of extreme complexity, the present study manages nonetheless to clearly define its limits and is therefore controllable. The will to restrict the objectives must be emphasized as it is rare in the field of social sciences. It constitutes nevertheless one of the necessary conditions for progress in knowledge.

In the present case, the objectives are clearly defined and limited : to demonstrate first that the appearance of craft specialization is linked to the difficulties encountered in learning the wheel-throwing technique and subsequently to fix, at the level of the morphological properties of ceramic, the threshold beyond which it is possible to infer that mastery over the wheel-throwing technique has been acquired.

3) For the first time, an ethnoarchaeological study attempts to go beyond the framework of typological regularities by trying to search for their foundations. Binford was one of the first archaeologists to ask himself this question while studying the Mask Eskimo site. Only the understanding of the mechanisms can ensure a certain validity to transcultural models. Too many are the studies of the kind undertaken by the Yellen on Bochimán camps which deal only with correlations between variables; the camp size, the quantity of vestiges, the number of occupants, the occupation time without being preoccupied with analysing what, in the natural environment, the techno-economic and social structure, justifies such an empirically perceived structure.

Studies dealing with such issues were unfortunately too rare. The first part of the present study clearly takes up the challenge. The relationship between wheel-thrown ceramic (P_i) and specialization ($P_i + 1$) finds its origin in the difficulties inherent in learning the wheel-throwing techniques, in other words in acquiring a certain mastery over the material. This mastery brings two poles into play, on the one hand the physical characteristics of the material (in the present case clay) and on the other hand the perceptual motor structures of *Homo sapiens sapiens* which are materialized in acquired automatic "chaînes opératoires".

The same type of approach is tested in the second part of the study. Here the regularities are presented in the form of a typology linking an indigenous classification of the degrees of throwing difficulty (OX, extrinsic characteristics of the F type, function) with the completed ceramic shapes (OI, intrinsic characteristics of the G type, geometrical shapes). The mechanisms discovered are the same but the perspective has been decentred. The first part emphasizes the nature of the perceptual motor process whereas the second part insists more particularly on the constraints arising out of the physical properties of the worked material.

We shall also note that in this latter case the explanation proposed by the scientist has been suggested by Indian and French potters who themselves possess a more-or-less explicit technical knowledge. We invite epistemologists

and logicians to reflect upon the operational know-how of the artisans and the necessarily new formulations constructed by the anthropologist when recounting facts. Valentine Roux's second work has the merit of implicitly raising this question even though the given answer, to our mind, is still not very clear.

However, the procedure followed is beyond criticism. In science, the progress of knowledge occurs through the sole way of description of "what is happening".

It is thus necessary to clearly distinguish between this type of functional explanation and any "functionalism" which explains observed structures by their finality.

4) A scientific approach is recognized as such by the links which can be set towards other fields in science. All isolated knowledge developing in closed circle is suspect. Here the opening towards other bodies of knowledge is particularly convincing. We have appreciated the linkage established between an eminently "social" characteristic, the specialization, and questions dealing with the maturation and perceptual motor control of the movement.

Having said this, in no way we want to assert that the social can and must be reduced to the psychological, rather an understanding of the social does not exclude the description of certain components in terms of experimental psychology and perceptual motor function.

A similar type of linkage could undoubtedly be established between the typology of degrees of throwing difficulty and solid-state physics allowing for a more rigorous approach of the dynamics of clay subject to a movement of rotation. Thus an articulated body of knowledge is constructed gradually, consistency coupled with efficiency being a sign of relative truth.

5) Valentine Roux and Danièla Corbetta offer us a functional (but not functionalist) explanation of reality. The facts brought to light thus escape cultural contingencies. They are based on the biological nature of *Homo sapiens sapiens* and on physical properties of matter. Here, one could cry scandal and we can already see anthropologists suggesting that one thus turns a blind eye to the very essence of culture(s). However, it is not a question of missing the target but simply that the objective is different. The way chosen is the only possible one because one stands explicitly in the transcultural realm. Such an approach does not eliminate the cultural by contesting its existence; it considers it as a different type of reality. Ethnoarchaeology does not attempt to understand the constantly renewed originality of cultures; it seeks to construct generalizable propositions about the latter.

6) We would like to underline finally the utility of presenting the results of the enquiry in the form of a logicist scheme. This latter highlights the fact that the acquired body of knowledge only constitutes a small fraction of reality, which in no way devoids it from its solidity, rather it enhances it.

It also shows that the mobilization of knowledge acquired at the time of an archaeological demonstration implies recourse to a whole new series of other propositions : to study the appearance of craft specialization necessitates for example to find out the means to demonstrate the non-craft specialization

in the earlier periods. Nowadays, many of these propositions are not demonstrated (neither demonstrable ?). We spoke of the integration of ethnoarchaeology with other scientific disciplines. Here we find ourselves in the field of integration and articulation of bodies of ethnoarchaeological knowledge. The logicist explanation of demonstrations proves to be extremely helpful in researching and exploring new spaces of analysis.

Finally, logicist schematization enables the discovery of the conditions required for establishing the networks of pyramidal demonstrations and avoiding fan order constructions which only lead to equivocal conclusions. This appears, to our mind, to be the necessary condition for the creation of an efficient body of archaeological knowledge.

One point will retain us again. We dealt with it lastly as it does not relate to the necessary and sufficient characteristics of ethnoarchaeological approach as is the case, to our mind, for the previous points. We want here to talk about the link established in the present work between observation and experimentation.

These last years, experimental archaeology has made great strides in many fields. We think especially to the study of microwear traces (traceology) or the reconstitution of chipping technique of chert. From a formal and epistemological point of view, experimental archaeology is not distinct from ethnoarchaeology. Both disciplines work indeed towards an external reference knowledge system which can be used in the interpretation of archaeological vestiges. We would like to underline here the interest of the joint use of both approaches in the resolution of a specific problem. Perhaps in the future it will be useful to better integrate both disciplines an example of which we have here and as is already practised by certain archaeologists. Experimental archaeology proposed by a citizen of the 20th century indeed runs the risk of being led astray on an unrealistic way if it is not constantly confronted with data given by traditional populations. But this is another matter.

As we wrote at the very outset, Valentine Roux and Daniëla Corbetta's work came to us as a revelation. After its reading, one question nevertheless remains, brutally asked, to which we still do not have answers. We want here to speak of middle-range theories. If we are convinced of the advisability and the great use of transcultural approaches, we do not see how to develop a useful approach which takes into account contingencies and cultural variabilities. Such studies indeed always come up against one unresolved question : how to delimit in an explicit, solid and formal manner the temporal and geographical field within which the propositions highlighted (be they regularities or mechanisms) are applicable. We have thus to ask ourselves the question whether ethnoarchaeology ought to be limited to a science of the species *Homo sapiens sapiens* or whether it can be also a science of diverse cultures?

One of the main merits of this beautiful study, and not the least, is in filigree to raise this essential question.

Preface

The book offers two ethnoarchaeological studies on ceramic vessels. These were written as separate articles, but being closely related to each other, it seemed appropriate, for the benefit of the reader, to publish them together in the form of a book. Their main concern is with the construction of a reference knowledge for the interpretation of archaeological facts. The theoretical framework used is the logicist analysis as outlined by Jean-Claude Gardin. Its main principles are the "bien-formé" and the "bien-fondé" of the interpretative constructs, which means the analysis of the foundations of interpretations and the demonstration of their validity. As emphasized by Alain Gallay, the interpretation of material facts implies by necessity a reference to ethnographic knowledge (in the broad sense of the word). According to epistemological principles, ethnographic data are applicable to archaeological facts only to the extent that the context of validity is defined, and that the archaeological context is analogous. The context of validity can be defined by ethnoarchaeological investigations or experimental observations. Thus, in the perspective of logicist analysis, ethnoarchaeology becomes a privileged and necessary way for building up of a reference knowledge against which the validity of interpretations can be evaluated.

The first study deals with the concept of craft specialization. This is one of the major concepts used to describe and understand the emergence of complex societies. The problem addressed here is to ascertain the particular features of material facts which are significant in pottery specialization. To this end, we undertook a study on the nature of the apprenticeship required for the mastery of the wheel-throwing technique. The hypothesis was that the apprenticeship is sufficiently long and difficult so that not everybody in a community can learn the craft. We collected: (a) ethnographic data on the process of apprenticeship, and (b) experimental data to define the perceptual motor problems characteristic of each stage of apprenticeship. It was then possible to assess the difficulties faced by the children in learning the craft, and also to understand the duration of the apprenticeship. According to our results, we propose to associate the material fact "throwing technique" with the attribute "craft specialization". This association should not be viewed as the reduction of a social phenomenon to a perceptual motor problem, but as the description of a relationship between two elements in terms of motor complexity.

The second study is the construction of a techno-morphological taxonomy for evaluating the difficulties of the throwing technique of pre- and protohistoric ceramic vessels. This taxonomy should enable us: (a) to define a threshold

beyond which the wheel-throwing technique is mastered and therefore significant in craft specialization, and (b) to study the diffusion of the wheel-throwing technique, regional distribution of the technical know-how, integration of the throwing technique with the techno-economic systems, evolution, maintenance and regression of the technique. The measures are provided by the ceramic traits which are significant of an indigenous classification of pot shapes according to an ascending order of difficulties. The classification was made by Indian potters. In this regard, the taxonomy pertains to an empirical reality. Its transcultural value is discussed on the basis of an investigation with French potters.

These studies should interest not only archaeologists who look for criteria significant in craft specialization, but also archaeologists interested in theory (problem of validating interpretative propositions), as well as ethnoarchaeologists (for a way of constructing a reference knowledge) and psychologists (experimental and intercultural psychology which deals with the development of motor skills.)

The fieldwork was carried out in 1986 and 1987 in Uttam Nagar, a suburb of New Delhi, in the framework of the Indo-French Archaeological Mission (M.A.F.I.) and in agreement with the Archaeological Survey of India (A.S.I.). I should like to express my gratitude to the A.S.I. and to the Ministry of Foreign Affairs in Paris (M.A.E.) for their full support throughout, and thanks to which this work has been achieved. Likewise, I am grateful to the French Institute of Pondicherry (I.F.P.) whose support gave me the opportunity to complete, in India, the writing and the translation of the book. In particular, I wish to thank Har Kishan, our informant in Uttam Nagar, who gave us so much of his time and knowledge, and who had the patience to explain at length to the children and other potters what we wanted from them. Without Har Kishan this work could not have been done. My gratitude extends also to his family and to all the potters who so kindly agreed to participate in our experiments.

During the course of the research, we received advice, criticism and encouragement, all of which has been very useful and contributed greatly to the present version of this book—our thanks therefore to H. Balfet, J. Fagard, J.C. Gardin, C. Gillièron, C.A. Hauert, C. Perlès and S. Van der Leeuw. We are grateful to M. Roduron for the excellent drawings.

June 1989

VALENTINE ROUX

**WHEEL-THROWING TECHNIQUE
AND
CRAFT SPECIALIZATION**

Valentine Roux and Danièla Corbetta

PART ONE

Context, Objectives and Strategies of Study

Malgré le caractère local des scénarios, l'interprétation nécessite toujours des références à un contexte extérieur, à un savoir souvent situé en dehors du domaine archéologique étudié.

A. Gallay (1986:175)

1. CONTEXT OF STUDY

1.1. Thematic choice

From 1983 to 1988, M.A.F.I. (Indo-French Archaeological Mission) has been conducting research on the settlement history of northwest India (Francfort, 1985) and on the modalities of development of the Harappan civilization. In this context, a study was designed for the phenomenon of craft specialization and its possible description on the basis of archaeological facts.

This phenomenon is, in fact, considered an essential factor in the evolution of complex societies or states. We may briefly recall that, since G. Childe, the definition of urban society is based on the notion of complexity and that socio-economic differentiation is one of the main criteria of urbanization. The concept of differentiation is so much a part of our vision of the development of societies that analysis of archaeological material from Neolithic times onwards implicitly postulates the following hypothesis: "the gradual appearance of societies that are more and more differentiated." Here, the meaning of "differentiation" is associated with that of "specialization". To support this statement, we need only to mention the recent book by Brumfiel and Earle (1987), *Specialization, Exchange and Complex Societies*, or the first sentence of the article by Tosi (1984:22): "Craft specialization has long been recognized by Marxists and non-Marxists as a factor of significant weight in the development of complex societies."

Craft specialization is the form of specialization studied in priority by archaeologists, because other forms of specialization (politic, ritual, for example) are, at the moment, difficult to identify and define on the basis of material remains, particularly when it comes to ancient periods (Neolithic).

1.2. Theoretical framework

The theoretical framework is that of logicist analysis (Gardin, 1979, 1981). The basic principles are the "bien-formé" of interpretative construction (the expression of derivations which enable us to pass from the facts mobilized in the construction towards an interpretation) and the empirical verifiability of the inferences proposed at each stage of the construction. The present study is summarized in a logicist diagram given in the conclusions, which highlights the foundations and the verifiability of the interpretative propositions, as well as the importance of ethnographic knowledge (in the broadest sense of the word) in the elaboration of interpretations.

The last point has been stressed by Gally (1986), who explains that the procedures of interpretation include an obligatory reference to **regularities**. These are the relationships between properties (intrinsic and/or extrinsic properties of material facts) and attributes (types of significance) that may be observed in a context outside the field of archaeology or induced from historical scenarios. Applied to archaeological data, regularities serve as a basis for the construction of historical scenarios.

In theoretical terms, this study on craft specialization may be defined as an analysis of the relationship between the observable fact "wheel-thrown ceramics" and the attribute "craft specialization". The statement of this relationship should be considered as a tool of analysis for interpreting the wheel-throwing technique in terms of pottery specialization. Of course, other ways exist to infer this latter. Our ambition is limited to the proposal of one way among others, that is to say the proposal of one regularity among a body of regularities aimed, in a long term, at describing the complex phenomenon of craft specialization.

2. OBJECTIVES OF STUDY

2.1. Definition of objectives

Archaeological studies of the phenomenon of craft specialization during protohistorical times are generally based on hypotheses drawn from socio-anthropological works. Their objectives consist mainly in defining the degree of craft specialization and the factors responsible for it. Craft specialization is considered a continuous phenomenon in which different degrees are perceptible through five variables:

1. Affiliation (independent specialists, i.e., those who cater to the general demand of the population, or attached specialists, i.e., those who cater to the demands of patrons only).
2. Intensity of specialization (part-time or full-time)
3. Organization of craft production (domestic, in workshops, at the village or regional level, with the "chaines opératoires" either spatially distributed or assembled at the same location).
4. Intensity of craft production (rate of production, output per specialist).
5. Quality of production (degree of sophistication and standardization).

Depending on the value assigned to these variables, a craftsman may be considered more or less specialized. The highly specialized craftsman, at the extreme end of the continuum, is the one whose sole economic revenue is derived from his craftsmanship.

Factors which could explain the evolution of craft specialization may be summarized as follows: population growth [and consequently a decrease in tillable land and an increase in demand for craft products (Arnold, 1985), or economic differentiation (Evans, 1978)]; intensification of agriculture [which encourages agricultural surpluses, making nurturing of specialized craftsmen possible (Dow, 1985)]; unequal access to economic resources [specialists appear who appropriate these resources (Rice, 1981)]; maximization of profits [a factor arising with an increase in demand for craft products, and which results in craft specialization (Torrence, 1986)]; and control of production by an elite [which promotes specialized craft production (Rice, 1981; Tosi, 1984)].

These approaches to the phenomenon of craft specialization propose rich and interesting hypotheses from an anthropological point of view. However, according to the principles of verifiability and validity, it appears that the given interpretations are of two kinds: either non-verifiable because they arise from propositions that do not refer to material facts (e.g., agricultural surpluses), or cannot pass tests of verification, keeping in mind ethnographic counter-examples, which reveal the multiplicity of interpretations of material facts considered significant here. We have expressed this point of view elsewhere (Roux, in press), having undertaken critical examination of archaeological writings and obtained data from two ethnoarchaeological studies: the first study concerns the criteria used in defining the degree of craft specialization (Roux, 1989) and the second, the problems raised by the description of some of these criteria (Roux, 1988). These studies highlight the multivocal nature of the material facts and the fragility of foundations for the interpretative propositions encountered.

Therefore, according to the theoretical principles retained, we have chosen to deal with the problem of craft specialization not in terms of degrees of specialization or factors responsible for it, but in terms of material traits which could present a univocal relationship with the attribute "specialization".

2.2. Objectives

The objectives of this study are twofold—synchronic and diachronic:

1. To construct an ethnographic frame of reference that makes it possible to **infer the existence** of specialists on the basis of ceramic facts.
2. To present a descriptive system of ceramics that makes it possible to **describe the phenomenon of craft specialization** at the local level, i.e., according to the individual case that each archaeological site represents.

By craft specialization we mean: **the takeover by part of the population of a craft activity, the products of which are consumed by the community.** The community is considered here in the broadest sense of the word: village or regional community. This definition in no way judges the economic status

(full-time, part-time) or social status of the craftsmen. It only describes the distribution of activities occurring within a community. The phenomenon of specialization should therefore be understood as the phenomenon of setting up of specialists and not as evolution towards full-time specialization.

Recourse to ethnoarchaeology for this research made detection of the significant material traits easy. Indeed, it may be noted that we have here an ideal situation wherein the attributes of the observable material facts are known. The task of the ethnoarchaeologist is, firstly, to identify the properties which are significant to the attributes sought and, secondly, to define the conditions or the context in which the properties retained present a univocal relationship with the attributes. The definition of this context is essential. It enables us to define the context of application of the regularity, in other words, of the property/attribute relationship to archaeological facts.

2.3. Craft specialization among potters

Our study of craft specialization focuses on potters, as ceramics is the archaeological material par excellence from which craft specialization is inferred. The results obtained are specific to the phenomenon of pottery. However, the method *per se* is applicable to the study of other crafts, and other research of this type will no doubt follow, ensuring a multiple approach to the urban phenomenon.

2.4. The Indus potters

Data on the ceramics of the Indus archaeological sites, especially those from the Chalcolithic period, present serious difficulties for analysis, keeping in mind the nature of the publications. The data often come from old excavations and, therefore, do not present the information sought: techniques of manufacturing, criteria for recognizing the techniques, and percentage of each type of pot per period. Moreover, criteria are not yet clearly defined, that permit the distinction to the naked eye between the different techniques of fashioning : fashioning by hand, with a tournette, with a wheel. In particular, it is difficult to distinguish the use of centrifugal force on pots whose fabrication wears can be attributed to a fashioning on tournette, as well as to a partial fashioning on a fast wheel. Research are conducted at the moment (by M.A. Courty) which aim at characterizing macro-wears significant in the fashioning techniques used during pre- and protohistoric periods. The definition of these macro-wears will allow us to study ceramic assemblages and to analyse the shapes and the proportions of wheel-thrown ceramics/ hand-made ceramics. Only such an analysis will permit the application of our ethnographic observations onto archaeological material.

3. STRATEGIES OF STUDY

3.1. Working hypotheses

Working hypotheses are the outcome of a confrontation between archaeological and ethnographic data.

Given the data presented by the site of Amri (published by Casal, 1964), ceramics of the 4th and 3rd millennia of the Indus civilization exhibit the following characteristics:

- Appearance of the wheel-throwing technique;
- Progressive mastery over this technique marked by a gradual increase in pot size;
- Progressive replacement of the coiling technique by the wheel-throwing technique.

Ethnographic data reveal two points:

- Apprenticeship in wheel-thrown pottery is marked by an increase in pot size, indicating progress in mastery of the technique;
- Apprenticeship in wheel-thrown pottery is longer and more complex than apprenticeship in coiled pottery.

On the basis of these archaeological and ethnographic data, we may formulate the following hypotheses:

1. *Theoretical hypothesis*

The stages of technological development of wheel-thrown pottery during the 4th and 3rd millennia seem comparable to the stages for apprenticeship in wheel-thrown pottery today. Consequently, if it is assumed that the wheel-throwing technique can be practised only by specialists, and if it is demonstrated that in the fourth millennium coiled ceramics were made domestically, it should be possible to describe the phenomenon of craft specialization based on a diachronic study of wheel-thrown ceramics. Let us note that this hypothesis does not refer to the hypothesis phylogenesis-ontogenesis : it is only a matter of describing a form of techno-economic organization on the basis of criteria one can infer from material data. The factors responsible for change of organization, that in no case one can infer from these criteria, will have to be highlighted locally. These factors will illustrate the diversity of cultures. So, will do the modalities for integrating the technical choices made by these cultures.

2. *Working hypothesis* (which translates the theoretical hypothesis into observational language)

It is possible to base the "wheel-throwing technique/craft specialization" relationship on a comparison between the learning processes witnessed in the wheel-throwing technique and the coiling technique respectively. The comparison relates to the degree of motor difficulty and complexity inherent in each of these techniques.

To study the "wheel-throwing technique/craft specialization" relationship, we collected observational data (ethnographic observations) and experimental data (perceptual motor tests). These data are presented in the second part of this study in the following manner:

1. Observational data: description of the different stages of apprenticeship in the wheel-throwing technique and in the coiling technique.

2. Experimental data: study of the motor skill difficulties which arise during the different stages of apprenticeship in wheel-thrown pottery. Comparison with the difficulties peculiar to apprenticeship in coiled pottery.

To apply the theoretical hypothesis to archaeological data and to describe the phenomenon of craft specialization at a particular site, we ascertain the intrinsic characteristics of pottery which are significant in the different stages of apprenticeship. These are presented in the third part.

The basis of our interpretative propositions is defined in the conclusions.

3.2. The field, or ethnographic investigation

The investigation was conducted mainly in Uttam Nagar, a suburb of New Delhi, about 30 km west of the capital. This suburb includes a colony of potters comprising more than a hundred families of the Khumar caste (traditional caste of potters), originally from villages in Haryana and Rajasthan. Every house regroups a nuclear or joint family which owns one or two wheel(s), placed under open shelters, and one furnace located in the courtyard. The clay, conveyed by truck, is stored in the courtyard or in the street, depending on room. Generally, the women helps for preparing the clay, for molding (technique which is also practised) and decorating the pots. The man is in charge of throwing and paddling (this operation is done after throwing and aims at obtaining pots with a round bottom and pots of big dimensions with thin walls). The ceramic production is made up with containers of different shapes and flower pots which are sold either directly on markets, or through middlemen. It constitutes potters' main income.

The choice of Uttam Nagar as the site of our investigation was dictated by the following:

1. Our informant, Har Kishan, lived here. A potter by caste and profession, he came from the village Mandhauti in Haryana;
2. Traditional manufacturing procedures were practised here: (a) use of the stick wheel, which rests on a wooden stand and is started by means of a stick; and (b) use of an open furnace with an ascending draught and one firing chamber.

Let us note that the particularity presented by the stick wheel in terms of subject's position (crouched) and of weight of the wheel is not, at the outset, a problem for studying difficulties arisen in general by the wheel throwing technique. On one hand, the crouched position is adopted by the Indians since childhood for a great number of daily tasks and is "natural" to them in this regard. On the other hand, the centrifugal force necessary to the wheel-throwing technique is function to the potter's strength to start the wheel, and not to the manner used to start the wheel (by means of a stick or of the foot in the case of kick wheel).

Let us note also that the different "chaînes opératoires", i.e. the operations before the throwing operation (preparation of the clay) and after it (paddling), are not described because it appeared they were elements which do not take place in our construct.

Part of the study (tests of non-potters' children, manufacturing of hearths and silos using the coiling technique) was conducted in Mandhauti, Har Kishan's village, situated about 50 km northwest of Delhi.

The study of motor skill problems arising during apprenticeship in wheel-thrown pottery was conducted by D. Corbetta, whose research deals with the problems of two-handed skills in the five-to-nine-year old child.

PART TWO

Study of The Wheel-Throwing Technique/Craft Specialization Relationship

The hypothesis on which this study is based pertains to the relationship between the property "wheel-throwing technique" and the attribute "craft specialization" (its meaning restricted to the definition given in the introduction). The hypothesis is analysed by a comparison in terms of motor evolution of the processes of learning involved in the wheel-throwing technique and the coiling technique respectively.

With this goal in mind, two categories of data were collected:

1. Observational data from ethnographic investigations carried out in northwest India and more particularly in Uttam Nagar.
2. Experimental data from analyses of the evolution of organization of two-handed gestures, and of perceptual motor tests applied to potter and non-potter subjects.

OBSERVATIONAL DATA

These data were compiled from interviews and videos on the wheel-throwing technique and the coiling technique.

1. WHEEL-THROWING TECHNIQUE

1.1. Learning conditions

In Uttam Nagar and other villages surveyed, children begin to make pots on the wheel at the age of eight to eleven years. The task is reserved for boys. During their early childhood, they help in clay preparation, beating operations, and in moving the pots during drying operations. The age at which apprenticeship begins depends on the family situation (greater or lesser need for economic help; greater or lesser desire of parents for their sons to become potters). Apprenticeship starts at the earliest at the age of eight years, due to physiological imperatives (length of arms for reaching the centre of the wheel).

Learning takes place through trial and error, during which the father gives advice when required to his son(s) about the gestures to be executed. Today,

the duration of apprenticeship depends on family and schooling. The family allows the child to practise more or less. Some families prefer that their child studies and becomes a civil servant.

The learning process itself is an unchanging one. It usually commences in August–September, a few weeks before the festival of *Divālī*, which falls in early November, and for which numerous fairy lamps are sold. These lamps are traditionally placed in front of the doors and windows of every house during *Divālī*. Hence the child first learns to make little fairy lamps. Aside from the fact that this is the smallest and therefore the easiest vessel to produce (it can be shaped out of uncentred lumps of clay), even if the little fairy lamp has been clumsily executed, it will be sold during *Divālī*. Thus the initial stage of apprenticeship in pottery involves no economic loss. To proceed to the following stages, the child has not only to master technical difficulties, but also show promise of economic profitability for each type of newly learnt pot.

The children learn on stick wheels that are slightly smaller (70 cm in diameter) than those used by adults (80–90 cm in diameter). The wheel is affixed to a wooden axis and launched by means of a stick inserted in a notch on the wheel surface. Centrifugal force keeps the wheel horizontal. The subject crouches while working, the wheel at the level of his ankles, and his arms extended towards its centre.

1.2. Learning process

The learning process, in indigenous terms, comprises six stages whose markers are the type of pot to be made:

1. Small fairy lamp (in Hindi, *chotā dīyā*);
2. Small vessel (large fairy lamp, small and large lids, beaker—*barā dīyā*, *dhakkan*, *sikorī*);
3. Flower pot 4 inches high (10 cm; in Hindi, *gamla*);
4. Flower pot 6 inches high (15 cm);
5. Flower pot 8 inches high (20 cm);
6. Flower pot 12 inches high (30 cm).

The denomination in inches corresponds to an indigenous designation peculiar to a morphological category in which the dimensions are not perfectly standardized.

The order of apprenticeship is inflexible. The different types of pots are given as markers of stages by potters themselves. The progressive knowledge required for producing increasingly larger utensils is necessary for passing from one stage to the next, and sufficiently enables the potter to make all types of pots. More precisely, the determining factor of the skill of a potter is his capability in throwing higher and higher vertical walls. This explains the absence of variety and the simplicity of shape of marker-types.

In the field, however, we worked with a slightly different classification. The six learning stages were combined into three, of which the first two were subdivided in view of the similarity of difficulties encountered in them respectively. This classification does not take into account the stage of apprenticeship for

6-inch pots, because the problems here were very similar to those encountered at a higher stage (8-inch pots). The three stages were organized as follows:

Stage 1: MANUFACTURING SMALL VESSELS (children)

Sub-stage 1A (small fairy lamps)

Sub-stage 1B (large fairy lamps, small and large lids)

Stage 2: MANUFACTURING FLOWER POTS (children)

Sub-stage 2A (4-inch pots)

Sub-stage 2B (8-inch pots)

Stage 3: MANUFACTURING 12-INCH FLOWER POTS (adults)

1.3. Apprenticeship of main motor controls

The apprenticeship process is described and analysed here in terms of the main motor controls exercised in the making of vessels during the different phases of fashioning: centring, hollowing, thinning and shaping.

For the purpose of the study, 30 potters were chosen according to their stage of apprenticeship (6 subjects per stage) and filmed. On the basis of the videos, the pattern of gestures observed was described, taking into account the stage of apprenticeship, the type of pot being made, and the activity performed by each hand.

Centring

The aim of centering is to make the clay turn in the middle of the revolving table so that, when the object is subsequently hollowed, the inner walls immediately have a horizontal section of a constant thickness and are equal in height (J. Colbeck, 1981:24, our translation).

Centring is accomplished by exerting pressures on the surface of the rotating piece of clay. These are horizontal internal and symmetrical pressures, executed simultaneously with the palms (Plate 1).

Mastery of this operation is long and difficult. Indeed, our observations showed that not one subject in the initial stages possessed it (see Table II.1). Small vessels (lids and fairy lamps) are generally made from the top of uncentred lumps of clay; this is possible due to the small size of the object.

Once at stage 2, the subject must necessarily acquire mastery over centring because, although it is possible to make 10-cm pots out of badly centred lumps, such is impossible with pots 20-cm high. Indeed, throwing of such high walls can only be done on centred lumps.

Table 1: Frequency of successful centrings per stage of apprenticeship

	1A (n=6)	1B (n=6)	2A (n=6)	2B (n=6)	3 (n=6)
CENTRED LUMP	–	–	2	6	6



Plate 1: Centring operation.

It can be seen from Table 1 that at the 2A sub-stage, the children begin to master centring of the lump (two of six children), while at the 2B sub-stage and in stage 3, centring has been achieved.

Hollowing

The aims of the hollowing operation are to determine the inner shape, the thickness, and the width of the thrown base, then to set up the initial wall of the object (J. Colbeck, 1981:30, our translation).

This operation comprises two essential steps, which are independent of the organization of the two-handed gestures required:

1. To determine at what moment hollowing the base should stop. The base should be thick enough that the thread which detaches the finished object does not cut through it, and fine enough that long trimming (scraping the clay to thin down the base and/or the walls) will not be required.
2. To estimate the quantity of clay required for the making of a specific sized vessel. It is necessary to determine when the quantity of clay constituting the initial inner walls suffices for throwing the desired pot.

During the first sub-stages (1A and 1B), the numerous failures and variations in size for a given type of pot are essentially due to hollowing errors.

From the point of view of organization of gestures, hollowing takes place generally with an asymmetrical movement of the hands, regardless of the size of the lump: the left hand supports the clay on the outer edge of the lump while exerting an inner horizontal pressure of the palm; the right hand meanwhile carries out the hollowing operation by means of the thumb and draws aside the clay with the help of the palm (Plate 2).

While the organization of gestures remains the same irrespective of the size of the lump hollowed, the force exerted varies according to the mass of clay to be hollowed. The number of hollowings done varies from one to two, depending not only on the size of the pot to be made, but also on the strength of the potter.

Throwing

Throwing is the operation by which the walls of a block of clay already hollowed and centred, are pressed between the fingers in a uniform manner while the two hands rise upwards together and at the same speed along these walls" (J. Colbeck, 1981:34, our translation).

This operation has two objectives: thinning and shaping the walls.

Thinning

Thinning walls is the operation which transforms the initial wall formed from hollowing and gives the final thickness to the walls. This is the most important operation, as it determines the basic shape of the pot. It distinguishes stages 1 and 2 according to the gestures employed for making the vessels characteristic of each stage (Figure 1).

In sub-stages 1A and 1B, the basic two-handed gestures required for making small vessels always take place with the arms held in their respective hemiplanes, each one acting equidistant on either side of the axis of rotation

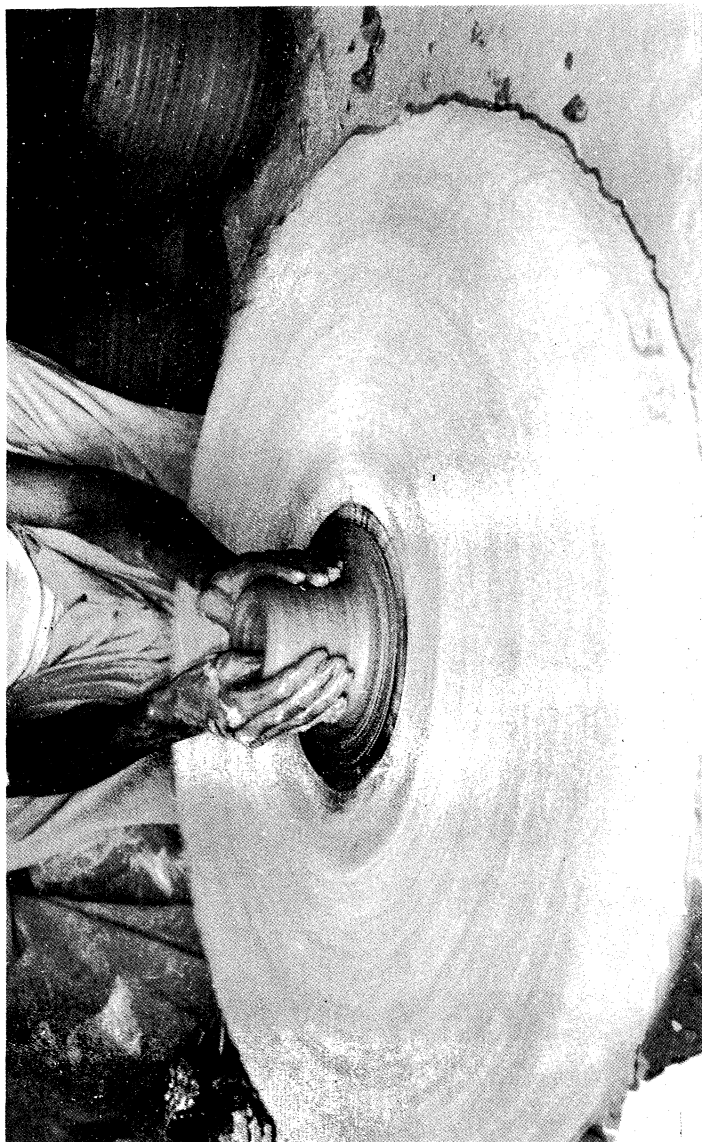


Plate 2: Hollowing operation.

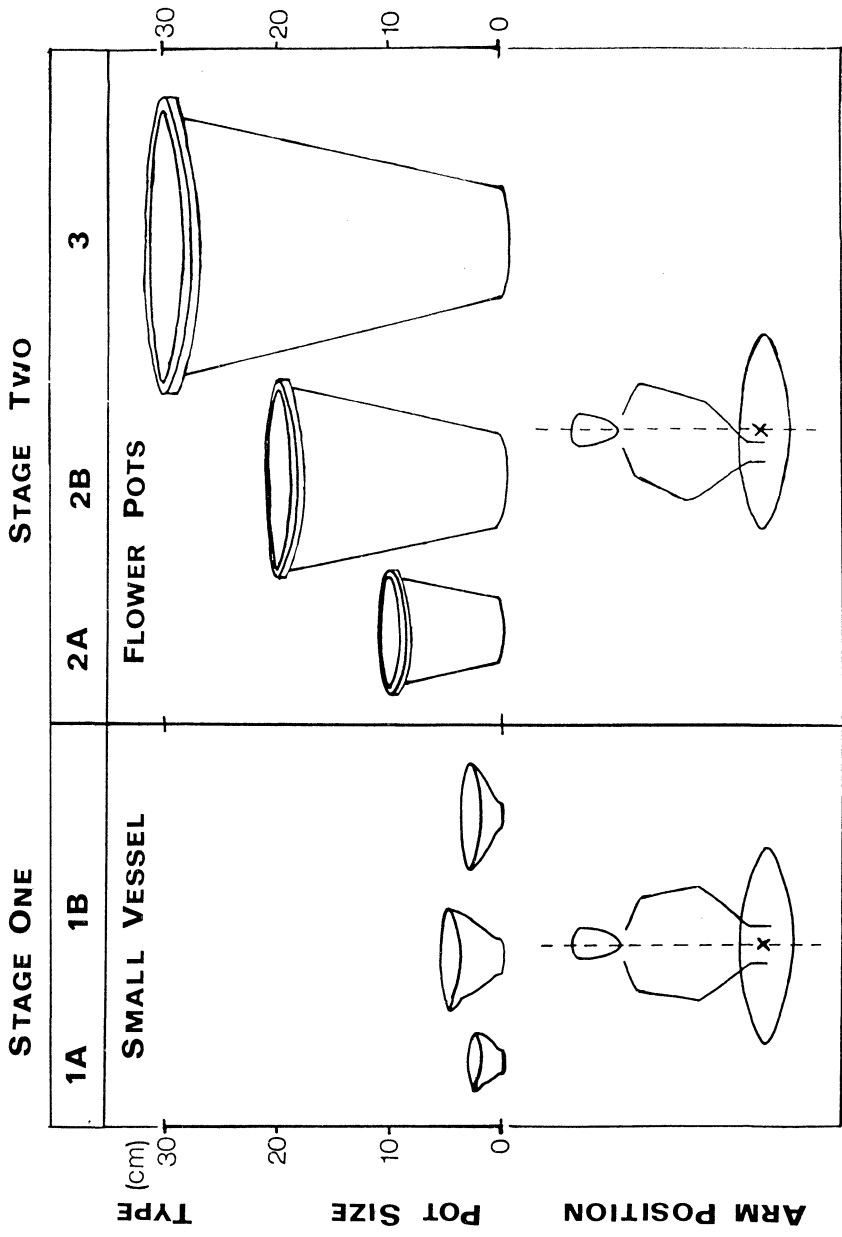


Figure 1: Representation of the size of the pot thrown in relation to the two-handed behaviour practiced as a function of the learning stage.

of the wheel. Two types of bimanual coordination render the thinning operation possible: either a symmetrical bimanual movement (mirror image) in which the two hands execute the same movements at the same time, or a combined bilateral movement of the two hands in which each plays its own particular role. In the latter case, the left hand supports the clay by exerting a slight horizontal inner pressure of the palm and the right hand raises the wall (Plates 3, 4, and 5).

In the making of small vessels, the thinning operation is done by exerting a pressure between the thumb placed inside and the index (or second finger) placed outside. This pressure movement can be accompanied by a continuous displacement of the thumb/index finger pressure either from below upwards (vertical displacement) or from the centre towards the exterior (horizontal displacement) relative to the central axis of the wheel. These variations in the thinning operation come into play according to the type of pot:

Stage IA: Small fairy lamps—thinning by simple thumb/index finger pressure.

Stage IB: Large fairy lamps—thinning by thumb/index finger pressure along with vertical displacement.

Small and large lids—thinning by thumb/index finger pressure along with horizontal displacement.

The difficulty that marks the transition from sub-stage 1A to sub-stage 1B lies in the movement of displacement which accompanies the thinning operation. The thumb/index finger pressure is no longer localized as in the making of a small fairy lamp, but has to be continuously and constantly exerted over a certain distance.

From stage 2A onwards, the child learns to throw flower pots, which requires learning a new two-handed activity relative to thinning the walls. This operation takes place in three successive phases, which include two phases in which the movements unfold with the arms still in their respective hemiplanes, and one phase in which the two arms act simultaneously in the right hemiplane of the subject.

1) The clay is thinned first of all by a two-handed complementary movement in which the right hand supports the clay and the left hand stretches it vertically, from below upwards, by pressing it between the fingers and thumb. Sometimes, in sub-stage 2A, this first thinning is done by means of a symmetrical two-handed movement, in which both hands simultaneously stretch the clay vertically from below upwards, while pressing it between the fingers and thumb (Plate 6).

2) The clay is thinned a second time through a symmetrical bimanual inner horizontal pressure of the palms on the outer face of the wall, moving from the base towards the top (cone-like ascent). The cylinder is thereby narrowed and the walls raised (Plates 7 and 8).

3) Finally, the clay is thinned a third time by a two-handed movement in the right hemiplane of the subject: the right hand works on the outer face of the wall, the left hand works on the inner face, and the wall is pressed between the two bent index fingers, which rise simultaneously in a continuous manner and at a steady pace from the base up to the top of the cylinder. The internal

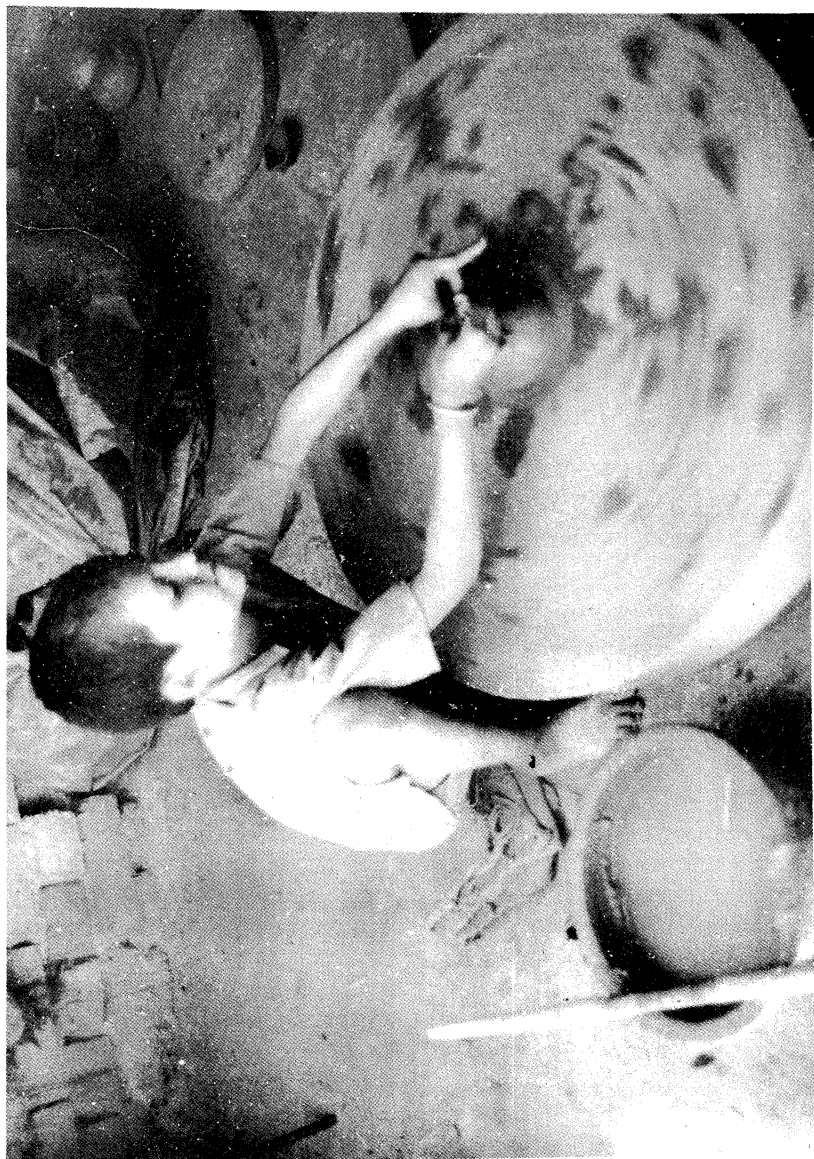


Plate 3: Symmetrical bilateral movement with hands carrying out the same movements at the same time. The subject is at stage 1A.



Plate 4: Symmetrical bilateral movement. The subject is at Stage 3A.

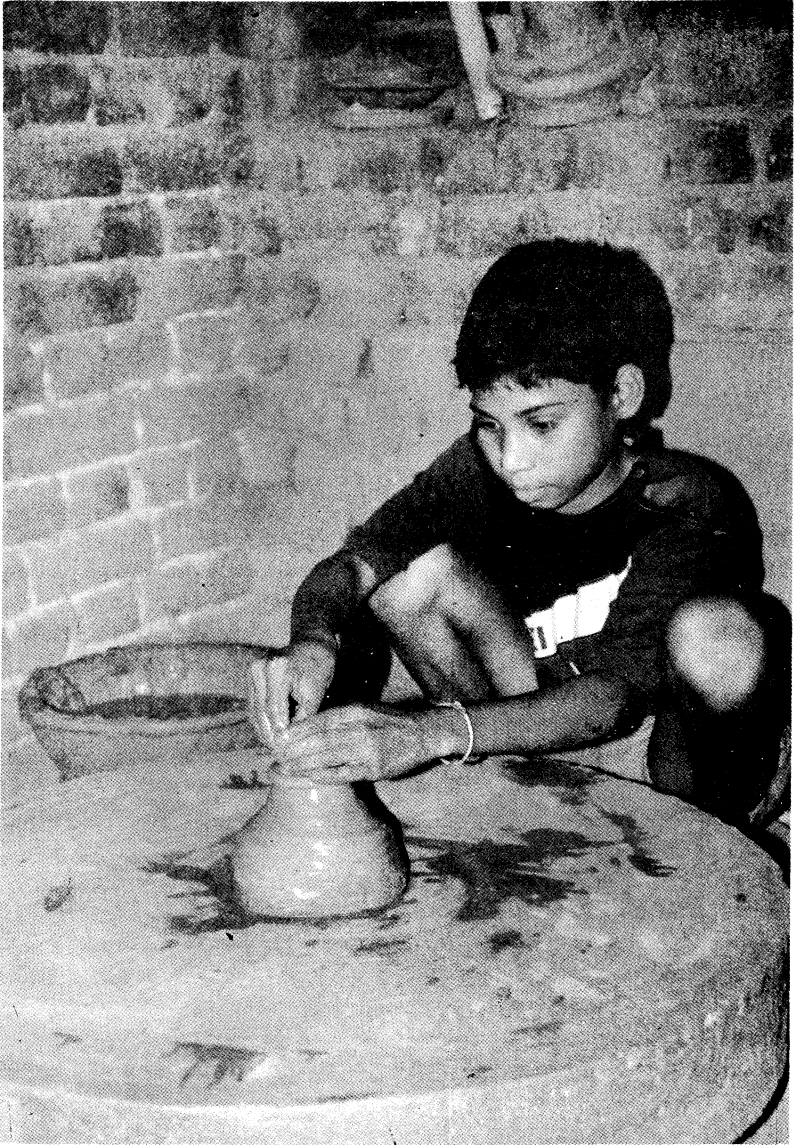


Plate 5: Combined bilateral movement of the hands with each hand having a specific role. For the small size vessel, the position of the arms is symmetrical in relation to the axis of rotation of the wheel.



Plate 6: Thinning by a combined two-handed movement.

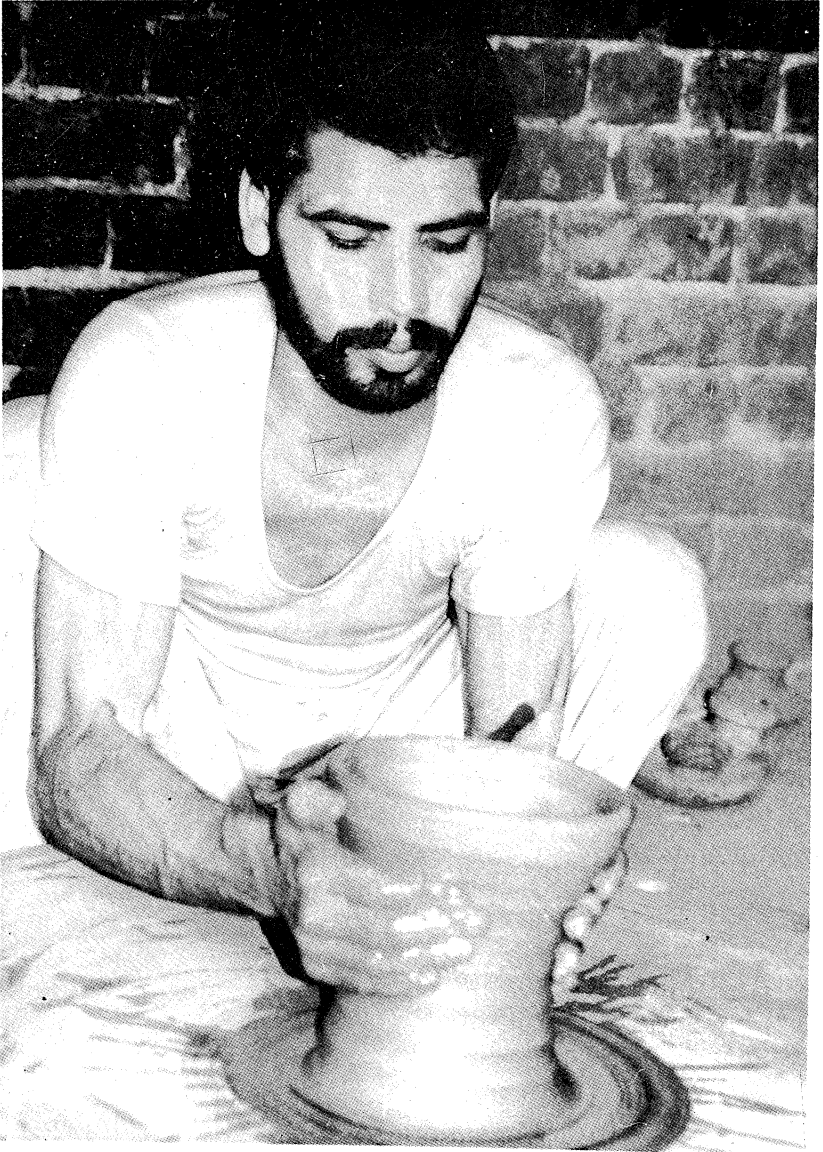


Plate 7: Thinning by symmetrical bimanual pressures of the inner palms, placed horizontally, on the external walls of the cylinder, going from the base up to the top.



Plate 8: The cylinder is narrowed into a cone and the walls rise up.

and external pressures respectively of the two index fingers make the clay rise upwards while tracing a spiral movement that widens the upper part of the pot. The third phase of the thinning operation is a decisive one in the manufacturing of flower pots and other large containers, because this new activity enables the raising of high walls. It is very difficult to perform since not only does the asymmetry of the gesture call for a greater firmness of the hands so that the pot remains centred, but in addition the pressure which displaces the clay from the bottom upwards must be absolutely constant. The other difficulty of this movement lies in exerting sufficiently strong bimanual pressures to thin the clay, while taking care not to press too firmly as this curbs the rotary movement and leads to irregularity in thickness. Moreover, the hands must simultaneously ascend at a very steady rate to effect a uniform and progressive thinning along the entire height of the body (Plate 9).

Once this skill has been acquired, transition to the subsequent stages (2B and 3) is just a matter of strength: the simultaneous and sequential organization of the movements always remains the same, but the amount of strength deployed varies according to the quantity of clay thrown. This difference of strength involves a renewed apprenticeship at each stage in determining the amount of bimanual pressures.

Shaping

This is the operation by which the final shape is given to the inner walls. It is distinguished from the operation of thinning insofar as the pressure exerted on the walls is less, though firm and steady.

This operation is not necessary in making the small fairy lamp, which is why it is only performed from the 1B sub-stage. For small vessels, it is executed by a symmetrical movement of the hands (mirror image). In manufacturing flower pots, shaping is done as in the third thinning, with the two hands in the right hemiplane of the subject. The wall is lightly pressed between the two extended index fingers (the right inside the pot and the left outside), which ascend simultaneously and steadily.

For both flower pots and small vessels, this operation tends essentially to reduce irregularities and to straighten the walls. The number of shapings depends therefore on the success of the last thinning or, more precisely, on its regularity (Plates 10 and 11).

Fashioning the Rim

Fashioning the rim of flower pots is a supplementary operation, detailed here simply to cover the range of primary motor activities involved in the production of the pots under study.

1) The rim is fashioned with both hands, each situated respectively on either side of the axis of rotation of the wheel. The right thumb folds the upper edge of the cylinder outwards and then downward against the outer face of the pot by means of pressure from the fingers. The left hand remains on the left edge of the pot throughout the entire operation.

2) Shaping the rim is done with both hands in the right hemiplane. The right index finger is placed horizontally on the upper edge of the rim and exerts

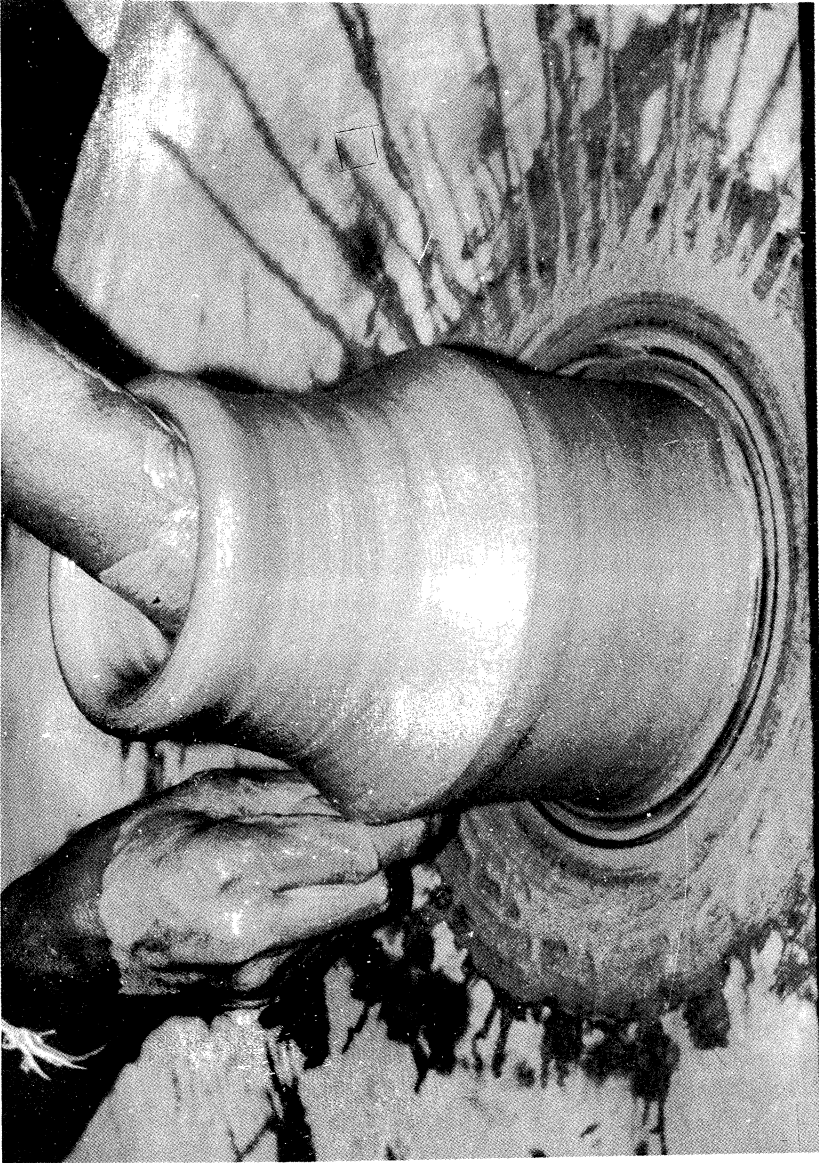


Plate 9: Thinning by a combined movements of the hands in the right hemiplane of the subject. The pressures of the two index fingers raise the clay.



Plate 10: Shaping by a combined movement of the hands in the right hemisphere of the subject.



Plate 11: The clay wall is lightly pressed between the two index fingers which rise simultaneously and regularly.

a slight vertical pressure towards the bottom, while the left hand supports the clay by pressing it slightly between the thumb and the index finger situated respectively on the outer and inner edges of the rim.

Fashioning and shaping of the rim are executed several times in the making of a pot. The rim is first fashioned after the second thinning. The purpose is to strengthen the upper part of the cone and to give sufficient thickness to the clay for the ultimate fashioning of the rim. After the third thinning, the rim is fashioned a second time. This operation concentrates on widening the mouth of the pot and aligning the rim to the axis of the walls. Shaping of the rim generally follows the second fashioning and shaping of the body. This shaping operation can be repeated as often as the potter considers necessary, but it often depends on the regularity of the walls of the pot or on the number of shapings of the body.

Time required for mastery over motor activities

Many years are required to attain mastery over the various motor activities involved in the making of pots of every size: for each size larger than the one learnt earlier, a new approach to motor activities is called for. Stage 3 is achieved only in adulthood. These observations are not peculiar to potters of Uttam Nagar. Below is an extract from comments by a potter from Gujarat (Fisher and Shah, 1970:118):

I learnt the craft from my uncle through daily practise. Learning our craft takes twenty to twenty-five years. I cannot yet consider myself a perfect potter. The work done by the children is of mediocre quality. However, that is how they learn the trade.

My son is ten years old. He has just started learning pottery. After ten or fifteen years he will be able to do the work. When the child possesses a natural aptitude, he can learn in less time.

The most difficult part of the work is using the wheel.

D. Miller also notes in Central India (Malwa region) a learning process similar to the one observed by us (1985:77, parenthetical comments ours):

One potter's son, having given up work in a shop in the local town for lack of pay, is now at the age of twenty, learning to make *chukliya*, the simplest container form, having previously made *divaniya*, *bujhara* and *kulhri* (fairy lamp, lid and small container). He will learn the remaining forms over the next five years, but may never learn *dhatri* (kneading trough whose difficulty in making lies in the width of the base) if he does not prove adept.

1.4 Apprenticeship in terms of number of fashioning operations

Based on an analysis of hand movements, it was possible to define for each subject the total number of fashioning operations implemented for each type of pot made. The mean results per stage of apprenticeship and per type of pot are shown in Table 2.

It is obvious from Table 2 that the mean number of operations increases with pot size but decreases according to the stage of apprenticeship. The fact that adults (stage 3) perform a larger number of operations than subjects at the 2B sub-stage is explained by the former's greater care in ceramic production; hence they carry out more thinning and shaping operations.

Table 2: Mean number of fashioning operations according to type of pot made and stage of apprenticeship

	1A (n=6)	1B n=6)	2A (n=6)	2B (n=6)	3 (n=6)
Small fairy lamp	4.17	3.14	3.00	2.17	2.50
Large fairy lamp		5.33	4.33	3.17	3.83
Large lid		6.00	5.33	3.50	4.17
4-inch pot			11.33	9.00	
8-inch pot				10.33	10.33
12-inch pot					12.50

1.5 Apprenticeship in terms of manufacturing time

The time required for manufacturing each type of pot was ascertained from videos. It was measured from the moment the subject began to hollow the lump of clay up to the moment he cut away the pot with a thread. The time during which the potter stopped throwing in order to restart the wheel, has not been included.

Data on manufacturing time (Table 3) corroborate those on number of fashioning operations, namely:

- For a single type of pot, a decrease in manufacturing time relative to stage of apprenticeship;
- An increase in manufacturing time relative to an increase in pot size.

The increase in manufacturing time for pots made by adults is also due to the fact that they are more particular about the finished product.

Table 3: Averages and standard deviations of manufacturing time (given in seconds) distributed according to type of pot thrown and stage of apprenticeship

		1A (n=6)	1B n=6)	2A (n=6)	2B (n=6)	3 (n=6)
Small fairy lamp	av	30.88	19.38	17.22	7.50	10.44
	σ	11.24	10.42	7.47	1.91	3.92
Large fairy lamp	av		28.83	29.94	19.11	20.61
	σ		12.28	15.90	6.71	8.34
Large lid	av		34.88	43.55	23.05	25.22
	σ		6.86	18.80	11.23	10.03
4-inch pot	av			113.68	56.00	
	σ			35.77	25.69	
8-inch pot	av				96.93	100.16
	σ				33.92	14.46
12-inch pot	av					165.33
	σ					17.30

av = average ; σ = Std. deviation

2. COILING TECHNIQUE¹

To study the learning process inherent in the coiling technique, we worked on three different situations:

1. Manufacturing *tandūr*. These are large clay jars (clay mixed with goat and horse hair) without a bottom, which serve as traditional ovens. Wheat pancakes are cooked in them on the inner walls of the body. The fire within the jar is fed through an opening at the base.
2. Manufacturing clay hearths and clay silos (clay mixed with straw). This task is traditionally assigned to women and young girls and was studied in the village Mandhauti.
3. Manufacturing jars for decorative purposes (flower-pot holders). In northwest India, large storage jars are no longer used and the coiling technique has disappeared. However, within the framework of projects for developing traditional crafts, some persons have revived the coiling technique for making fancy jars.

The apprenticeship process and manufacturing procedures were filmed for each situation.

2.1. Tandūr

According to verbal reports, the technique we observed is a fairly recent one. Traditionally, *tandūr* were made by the same technique employed for hearths and silos (see 2.2).

Manufacturing procedure and movements

The *tandūr* is made by the successive addition of coils, the number depending on the size of the *tandūr*.

The coil (about 60 cm long and 18 cm in diameter) is made by rolling a lump of clay in the palms pointed downwards. The movement is a symmetrical, two-handed, to-and-fro gesture in a horizontal plane.

To make the lower part of the *tandūr*, the coil is flattened by alternately tapping the palms. The result is a flat slab about 4-cm thick and 20-cm wide. Two slabs are required for making the lower part of the *tandūr*. They are aligned lengthwise vertically and joined together with finger pressures. The potter then executes a series of operations while walking backwards around the pot. The purpose of these operations is to thin and shape the slabs. They are repeated alternately several times.

1) Thinning operation using a wet cloth (or index finger): the right hand executes a vertical pressure from below upwards while the left palm, in the inner horizontal position, supports the clay. The role of the hands is reversed as many times as the operation is repeated.

2) Thinning operation by movements from below upwards, of bimanual pressures of the two palms placed symmetrically on either side of the wall.

3) Smoothing operation of the slabs: the palms exert a symmetrical interior horizontal pressure on either side of the wall of the *tandūr*, from below

¹ A coil is a roll of clay with which a pot is fashioned without using a wheel.

upwards. This movement is differentiated from the thinning movement described above insofar as the pressure is lighter. Smoothing is also performed by means of the same movement, using a beater and an anvil.

4) Beating operation: it corresponds to the shaping and consolidation of the walls. The right hand beats with a wooden beater, while the left hand, holding a ceramic anvil, counter-balances the beating movement. This is executed from below upwards.

The upper part of the *tandūr* consists of large coils. They are only added after the lower part has dried sufficiently. They are first placed on the edge of the lower slabs, then joined with a pressure movement of the fingers. The outer face of the coil is then aligned with the outer face of the slabs by a movement similar to the one performed for thinning, using a wet cloth. The coil is then unrolled from the inside upwards with the help of the right hand, while the left hand supports the outer part. Then the series of operations performed while walking backwards is executed (See Plates 12 to 16).

The time of manufacturing depends on the speed at which the clay dries and therefore on the climate: in July-August, the monsoon season, up to eight days are required for making a *tandūr* 74-cm high, 70-cm wide and 2.5-cm thick. During the hot season, four days suffice.

Learning process

Apprenticeship is scaffolded (Greenfield and Lave, 1979) : the father is involved in every phase of construction of the *tandūr*, the son being left on his own only after acquiring the know-how. This type of apprenticeship saves the child from failing in the first specimens, unlike the typical apprenticeship by trial and error.

Apprenticeship commences only around the age of 15 to 16 because thinning the walls of a *tandūr* calls for a certain amount of strength. This period lasts about 6 months, following which the child is able to produce all the desired sizes of *tandūr*. The movements are absolutely identical from one size to another and the only difficulties in this technique are, firstly, learning to recognize the moment at which the clay is "just right" for taking on the upper coil (it should be neither too dry, nor too wet, and leathery in consistency) and, secondly, learning how to beat (which takes about one-and-a-half month).

2.2. Hearths and silos

Manufacturing procedure and gestures

Hearths and silos are also made through successive additions of rolls or rough coils of clay.

Rolls are made by pressing the clay in one or both hands depending on their size. They are then assembled in this manner:

1. The upper roll is attached to the lower through joint bimanual pressures of the three fingers. The index and second fingers exert an interior horizontal pressure that thins the roll, and the thumbs, placed on the upper part of the roll exert a vertical pressure downwards that affixes the upper roll to the lower.



Plate 12: Manufacture of a clay slab aimed at constructing the lower part of a tandūr.



Plate 13: Shaping and consolidation by beating the lower parts of a tandūr.

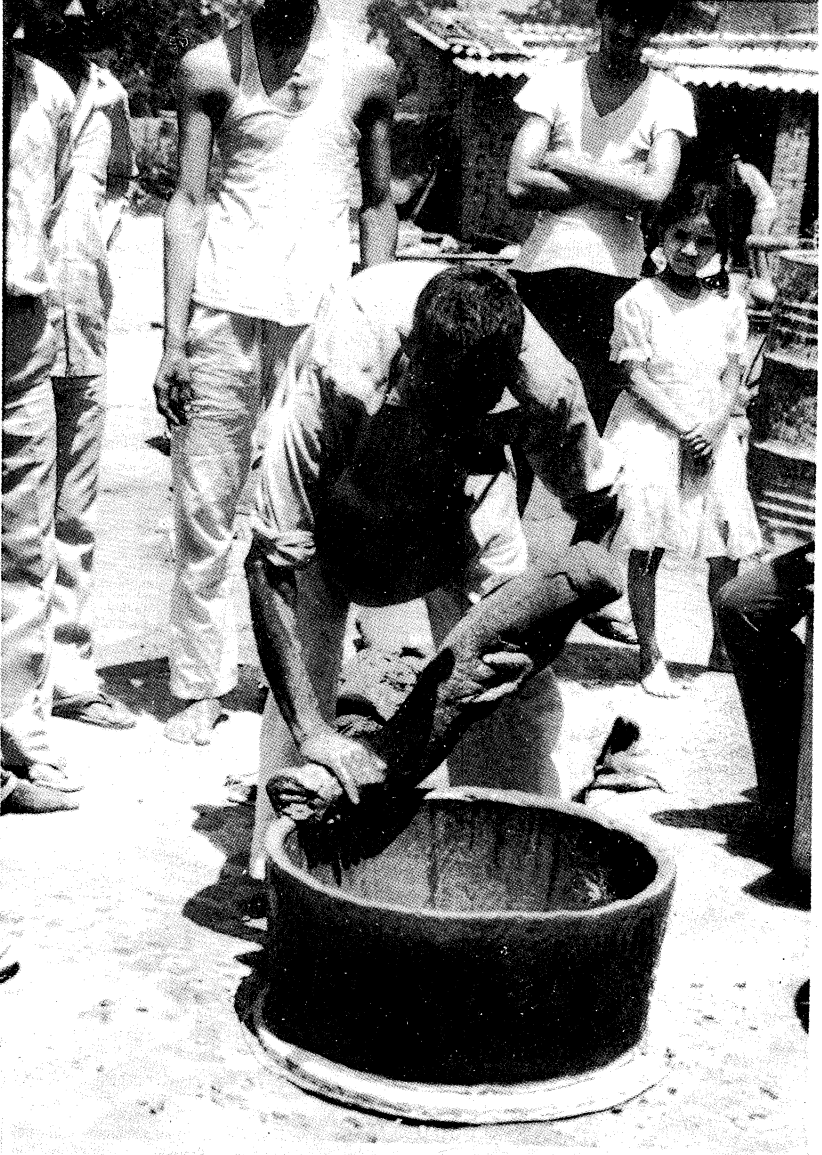


Plate 14: Placing a coil on the lower part of the tandūr.



Plate 15: Joining the coil to the lower part by a movement of pressure of the fingers. The coil is then unrolled from inside upwards.



Plate 16: Thinning operation by a movement from below upwards of bimanual pressures of the palms, symmetrically placed on either side of the wall.

2. The roll is shaped by the internal horizontal pressure, from topside down, of the thumbs on the walls of the roll.
3. The walls are smoothed by the fingers.

Like the technique of the *tandūr*, the speed of construction of hearths and silos depends on the time required for the lower parts to dry. The construction of a silo 0.66 m wide, 1 m long, and 1.40 cm high may take about 15 days.

Learning process

Here, also, apprenticeship is scaffolded, with the mother involved at every step to correct the errors of her daughter. We filmed three subjects in action: an adult woman and two 10-year-old girls, one of whom had already constructed two hearths, while the other was making one for the first time. It was obvious at the outset that a novice can construct a hearth, given the simplicity of the movements, the ever-present correction of mistakes, and the possible intervention at any moment of the expert (the mother). The difficulties encountered by the two young girls were:

- Simultaneous performance of the vertical and horizontal pressures for attaching the roll. They exerted only the vertical pressure, obliging them to do a second operation: erection and thinning of the roll through an inner bimanual horizontal pressure of both palms.
- Planning and fashioning the rolls in terms of the overall object projected; in the absence of this concept, acquired during apprenticeship, the young girls had problems in constructing regular walls.

The duration of apprenticeship is very difficult to pinpoint. The little girl may be efficient from the first day, all the more so since the walls of hearths are low (around 20 cm high) and thus the consequences of the factor of irregularity are not dramatic (collapse of the walls in the case of *tandūr*). Furthermore, silos are usually the result of collective endeavour and it is difficult to determine the moment at which interaction ceases between novice and expert. Generally, adults speak of a rapid apprenticeship that does not exceed several months. (See Plates 17 and 18).

2.3. Coiled jars

Manufacturing procedure and movements

The bases of the jars are obtained first of all by throwing or moulding. They are then placed on a tournette (base that revolves slowly, successively presenting each face of the pot to the potter: the circular movement only plays an accessory role here and, confronted with a large and fragile piece, it is the potter who turns around the jar). The body is then constructed by successive additions of coils.

The coil is prepared by rolling the clay in both palms, which execute a simultaneous and symmetrical to-and-fro movement. This movement is repeated until the coil reaches a certain length. Then it is executed simultaneously or alternately at each extremity of the coil: the hands move towards the right or towards the left, sometimes symmetrically, sometimes



Plate 17: Construction of an hearth by successive additions of coils.



Plate 18: Intervention of the mother in the manufacture of the hearth.

concurrently. From time to time, only one hand works while the other holds the coil at its extremity. The difficulty of this task lies in the making of perfectly regular coils, i.e., of an equal diameter throughout their length.

The coil is then placed and joined to the lower part of the jar by compacting its faces inside and outside the jar with the thumb, which moves from the top downwards. The hand opposite to the one with the working thumb supports the outer or inner part of the coil. This operation requires that the pressures be regular and that the clay not be too soft.

The shaping of the coil is done by successive combined pressures of the thumb and fingers of the right hand. From time to time the left hand takes over while the thumb of the right hand smoothens the lower outer part of the coil. This shaping operation may also include a beating operation. It should be noted that the shaping gestures are repeated in an identical manner during the entire operation of fashioning, irrespective of whether the jar is immobile or moving with the activation of the tournette (See Plate 19).

Learning process

Here, also, apprenticeship is scaffolded, the father allowing greater and greater initiative to the son. The first stage consists in making coils. The son has to practise to make them long and regular. Then comes the stage of laying the coil, during which the father teaches the son how to execute the pressures for balancing the coil and preventing it from falling inside the jar. The last stage consists in getting "the knack" of it, which, in this case, means visualising the overall shape of the pot while repeating on each segment of the jar shaping gestures that are so identical that the walls of the jar are absolutely regular.

This apprenticeship is valid for all pots, irrespective of size. The only difficulty inherent to large jars is the organization of gestures for shaping since global perception becomes more difficult when the pot increases in size.

According to oral reports, the duration of apprenticeship for a perfect and total mastery of the coiling technique does not exceed a year. It may be noted that one year is quite common. In Manipur in east India, all the pottery is made with the slab construction technique (a variation of the coil). The women in charge of making this type of pot need only one year (around the age of 12) to master the entire know-how.

EXPERIMENTAL DATA

The objective of the experimental data was to specify the difficulties inherent in the wheel-throwing technique. Two categories of data are distinguished: analysis of the evolution of the two-handed strategies for the manufacturing of small vessels during the various stages of apprenticeship and the measurement of the main motor abilities involved in the wheel-throwing activity.

1. TWO-HANDED STRATEGIES AND EXPERIMENTAL PRODUCTION

For this study, we asked the potters to make containers characteristic of the

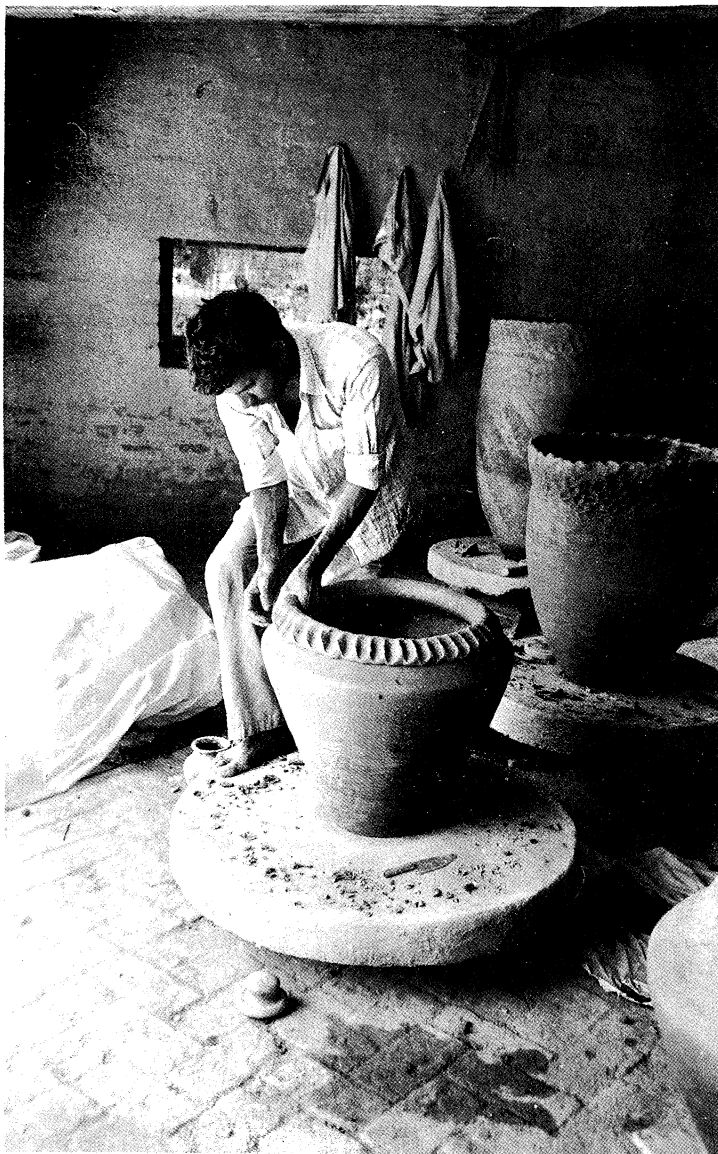


Plate 19: Manufacture of a coiled jar. The coil is placed and joined to the lower part of the jar by crushing its edges with pressures of the thumb from below upwards.

first stage of apprenticeship (small vessels) since only these containers are made by all potters. In this experiment, we studied the evolution of the organization of movements from one stage to the next for a single object, according to a single criterion of comparison. The evaluation enabled us to note whether the strategies of two-hand coordination built up in the course of sub-stages 1A and 1B are kept during the second and third stages for the making of small vessels.

Analysis was done on the basis of descriptive patterns of the movements in terms of the two categories of two-handed movements or strategies possible for the making of small vessels: symmetrical hands (mirror image activity; to transform the clay, both hands carry out the same gestures at the same time) and asymmetrical hands (complementary activity; one hand supports the clay while the other shapes it). These movements are described for the main manufacturing phases: hollowing, thinning and shaping (Figure 2).

In this situation, in which the task can be carried out by one or the other of these two-handed strategies, the type of organization of the gestures observed informed us of the level of mastery of the work. In various studies, symmetrical two-handed gestures are generally described as being easier and more spontaneous (the dominant tendency), whereas asymmetrical gestures require much greater concentration for execution (Cohen, 1971; Fagard, Morioka and Wolff, 1985; Woodworth, 1903). However, if the asymmetry of the gestures permit manual complementariness, as is the case in the making of small vessels, then this strategy allows a better control of the gestures than the symmetrical strategy. In fact, in the case of manual complementariness (asymmetry), the control of the gestures is exercised mainly by the "active" hand (the one which shapes the clay) and only slightly by the "passive" hand (the one which supports the clay). Contrarily, the symmetrical strategy (where the two hands participate in shaping the clay) requires a control that is simultaneous and sustained from both hands in spite of their functional symmetry.

Regarding the question of development of the ability for two-handed collaboration in a child, studies have shown that the initial, spontaneous tendency which consists in producing symmetrical bimanual gestures, progressively evolves towards a lateralization of gestures (manual complementariness) (Bruml, 1972; Corbetta and Mounoud, 1985). These results increase in favour of a lateralization of control of the two-handed gestures, which facilitates mastery (see also Fagard, 1984).

Hollowing

Analysis of the two-handed strategies used in the hollowing activity revealed, first of all, that the organization of movements tends towards lateralization, i.e., towards manual complementariness (asymmetry) (Figure 2, part A).

Indeed, asymmetrical hollowing activities predominate in the last stages of apprenticeship (2B and 3), while in the first stages hollowing is also executed through symmetrical activities: some children hollowed out and drew aside the walls of their lump using both thumbs.

TWO-HANDED STRATEGIES

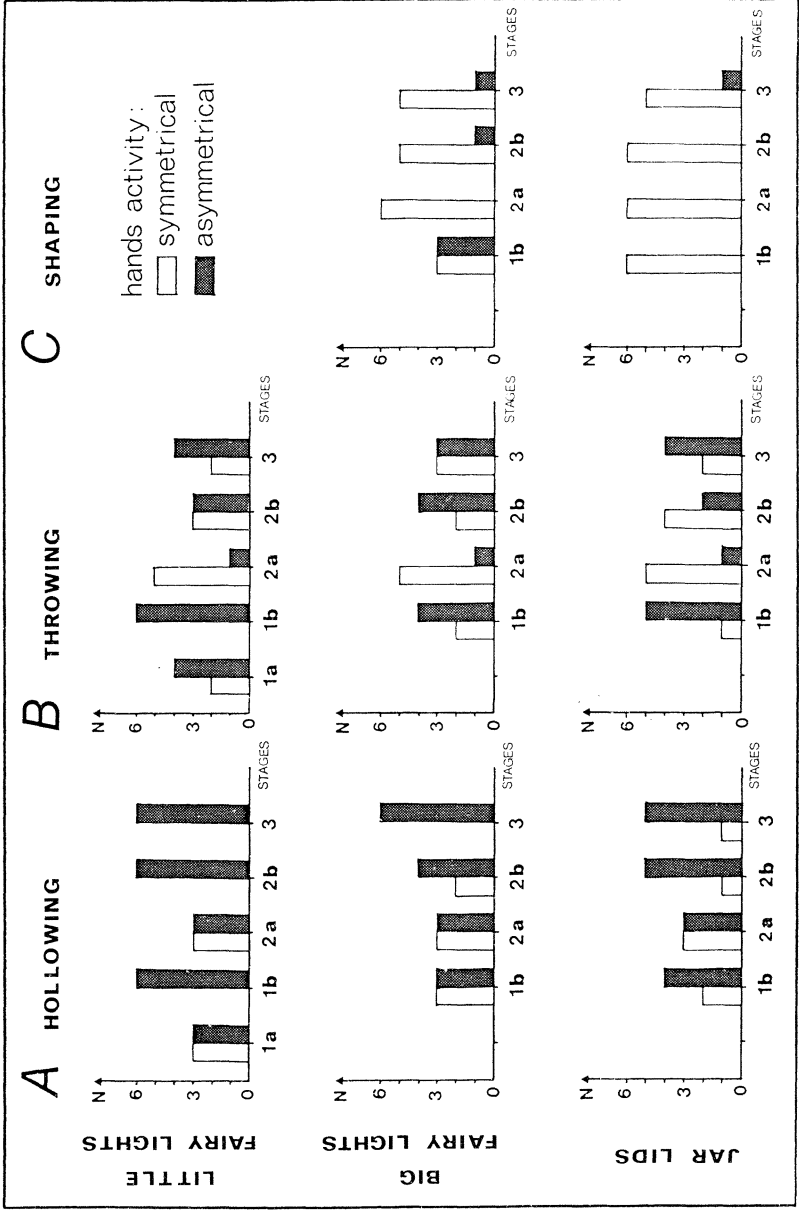


Figure 2: Small Vessel Manufacture.

The presence of symmetrical activity during the stages the child begins to throw (sub-stage 1A) and learns to produce pots of a larger size (sub-stage 1B) is probably due to the spontaneous initial tendency to act in symmetry. But this phenomenon may also be due to the need for exerting sufficient strength in hollowing. Indeed, the results of the 1B group already show a tendency towards lateralizing this activity, which is clearly seen in the hollowing of lumps meant for the production of small fairy lamps (Figure 2, part A). However, this tendency is not confirmed in the hollowing of lumps meant for large fairy lamps or large lids. This change of motor behaviour acquired in sub-stage 1B during the production of small fairy lamps can only be attributed to the constraints of strength, taking into account the fact that symmetrical movements involve a greater control of the gestures if the lump is not to be decentered.

This explanation cannot be given for the results of the 2A group in which 50% of the subjects again adopted a symmetrical hollowing strategy in the production of small vessels. This is a surprising results as the subjects of the 2A sub-stage master the throwing of small vessels and, like subjects of the higher stages, would be capable of performing an asymmetrical activity. However, it should be remembered that the 2A sub-stage is a stage in which the bimanual synergies relating to throwing are reorganized: until the 1B sub-stage, both hands move on either side respectively of the axis of rotation of the wheel and enable a unilateral control (only the active hand does the throwing), while from the 2A sub-stage both hands perform together to the right of the axis of rotation of the wheel requiring a bilateral control (both hands participate in the throwing). This reorganization of the position of the arms in the reciprocal role of the hands interferes with the activities acquired during the preceding stages.

Thinning

Thinning is the operation by which the first and second stages are differentiated from each other in terms of two-handed activities.

Analysis of the thinning activity (Figure 2, part B) showed that the two possible two-handed strategies (symmetrical movement or complementary movement) follow different tendencies depending on the stages of apprenticeship. In the first stages (1A and 1B), the dominant movement is the complementary two-handed movement (asymmetry of the hands) while in sub-stage 2A, the mirror image movement (symmetry of the hands) predominates. In stages 2B and 3, neither tendency prevailed.

The dominance of asymmetrical activities in the first sub-stages seems related to the fact that only the subjects in this stage devote themselves regularly to the throwing of containers of the "small vessels" type. This lateralized activity may be interpreted as a specialization of gestures for fashioning pots characteristic of the first stages (from stage 2 onwards, the subjects make only flower pots). These gestures performed in this manner are easier to control.

The radical change in two-handed strategies of the 2A sub-stage is explained by the fact that the subjects modify the organization of the two-

handed activities acquired earlier into new two-handed activities which, firstly, impose a disymmetry of gestures relative to the axis of rotation of the wheel and, secondly, lead no longer to complementariness, but to an association of gestures (both hands play an active role). This new performance calls for a strong bilateral control. The use of symmetrical gestures for the shaping of small vessels restores the balance in the reciprocal activity of the hands, while concomitantly allowing each hand to play an active role, as the subject will later learn, in the production of flower pots. This explanation is corroborated by the manufacturing time of flower pots (See Table 3), which shows a slowing down in duration among subjects of the 2A sub-stage compared to the 1B sub-stage. Indeed, the learning of new, associative, two-handed activities involves a slowing down of movements in order to control them (Fagard, 1982; Fagard *et al.*, 1985).

Shaping

This operation generates few modifications in the form of "small vessels" and therefore little control over the gestures. Thus it undergoes no evolution in terms of the stage of apprenticeship (Figure 2 part C).

Conclusion

From the foregoing results, two points follow:

1. In the first stage, the activities evolve towards a specialization in gestures characterized by a two-handed complementariness. This complementariness makes the task easier since it permits better control over the movements (essentially unilateral).
2. In the second stage, this bimanual specialization is masked by the learning of a new, thinning, activity. This involves a reorganization of the reciprocal activity of the hands into two active gestures which must not only be controlled simultaneously, but must unfold in an asymmetrical manner relative to the axis of rotation of the wheel.

2. PERCEPTUAL MOTOR TESTS OF PRESSURE AND TWO-HANDED POINTING

Based on detailed observations of the two-handed activities executed in the making of pottery, we set up four perceptual motor tests relating to the various motor abilities required for throwing and specific for the different stages of apprenticeship.

The objectives of these tests were:

1. To determine more precisely the two-handed motor abilities performed by child potters, in order to reveal the difficulties characteristic of learning, the wheel-throwing technique.
2. To analyse the results obtained in the study of the evolution of two-handed strategies, in order to specify the difficulties characteristic of the transition from one stage of apprenticeship to the next.

To fulfill these objectives, we compared the performances of potters (children and adults) with those of four groups of non-potter children 8 to 14

years old and a group of non-potter adults. Moreover, we devised our perceptual motor tests in such a way as to obtain an index of measurement which relates to activities typically performed in pottery. Two of them measure the basic general motor abilities indispensable to a mastery over the wheel-throwing technique. Two others measure the two activities specific to stages 1 and 2.

Let us emphasize that our intention is not to demonstrate the absence of specialization among potters who practise the coiling technique. Thus, our demonstration of the "wheel-throwing technique/craft specialization" relationship will not be weakened by the fact that the tests were applied to non-potters instead of potters who practise the coiling technique.

Perceptual Motor Tests

Generally speaking, the two basic motor abilities indispensable for mastery over the wheel-throwing technique are: (1) the capability for maintaining the forearms in a stable position, and (2) the capability for producing and maintaining constant pressures. The first capability is essential for keeping the lump of clay centred during all the hollowing, thinning and shaping operations; the second capability is necessary for centring the lump and for thinning regular walls. These two aspects of movement are normally carried out simultaneously in the wheel-throwing activity. One of the major difficulties in this technique is the ability to exert a constant pressure on the clay while concomitantly maintaining both arms firm and stable. Unfortunately, it is difficult to create a situation in which both the pressure and the stability of the forearms can be measured. For this reason, the tests devised measure these two aspects of movement in a dissociated manner. One test measures two-handed symmetrical pressures, two other tests measure the stability of the forearms relative to different arm positions (hand on each side or on the same side of the axis of rotation of the wheel). The last test measures the pressure exerted by one hand, combined with the measurement of stability of the other hand.

Each test is detailed below, either in relation to the throwing gesture it pertains to or to the motor skill it evaluates.

Subjects of Study

The experimental group included:

1. Thirty potters (the same ones who participated in the other parts of our investigation). Of these 30 potters, 24 were children between eight and 15 years of age, while 6 were adults 23 to 40 years old. They were regrouped according to the five stages of apprenticeship defined earlier.
2. Thirty non-potters. Of these, 24 were children whose ages matched the age range covered by the group of potters, and 6 were adults. All the subjects were from the village Mandhauti (Haryana) and sons of farmers or of potters who had stopped making pottery long ago. These subjects were selected and grouped according to age in order to obtain a measurement of the evolution of motor abilities in terms of the factor of maturity. Thus we have five age groups with six subjects in each: 8 years, 10 years, 12 years, 14 years and adults (from 19 to 25 years old; mean age = 21.5).

All the subjects were right-handed and knew how to write at least their name. All the tests were carried out on Har Kishan's wheel (our informant), which was mounted on a tripod. This gave the wheel the advantage of not tilting to one side when motionless, contrary to the traditional potter's wheel, which is mounted on a pivot. We carried this wheel to the village Mandhauti so that the two groups—potters and non-potters—performed the tests under the same conditions.

2.1. Test of simultaneous symmetrical pressures

To set up this test, we drew inspiration from a perceptual test for measuring manual stathesis, devised by A. Ray (1969).

This test evaluates the ability to exert internal horizontal symmetrical pressures by both arms simultaneously on each side of the axis of rotation of the wheel. It involves the centring operation, which requires the execution of two-handed pressures simultaneously on each side of the lump. This activity is carried out at every stage by using the same gestures, irrespective of the pot made.

It may be recalled that successful centring is a *sine qua non* for throwing. This operation calls for the same strength from both arms. The intensity of strength to be deployed varies with the size of the lump.

Centring is not mastered before the 2B sub-stage (see Table II.1). To understand the reasons for this, we tried by means of this test to ascertain whether the inability to centre the lump in the first stages was due to the inability to exert a symmetrical pressure of both arms, or simply the inability to produce enough strength.

Two important points must be emphasized:

- Our test only measures the pressure of the arms and not of the hands since it is the arms (in the group observed) that are truly involved in the centring activity.
- Our test only indicates a partial measurement of the motor parameters involved in the centring activity. Indeed, it takes place in a static situation which does not permit taking into account the proprioceptive information given by the rotating lump. Such information plays an important role in the sense that it leads to a continuous modulation of pressures.

Equipment

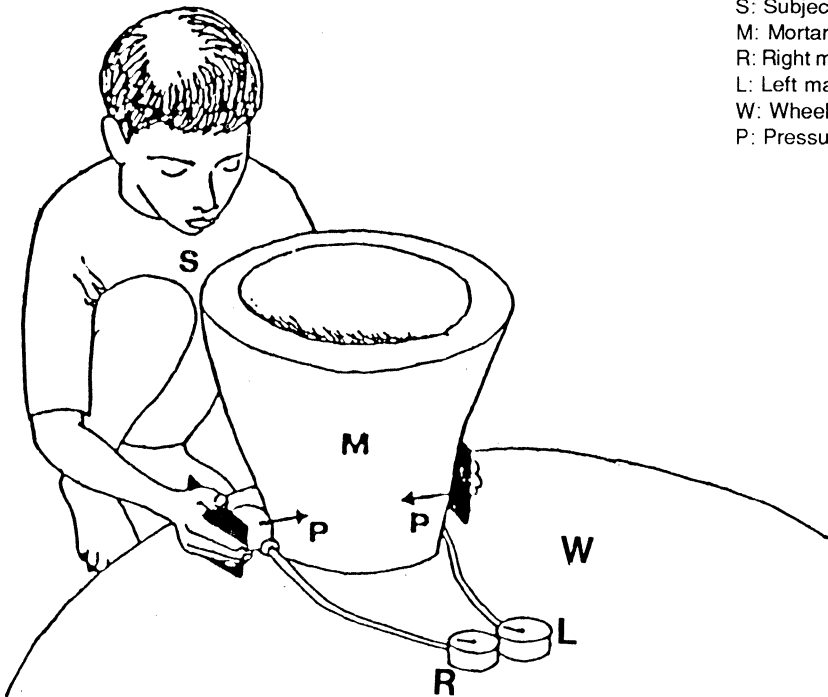
- Two Jacquet manometers recording pressures from 0 to 300 mm/hg. Each of these manometers was connected by a flexible plastic tube 25 cm long to a round plastic pear 54 mm in diameter. This pressurized system enables the needle of the manometer to vary in terms of the pressure exerted on the pear and to read its graduation.
- Cement mortar of about 25 kg substituted for the lump. Pressure was exerted on either side of the base of the mortar. Its outer dimensions were:
 - base: 18 cm diameter
 - height: 25.9 cm
 - orifice: 32.5 cm at outer diameter.

- Two small wooden plaques 14 cm x 9 cm square and 5 mm thick were inserted between the pears of the manometers and the hands of the subject. The utilization of flat surfaces for pressing the pears permitted control of our index of measurement of the force exerted by the arms and not by the hands.
- Har Kishan's wheel.

Experimental procedure and instructions

The mortar is placed at the edge of the wheel which is motionless. The pears of the manometers are placed on either side of the base of the mortar. The manometers are placed behind the mortar in such a way that the subject cannot see them (see diagram below). This test should take always place in an "open loop" (i.e., without visual refference to the pressure exerted) since the success of centring does not require visual information.

In an ideal situation, the mortar should be placed in the centre of the wheel. However, the experiment was carried out with Har Kishan's wheel, which is larger in dimensions that those on which children begin to learn; most of the children could not reach the centre.



S: Subject
 M: Mortar
 R: Right manometer
 L: Left manometer
 W: Wheel
 P: Pressure

The subject, squatting by the wheel and facing the mortar, placed both palms flat against each small wooden plaque. We gave him the instruction to simultaneously exert with both arms an identical horizontal internal pressure against the mortar and to maintain it for five seconds. We indicated that it was not pressing as hard as possible that was important, but rather maintaining an identical pressure with both hands, similar to the pressure exerted when centring a lump.

We counted five seconds from the time the two needles on the manometers stabilized and recorded the value shown on each manometer. The test was repeated three times (Plate 20).

Presentation of results and interpretation

Two discriminant analyses were done on each of the subject groups. Both reclassified 53.33% of the subjects in their own divisions. In other words, the criteria utilized for selecting our two groups of subjects (stage of apprenticeship for potters and age for non-potters) proved relevant.

Two ANOVA (Analysis of Variance) for repeated measures [Stage (5) x Hand (2) x Trial (3) and Age (5) x Hand (2) x Trial (3)] were done on the results of the pressures exerted by potters and non-potters. The Stage and Age factors comprised five levels respectively, which corresponded to the five stages of apprenticeship and the five age groups retained. The Hand factor comprised two levels: left hand and right hand. The trial factor included three levels, which corresponded to the three test replications.

The only factors which proved significant in our two groups of subjects were the Stage factor for potters, and the Age factor for non-potters [respectively: $F(4,25) = 4.56925$, $P < .007$ and $F(4,25) = 6.92375$, $p < .001$]. (See Figure 3: Histograms A and B)

Regardless of the group of subjects or their level (stage or age), the slight differences in pressure between the right and the left hand were not significant. Indeed, these differences never exceeded 10 mm/hg (the maximum difference among potters was equal in the sub-stage 2B at 9.17 mm/hg and among potters in the adult groups at 6.84 mm/hg).

Among potters, the force of the two-handed pressure increased through each stage of apprenticeship. Among non-potters, the two-handed pressures were always weak among those in the age group 8 to 14 years and only increased in adults.

These results show that the inability to centre a lump before sub-stage 2B is not due to the inability to produce an equivalent force in the two arms. Hence, since the first three sub-stages attest to weaker pressures than stages 2B and 3, our hypothesis partly attributes this inability to centre to a lack of strength. This is not the only factor that contributes to the success of this operation. Other factors, such as the rigidity of the forearms, play an important role.

Contrary to non-potters, potters show a progressive increase in horizontal internal symmetrical pressures. This result underscores, firstly, the progressive character of the acquisition of the centring skill and, secondly, the fact that this activity is specific to the wheel-throwing technique.

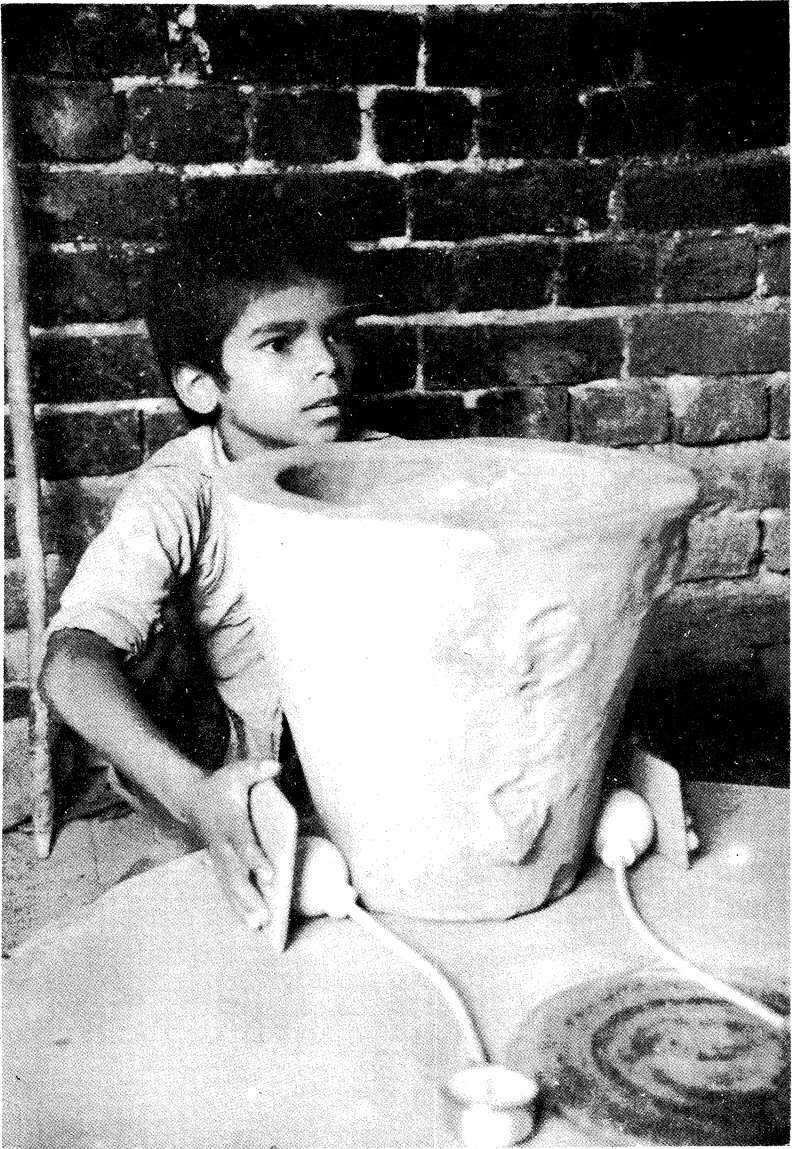


Plate 20: Test of simultaneous symmetrical pressures.

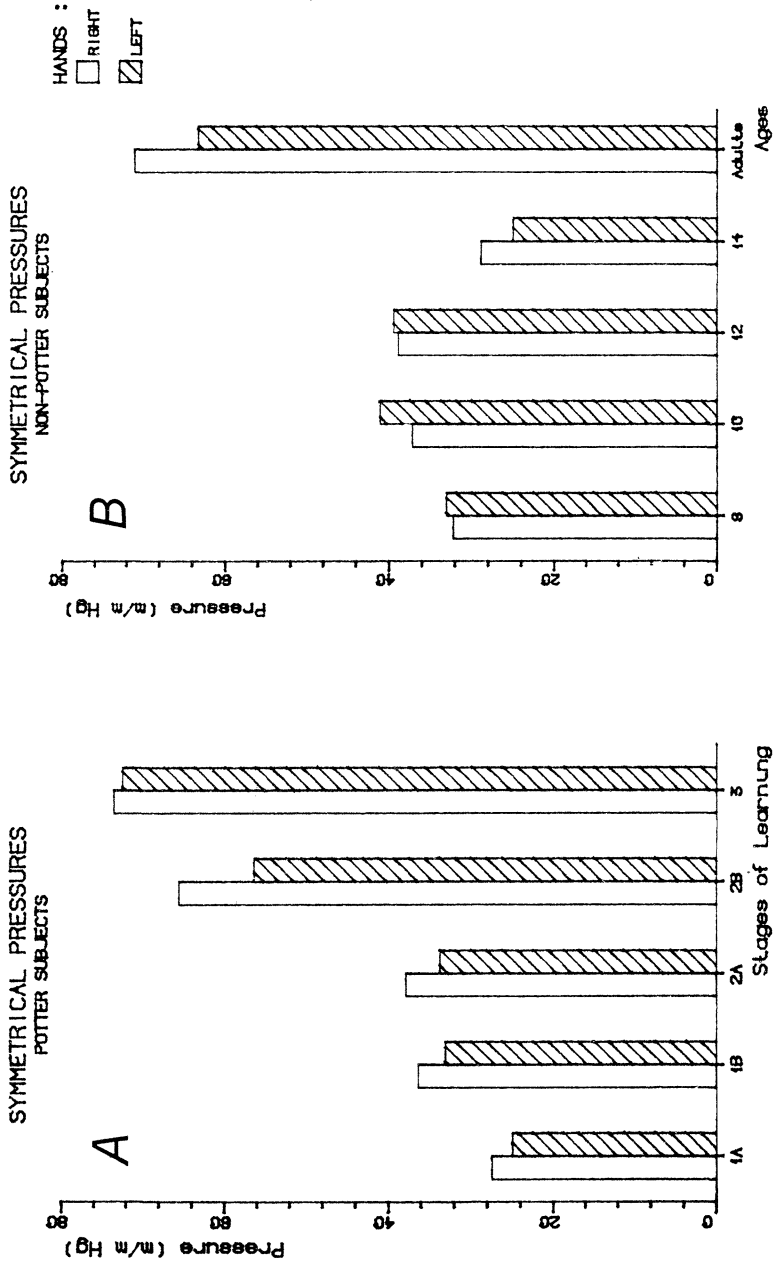


Figure 3: Evolution of the mean pressures exerted by each limb as a function of learning stage for potters (panel A) and as a function of age for non potters (panel B).

2.2. Test of simultaneous symmetrical pointings

This second test measures a basic ability that is required for mastering the wheel-throwing technique, namely, the ability to simultaneously maintain both forearms firmly on either side of the axis of rotation of the wheel in such a manner that they are not drawn away by the movement of the lump.

The building of this ability starts right from the first sub-stage (1A). The child has to learn to keep his hands firm to avoid spoiling his pot or breaking the walls during the throwing. In subsequent stages, this motor skill becomes all the more crucial as it is associated with the displacement of the hands along a vertical or a horizontal axis.

We used this test to study the development of this motor ability during the various stages and ages, and to compare this development between children of potters and non-potters. Moreover, from the results of a study of the gestures, we could ascertain whether the subjects of sub-stage 2A gave a better performance than subjects at other stages of apprenticeship. This test requires a symmetrical activity of the hands and arms and the potters of sub-stage 2A showed a preference for symmetrical activities in which both hands are placed on either side of the axis of rotation of the wheel.

Equipment

- Two large felt pens, a black one for the left hand and a red one for the right, to leave tracings of the position of each hand.
- Sheets of white paper, A4 format, on which the tracings would show.
- Har Kishan's wheel.
- A stop watch.

Experimental procedure and instructions

A white sheet of paper is affixed to the centre of the wheel with adhesive tape. The subject, squatting by the wheel, holds the red felt pen in his right hand and the black felt pen in his left. His task is to simultaneously keep the two felt tips poised on the sheet of paper on either side of the axis of rotation of the wheel while it is in motion, and to hold his arms as still as possible for 10 seconds so that the felt tips remain in their respective tracings. The stop watch is started as soon as the two felt tips touch the sheet of paper. The pens are removed from the paper when the experimenter gives the signal to do so. This test was repeated three times in succession (Plate 21).

Presentation of results and interpretation

Each test was subjected to two measurements:

1. Calculation of the diameter of the circles produced by the penholder. Each measurement enabled us, firstly, to evaluate the distance at which the tracings were made relative to the centre of the wheel and, secondly, to verify that these distances did not vary greatly between subjects or between groups.
2. Measurement of the stability index for each hand. This was obtained by measuring the thickness of the tracing produced. The greater the immobility

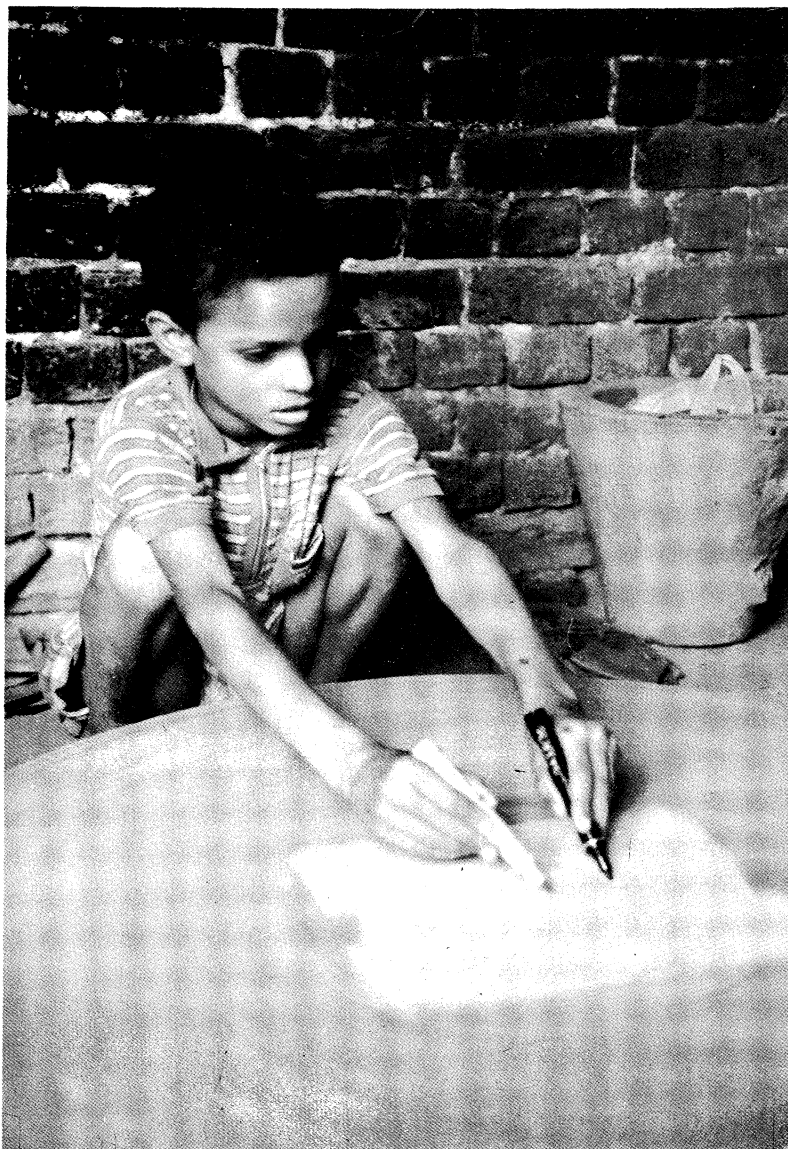


Plate 21: Test of simultaneous symmetrical pointings.

of the hand in relation to its initial position, the finer the tracing; the more the hand moved or drifted towards the exterior or interior of the wheel, the thicker the tracing. The index of stability was calculated from the mean of four thicknesses measured at 0°, 90°, 180°, and 270° of a single circle.

The results of the diameters show that, on the average, the size of the circles produced were between 9 and 15 cm in diameter. In other words, each hand acted about 4.5 to 7.5 cm away from the centre of the wheel, which makes the differences between the hands and the groups negligible, and therefore also the fact of not having controlled the position of the hands relative to the centre of the wheel.

Two discriminant analyses of the stability index reclassified 63.33% of the potters, and 66.68% of the non-potters in their own divisions. These results confirm that the criteria adopted in the selection of subjects are relevant.

Two ANOVA for repeated measures [Stage (5) x Hand (2) x Trial (3) and Age (5) x Hand (2) x Trial (3)] were done on the results of the index of stability for potters and non-potters. Among potters, the only significant factor was the Stage [$F(4,25) = 3.83647$, $p < .015$]. Among non-potters, two factors, Age and Trial, appeared significant [respectively $F(4,25) = 4.36515$, $p < .008$ and $F(4,25) = 4.52415$, $p < .022$], as well as two interactions: Age x Hand [$F(4,25) = 3.88016$, $p < .014$] and Age x Hand x Trial [$F(8,50) = 2.72116$, $p < .014$].

To determine the extent of interaction between these factors among non-potters, we made five supplementary analyses of variance [Hand (2) x Trial (3)] for each age group. The only significant factors appeared in the group of eight-year-olds: a factor Hand [$F(1,5) = 12.73664$, $p < .016$] and a Hand x Trial interaction [$F(2,4) = 7.87264$, $p < .041$]. The factor Trial was not significant in any case. The two interactions recorded earlier occurred only in the group of eight-year-olds. The Age x Hand interaction can be seen in Figure 4/B in which performances of the left and the right hands respectively are depicted for the eight- and ten-year-old subjects; the curves cross. The Age x Hand x Trial interaction is explained by the fact that the eight-year-old, contrary to the other age groups, did not have one hand consistently more stable than the other. Depending on the trial, the stable hand was sometimes the right, sometimes the left.

It can be seen in Figure 4 that the index of stability decreases both in terms of apprenticeship stages (potter subjects) and ages (non-potter subjects). However, the potter subjects attest at every stage to a greater stability of arms than the non-potter subjects. Among the latter, only the 14-year-olds and the adults showed performances comparable to those of potters; they are comparable to those of potters of the 1B and 2B sub-stages respectively.

Although the differences in stability between the right and left hands are not significant, we did observe a tendency in the two groups of subjects towards a better right-hand performance compared to the left hand. Only the non-potter group of eight-year-olds was an exception. This difference in stability between the hands is undoubtedly due to the fact that all our subjects were right-handed and therefore their dominant hand more controlled.

It should be noted that the performance of the sub-stage 2A is distinctly

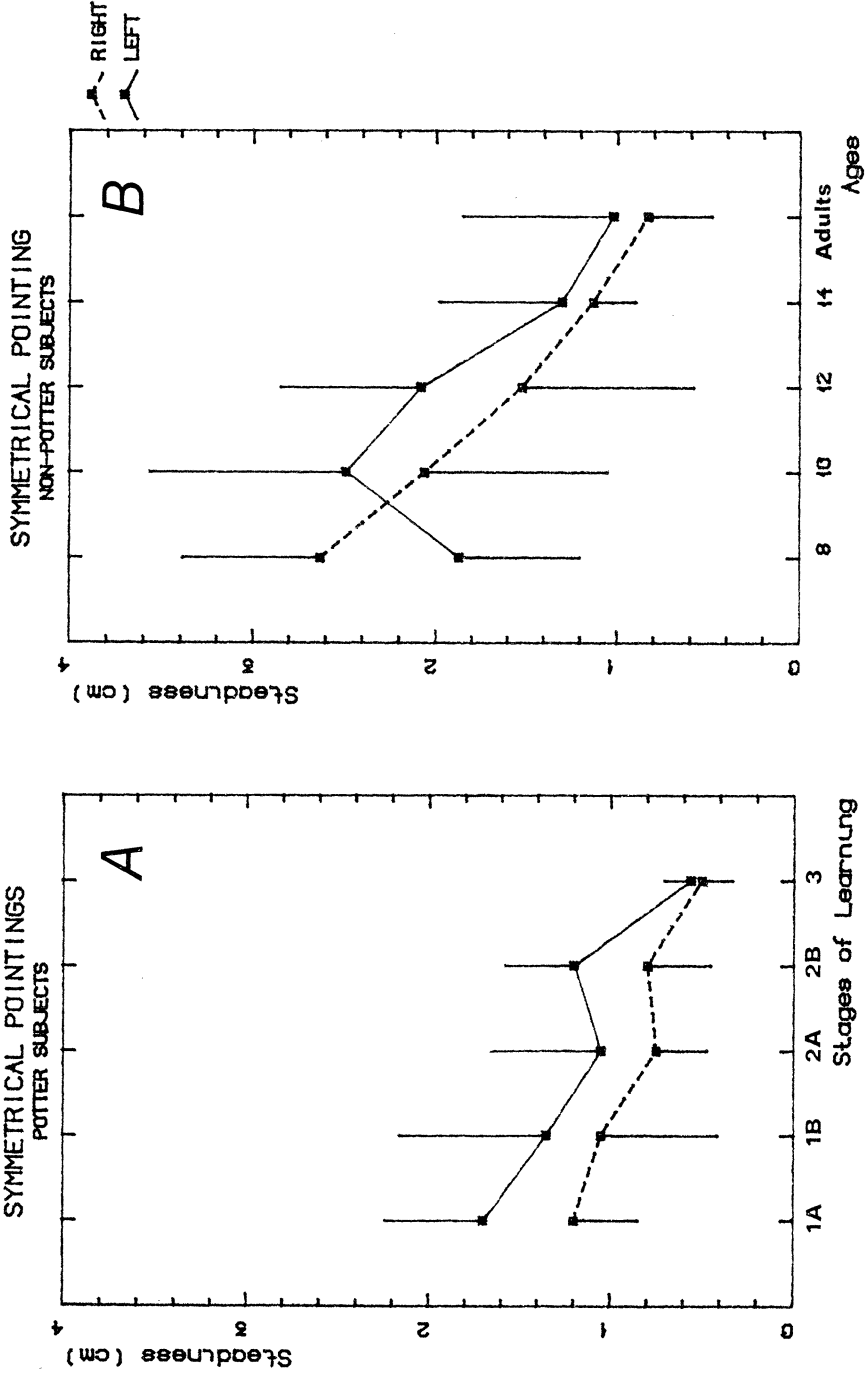


Figure 4: Evolution of the steadiness of each pointing hand (means and standard deviations) as a function of learning stage for potters (panel A) and as a function of age for non potters (panel B).

better than the performances of sub-stages 1A, 1B and 2B, but not as good as that of stage 3. However, this result was not statistically significant.

Results show that : (a) potters develop the ability to keep the forearms stable right from sub-stage 1A, and (b) this ability is specific to the wheel-throwing technique; in non-potters, not until the age of 14 were performances equal to those of the first stage.

2.3. Two-handed test of combined pressures in pointing

This third test measures the ability to maintain a stable position with one hand and a constant pressure with the other. This skill corresponds to the thinning operation exerted only in the making of small vessels. In this sense, it is typical of stage 1. The left hand supports the clay in the left hemiplane of the subject (passive role) and the right hand throws the pot in the right hemiplane of the subject (active role), while exerting constant and simultaneous pressures of the thumb and the index finger (or thumb/second finger).

By means of this test, we studied the following:

- Motor abilities which develop between sub-stages 1A and 1B. Is it the ability to maintain a much greater stability of the hands, or of producing more constant pressures, or both?
- To what extent do these abilities deteriorate in the second and third stages, considering that at these stages this activity is no longer executed at all. Would we observe, in particular, in sub-stage 2A, a greater deterioration because (a) this test calls for a unilateral pressure and (b) analysis of the gestures had shown a return to a symmetrical activity of the hands (symmetrical thumb/index finger pressure) in children at this sub-stage?
- To what extent does the thinning activity develop a right-hand specialization, since analysis of two-handed strategies had brought to light a right-hand lateralization in sub-stages 1A and 1B. With this question in mind, we also carried out this test by reversing the role of the hands (the left hand presses and the right hand points).

Equipment

- One Jacquet manometer of the same type used in the test of symmetrical two-handed pressures (see 2.1.).
- Some sheets of white paper, A4 format.
- A red or black felt pen for measuring the position and stability of the hands.
- Har Kishan's wheel.
- A stop watch.

Experimental procedure and instructions

A sheet of white paper is affixed to the centre of the wheel with the adhesive tape. The subject, squatting by the rotating wheel, holds the felt pen in his left hand, and the pear of the manometer between the thumb and index finger of his right. His task is to keep the felt pen in the left hand poised on the sheet of paper to the left of the axis of rotation of the wheel while simultaneously exerting pressure with the thumb/index finger of the right hand on the pear of the manometer. The pear is situated in the right hemiplane of the subject

at the same distance from the axis of rotation of the wheel as is the left hand. He is instructed to maintain for 10 seconds as stable and constant a position and pressure as possible. As in the test of two-handed pressures, the subject does not see the needle of the manometer.

This test was repeated three times with the right hand pressing and the left hand tracing, then replicated thrice with the role of the hands reversed (left hand presses and right traces). The maximum and minimum values between which the needle of the manometer oscillated were recorded for each trial, in order to ascertain the variation in pressure exerted.

Presentation of results and interpretation

Three indexes were considered:

1. Measurement of the diameters of the circles produced by each tracing hand during each trial. What we wanted to verify again was whether the fact of not having fixed the distance at which the hand traced relative to the axis of rotation of the wheel, led to a large intersubject and intergroup variation. Let it be noted that the hands were positioned from 5.36 to 8.19 cm from the axis of rotation of the wheel. Therefore these differences are absolutely negligible.
2. Measurement of the index of stability according to the same procedure utilized in the symmetrical two-handed tracing test (see 2.2.).
3. Measurement of the index of variation in pressure obtained by the difference between maximum and minimum values recorded. This variation was calculated as a percentage of the pressure exerted.

Four discriminant analyses reclassified 53.33% and 60.00% of the potters and 50.00% and 66.67% of the non-potters in their own divisions for the indexes of stability and pressure variation respectively. In other words, the criteria defined for selection of the subjects proved relevant to the two indexes measured.

Four ANOVA for repeated measures [Stage (5) x Hand (2) x Trial (3) and Age (5) x Hand (2) x Trial (3)] were done, while dissociating the indexes of stability of the arm and those of pressure variation.

Analysis of the stability index for the arms (Figure 5) illustrated a significant Hand factor among potters [$F(1,25) = 10.17115, p < .004$] and a significant Age factor among non-potters [$F(4,25) = 2.98196, p < .038$].

In an analysis of the index of pressure variation (Figure 5) none of the three factors appeared significant among potters, while among non-potters the Age factor was significant [$F(4,25) = 5.18833, p < .003$].

Figure 5 shows:

- Among non-potters, the stability index decreases progressively for the two hands according to age (Figure 5/B).
Among potters, contrarily (Figure 5/A), the only appreciable modifications in performance are an increase in stability index of the right hand between sub-stages 1A and 1B, and progressive improvement in performances of the left hand from sub-stage 2A onwards.
- Among potters, the right and left hands show a significant difference in performance. This difference does not appear among non-potters.

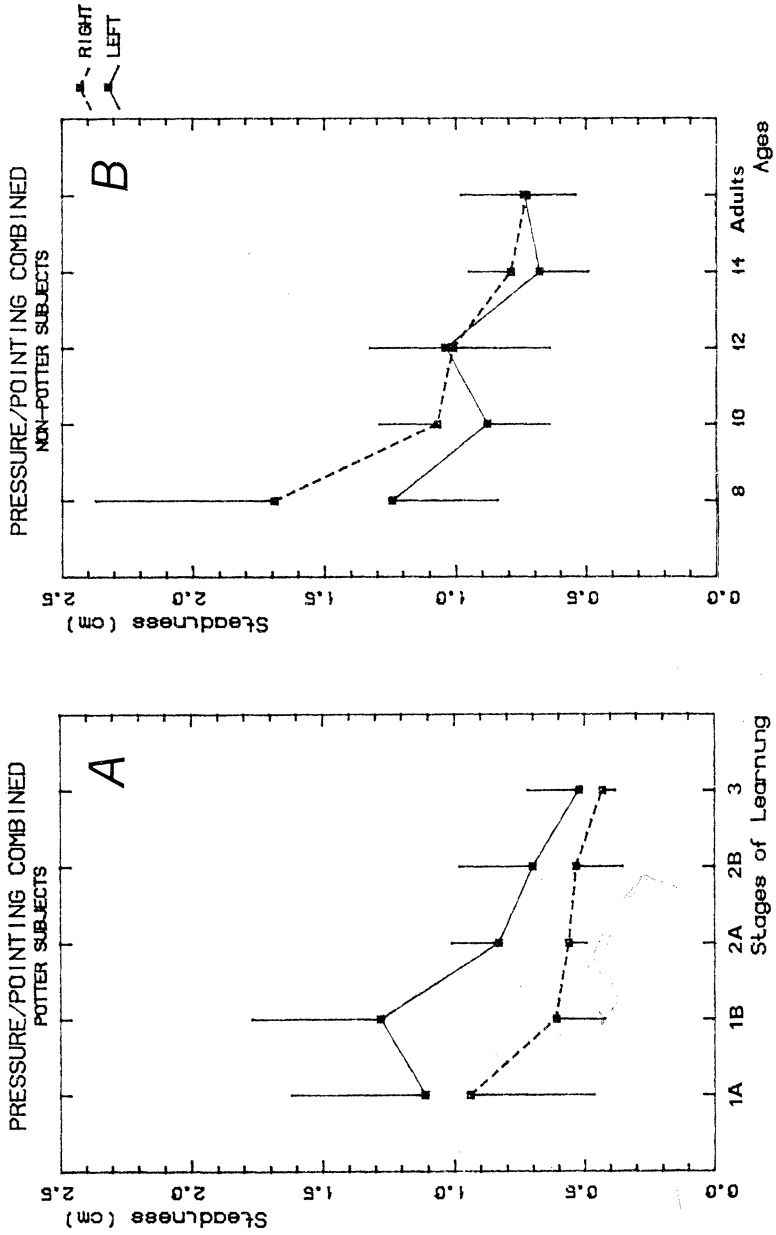


Figure 5: Evolution of the steadiness of each pointing hand (means and standard deviations) as a function of learning stage for potters (panel A) and as a function of age for non potters (panel B).

- Among potters, the right hand not only scores higher than the left, but also higher than the right and left hands of non-potters.

Figure 6 shows:

- Among potters, variation in pressure decreases only between sub-stage 1A and sub-stage 1B, and between sub-stage 2B and stage 3. Among non-potters, this variation decreases progressively according to age.
- Performance of the right and left hands do not differ for either potters or non-potters.

These results offer some elements of an answer to the three questions asked initially.

To the question regarding the motor abilities developed between sub-stages 1A and 1B, we may reply that the child acquires a greater mastery over the control of pressures and control of firmness (especially for the right hand) at sub-stage 1B. An improvement in the performances for these two parameters was noted from sub-stage 1A to 1B.

As for the problem of deterioration of these abilities during subsequent stages, it appears that the fact of no longer carrying out a similar activity during subsequent stages leads neither to a deterioration nor to an improvement in the skills acquired during the first two stages. The only result that improves from the 2A sub-stage onwards is the firmness of the left hand. This can be explained by a change, at this stage, in the role of the left hand—from passive (support activity) to active (participates in thinning).

To reply to the question pertaining to the specialization of the right hand (keeping in mind the important role it played in the first stage), let us state that the index of stability shown by the tracing hand demonstrates a right lateral dominance, particularly among potters at sub-stage 1B. This result is not surprising since in the thinning operation in the making of small vessels, the right hand plays the active role and has not only to transform the clay by means of a regular thumb/index finger pressure, but has at any cost to remain firm so that the pot does not become decentred. It should also be remembered that in the study of two-handed strategies, it is basically at sub-stage 1B that lateralized activities predominate.

Regarding control of pressures, no manual dominance was observed despite the fact that, in most cases, during the first stage it is only the right hand which exerts pressure. The relevance of this observation is unfortunately annulled due to the fact that our pressure measurements were done under static conditions. Moreover, the results of pressure variations for potters are not better than those for non-potters. This can be explained by the fact that the thumb/index finger pressure activity is a part of everyday activities, such as holding a pencil, a glass etc.

2.4 Test of asymmetrical pointings

This test measures the ability to keep one hand steady at a certain distance from the axis of rotation of the wheel while the other hand carries out a regular lateral displacement, starting from the centre of the wheel and travelling

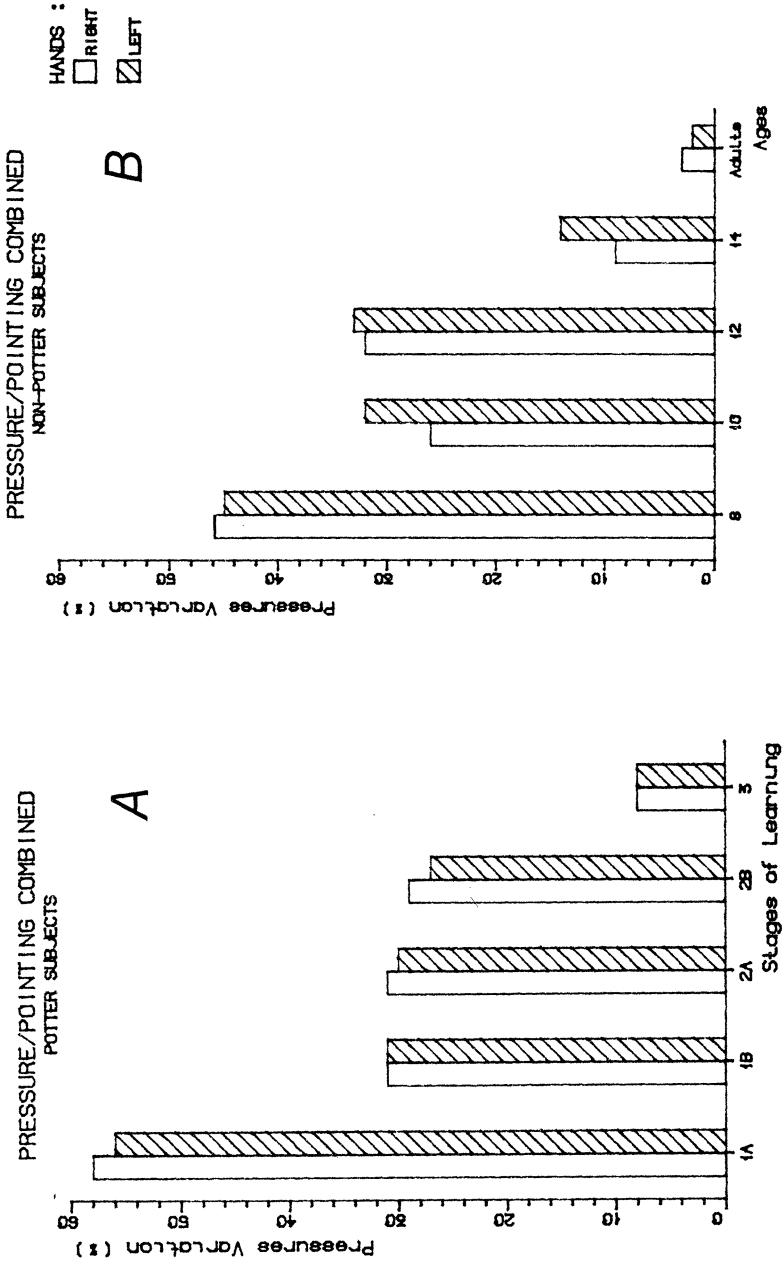


Figure 6: Evolution of the variation of the pressures exerted by each hand (given in rate of the pressure exerted) as a function of learning stage for potters (panel A) and as a function of age for non potters (panel B).

towards the first hand. This motor ability corresponds to the two-handed activity carried out during the third thinning in the making of flower pots. It may be recalled that this activity is difficult to master because it takes place with both active hands in the right hemiplane of the subject. It is developed only from the second stage onwards.

In this movement, the right hand pressure against the outer wall counterbalances the pressure of the left hand against the inner wall, holding the clay which rises in a vertical axis. In addition, the left hand moves from the centre towards the right and traces a spiral movement meant to widen the pot. This test strives to measure two dimensions required for the success of this movement in order to observe a possible evolution during the course of the stages. The indexes are as follows:

- Index of stability related to the right-hand activity, which should never vary when the left hand is displaced.
- Index of speed and regularity of displacement of the left hand, which should be slow and steady.

The success of this thinning operation also depends on the correct determination of pressures exerted by each hand. However, we had no means available for measuring this dimension of movement.

By means of this test, we wanted to define the motor abilities that are progressively developed from sub-stage 2A onwards, determining in particular the degree of difficulty in the indexes examined earlier.

Moreover, we wanted to ascertain to what extent the motor abilities developed in stage 2 depend on hand specialization. With this in mind, we reversed the hand roles and consequently the position of the arms relative to the axis of rotation of the wheel (the arms are held in the left hemiplane of the subject).

Equipment

Identical to that used for the test of symmetrical two-handed pointings (see 2.2.).

Experimental procedure and instructions

A sheet of white paper is affixed to the centre of the wheel with adhesive tape. The subject, squatting by the rotating wheel, holds the red felt pen in his right hand and the black felt pen in his left. His task is to hold the right hand right of the axis of rotation of the moving wheel and to produce at the same time with his left hand a lateral displacement, moving from the centre towards the right of the wheel until it meets the right hand. The subject is instructed: (1) keep the right hand as stable as possible while the left hand displaces and (2) produce from the left hand as slow and regular a displacement as possible over the entire distance traversed. Each time that the instruction is given, the experimenter displays an example of the ideal, showing that this displacement draws a spiral on the paper and ends when the left hand has joined the right.

This test was carried out three times in the right hemiplane of the subject (the right hand remaining on the right and the left hand moving towards it)

and thrice in the left hemiplane by reversing the role of the hands (the left hand remaining on the left and the right hand moving leftwards)(Plate 22).

Presentation of results and interpretation

The hand stability index (Figure 7) was analysed by the same method of calculation used for the test of symmetrical two-handed pointings (see 2.2).

Verification of measurements of the diameter of the circles traced by the immobile hand led us to the same conclusions drawn for the earlier tests, i.e., variation in the intersubject and intergroup tracing positions is very slight.

For lateral displacements, we measured two indexes:

1. Speed of displacement assessed on the basis of calculation of all distances situated between each passage of the marker tracing at 0°, 90°, 180° and 270° of the spiral (these measurements also include the distance between the centre of the circle and the place where the felt pen was placed at the beginning of the spiral). The speed of displacement is expressed by the mean of all these values.
2. Regularity of displacement obtained from root-mean squares of the mean of the distances measured. Indeed, the more regular the displacement, the smaller the standard deviation, and vice versa.

Six discriminant analyses reclassified 50.00%, 63.33% and 43.33% of the potters and 66.67%, 50.00% and 60.00% of the non-potters in their own divisions for each of the three indexes respectively. In other words, the criteria defined by us in selecting the subject groups proved relevant for the three indexes measured.

Six ANOVA for repeated measures [Stage (5) x Hand (2) x Trial (3) and Age (5) x Hand (2) x Trial (3)] were done while dissociating the three indexes retained and the two subject groups tested.

For the stability index (Figure 7), variance analysis revealed Stage and Hand factors among potters [respectively: $F(4,25) = 5.12565$, $p < .004$ and $F(1,25) = 9.56344$, $p < .004$]. Among non-potters, no factor was significant.

For the index of speed displacement (Figure 8), the only significant factor among potters was the Stage factor [$F(4,25) = 4.94529$, $p < .004$]. There was no factor of significance among non-potters.

Lastly, analysis of variance of the index of regularity of displacement (Figure 9) revealed a Stage factor among potters [$F(4,25) = 5.46448$, $p < .003$]. No factor was significant among non-potters.

For the stability index, Figure 7 shows a sharp superiority of the potters' right hand scores (Figure 7/A) compared to scores for their left hand, and also to scores for the right and left hands of non-potters (Figure 7/B).

Figure 8 shows a decrease in speed of displacement from the 2A sub-stage onwards among potters (Figure 8/A). Among non-potters, no evolution appears as a function of age: all the groups demonstrate equivalent scores (Figure 8/B). The performances of the 1A, 1B and 2A sub-stages are equivalent to those of non-potters.

The right and left hands of potters and non-potters show equivalent scores, which means they move at the same speed.



Plate 22: Test of asymmetrical pointings.

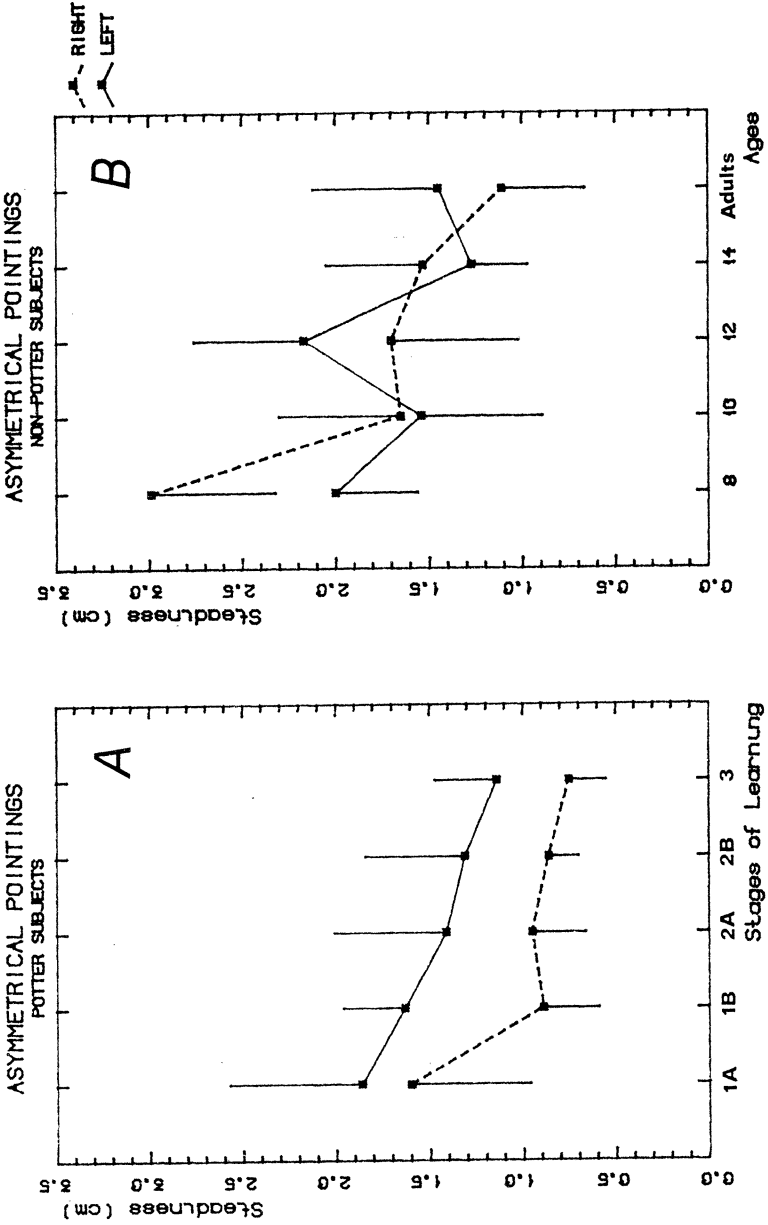


Figure 7: Evolution of the steadiness of each pointing hand (means and standard deviations) as a function of learning stage for potters (panel A) and as a function of age for non potters (panel B).

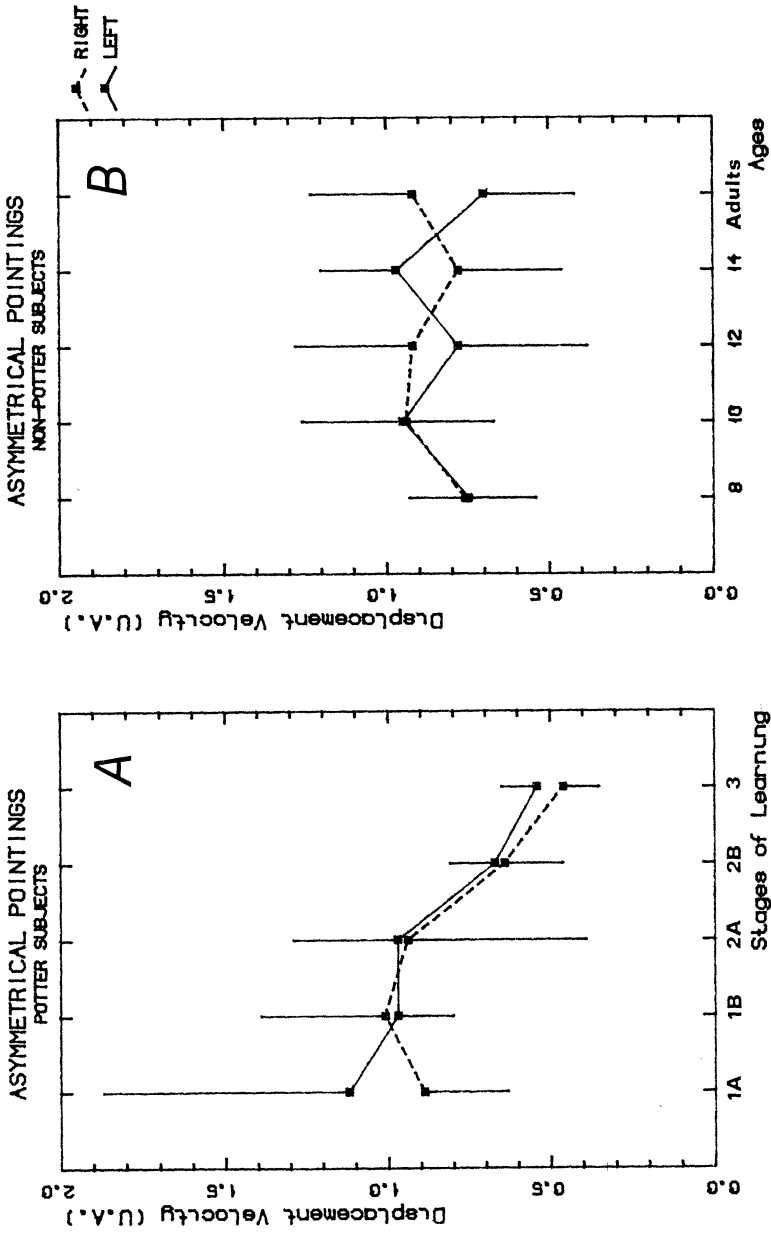


Figure 8: Evolution of the displacement velocity of each moving hand (means and standard deviations) as a function of learning stage for potters (panel A) and as a function of age for non potters (panel B).

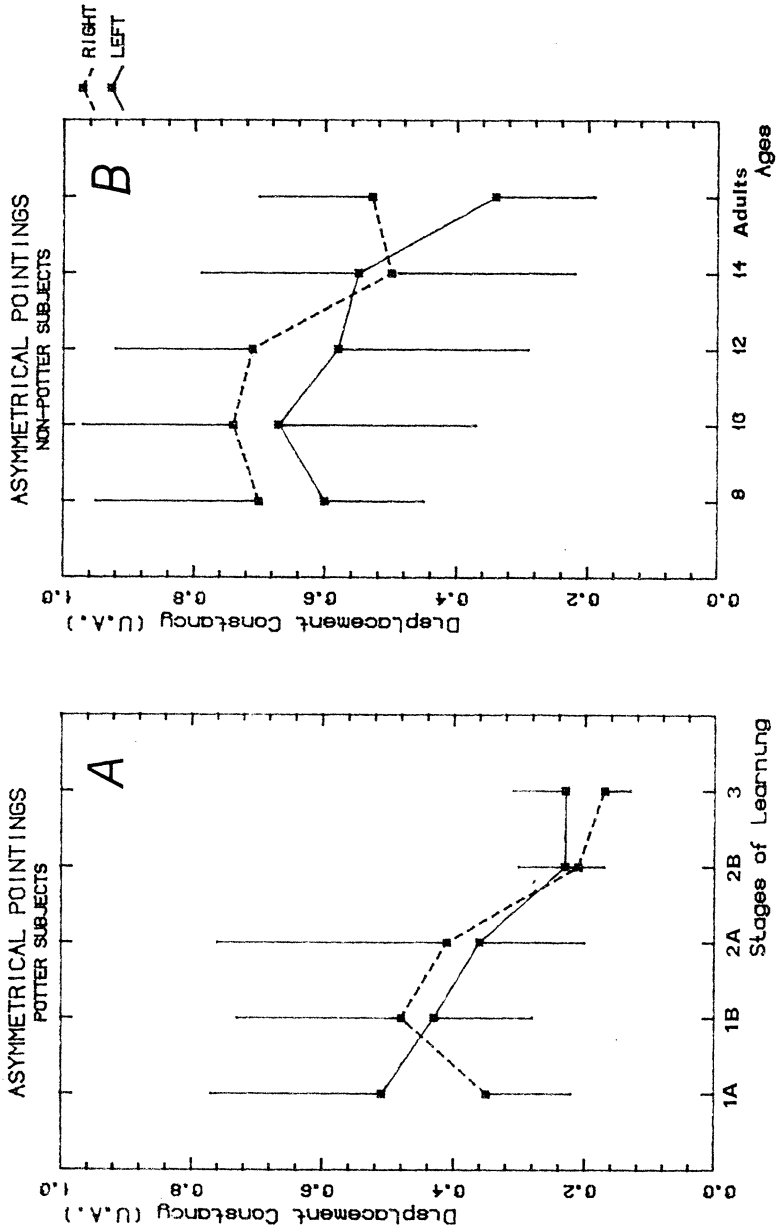


Figure 9: Evolution of the displacement constancy of each moving hand (means and standard deviations) as a function of learning stage for potters (panel A) and as a function of age for non potters (panel B).

Lastly, the results of the third index show (Figure 9), firstly, a greater regularity of movement among potters than among non-potters, at every stage; secondly, they show a significant decrease in this index at sub-stage 2B (T-test, $t = 2.26980$, $p < .032$).

Among non-potters, this index does not decrease significantly. The values obtained for the groups of 14-year-olds and adults are close to the values obtained for the 1A, 1B or 2A sub-stages.

Neither among potters nor non-potters do the results show any superiority of one hand over the other.

The results of the three indexes measured underscore the specificity of the motor abilities that develop in the wheel-throwing technique. First of all, it is clear that in the absence of apprenticeship in this technique, the subjects showed no ability to keep one hand firm while the other produced a slow and regular displacement. Furthermore, it is clear that this ability is developed among potters only from sub-stage 2A. In this sense, it is typical of stages 2 and 3.

One of the difficulties in the acquisition of this activity, which is typical of stage 2, seems to be development of the ability to produce a slow and regular displacement. In the 1B sub-stage, potters develop a displacement activity (associated with pressures) which should facilitate the learning of the activity typical of stage 2. Equivalence of scores between subjects of the 1B sub-stage and non-potters shows that this is not so.

By asking our subjects to carry out the test with the roles of the hand reversed, we thought we would obtain higher left-hand than right-hand scores for the speed and regularity indexes of movement. The results do not corroborate this hypothesis. This may be explained by the fact that from stage 2 onwards, both hands perform an active role.

DISCUSSION OF THE "WHEEL-THROWING TECHNIQUE AND CRAFT SPECIALIZATION" HYPOTHESIS

1. CHARACTERISTICS OF APPRENTICESHIP IN WHEEL-THROWING TECHNIQUE

Observational data enable us to illustrate two points: the *complexity* inherent in mastery of the wheel-throwing technique and *duration* of apprenticeship in this technique.

The complexity is characterized by the number of factors that simultaneously come into play in throwing:

- a) Mastery over physical parameters:
 - Speed of wheel
 - Plasticity of clay
 - Size of lump
- b) Mastery over motor parameters:
 - Simultaneous control over the respective gestures of each arm

- Stability of the forearms
 - Regularity and constancy of pressures
 - Modulation of pressures according to clay plasticity, speed of wheel, and fashioning operation
- c) Understanding the relationships which determine the succession of the different fashioning operations. These operations follow each other in an invariable order and the execution of each depends on the success of the preceding ones.

The duration of apprenticeship is expressed by the existence of successive stages, which are marked by pot size, and in the progressive development of activities specific to the forming of different sizes. In this sense, it correlates with the complexity inherent in mastery of the wheel-throwing technique which, in the course of stages, calls for a more and more necessary integration of all the factors enumerated above. This integration follows a gradual process related to the difficulties to which it corresponds. Thus, the abilities acquired in stage 1 are not sufficient for advancing to stage 3. The latter requires total mastery of several factors not imperative at stage 1.

To highlight the *difficulties* that make apprenticeship in the wheel-throwing technique a long one, we had recourse to experimental data. These data pertain to the organization of two-handed strategies and to the measurement of the motor parameters that develop during the various apprenticeship stages.

Results of the two-handed strategies revealed:

1. In the first stage, development of a two-handed complementariness relative to the respective roles of each hand (active or passive). In terms of motor control, this activity is easy as it involves unilateral control. Indeed, it relates mostly to the right hand which hollows or thins.
2. In the second stage, development of an asymmetry of the forearms relative to the axis of rotation of the wheel, along with the development of a two-handed associativeness, understood in the sense that both hands play an active role. In terms of motor control, this is a much more difficult activity as control involves both hands, which are not only asymmetrical relative to the axis of the wheel, but are also simultaneously active and therefore set in a relationship with each other.

The results of these tests enabled us to delve deeper into the difficulties presented in learning the potter's gestures. These difficulties underlie both types of two-handed organization described above and comprise:

1. Specificity of the motor abilities developed by potters (compared to those of non-potters).
 - Ability to keep the arms stable;
 - Right hand specialization, which is expressed in its greater firmness compared to the left hand (especially in the first stage of apprenticeship).
2. Specificity of newly developed motor abilities in the activities of each stage:
 - a. Development of a unilateral two-handed control:
 - Great hand stability developed in the first stage (1B);

- Ability to keep the thumb/index finger pressures constant, already developed in the first stage (1B).
- b. Development of two-handed bilateral control:
 - Stability of left hand, developed only from the second stage (2A); it participates with the right in thinning;
 - Ability to execute a slow and regular displacement to the right of the axis of rotation of the wheel, acquired at the second stage (2A).

The acquisition of these motor abilities takes time and is difficult given the fact that they are not natural but specific to the wheel-throwing technique. This explains why the children observed take from one to two years to pass from one stage to the next.

2. CHARACTERISTICS OF APPRENTICESHIP IN COILING TECHNIQUE

Apprenticeship in coiling can be characterized as follows:

1. The gestures employed for making a coiled pot are similar to those performed naturally right from childhood and in domestic activities (all gestures for gripping, making clay balls, etc.).
2. These gestures, compared to those involved in the wheel-throwing technique, are all the more natural as it is the hand which moves and the pot which remains immobile, not the reverse (as in the case in the wheel-throwing technique). In this sense, they are much easier because absolute firmness of the arms is not required, and because they are organized around a single parameter, namely, pressure of the fingers.
3. The difficulty in apprenticeship does not lie in the acquisition of gestures, but in the ability to juxtapose the coils in the desired alignment, i.e., relative to the lower part and shape of the pot to be made.

These characteristics of apprenticeship in the coiling technique explain why it is so short in duration: there is only one stage of apprenticeship, requiring no more than a year.

3. CONCLUSIONS

The traits distinguishing the two pottery techniques under study here are presented in Table 4.

These distinguishing traits argue strongly in favour of the hypothesis regarding "craft specialization". Indeed, it appears that the wheel-throwing technique, contrary to the coiling technique, requires an investment in time and skills from domestic groups which not everyone is able to satisfy. The investment in time covers the duration of apprenticeship to pass from one stage to the next (one to two years) and the time required to acquire the know-how (several years). The skills involve the development of those motor abilities peculiar to this technique.

In support of this hypothesis, let us mention the fact that there is no example of wheel-made pottery executed by potters who have not specialized.

Our hypothesis in no way prejudices the socio-economic status of potters before the appearance and mastery of the wheel-throwing technique. Hand-

Table 4: Traits which distinguish the wheel-throwing technique from the coiling technique

Wheel-Throwing Technique	Coiling Technique
<ul style="list-style-type: none"> • Actions on clay mediated by wheel • Potter stands still while clay turns • Operations of potter consist in successively transforming a single mass of clay • An unsuccessful operation cannot be corrected • Success of one operation determines that of the next • Mastery of the technique requires development of specific motor abilities • Apprenticeship is by trial and error • Apprenticeship is long and arduous 	<ul style="list-style-type: none"> • Actions performed directly on clay • Potter moves around motionless clay • Operations of potter consist in successively assembling pieces of clay • An unsuccessful operation can be corrected at any point • Success of each operation is independent • Mastery of the technique requires no particular motor ability • Apprenticeship is scaffolded • Apprenticeship is short and easy

made ceramic vessels may be the work of specialized or non-specialized craftsmen and up to now no criteria existed for distinguishing between the two.

As for ceramic vessels made on *tournette*, used like wheels in some manufacturing phases,² it is difficult to assess the significance of this instrument given the present level of our research. Another study is required to ascertain the differences in the motor skills involved in the *tournette* technique versus the throwing technique on a fast wheel. Such a study would enable us to specify to what extent the *tournette* technique reflects the socio-economic status of the craftsmen.

². See Balfet, 1973 for example. The author says that in Morocco, at Karia-ba-Mohammed, the stick wheel is used like a *tournette* for hollowing and rough shaping of a pot, and as a wheel for raising the walls.

PART THREE

Significant Material Study

1. RESEARCH PROCEDURE

Our research procedure is based on that of deduced typologies (Gardin, 1979:131) in which the extrinsic characteristics of the objects are not restored but given through facts, and the intrinsic characteristics ascertained on the basis of the relationships they reveal with these facts. The typological construction made here accords with an ethnographic order, which provides an explanation for the morphological traits mobilized.

In this case, the extrinsic characteristics are the different stages of apprenticeship in wheel-made pottery, and the intrinsic characteristics are the morphological properties of the pots, necessary and sufficient for characterizing each stage.

1.1. Constitution of a significant ethnographic corpus

In order to work on a significant corpus for our research, we asked the six children of each stage of apprenticeship, who were interviewed at Har Kishan's house, to make three samples of the different types of pots learnt during the various stages.

STAGE 1A: Three fairy lamps

STAGE 1B: Three small and three large fairy lamps, three large jar lids

2 STAGE 2A: Three small and three large fairy lamps, three large jar lids, three pots, four inches high

STAGE 2B: Three small and three large fairy lamps, three large jar lids, three pots, four inches high, and three pots, eight inches high

STAGE 3: Three small and three large fairy lamps, three large jar lids, three pots, eight inches high, and three pots, 12 inches high

The ceramic production studied is thus an "experimental" production which has the advantages of being:

- Representative, from the indigenous point of view, of the different apprenticeship stages;
- Obtained under homogeneous conditions—clay of the same composition and execution on the same potter's wheel.

However, one criticism may be made: the number of subjects per stage of apprenticeship ($n = 6$) and the number of specimens per type of pot learnt ($n = 3$) is too small to statistically demonstrate significant tendencies. It was, difficult to overcome this problem considering the limited time allotted to us (3 months) and the length of the interviews (we could only manage 2 to 3 subjects per day).

2. DESCRIPTIVE SYSTEM

The ceramic production studied comprises simple-shaped wares: unrestricted forms (maximum diameter = orifice), without neck, and with a flat base, consisting of three types—the fairy lamp, the jar lid and the flower pot. The fairy lamp differs from the lids in the slope of the walls: the walls of the fairy lamps tend to be vertical while those of the lid tend to be horizontal. The flower pots are distinguished by the presence of a rim and of high walls.

2.1. Dimensions

To set up a descriptive system (Figure 10, Plate 23) that would express the manufacturing difficulties encountered at each stage of apprenticeship, very precise measurements were required. With this purpose in mind, all the pots were divided into two parts and the thicknesses of the walls and of the base, and the thicknesses and width of the rim (if there was one) measured for the right and left parts respectively. Three thicknesses were noted for each wall of the small vessels (lids and fairy lamps): distal, median and proximal; five wall thicknesses were noted for the flower pots, at an equal distance from each other. The orifice, height and basal width of each item was likewise measured.

Absolute and proportional dimensions

The absolute dimensions are the height, the orifice, the basal width and the thickness. For the latter, the left median thickness yields an absolute value.

Among the proportional dimensions, only the height/thickness ratio was studied: it is the only one which involves technical difficulties. The height/orifice, width of the base/height, or width of the base/orifice ratios would be interesting to study in more complex assemblages, i.e. those types of pots produced once stage 3 has been achieved.

Index of shaping regularity

Detailed notations of the thickness strove to evaluate the degree of regularity in fashioning. The index of regularity is established from the sum of the squares of the differences between the right (R) and left (L) thicknesses:

- Index of shaping regularity of walls of fairy lamps and lids: $(\text{thick. L1} - \text{thick. R1})^2 + (\text{thick. L2} - \text{thick. R2})^2 + (\text{thick. L3} - \text{thick. R3})^2$.
- Index of shaping regularity of walls of flower pots:
 $(\text{thick. L1} - \text{thick. R1})^2 + (\text{thick. L2} - \text{thick. R2})^2 + (\text{thick. L3} - \text{thick. R3})^2$
 $+ (\text{thick. L4} - \text{thick. R4})^2 + (\text{thick. L5} - \text{thick. R5})^2$.

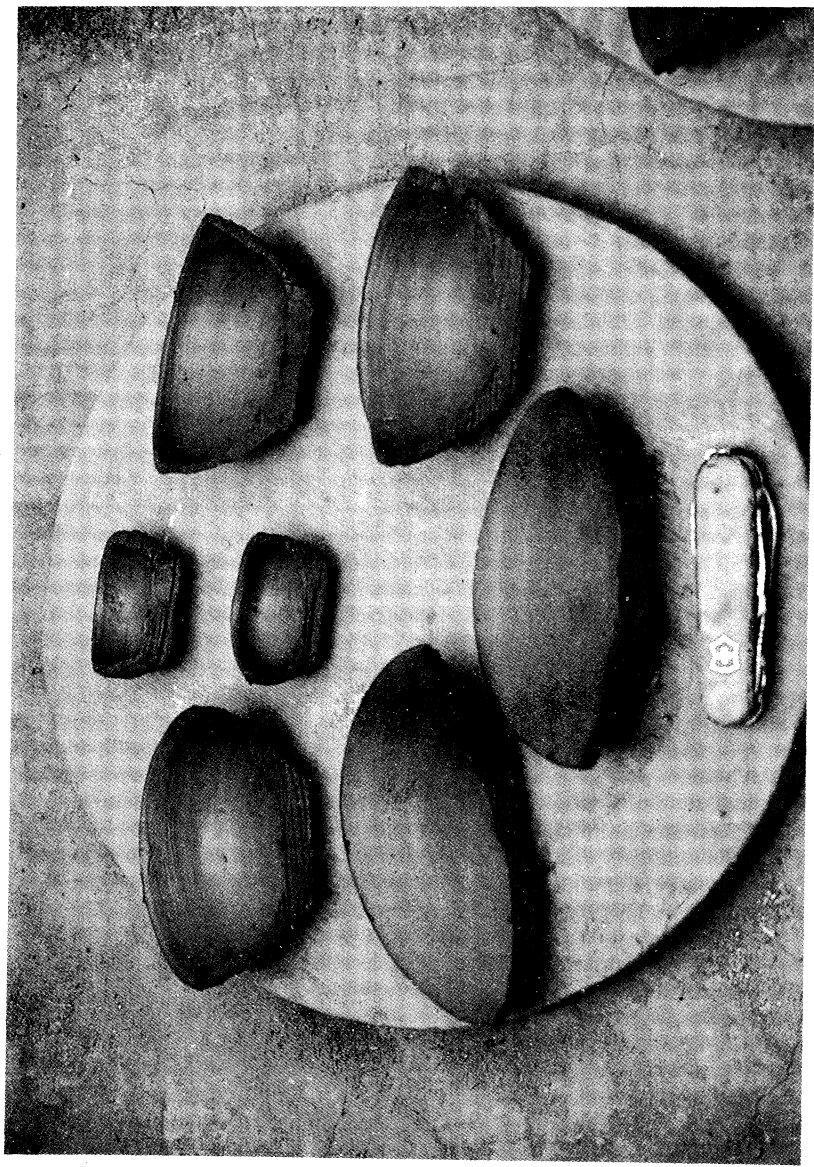


Plate 23: Experimental production consisting of small and big fairy lights and a large lid. Their section permits us to easily note their measurements.

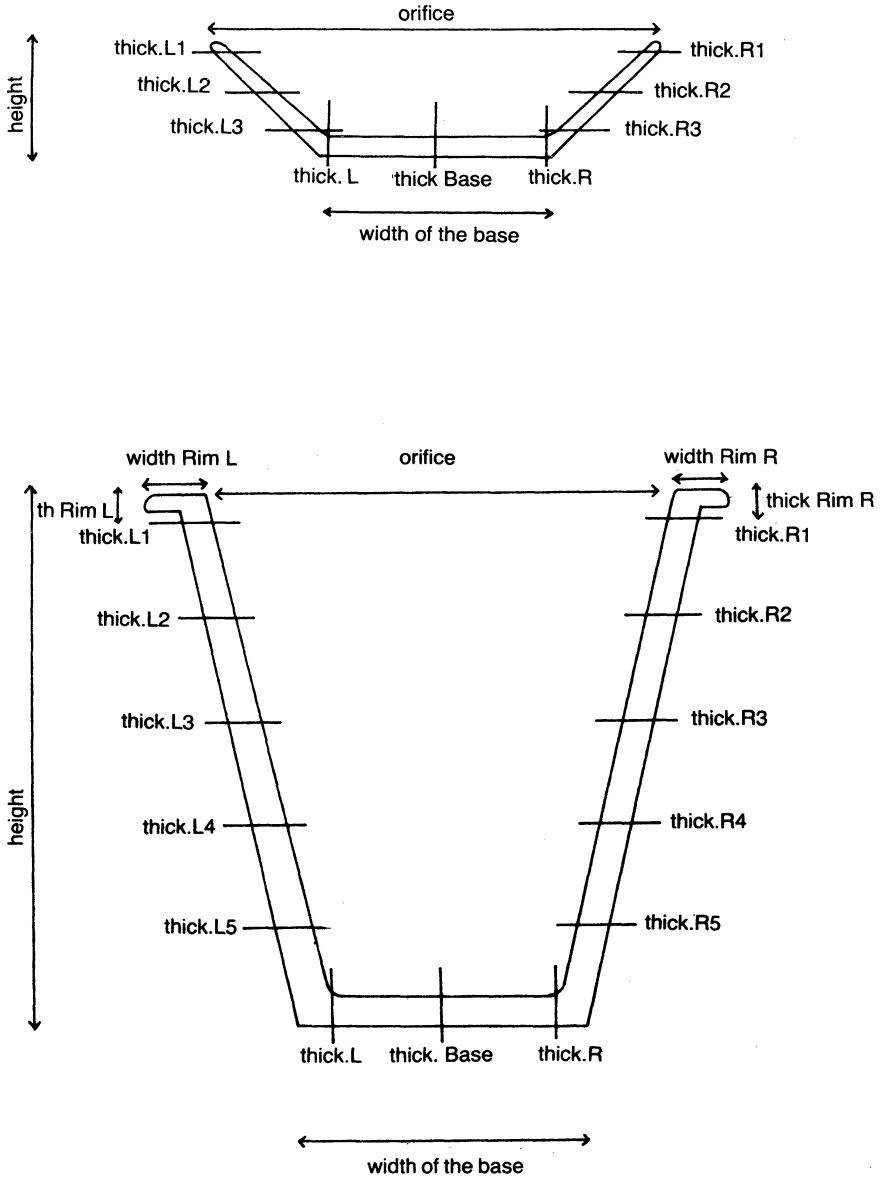


Figure 10: Descriptive system retained for the study of the ethnographic material.

- Index of shaping regularity of base: (thick. Base L—thick. Base R)².
- Index of shaping regularity of rim: (thick. Rim L—thick. Rim R)² and (width Rim L—width Rim R)².

Index of standardization

To evaluate the performance of potters in fashioning a given type of pot on the wheel (with reference to norms of shape and size), the standard deviations of the absolute dimensions (height, orifice, width of base) of each type of pot were analysed. The value of the standard deviations is the measure of evaluation of the index of standardization.

3. SIGNIFICANT MEASURES OF TECHNICAL DIFFICULTIES ARISING DURING TRANSIT FROM ONE STAGE TO THE NEXT

3.1 Absolute and proportional dimensions (Tables 5 and 6)

Height is the pre-eminent variable in stage of apprenticeship because this variable determines the stage. It represents one of the major difficulties encountered in the course of apprenticeship: raising walls in accordance with asymmetrical two-hand activities, accompanied by a control of pressures over larger and larger lumps of clay. Five groups are defined by this parameter:

	$h \leq$	3 cm:	STAGE 1A
	$h \leq$	6 cm:	STAGE 1B
6	$\angle h \leq$	12 cm:	STAGE 2A
12	$\angle h \leq$	22 cm:	STAGE 2B
	$h >$	22 cm:	STAGE 3

Table 5: Means and standard deviations of absolute dimensions of pots (in millimetres) as a function of type of pot and stage of learning.

TYPE OF POT (n=18)	STAGE	HEIGHT		ORIFICE		BASE WIDTH	
		av	σ	av	σ	av	σ
Little Fairy Lamp	1A	24.50	4.10	62.66	8.30	35.44	11.06
	1B	24.16	3.29	60.38	5.19	38.00	4.49
	2A	24.61	3.22	61.44	5.00	35.70	3.59
	2B	22.44	3.07	58.72	4.96	34.33	4.57
	3	22.11	3.77	59.27	8.11	30.83	4.81
Big Fairy Lamp	1B	42.88	5.23	103.27	10.12	52.72	6.71
	2A	49.77	5.44	118.50	14.21	54.55	6.77
	2B	51.50	2.20	122.55	5.22	53.38	4.67
	3	48.61	4.34	123.00	10.40	50.27	5.01
Jar Lid	1B	35.16	4.81	140.16	9.84	57.83	6.35
	2A	39.50	5.55	150.33	12.57	59.44	7.61
	2B	43.27	2.58	163.55	7.06	58.66	3.59
	3	43.66	5.02	169.22	12.73	57.88	8.06
4-inch pot	2A	112.88	19.48	115.55	19.71	82.61	12.57
	2B	115.11	13.04	124.88	11.25	67.44	22.89
8-inch pot	2B	219.00	14.50	223.20	12.77	134.60	12.21
	3	206.66	9.97	212.11	10.50	125.33	7.45
12-inch pot	3	317.83	13.43	308.11	14.13	175.77	8.51

The orifice is also related to the stages of apprenticeship. We shall retain it as a significant intrinsic property for the following technical reasons: the wider the opening of a pot, the more the centrifugal force exerted; the greater the latter, the more difficult the pot is to make.

The width of the base presents no technical difficulties in manufacturing and therefore will not be retained.

Thickness *per se* has no discriminant value. However, the height/thickness ratio is significant and will be retained. This ratio increases not only relative to the height of the pot, but also relative to the stage of apprenticeship (Figures 11 and 12). The raising of more or less fine walls is a technical operation and its success depends on the greater or lesser degree of skill of the potter.

Table 6: Means and standard deviations of thickness (in millimetres) and height/thickness ratio as a function of type of pot and stage of learning.

TYPE OF POT (n=18 or 15)	STAGE	THICKNESS		HEIGHT/THICKNESS RATIO	
		av	σ	av	σ
Little Fairy Lamp	1A	6.26	1.86	4.06	1.33
	1B	6.20	0.94	4.06	0.79
	2A	5.66	1.04	4.33	0.81
	2B	6.00	0.68	3.83	0.78
	3	5.61	0.97	4.16	1.42
Big Fairy Lamp	1B	6.86	1.95	6.53	1.92
	2A	6.46	0.63	7.73	0.79
	2B	6.61	1.64	8.22	1.95
	3	6.11	1.18	8.16	1.61
Jar Lid	1B	7.20	1.14	4.86	0.99
	2A	7.00	1.06	5.73	1.22
	2B	7.00	1.60	6.55	1.82
	3	7.22	1.66	6.27	1.36
4-inch pot	2A	9.39	1.68	12.26	3.53
	2B	7.83	1.72	15.38	3.77
8-inch pot	2B	9.93	1.43	22.53	4.20
	3	9.33	1.87	23.22	4.82
12-inch pot	3	12.88	1.23	24.94	2.57

3.2 Index of shaping regularity (Tables 7 and 8, Figures 13 to 16)

The sum of the square of the differences shown between the thicknesses of the right and left walls of the vessels is a very good marker of the different stages of apprenticeship per type of pot. For each type of pot, i.e., for each stage of apprenticeship, the differences decrease according to the level of the learning groups.

This index highlights one of the main difficulties in the wheel-throwing technique: control of pressures over the clay whose strength varies according to pot size.

For the small vessels, when throwing is not mastered, the index approaches 8; when mastered, the index approaches 4.

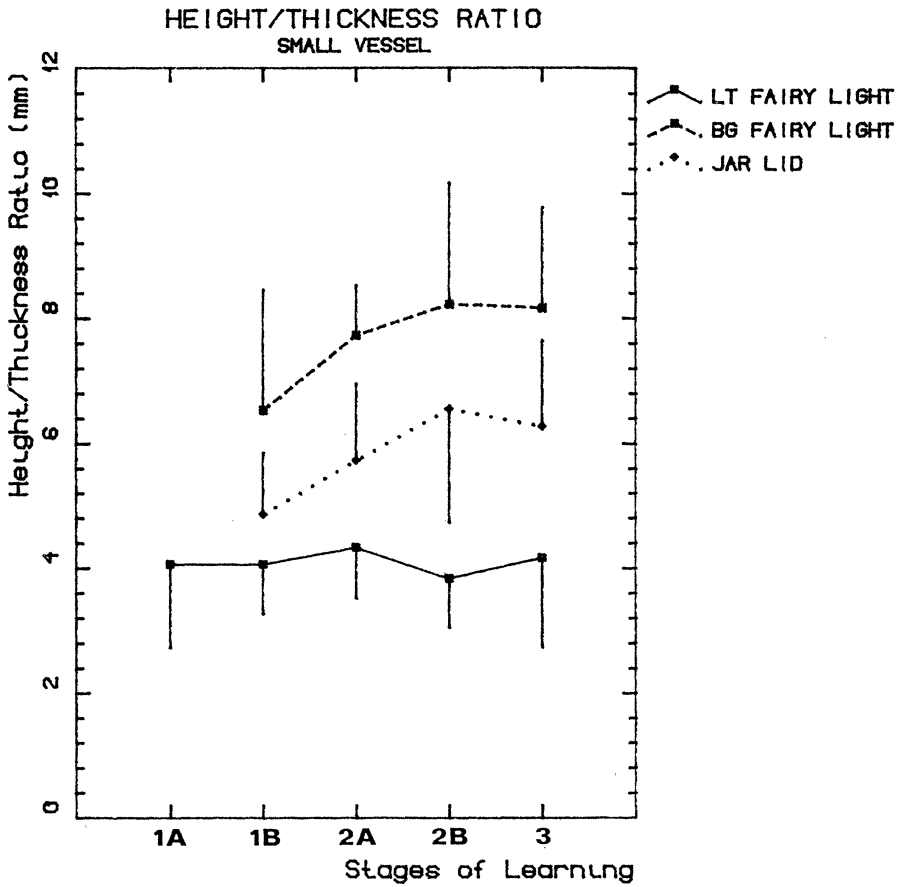


Figure 11: Means and standard deviations of the height/thickness ratio of the little fairy lights, big fairy lights and jar lids as a function of the learning stage.

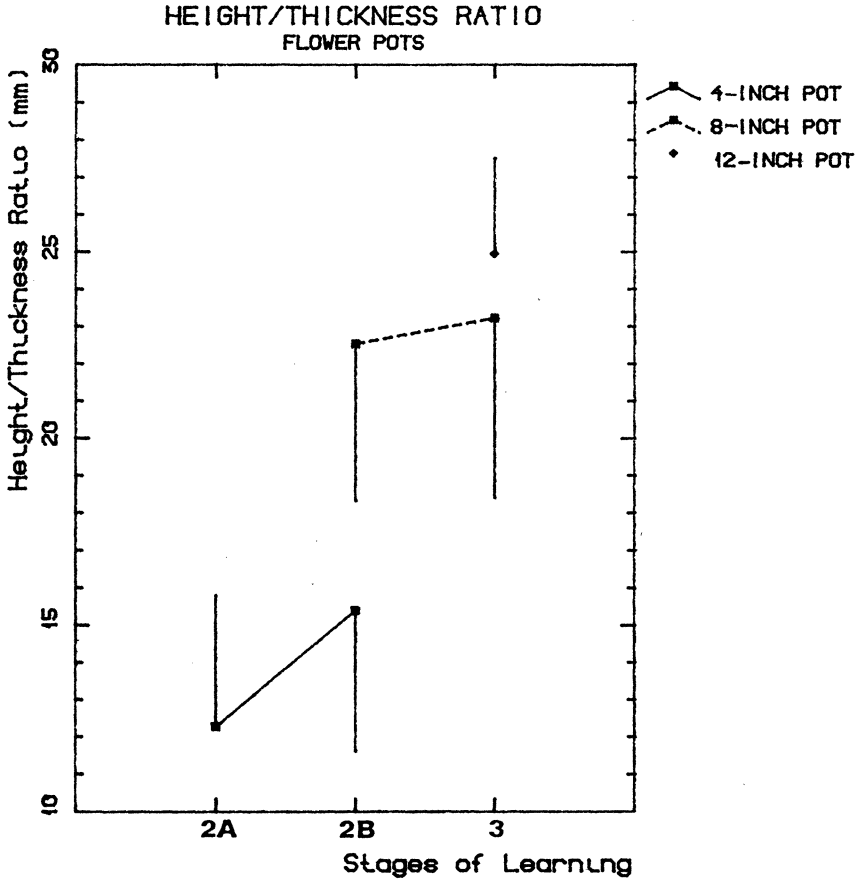


Figure 12: Means and standard deviations of the height/thickness ratio of the flower pots of 4, 8 and 12 inches as a function of the learning stage.

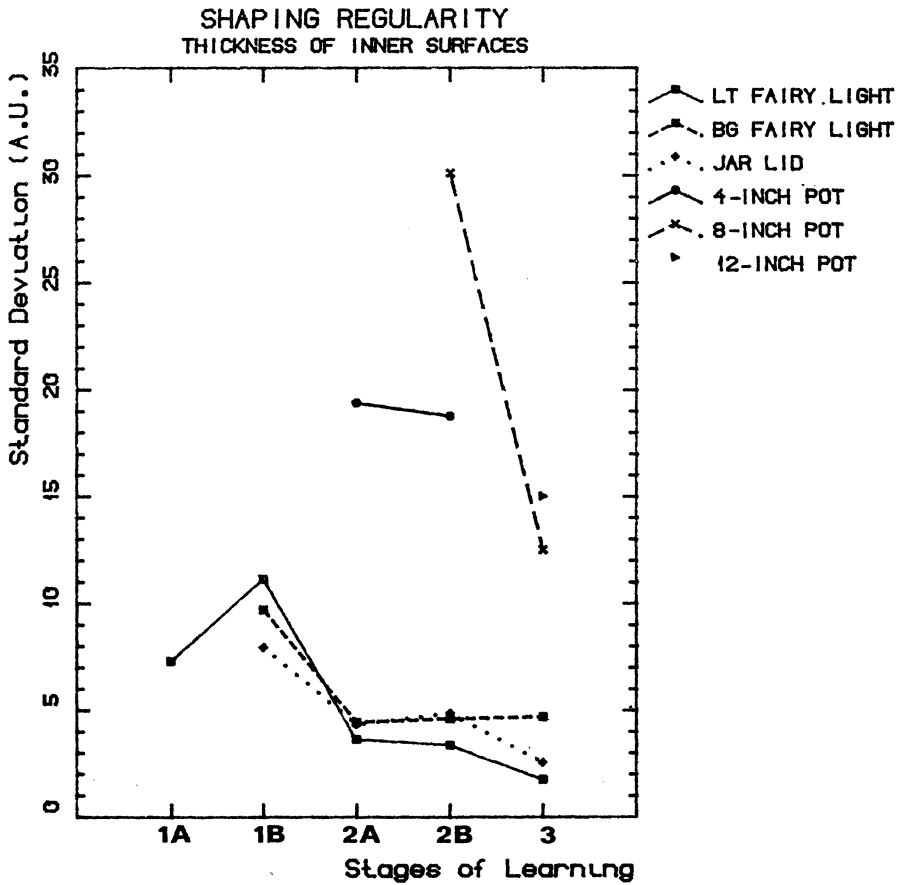


Figure 13: Standard deviations of the index of shaping regularity related to the inner surfaces of pots as a function of the type of pot and the stage of learning.

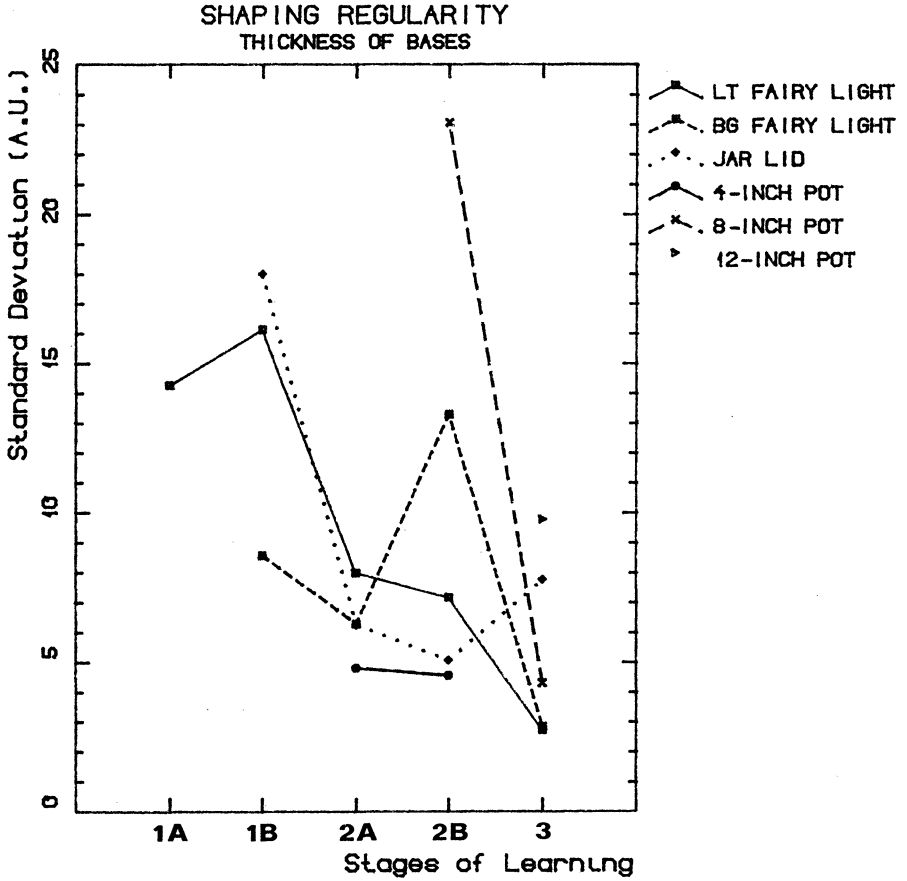


Figure 14: Standard deviations of the index of shaping regularity related to the thickness of bases as a function of the type of pot and the stage of learning.

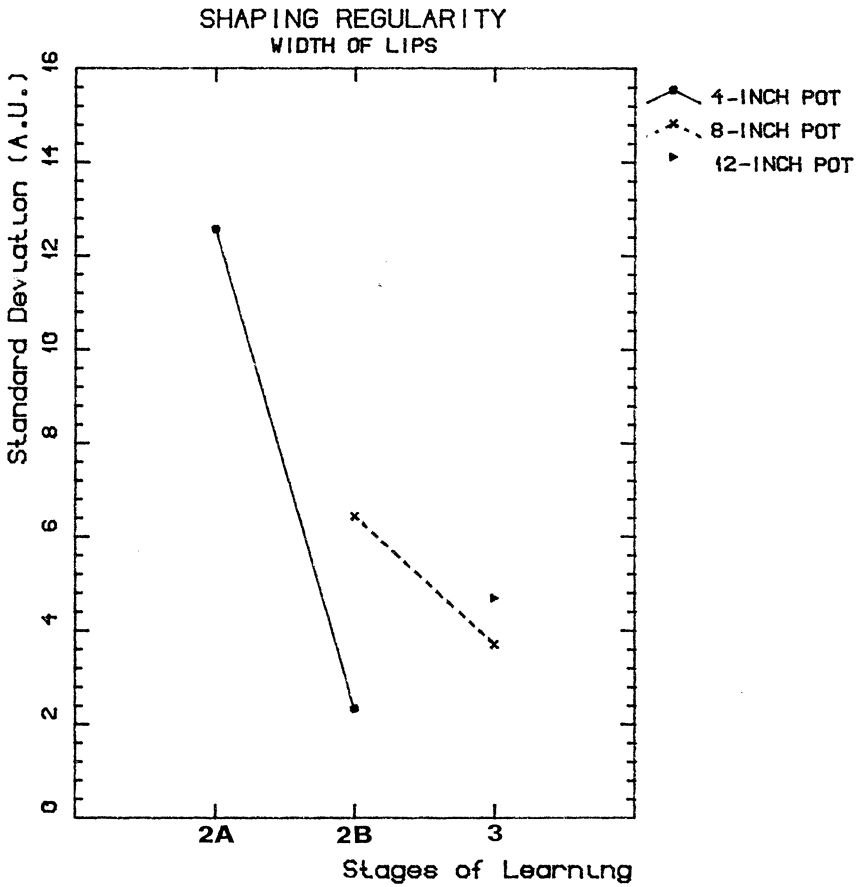


Figure 15: Standard deviations of the index of shaping regularity related to the width of the lips as a function of the type of pot and the stage of learning.

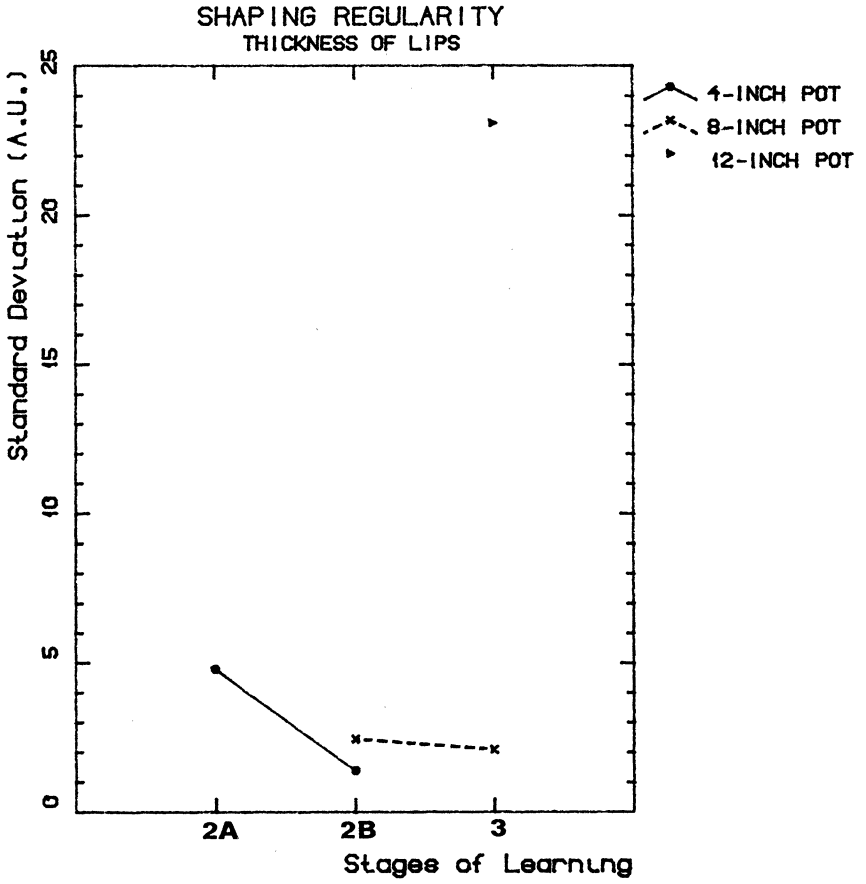


Figure 16: Standard deviations of the index of shaping regularity related to the thickness of the lips as a function of the type of pot and the stage of learning.

The sum of the square of the differences between the right and left thicknesses of the base is also a good index for evaluating the skill of the potter. The index measures the difficulty in mastering hollowing and detachment of the object from the lump. In this regard, potters of stage 3 are far more superior.

The index of fashioning regularity of the rim is also relevant (width and thickness of the rim). The greater the mastery, the lower the indexes.

We will retain these various indexes for the description of archaeological data.

Table 7 : Means and standard deviations of regularity index of walls and base shaping as a function of type of pot and stage of learning.

TYPE OF POT (n=18 or 15)	STAGE	WALLS		BASE	
		av	σ	av	σ
Little Fairy Lamp	1A	7.88	7.29	12.16	14.26
	1B	6.61	11.15	11.77	16.13
	2A	3.86	3.64	7.06	7.98
	2B	3.94	3.36	7.11	7.16
	3	2.50	1.75	1.61	2.72
Big Fairy Lamp	1B	7.66	9.72	11.11	8.58
	2A	4.60	4.45	4.60	6.29
	2B	4.33	4.62	12.38	13.29
	3	5.94	4.70	2.11	2.84
Jar Lid	1B	7.83	7.95	14.33	18.00
	2A	6.53	4.35	6.13	6.25
	2B	4.72	4.87	3.66	5.06
	3	3.61	2.54	3.94	7.77
4-inch pot	2A	14.86	19.39	4.53	4.80
	2B	13.83	18.77	3.33	4.55
8-inch pot	2B	16.93	30.12	12.33	23.07
	3	12.27	12.50	3.22	4.30
12-inch pot	3	20.27	15.00	4.88	9.77

Table 8 : Means and standard deviations of regularity index of rim shaping (width and thickness) as a function of type of pot and stage of learning.

TYPE OF POT (n=18 or 15)	STAGE	RIM/WIDTH		RIM/THICKNESS	
		av	σ	av	σ
4-inch pot	2A	5.86	12.56	2.80	4.78
	2B	2.05	2.33	1.16	1.38
8-inch pot	2B	3.46	6.43	2.13	2.44
	3	1.88	3.70	1.38	2.09
12-inch pot	3	3.88	4.68	9.16	23.08

3.3 Index of standardization (see Table 6, Figures 17 to 19)

For small vessels, the standard deviations of the absolute dimensions (height, orifice, width of base) show a gradual reduction from sub-stage 1A to sub-stage 2A. Group 3 gives mediocre results, associated with the fact that adults are not longer in the habit of making these pots.

The standard deviations also decrease for the 4- and 8-inch pots from the 2A group to the 2B and 3 groups.

This reduction in standard deviations to the mean during the different stages of apprenticeship is directly related to a growing mastery over the wheel-throwing technique and the consequent ability to produce a vessel with dimensions which conform to norms.

The index of standardization therefore appears to be a good index of mastery over the wheel. Its study may be applied to various specimens of a single type of pot and comparisons made for comparable dimensions, based on values shown by the standard deviations per period.

4. CONCLUSION

With respect to the intrinsic characteristics retained in this study, an analysis of the ceramic assemblages of the periods which follow the appearance of the potter's wheel, should enable a description of the rhythm according to which the know-how related to this technique was developed. This rhythm should reveal the process of specialization, if it has been demonstrated at the first instance that before the advent of the wheel-throwing technique, ceramic vessels were made by non-specialists.

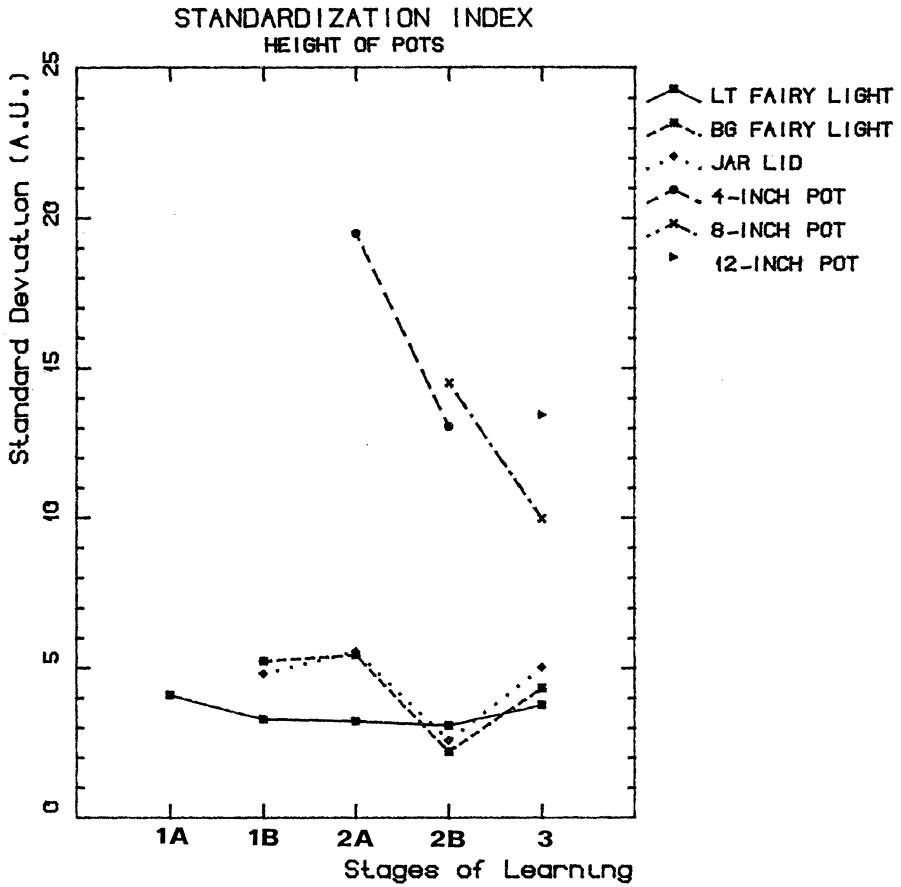


Figure 17: Standard deviations of the height of the pots produced as a function of the type of pot and the stage of learning.

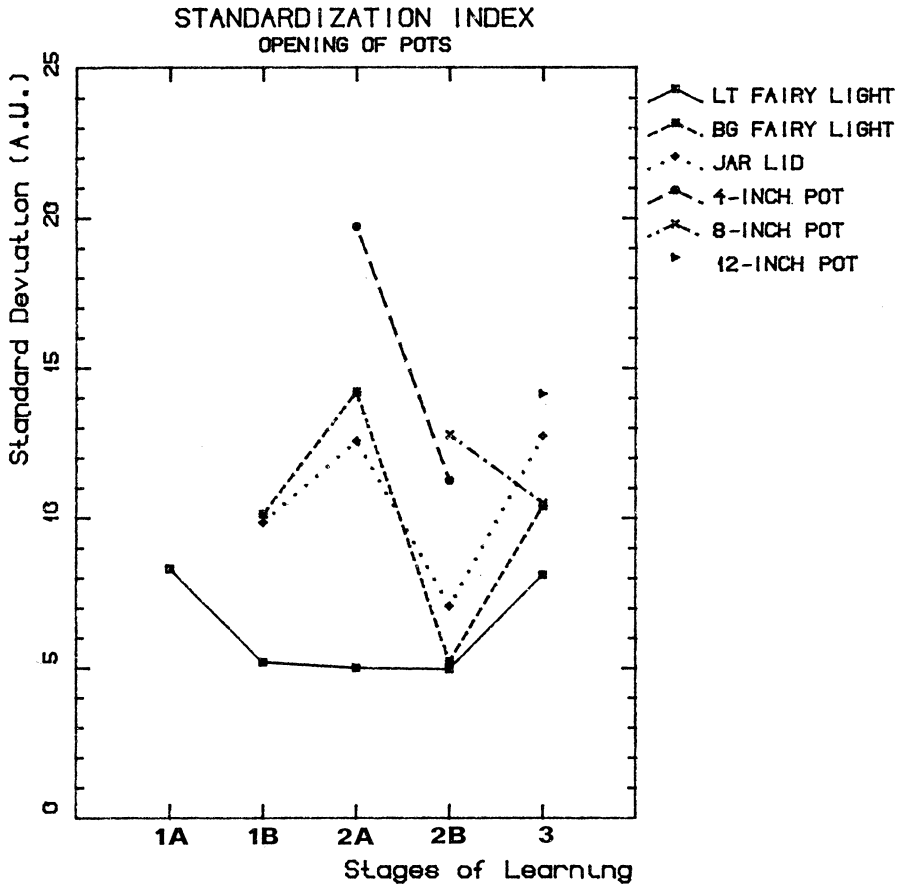


Figure 18: Standard deviations of the opening of the pots produced as a function of the type of pot and the stage of learning.

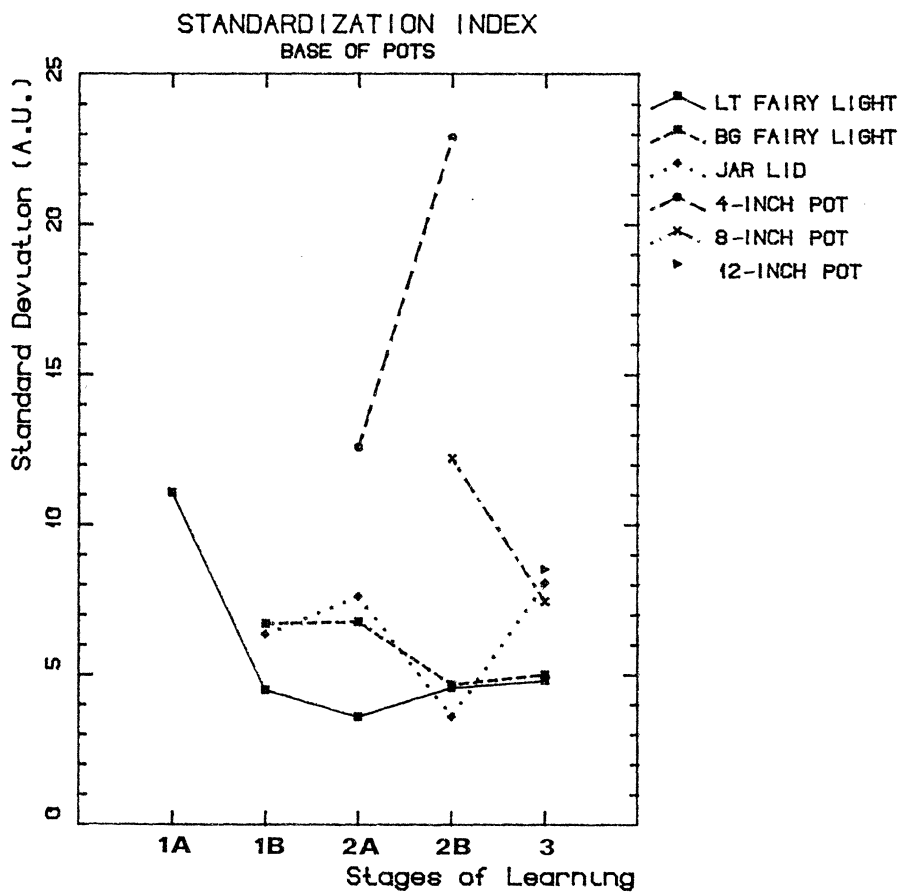


Figure 19: Standard deviations of the bases of the pots produced as a function of the type of pot and the stage of learning.

PART FOUR

Conclusions

In order to conveniently discuss the problems of validity our study presents for the interpretation of archaeological data, we have summarized the construction developed earlier in the form of a logicist diagram (Figure 20). The initial propositions (PO1 to PO9) are the facts mobilized in the construction while the intermediate propositions (P1, P2, P3) connect the initial data with the terminal proposition (P4). The initial propositions presented are the main results of our investigation, enabling simplification of the construction diagram. They are nonetheless micro-constructions whose successive derivations could also be the subject of distinct diagrams. With reference to PO8, we have assumed that the archaeological data have presented traits comparable to those significant at the different stages of apprenticeship, in order to give an example of the type of interpretative construction that may be foreseen. Similarly, in PO9 we have assumed that hand-made ceramics, prior to the invention of the potter's wheel, were fashioned by non-specialists. It is possible that a contrary situation existed, which would modify the inferences of the construction. Only the section to the left of the diagram (P1 and P2) would not change since it constitutes the hypothesis of the "wheel-throwing technique/craft specialization" relationship, which belongs to the ethnographic field.

The foundations of the intermediate propositions will now be examined. The foundations of the initial propositions, which belong to the ethnographic field, have already been noted in the procedures followed for gathering significant information (relevance of oral investigation, tests and experimental ceramic production). They shall not be repeated here.

Proposition P1 states a relationship between the "wheel-throwing technique" and "a long and difficult apprenticeship". This relationship can be considered a universal one, keeping in mind the results of perceptual motor tests which corroborate in causal terms the observational data that were assumed to have transcultural value (they explain why the apprenticeship is long and arduous).

Let us clarify that the transcultural value of the relationship does not relate to the modalities of the apprenticeship, which may be different from one culture to another (in Europe, apprenticeship in wheel-throwing starts with the centring operation, while in India it starts with the making of small fairy lamps), but relates to the difficulty in mastering the technique of throwing. Whatever the socio-cultural context, the potter has to practise for several years and possess the strength of an adult before he can master the throwing of large vessels.

The relationship expressed by P1 is verifiable through experiments. Moreover, it is univocal and necessary: it is not possible to learn the wheel-throwing technique rapidly because of physiological constraints, which are postulated as identical from generation to generation.

Proposition P2 expresses the "wheel-throwing technique/craft specialization" relationship. This relationship is not necessary in the sense that the wheel-throwing technique *must* imply craft specialization; rather, it reflects a socio-cultural environment favourable to the adoption and development of an inventive technique and its consequences. The relationship is a univocal one, considering P1. It is not bi-univocal since craft specialization applies to techniques other than wheel-throwing, such as the coiling technique. Its context of application is the context in which P1 is univocal: the *homo sapiens sapiens* communities.

To refute the proposition, it suffices to find some ceramic assemblages that have been produced by overall domestic groups of a community (while ensuring that such communities do not consist of specialists who are producing ceramics for neighbouring communities).

To support such an hypothesis, it would be necessary:

- Either to show, for other crafts, the systematic existence of a cause-effect relationship between the "long and arduous apprenticeship" variable and the craft specialization phenomenon;
- Or to approach craft specialization through another variable and yet arrive, in terms of interpreting the data, at the same results. *A priori*, the "apprenticeship" variable is not the only one significant in craft specialization. Others could be significant, which have yet to be defined.

Proposition P3 pertains to the description of the phenomenon of craft specialization according to the descriptive traits that wheel-thrown ceramics present. It raises the problem of the transfer of exterior knowledge to archaeological data.

P3 is admissible considering:

- Similarity of context (*homo sapiens sapiens* community) and of material (wheel-thrown ceramics) in archaeological and ethnographic fields;
- Univocal character of the relationship transferred to archaeological data (wheel-throwing technique/craft specialization);
- Proposition PO9, i.e. the absence of craft specialization before the invention of the potter's wheel.

Let us clarify that P3 is strictly a description of the rhythm of appearance of specialists: it does not at all imply an ontogenesis/phylogenesis hypothesis. In other words, it does not assume that the mode of development of the wheel-throwing technique is related to the difficulties resulting from apprenticeship in this technique. Innovation and development of a technique as well as the installation of specialists correspond to important techno- and socio-economic changes, which should entail more or less time according to the environment in which they take place. Aware of the importance of this, we suggest as an inference a description of the phenomenon which contains no explanatory term. Ethnographic knowledge is not used here as a model of evolution, but as a

heuristic tool for describing the techno-economic phenomenon locally and interpreting it according to archaeological data.

P4 is the terminal proposition. It expresses an inference from the relationship observable between the craft specialization phenomenon and the techno-economic environment. It is verifiable and decidable on the basis of P3 and of the inferences from the socio-economic context.

We have not analysed craft specialization from the aspect of the socio-economic status of the artisans (part-time, full-time, possessing land, landless etc.); we specified in the introduction that this would not be done. This does not mean that it is not possible to do so. Once the craft specialization has been attested, all that is required is to identify the material facts which are significant for the different status sought. For this purpose, other references of knowledge would have to be constructed. Their context of validity would define their context of application to archaeological data. These references would enable us to answer the question regarding the representativeness of archaeological facts for interpreting the economic resources of artisans and their social position.

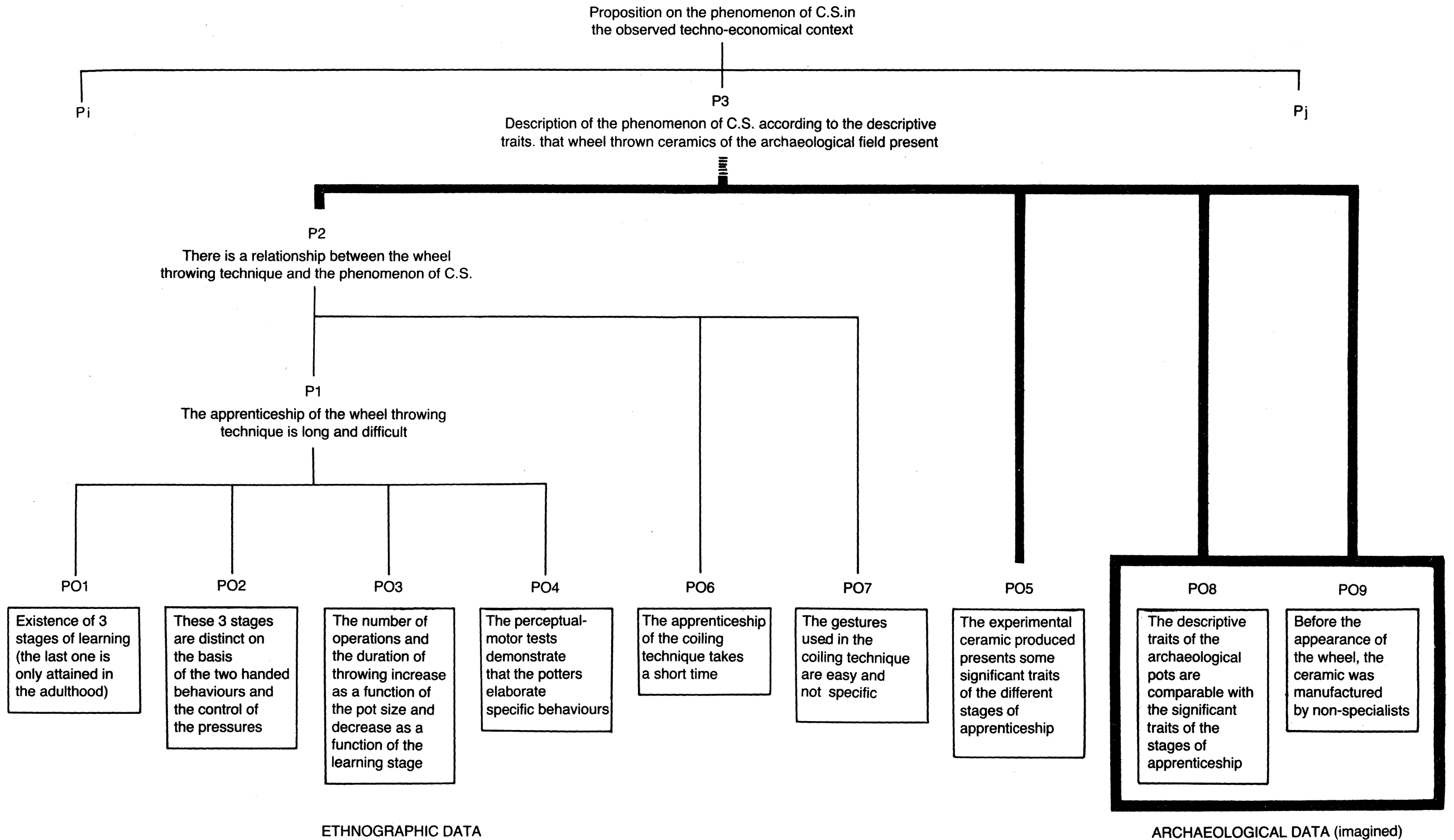


Figure 20: Logicist diagram of the interpretative construction on craft specialization (referred as C.S.)

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**DEVELOPMENT OF A TAXONOMY TO MEASURE
THROWING DIFFICULTIES OF PREHISTORICAL
AND PROTOHISTORICAL CERAMIC VESSELS**

Valentine Roux

INTRODUCTION

Research hypothesis

In our preceding study, it was demonstrated that the motor skills involved in the coiling technique do not apply to the wheel-throwing technique. The latter requires the development of specific abilities which are difficult and take time to acquire. This slow acquisition is explained not only by the difficulties of the motor activities to be learnt, but also by the existence of activities whose nature and complexity vary according to the size and shape of the pot. Following this observation, it was concluded that only specialists are in a position to practise and to master the wheel-throwing technique. Now the mastery of this technique has been noted only for high unrestricted pots, while the archaeological assemblages are made up of restricted and unrestricted vessels of different shapes and sizes. Therefore, to describe the process according to which the wheel-throwing was adopted and mastered, it became evident that one had to develop a techno-morphological taxonomy which reveals the difficulties related to ceramic shapes : these difficulties are representative of the level of competence of the potters, or the way the wheel is used. With this purpose in mind, we decided to work out measurements which would enable us to assess the throwing difficulties of archaeological vessels. The following study is a construction of these measurements, on the basis of ethnoarchaeological data collected in northwest India.

Objectives of study

A description of the techno-morphological evolution of ceramic vessels according to their throwing difficulties, or of the process through which the wheel was adopted and used, permits us to take up the following synchronic and diachronic studies.

Synchronic studies

A study of *pottery specialization*. Our preceding study showed that the wheel-throwing technique is significant in craft specialization, taking into account the long and arduous apprenticeship its mastery requires. Therefore, to infer pottery specialization, the archaeological ceramic assemblages should attest to the mastery of this technique. One of the aims of this study is to define a threshold beyond which vessel-manufacturing difficulties could be considered representative of a mastery of the wheel-throwing technique.

A study of the *diffusion of the wheel-throwing technique*. Through a techno-morphological study of ceramic vessels, it should be possible to distinguish between the sites where the wheel-throwing technique was either devised or imported. One may assume that, in the first case, the sites would bear witness to a gradual mastery of this technique. In the second case, a complete mastery of the technique would be immediate.

A study of the *spatial distribution of the technical know-how*. The study of ceramic assemblages according to throwing difficulties should permit us to analyse, at the regional level, the distribution of potters according to their stage of competence.

Diachronic studies

A study of the *integration of the wheel-throwing technique into prehistoric techno-economic systems*. This study bears on the role of the socio-economic milieu in the adoption and evolution of the wheel-throwing technique. It consists of comparative analyses of the techno-morphological evolution of wheel-thrown ceramic vessels between sites of a single region or from different regions. Such analyses will highlight, at the local level, the importance of certain factors in the development of the wheel-throwing technique: procedures of manufacturing, taste and demand of the clients, socio-economic conditions of pottery production, and so forth.

The hypothesis concerning the complexity of integration of the wheel-throwing technique is formulated through ethnographic examples. These examples show that the knowledge of the wheel implies neither its adoption nor the full utilization of its potential. Three factors may explain this:

1. The techno-economic profit linked to this technique is not effective or apparent on a short-term basis. It is a difficult technique, which is not necessarily more rapid than the hand-building techniques, particularly in the case of partial exploitation of the wheel-throwing technique (e.g., the wheel is used only for manufacturing rough models). In India, the manufacturing times of hand-made and paddled pots (pots from Manipur) are thus comparable to the manufacturing times of wheel-thrown and paddled pots. In Tzintzuntan, Mexico, Foster (1959, 1965) notes that the relative rapidity with which the pots are moulded is a major factor in resisting the adoption of the wheel. Similarly, in Karia-ba-Mohammed (Balfet, 1973), the shapes of the hand-made pots and organization of the work are such that the wheel-throwing technique does not offer saving of time over the traditional fashioning techniques. According to Balfet, the wheel was never adopted there for this reason.
2. The practise of throwing may represent an economic risk since new ceramic shapes could come from it that might not necessarily be valued by social demand. This could be a decisive factor in the conservation of traditional techniques (Balfet, 1984; Nicklin, 1971).
3. There is no particular factor which necessarily implies the adoption of the wheel. Thus the increase in demand for ceramic vessels does not *ipso*

facto imply the adoption of this technique, as Foster observed in Mexico (1959: 113-114):

Commercialization may be the motivation that leads potters to abandon traditional techniques, and to undergo the difficult experience of learning new motor patterns in order to keep up with market demands. Yet even this motivation is not necessarily compelling, as evidenced by the resistance of the Mexican potter to the wheel, or its full exploitation, in spite of familiarity with its existence and capabilities.

During the Chalcolithic period, in the Indus valley or in Mesopotamia, the situation was even more complex because (a) the wheel-throwing technique was in the infant stage, and the motor activities necessary for achieving the desired goal had yet to be invented and then integrated into pottery practise; and (b) mastery of all the activities related to the wheel-throwing technique is determined by the fabrication of different vessel shapes. These shapes, because of the manufacturing process, constitute new shapes. Consequently, their adoption and the adoption of the wheel might depend on socio-economic factors that may hold sway over the technical progress that the wheel represents.

A study of the *phenomena of evolution, maintenance and regression of a technique*. Analysis of ceramic assemblages according to their throwing difficulties enables us to measure the amplitude of these phenomena.

The wheel-throwing technique

A wheel may be used without the wheel-throwing technique and, inversely, the throwing technique may be practised without a wheel due to instruments such as the tournette (Balfet, 1973, 1984). In an archaeological or an ethnographic situation, the significant technological element is not the tool, but the technique of throwing: first, the development of motor capabilities is understood since these differ from those involved in the traditional hand-building techniques; and second, it is the use of the throwing activity which determines the manner in which the wheel is exploited—fully, partially (throwing of small vessels, parts of vessels, or rough models only), or not at all (use of the wheel as a tournette).

Research procedure

To set up measurements whereby the throwing difficulties of ceramic vessels might be assessed, we carried out a series of experiments with potters from northwest India (natives of Rajasthan and Haryana). These experiments consisted of having different ceramic shapes reproduced by three groups of potters acknowledged to differ in competence. These shapes were defined against the principal shapes found in the Indus valley during the Chalcolithic and protohistoric periods. It should be noted that it was not possible to base the experiments on local shapes, because in India the majority of

containers are obtained by beating after throwing rough models. These rough models, as their name indicates, are coarse shapes with very thick walls whose reproduction would not permit us to grasp the various throwing difficulties presented by the archaeological vessels.

The reproduction of pots by subjects of differing competence sought to verify empirically the oral data on throwing difficulties. The experimental production enabled us to study in particular to what extent the performances of the potters varied according to their stage of competence and the classes of containers.

Once the ceramic containers were reproduced, they were classified by the three groups of potters in ascending order of throwing difficulties. From this classification, we subsequently elaborated a techno-morphological taxonomy. This procedure takes place within the framework of deduced typologies (Gardin, 1979). The classification is given by ethnographic facts and our task consists of researching the intrinsic criteria necessary to find this classification again. At this level, the interpretation of the typology obtained is, by construction, univocal in the context of observation (Gallay, 1980). In the circumstances, we devised a taxonomy which enabled us to classify different pot shapes according to an ascending order of throwing difficulties as indicated by the potters interviewed. The classes that form the taxonomy represent the measurement of throwing difficulties. Their interpretation is restricted to ceramic assemblages made by northwest Indian potters.

To estimate the validity of this taxonomy in other cultural contexts, we asked some French potters to define the measurements against which the throwing difficulties of a pot are assessed. Then, the shapes of the pots reproduced by the Indian potters were classified according to these measurements and we tried to ascertain whether there is a correlation between the Indian classification and the French one.

This research procedure is summarized in Figure 1.

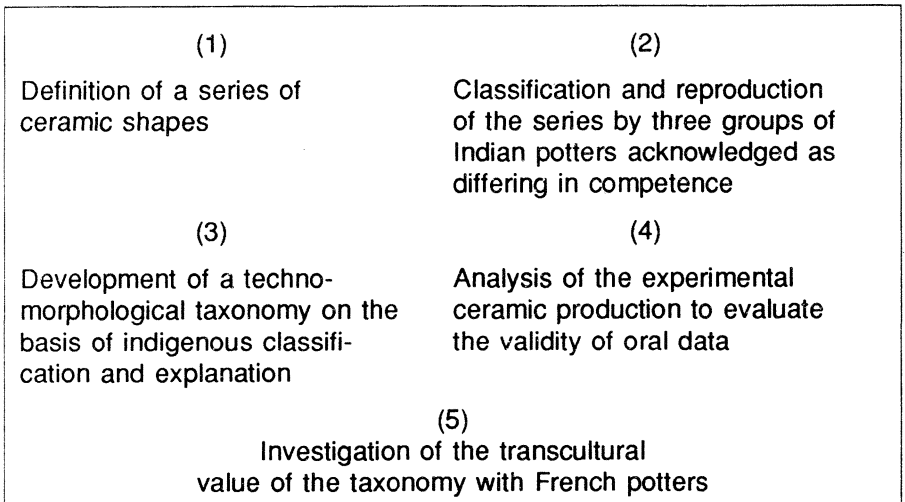


Figure 1: Research procedure conducted for the development of a techno-morphological taxonomy for evaluating the throwing difficulties of pre- and protohistoric ceramic forms.

1. DEFINITION OF A MORPHOLOGICAL SERIES OF CONTAINERS

The series of ceramic shapes defined in our experimental reproduction represent the material on which the techno-morphological taxonomy has been constructed. These shapes were defined against technological criteria (keeping in mind our preceding study) and morphological criteria (absolute and relative dimensions which include the principal forms encountered during the pre- and protohistory of the Indus valley). They should not be considered types, but rather examples of ceramic shapes within morphological categories.

Firstly, two main categories of containers are distinguished—restricted containers and unrestricted containers—since these two categories demonstrate throwing difficulties of a different nature:

- Restricted containers : orifice diameter < maximum diameter;
- Unrestricted containers: orifice diameter \geq maximum diameter.

For either of these two categories, the elements "rim and "foot" are not taken into consideration; our earlier study showed that these are minor elements in terms of fashioning difficulties.

As for thickness, it is homogeneous for the entire corpus, i.e. between 5 mm and 1 cm. Indeed, it was noted earlier that the ratio height/thickness significantly reflects degree of difficulty. At the time of constructing a techno-morphological taxonomy, one ought to insert this information as it is definitely pertinent. The value between 5 mm and 1 cm was selected with reference to archaeological examples since the value encountered most often is 5 mm. Therefore, at the time of throwing, i.e. for an unfired clay, the average thickness had to be between 5 mm and 1 cm.

1.1. Restricted containers (Table 1)

Four groups of containers were distinguished on the basis of the various values possible according to height (H). It will be recalled that this is a major variable by which the difficulties of transiting from one stage of apprenticeship to another are expressed. The four groups are as follows:

- 20-cm high containers ($20 \leq H < 30$)
- 30-cm high containers ($30 \leq H < 40$)
- 40-cm high containers ($40 \leq H < 50$)
- 50-cm high containers ($50 \leq H < 60$)

Pots 10-cm high have not been taken into consideration because, whatever their shape, they are always easier to throw than 20-cm high pots (see our preceding study, as well as 2.2.3)

Pots higher than 60 cm were not included in experiments because in northwest India, pots of this size are not made in one piece, but in several.

Within the four groups of containers, shapes have been defined based on the different values the following variables could take: maximum diameter (MD), base diameter (BA), and orifice diameter (OR).

	Maximum diameter	Base and orifice
	MD < 1/2 H	BA and OR < 1/2 MD
H >	MD ≥ 1/2 H	BA and OR ≥ 1/2 MD
	MD = H	
2H >	MD > H	
	MD ≥ 2H	

The different values of these variables allowed us to establish 28 shapes of containers. Some of the combinations could not be produced by Indian potters, namely:

< 30-cm high containers:	MD ≥ 2 H	and BA and OR < 1/2 MD
< 40-cm high containers:	MD < 1/2 H	and BA and OR < 1/2 MD
	MD ≥ 2 H	and BA and OR ≥ 1/2 MD
	MD ≥ 2 H	and BA and OR < 1/2 MD

Table 1: Registration numbers and absolute dimensions of restricted vessels, given in centimeters

Relative Dimensions	N°	H	MD	OR	BA	Relative Dimensions
H > MD ≥ 1/2H	1	20	14	10	10	BA & OR ≥ 1/2MD
MD = H	2	20	20	15	15	BA & OR ≥ 1/2MD
MD < 1/2H	3	20	8	5	5	BA & OR ≥ 1/2MD
H > MD ≥ 1/2MD	4	20	14	5	5	BA & OR < 1/2MD
MD = H	5	20	20	7	7	BA & OR < 1/2MD
MD < 1/2H	6	20	8	3	3	BA & OR < 1/2MD
2H > MD > H	7	20	26	13	13	BA & OR ≥ 1/2MD
2H > MD > H	8	20	26	9	9	BA & OR < 1/2MD
MD ≥ 2H	9	20	40	22	22	BA & OR ≥ 1/2MD
MD ≥ 2H	10	20	40	18	18	BA & OR < 1/2MD
H > MD ≥ 1/2H	11	30	21	15	15	BA & OR ≥ 1/2MD
MD = H	12	30	30	22,5	22,5	BA & OR ≥ 1/2MD
MD < 1/2MD	13	30	12	7,5	7,5	BA & OR ≥ 1/2MD
H > MD ≥ 1/2H	14	30	21	7,5	7,5	BA & OR < 1/2MD
MD = H	15	30	30	10,5	10,5	BA & OR < 1/2MD
MD < 1/2H	16	30	12	4,5	4,5	BA & OR < 1/2MD
2H > MD > H	17	30	39	20,5	20,5	BA & OR ≥ 1/2MD
2H > MD > H	18	30	39	13,5	13,5	BA & OR < 1/2MD
M ≥ 2H	19	30	60	33	33	BA & OR ≥ 1/2MD
H > MD ≥ 1/2H	20	40	30	20	20	BA & OR ≥ 1/2MD
MD = H	21	40	40	30	30	BA & OR ≥ 1/2MD
MD < 1/2H	22	40	15	7,5	7,5	BA & OR ≥ 1/2MD
H > MD ≥ 1/2MD	23	40	30	12,5	12,5	BA & OR < 1/2MD
MD = H	24	40	40	17,5	17,5	BA & OR < 1/2MD
2H > MD > H	25	40	45	30	30	BA & OR ≥ 1/2MD
2H > MD > H	26	40	45	20	20	BA & OR < 1/2MD
H > MD ≥ 1/2H	27	50	25	18	18	BA & OR ≥ 1/2MD
MD < 1/2H	28	50	20	13	13	BA & OR ≥ 1/2MD

For 50-cm high containers, only two combinations are possible:

- $H > MD \geq 1/2 H$ and BA and $OR \geq 1/2 MD$
- $MD < 1/2 H$ and BA and $OR \geq 1/2 MD$

The different groups of containers were of the following number of shapes:

- group of 20-cm high containers: 10 shapes
- group of 30-cm high containers: 9 shapes
- group of 40-cm high containers: 7 shapes
- group of 50-cm high containers: 2 shapes

Table 1 gives the respective dimensions of the 28 shapes as well as their registration number. For each of these shapes, one must consider a maximum diameter located in the lower, middle or upper part of the container. Likewise, one must consider continuous or carinated bodies.

1.2. Unrestricted containers (Table 2)

For this category of containers, the pertinent variable is the orifice (according to our preceding study), and these four groups were defined:

- 20-cm orifice containers ($20 \leq OR < 30$)
- 30-cm orifice containers ($30 \leq OR < 40$)
- 40-cm orifice containers ($40 \leq OR < 50$)
- 50-cm orifice containers ($50 \leq OR < 60$)

The 60-cm and 70-cm orifice containers were not included in experiments, although technically feasible, because apparently, Chalcolithic assemblages do not include wheel-thrown unrestricted containers whose orifice exceeds 60 cm.

Table 2: Registration numbers and dimensions of unrestricted vessels, given in centimeters.

Relative Dimensions	N°	H	OR	BA	Relative Dimensions
$1/2 OR \leq H < OR$	30	10	20	15	$BA \geq 1/2 OR$
$1/2 OR > H$	31	7	20	15	$BA \geq 1/2 OR$
$1/2 OR \leq H < OR$	32	10	20	5	$BA < 1/2 OR$
$1/2 OR > H$	33	7	20	5	$BA < 1/2 OR$
$1/2 OR \leq H < OR$	34	15	30	22,5	$BA \geq 1/2 OR$
$1/2 OR > H$	35	10,5	30	22,5	$BA \geq 1/2 OR$
$1/2 OR \leq H < OR$	36	15	30	7	$BA < 1/2 OR$
$1/2 OR > H$	37	10,5	30	7	$BA < 1/2 OR$
$1/2 OR \leq H < OR$	38	20	40	20	$BA \geq 1/2 OR$
$1/2 OR > H$	39	15	40	20	$BA \geq 1/2 OR$
$1/2 OR \leq H < OR$	40	20	40	10	$BA < 1/2 OR$
$1/2 OR > H$	41	15	40	10	$BA < 1/2 OR$
$1/2 OR \leq H < OR$	42	25	50	25	$BA \geq 1/2 OR$
$1/2 OR > H$	43	20	50	25	$BA \geq 1/2 OR$
$1/2 OR \leq H < OR$	44	25	50	20	$BA < 1/2 OR$
$1/2 OR > H$	45	20	50	20	$BA < 1/2 OR$

Within these four groups, the shapes are defined according to the values for the height and base.

Height

$$\text{OR } > H \geq 1/2 \text{ OR} \\ H < 1/2 \text{ OR}$$

Base

$$\text{BA } < 1/2 \text{ OR} \\ \text{BA } \geq 1/2 \text{ OR}$$

A total of 16 shapes resulted:

- group of 20-cm orifice containers: 4 shapes
- group of 30-cm orifice containers: 4 shapes
- group of 40-cm orifice containers: 4 shapes
- group of 50-cm orifice containers: 4 shapes

Dimensions are given in Table 2 together with registration numbers (30 to 45).

2. REPRODUCTION AND INDIGENOUS CLASSIFICATION OF MORPHOLOGICAL SERIES

The potters we worked with live in the environs of New Delhi, in the suburb of Uttam Nagar. They are natives from Rajasthan and Haryana. The interviews and experiments in which they participated were conducted in the home of our informant, the potter Har Kishan. The experimental conditions were thus homogeneous: the various containers were reproduced by all the potters on Har Kishan's wheel and with his clay. The wheel is a stick wheel.

2.1 Experimental procedure

Initially, we worked with Har Kishan who, it should be noted, is a potter of extraordinary skill. For various reasons, he has specialized in ornamental pots and flower-pot holders, and developed a unique know-how very superior to that required for producing traditional ceramic vessels. We asked him to make every container of the techno-morphological series (Plate 1). In his first essay, Har Kishan estimated the lump of clay required for the throwing of a particular pot and the course to be followed to obtain the dimensions desired. His second essay was the final one, which we filmed. Specimens from the first essay were reserved as visual samples for other potters, while the dimensions of specimens from the second essay were recorded.

After fabricating each pot, Har Kishan detailed the throwing difficulties encountered. Then he compared these and classified the containers in ascending order of fashioning difficulty.

We next worked with three groups of potters, seven persons in each group, who differed in competence. Competence was determined by the potters themselves with respect to the type of pots they threw daily on the wheel.



Plate 1 : Experimentation with Har Kishan

- GROUP 2B: Potters who made unrestricted containers below 30-cm height
- GROUP 3A: Potters who made unrestricted containers above 30-cm height
- GROUP 3B: Potters who made unrestricted and restricted containers above 30-cm height

The groups of potters were classified in accordance with the scheme given in the preceding study, where we have explained that the height of wheel-thrown pots is used as a marker in Uttam Nagar for the stage of apprenticeship in pottery. Potters who throw 20- to 30-cm high pots are at stage 2B according to this system. Potters who throw pots equal to or above 30-cm height belong to stage 3A. Potters of stage 3B are acknowledged as superior in competence to potters of stage 3A, on the basis of type of pot thrown on the wheel: the latter group make only flower pots, i.e. unrestricted containers, whereas potters of stage 3B make all the different types of pots traditionally found in homes (restricted containers of different size). Potters at stage 3B have settled more recently in Uttam Nagar and still possess the know-how requisite for the production of vessels used in the countryside.

Group 2B was asked to make restricted containers Nos. 1, 2, 4 and 5 (see Table 1) and unrestricted containers Nos. 31 and 33 (see Table 2).

Groups 3A and 3B were asked to make restricted containers Nos. 1, 2, 4, 5, 6, 8, and 9 (see Table 1) and unrestricted containers Nos. 31 and 33 (see Table 2).

The experiment covered only 20-cm high and 20-cm orifice containers, in order that comparison of performance could include potters of group 2B, who make only 20-cm high unrestricted containers. Group 2B was not asked to reproduce container Nos. 6, 8 and 9, as it was very quickly discerned that they were not capable of doing so. Containers Nos. 3, 7, 30 and 32, i.e. the other 20-cm high and 20-cm orifice groups, were not reproduced due to contingent reasons: the potters could not be asked to throw so many pots. The degree of difficulty was estimated by oral survey.

Each potter reproduced the various containers twice, consecutively. A sample of Har Kishan's work served as a visual model. The second essay was filmed and the dimensions of the containers recorded. Following the throwing of each container, the potter assessed its difficulties and later classified all the pots in ascending order of throwing difficulties.

All the restricted containers made by Har Kishan and the other potters had a maximum diameter in the middle of the body. During experiments with Har Kishan it appeared that, whatever the pot shape, throwing is more difficult when the maximum diameter occurs in the lower part of the pot, and easier when located in the upper part (see 2.2.2). The middle course was chosen, i.e. production of pots with the maximum diameter occurring in the middle of the body.

It should also be mentioned that all the pots produced had a carination, even though this type of container is more difficult to execute than pots with a continuous body (see 2.2.2). We discovered that in seeking to respect the

given measurements of the maximum diameter, all the potters tended to mark out the diameter with a carination (Plate 2).

The various shapes of 20-cm high pots and 20-cm orifice pots produced by the three groups of potters are depicted in Figures 2 and 3.

2.2. Indigenous classification

The 20-cm high and 20-cm orifice containers were classified by the three groups of potters (Har Kishan is in group 3B) according to the same classification which expresses an ascending order of throwing difficulties. This unique classification and that by Har Kishan for the other containers are noted in Figure 6. The oral explanations justifying this classification are given below. They relate to the difficulties posed by absolute and relative dimensions.

2.2.1 *Distinction between restricted and unrestricted containers*

Within the limit of the corpus (the morphological series), most of the restricted containers are considered more difficult to throw than unrestricted containers. Contrary to the latter, the maximum diameter of restricted containers has to support clay wall, which implies a more complex know-how. This consists in knowing how to balance the masses of clay between the upper and lower parts of the body or, further, to control the pressures of the fingers which have to distribute the clay in such a manner that the lower walls and the maximum diameter are sufficiently thick to support the upper walls. For a novice, one of the most difficult exercises is estimation of the amount of clay to collect at the level of the maximum diameter in order to then raise the upper walls.

Unrestricted containers for which throwing difficulties definitely surpass those of restricted containers have an orifice above 40 cm. In this case, throwing of the required quantity of clay is an operation that is more difficult to master than throwing of upper walls.

In Figure 6, restricted containers Nos. 1, 2 and 3 are ranked before unrestricted container Nos. 30, 31, 32 and 33. As a matter of fact, however, the potters found the throwing difficulties of these pots very similar and classifying them somewhat problematical.

2.2.2. *Location of maximum diameter and distinction between continuous and carinated body*

Taking into account the problem of the weight of the upper parts of the body on the maximum diameter, the location of the latter determines three degrees of difficulty, given here in ascending order:

- MD in upper part
- MD in median part
- MD in lower part

Carinated pots are more difficult to make than pots with a continuous body because a rupture point increases the risk of folding. Sufficient thickening at the level of carination offsets this risk.

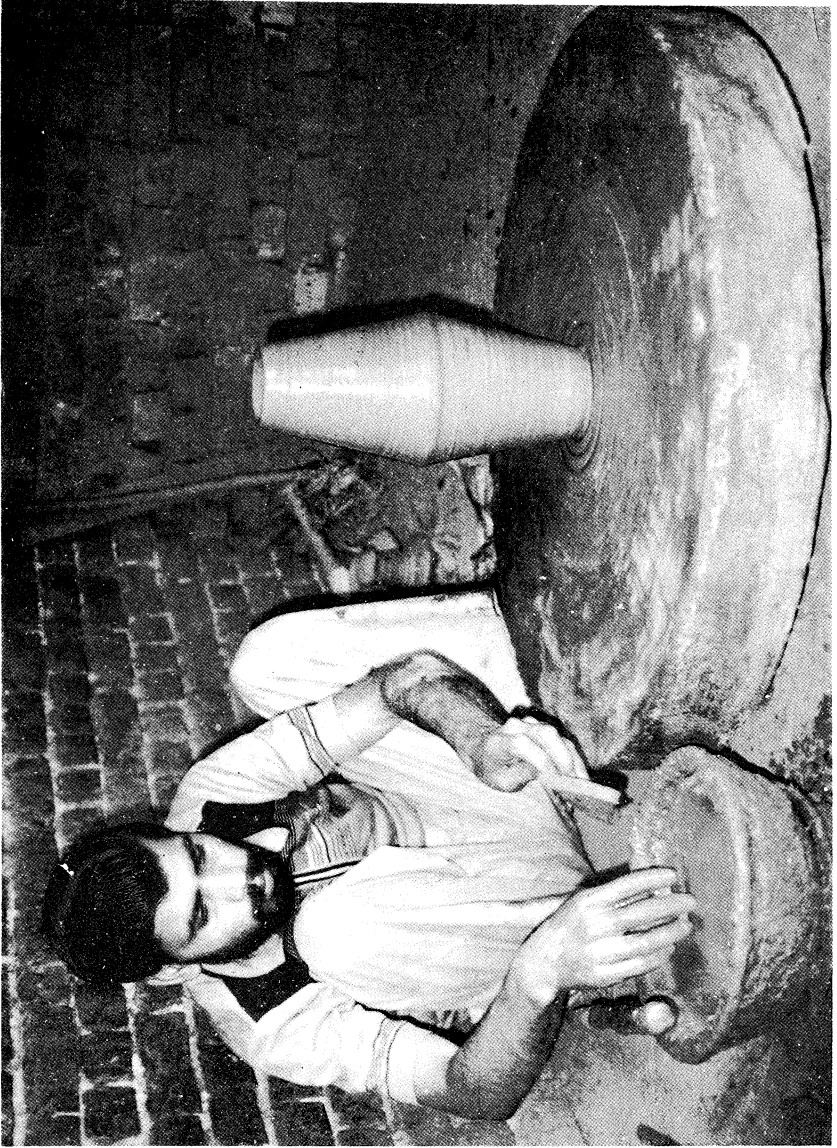


Plate 2 : Container n°4 reproduced by Har Kishan. The first specimen was kept aside and used as visual example for the other potters.

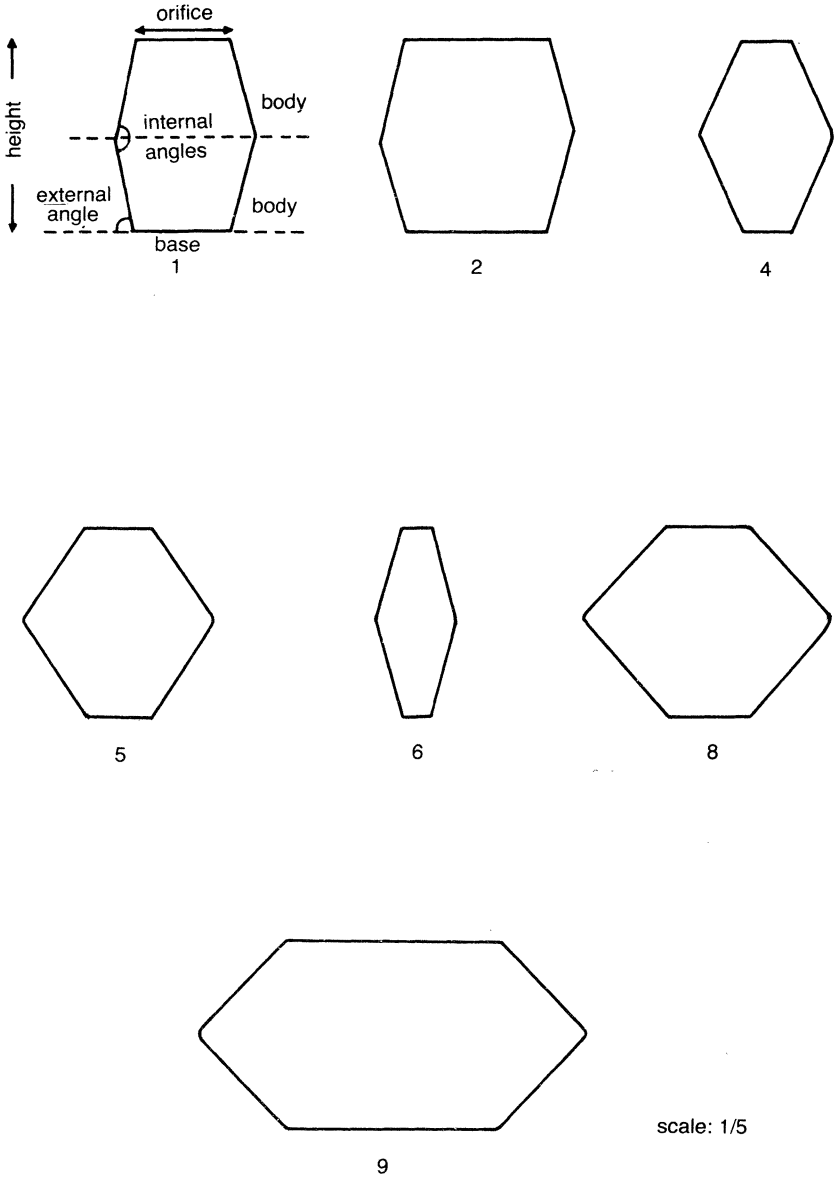


Fig.2 : 20 cm high restricted vessels reproduced by three groups of potters. The numbering of the pots refers to their registration number.

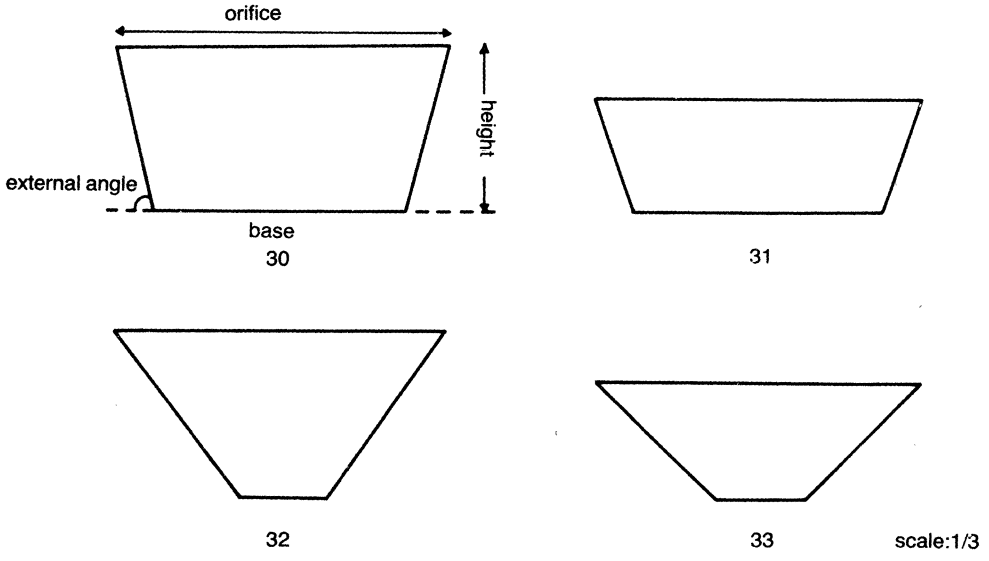


Fig.3 : 20 cm orifice unrestricted vessels. The containers n°30, 31, 32 and 33 were reproduced by Har Kishan and vessels n°31 and 33 by the three groups of potters.

CLASS I

$MD < H$
 BA/MD: $x > 0.50$ and tends to 0.50
 OR/MD: $x > 0.50$ and tends to 0.50
 H/MD > 1 $x > 1$ and tends to 1

increasing
difficulties



(I-20: 1, 2, 3, I-30: 11, 12, 13, I-40: 20, 21, 22, I-50: 27, 28)

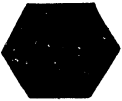
CLASS II

$MD < H$
 BA/MD: $x < 0.50$ and tends to 0
 OR/MD: $x < 0.50$ and tends to 0
 H/DM > 1 $x > 1$ and tends to 1

increasing
difficulties



(II-20: 4, 5, 6, II-30: 14, 15, 16, II-40: 23, 24)

CLASS III

$2H > MD > H$
 BA/MD: $x > 0.50$ and tends to 0.50
 OR/MD: $x > 0.50$ and tends to 0.50
 $0.50 < H/MD < 1$ x tends to 0.50

increasing
difficulties



(III-20: 7, III-30: 17, III-40: 25)

CLASS IV

$2H > MD > H$
 BA/MD: $x < 0.50$ and tends to 0
 OR/MD: $x < 0.50$ and tends to 0
 $0.50 < H/MD < 1$ x tends to 0.50

increasing
difficulties



(IV-20: 8, IV-30: 18, IV-40: 26)

CLASS V

$MD > 2H$
 BA/MD: $x > 0.50$ and tends to 0.50
 OR/MD: $x > 0.50$ and tends to 0.50
 H/MD < 0.50 x tends to 0

increasing
difficulties



(V-20: 9, V-30: 19)

CLASS VI

$MD > 2H$
 BA/MD: $x < 0.50$ and tends to 0
 OR/MD: $x < 0.50$ and tends to 0
 H/MD < 0.50 x tends to 0



(VI-20: 10)

Fig.4 : Definition and representation of the techno-morphological classes of the restricted vessels. In brackets are indicated the registration number of the containers which belong to these different classes. The numeric index associated with the numbering of the classes corresponds to the vessel height.

CLASS VII

$$\begin{aligned} \text{OR} &> \text{BA} \geq 1/2 \text{ OR} \\ \text{H} &\geq 1/2 \text{ OR} \end{aligned}$$

(VII-20: 30, VII-30: 34, VII-40: 38, VII-50: 42)

CLASS VIII

$$\begin{aligned} \text{OR} &> \text{BA} \geq 1/2 \text{ OR} \\ \text{H} &< 1/2 \text{ OR} \end{aligned}$$

(VIII-20: 31, VIII-30: 35, VIII-40: 39, VIII-50: 43)

CLASS IX

$$\begin{aligned} \text{BA} &< 1/2 \text{ OR} \\ \text{H} &\geq 1/2 \text{ OR} \end{aligned}$$

(IX-20: 32, IX-30: 36, IX-40: 40, IX-50: 44)

CLASS X

$$\begin{aligned} \text{BA} &< 1/2 \text{ OR} \\ \text{H} &< 1/2 \text{ OR} \end{aligned}$$

(X-20: 33, X-30: 37, X-40: 41, X-50: 45)

Fig.5 : Definition and representation of the techno-morphological classes of the unrestricted vessels. In brackets are indicated the registration numbers of the containers which belong to these different classes. The numeric index associated with the numbering of the classes corresponds to the vessel orifice.

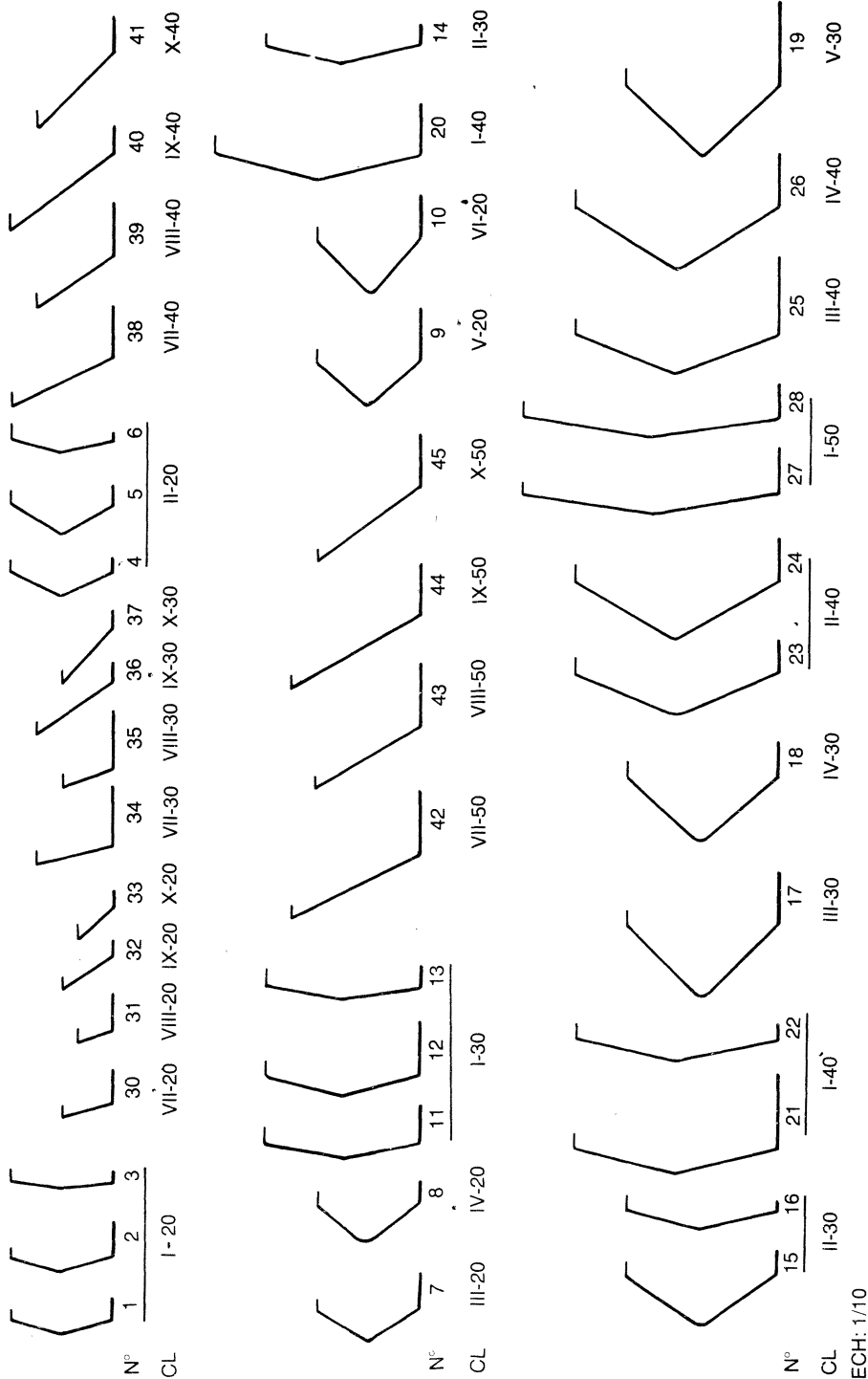


Fig.6 : Classification of restricted and unrestricted vessels in ascending order of difficulty. The first line of numbering corresponds to the registration number. The second line corresponds to the numbering of the techno-morphological classes.

ECH: 1/10

2.2.3. Orifice of restricted containers

The difficulty of fashioning a restricted container increases with the diminution of the orifice because of these two factors:

1. When the orifice is less than the width of a hand, the upper walls have to be thinned and shaped without the whole palm inside the pot. This operation requires a special knack of handling and explains why 10-cm high restricted containers are always much easier to make than 20-cm high restricted ones. In the former case, the finger can thin the pot along the full length of its wall.
2. The smaller the orifice, the more acute the internal angle formed by the upper walls of the body and the maximum diameter. This diminution of angle increases, first of all, the danger of the upper walls slumping on the inner face of the pot and, secondly, the throwing difficulties because the inclination of the walls becomes more and more oblique. These difficulties are expressed by the ratio OR/MD. The greatest difficulties correspond to the lowest indexes.

2.2.4. Maximum diameter of restricted containers or orifice of unrestricted containers

Two problems are related to the maximum diameter of restricted containers and to the orifice of unrestricted containers:

1. The weight of the clay increases with an increment in maximum diameter. Mastery of the wheel-throwing technique become much more challenging as the centrifugal force increases with the size of the diameter.
2. The more acute the internal angle formed by the intersection of the upper and lower walls, the greater the risk of wall collapse. This difficulty is reflected in the ratio H/MD and low indexes.

2.2.5 Container base

The base is problematical when its width reaches about 25 cm. From this dimension onwards, the base has to be widened during hollowing with a force that can decentre the lump of clay.

If the base is too narrow, the balance of the container may also be problematical. This is the only case in which the ratio BA/H is significant in categorizing difficulties.

The other problem arises when extension of the base entails an outer angle with the external walls of the body: the more acute this angle, the greater the risk of wall collapse on the outer surface of the pot. Besides, it is easier to thin walls whose inclination is closer to vertical. Thus the containers which are the easiest to throw have a base whose width is greater than half the maximum diameter. Angle difficulties are specifically reflected in the ratio BA/MD. The lowest indexes correspond to the greatest difficulties.

2.2.6 Container height

The higher the walls of a container, the more difficult the process of pressures required for thinning the clay: the pressures must be stronger and

stronger and concomitantly maintain a perfect equilibrium on each part of the walls. Furthermore, the height determines the weight of the clay sustained by the lower parts of the container. Correct calculation of this weight constitutes one of the most difficult exercises to master.

2.2.7 Container thickness

To obtain thin walls, in particular at the lower body level, is difficulty *per se*. Indeed, it implies that the minimum thickness should be perfectly estimated, not only to ensure that the walls will stand, but also that the lower walls will support the upper. Estimation of the thickness at the level of the maximum diameter is a particularly delicate exercise from this point of view.

The ratio H/THICK represents another difficulty in the sense that, due to centrifugal force, the higher and thinner the container, the greater the tendency of the walls to whirl and collapse.

3. DEVELOPMENT OF A TECHNO-MORPHOLOGICAL TAXONOMY

Let us now ascertain the intrinsic properties of the containers which will permit us to reconstitute the indigenous classification of the ceramic shapes in ascending order of throwing difficulty.

For this purpose, we have examined the order according to which the indigenous classification organizes the measurements of containers. The measurements are the absolute and relative dimensions noted during the oral survey as significant indexes of throwing difficulties: BA/MD, OR/MD, H/MD for restricted containers (see Table 3) and BA/OR, H/OR for unrestricted containers (see Table 4). Scrutiny revealed that the containers could be arranged in a two-level classification.

First, the containers were classified within each group defined by the values of height (for restricted containers) or orifice (for unrestricted containers), according to the ratio of height to maximum diameter or that of orifice to base. This distinguishes, in ascending order of throwing difficulty, restricted containers whose maximum diameter is less than or equal to the height, between once and twice the height, or greater than or equal to two heights. It likewise distinguishes, in ascending order of throwing difficulty, unrestricted containers whose base is between half and once the orifice, and those whose base is less than half the orifice.

Second, within the groups defined by the first level of classification, restricted containers were classified according to the values of the indexes presented by the relative dimensions. They were classified, firstly, in terms of the indexes of the ratio BA/MD and OR/MD. These indexes were regrouped in two orders of size, and one can distinguish indexes higher than and lower than 0.50. The lowest indexes correspond to the containers that are the most difficult to throw. Then followed a classification in function with the indexes of the ratio H/MD which vary in a similar manner: the lowest indexes reflect the greatest throwing difficulties. They were revamped into three groups according to size: higher or equal to 1, between 1 and 0.50, and lower than 0.50.

Table 3: Classification of the restricted vessels by the Indian potters, in ascending order of difficulty. The column "class" indicates the belonging to a techno-morphological class and to a group of vessel that is defined by the height. The numbers of the containers refer to the registration numbers of the morphological series.

CLASSES	N°	H	MD	BA	OR	BA/MD	OR/DM	H/MD
I-20	1	20	14	10	10	0,71	0,71	1,42
	2	20	20	15	15	0,75	0,75	1
	3	20	8	5	5	0,62	0,62	2,5
II-20	4	20	14	5	5	0,35	0,35	1,42
	5	20	20	7	7	0,35	0,35	1
	6	20	8	3	3	0,37	0,37	2,5
III-20	7	20	26	13	13	0,50	0,50	0,76
IV-20	8	20	26	9	9	0,34	0,34	0,76
I-30	11	30	21	15	15	0,71	0,71	1,42
	12	30	30	22,5	22,25	0,75	0,75	1
	13	30	12	7,5	7,5	0,62	0,62	2,5
V-20	9	20	40	22	22	0,55	0,55	0,50
VI-20	10	20	40	18	18	0,45	0,45	0,50
I-40	20	40	30	20	20	0,66	0,66	1,33
II-30	14	30	21	7,5	7,5	0,35	0,35	1,42
	15	30	30	10,5	10,5	0,35	0,35	1
	16	30	12	4,5	4,5	0,37	0,37	2,5
I-40	21	40	40	30	30	0,75	0,75	1
	22	40	15	7,5	7,5	0,50	0,50	2,66
III-30	17	30	39	20,5	20,5	0,52	0,52	0,76
IV-30	18	30	39	13,5	13,5	0,34	0,34	0,76
II-40	23	40	30	12,5	12,5	0,41	0,41	1,33
	24	40	40	17,5	17,5	0,43	0,43	1
I-50	27	50	25	18	18	0,72	0,72	2
	28	50	20	13	13	0,65	0,65	2,5
III-40	25	40	45	30	30	0,66	0,66	0,88
IV-40	26	40	45	20	20	0,44	0,44	0,88
V-30	19	30	60	33	33	0,55	0,55	0,50

Unrestricted containers were classified on the basis of ratio of height to orifice. Containers whose height is less than half the width of the orifice represent the most difficult, opposed to containers whose height is equal to or greater than half the width of the orifice.

Given these intrinsic properties, which enabled us to reconstitute the classification of the containers within each group of pots defined by the height and the orifice, it was now possible to construct classes.

Table 4: Classification of the unrestricted vessels by the Indian potters, in ascending order of difficulty. The column "class" indicates the belonging to a techno-morphological class and to a group of vessels that is defined by the orifice. The numbers of the containers refer to the numbers of the morphological series.

CLASSES	N'	H	OR	BA	BA/OR	H/OR
VII-20	30	10	20	15	0,75	0,50
VIII-20	31	7	20	15	0,75	0,35
IX-20	32	10	20	5	0,25	0,50
X-20	33	7	20	5	0,25	0,35
VII-30	34	15	30	15	0,50	0,50
VIII-30	35	10,5	30	15	0,50	0,35
IX-30	36	15	30	7	0,23	0,50
X-30	37	10,5	30	7	0,23	0,35
VII-40	38	20	40	20	0,43	0,50
VIII-40	39	15	40	20	0,43	0,37
IX-40	40	20	40	10	0,25	0,50
X-40	41	15	40	10	0,25	0,37
VII-50	42	25	50	25	0,50	0,50
VIII-50	43	20	50	25	0,50	0,40
IX-50	44	25	50	20	0,40	0,50
X-50	45	20	50	20	0,40	0,40

For the **restricted containers**, we formed six classes (Figure 4) which enabled us to find again the indigenous classification within the 4 groups of pots (20-cm, 30-cm, 40-cm and 50-cm high). Each class is defined on the basis of 4 measurements. To determine which one of the six classes a pot belongs to, one must examine *in the correct order* the values taken *simultaneously* by these measurements. The first measurement to examine is height in relation to maximum diameter. It corresponds to the first level of classification and distinguishes the classes I and II, III and IV, V and VI. Then follows successive consideration of the ratio BA/MD, OR/MD and H/MD. Their indexes enabled us to distinguish each of the classes on the basis of a threshold that we arbitrarily fixed at 0.50 for the ratio BA/MD and OR/MD, and at 1 and 0.50 for the ratio H/MD. Pots may belong to one class only on the basis of the first three measurements. This is particularly the case of some containers belonging to classes I and II: the indexes of the ratio H/MD do not correspond to those defined for these classes. This situation may also occur with the ratio OR/MD:

a container may have a ratio BA/MD above 0.50 and a ratio OR/MD below 0.50. In this case, the vessel will belong to class I as the oral data have shown that the ratio BA/MD is a measurement which causes more difficulties than the ratio OR/MD. In any case, its throwing difficulty will be defined as greater than that of the containers belonging to class I and whose ratio OR/MD is above 0.50.

Each of these six classes may be subdivided on the basis of the following variables and descriptive elements:

1. Ratio THICK/H: the lower the ratio, the greater the difficulty (see 2.2.7);
2. Location of maximum diameter on the body (see 2.2.2);
3. Presence of a carination or of a continuous body (see 2.2.2);
4. Quality of clay: throwing difficulties increase with a too sandy or too plastic clay, and decrease proportionate to the extent that the clay approaches an optimal degree of plasticity.

For the **unrestricted containers**, we formed four classes (Figure 5) on the basis of two dimensional ratios: the base in ratio to the orifice, and the height in ratio to the orifice. The first ratio allowed us to distinguish classes VII and VIII from classes IX and X. The second ratio distinguishes each class from the others. These classes arrange the pots with the same size orifice in ascending order of difficulty.

The classes may also be subdivided on the basis of thickness of walls and quality of clay.

The arrangement of the **entire series of containers** according to their group (restricted/unrestricted), class and size (height for restricted containers and width for unrestricted) is given by the indigenous classification in Figure 6.

It should be noted that the classes elaborated here are simple norms. In other words, vessels whose measurements place them at the border of two classes belong to a "blurred zone"; their assignment to one class rather than another is arbitrary.

It should also be noted that the techno-morphological classes have been set up on the basis of containers made at one go. They cannot, therefore, be applied to trimmed containers whose initial dimensions have been obliterated.

4. PERTINENCE OF INDIGENOUS CLASSIFICATION

The techno-morphological taxonomy presented earlier is based on an indigenous classification obtained through oral investigation. The empirical value of oral information will now be tested by studying the experimental production and the performances of the potters according to their level of competence and the class of containers. The performance of the potters is estimated in terms of:

- Margin between measurements of experimental production and norms given in instructions;

- Total manufacturing time of the various containers;
- Thinning and shaping operations, described in terms of gestures, number and duration.

The retained dimensions of the experimental production are: height, maximum diameter, orifice, base, thickness of base, and median thickness of right and left walls (obtained after sectioning the vessels). Absolute and relative dimensions of the restricted and unrestricted containers are listed in Tables 5, 6, 7 and 8.

Only the performances in production of restricted vessels are analysed. Indeed, the measurements of unrestricted containers do not permit us to distinguish different levels of competence (see Tables 5 and 6). This results should not be surprising since the 20-cm orifice unrestricted container is easy to execute, and made sometimes even by group 2B. Consequently, group 2B might well yield results as good as group 3B.

Table 5: Means and standard deviations of the absolute dimensions (given in millimeters) of the unrestricted vessels obtained by experimentation, distributed according to the shape and to the stage of competence of the potters.

STAGE	N' (n=7)	H	OR	BASE	THICK BA	THICK 1	THICK 2	av
2A	31	70,57	201	141	8,57	10,28	10,14	av
		9,72	7,65	56,32	1,90	2,05	2,41	σ
3A	31	70	208	136	10	8,57	10,42	av
		5,88	12,45	53,71	2,70	0,97	1,39	σ
3B	31	71,28	211,14	163,14	9,28	7,85	9,14	av
		8,07	7,47	10,49	2,87	1,21	3,38	σ
2A	33	77,57	193,85	71,14	10,85	8,14	10,28	av
		10,59	8,27	4,33	2,11	1,67	2,42	σ
3A	33	67,71	197,28	69,71	11,42	6,71	9,85	av
		3,25	14,40	6,21	2,37	2,13	3,28	σ
3B	33	68,28	200,57	64	9,57	7,85	7,42	av
		8,67	8,73	6,27	1,71	2,19	1,98	σ

av = average

σ = standard deviation

4.1 Margin between measurements of experimental production and norms given in instructions

Relative and absolute dimensions are considered successively. A study of the relative dimensions and their indexes enabled us to assess the relationship between the level of competence, and the capability for achieving the most difficult ratios. A study of the absolute dimensions enabled us to estimate the

margin between these dimensions and the norms given in the instructions, and the tendencies to which this margin corresponds. Subsequently, it was possible to verify the validity of the explanations given for the wheel-throwing difficulties and for the classification of the containers, i.e. to verify the correspondance between these explanations and empirical reality.

Table 6: Means and standard deviations of the relative dimensions (given in millimetres) of the unrestricted vessels obtained by experimentation, distributed according to the shape and to the stage of competence of the potters.

STAGE	N' (n=7)	BA/OR		H/OR	
		av	σ	av	σ
2B	31	0,70	0,27	0,35	0,05
3A	31	0,66	0,26	0,33	0,01
3B	31	0,77	0,04	0,33	0,03
2B	33	0,36	0,02	0,40	0,05
3A	33	0,35	0,03	0,34	0,02
3B	33	0,32	0,02	0,34	0,04

Relative dimensions of restricted containers (Table 8)

Ratio BA/MD

According to the classification of ceramics by Indian potters, the index of the ratio BA/MD is significant of difficulty when below 0.50. The classes II-20 and IV-20 are distinguished from classes I-20 and III-20 on the basis of this index. To class II-20 correspond containers Nos. 4, 5, and 6, and to class IV-20, container No. 8. These containers are the ones examined.

The results of the experimental production permit the distinction of the group of potters 3B from the groups 2B and 3A. First of all, only the subjects of group 3B succeeded in throwing vessels which show a ratio BA/MD below 0.50 (containers Nos. 4 and 5). Secondly, while throwing containers Nos. 6 and 8, they achieved the most difficult ratios of BA/MD, i.e., those whose indexes are the lowest. As for the 3A group of potters, the results do not differentiate them from this point of view.

Ratio OR/MD

The classes II-20 are also defined by an index OR/MD which is below 0.50.

The group 3B gives the best scores, in the sense that the containers Nos. 4, 5, 6 and 8 of this group present the lowest indexes for the ratio OR/MD. Group 3A is distinguishable from group 2B on the basis of the indexes presented by the ratio OR/MD of containers Nos. 4 and 5.

Ratio H/MD

The six techno-morphological classes defined are also distinguishable on the basis of the index of the ratio H/MD. In every case, the lowest value is representative of the greatest difficulties.

Table 7: Means and standard deviations of the absolute dimensions (given in millimetres) of the restricted vessels obtained by experimentation, distributed according to the shape and to the stage of competence of the potters.

STAGE	N'	H	MD	OR	BA	THICKBA	THICK1	THICK2	(n=7)
2B	1	201,42 18,41	140 7,63	96,71 6,77	93,14 5,98	11,42 6,32	7,85 2,19	11,71 2,42	av σ
3A	1	207 17,84	142 11,09	99,14 5,61	100,28 2,75	10 4,32	9,14 1,46	11,57 2,22	av σ
3B	1	212 12,79	153 9,72	108,57 6,26	105,42 5,88	6,71 4,27	8,41 1,86	8,71 1,38	av σ
2B	2	215,71 11,23	196,14, 15,24	147,42 5,59	137 8,56	11 7,74	9,28 1,97	11,85 4,74	av σ
3A	2	226,71 12,48	199,57 13,81	146,85 7,33	147,85 11,49	9 6,53	10,42 1,61	11,57 1,98	av σ
3B	2	212,42 7,54	208,14 12,48	146 11,34	148,42 7,25	8 4,83	10,14 1,34	10,85 1,77	av σ
2B	4	196,66 12,04	146,83 11,51	73,33 11,55	80,5 5,04	11 8,04	7,16 2,48	11 2	av σ
3A	4	201,14 13,71	152,78 24,52	67,28 15,07	84 9,30	11,14 3,93	8,28 2,21	12,14 2,60	av σ
3B	4	200,71 11,71	153,42 13,58	62,57 9,50	74,57 8,61	11,71 3,72	9,42 1,61	10,85 2,11	av σ
2B	5	218,57 15,09	185,14 12,40	100 8,34	103 10,87	13,71 5,21	9,14 2,11	13 2,38	av σ
3A	5	226 25,14	182,85 15,77	84,71 13,58	98,28 11,49	10,57 4,11	9 2	10 2,23	av σ
3B	5	212,85 11,96	198,28 8,47	87,71 8,92	98,14 5,45	8,14 4,81	10,42 1,90	11,28 1,25	av σ
3A	6	198,57 12,43	104,57 8,71	45,42 5,65	63,14 5,08	10,14 3,62	7,28 1,97	12,42 3,40	av σ
3B	6	203,28 14,45	111 5,85	46,85 3,76	58,85 3,43	10,85 6,69	8,28 2,98	8,28 1,49	av σ
3A	8	221,85 12,19	229,28 29,49	87,85 7,55	111,42 10,29	10,71 9,21	11,57 3,15	13,57 3,45	av σ
3B	8	218,71 19,10	252,85 33,02	93,57 16,47	113,57 12,48	13,71 4,68	11,14 2,79	11,42 1,90	av σ
3A	9	216,28 20,30	327,28 23,52	210,71 16,42	224,57 16,47	11,57 8,14	13,28 1,60	14,28 1,79	av σ
3B	9	204,85 19,14	355,14 60,92	247,28 63,63	230,57 9,16	14,85 4,74	9,57 1,51	13,71 2,62	av σ

The index of this ratio, for all the containers, differentiates the production of group 3B from that of groups 3A and 2B. It is the production of group 3B which presents the lowest indexes. The production of groups 3A and 2B are not distinguishable on the basis of their ratio.

Table 8: Means and standard deviations of the relative dimensions (given in millimetres) of the restricted vessels obtained by experimentation, distributed according to the shape and to the stage of competence of the potters.

STAGE	N' (n=7)	BA/MD		MD/OR		MD/H	
		av	σ	av	σ	av	σ
2B	1	0,66	0,02	0,69	0,05	1,43	0,10
3A	1	0,71	0,05	0,70	0,07	1,46	0,15
3B	1	0,69	0,04	0,71	0,05	1,24	0,11
2B	2	0,70	0,03	0,75	0,06	1,10	0,11
3A	2	0,74	0,04	0,74	0,05	1,14	0,10
3B	2	0,71	0,02	0,70	0,05	1,02	0,08
2B	4	0,55	0,04	0,50	0,06	1,35	0,16
3A	4	0,55	0,05	0,44	0,05	1,35	0,24
3B	4	0,48	0,07	0,40	0,06	1,31	0,08
2B	5	0,55	0,04	0,54	0,05	1,18	0,06
3A	5	0,53	0,03	0,46	0,08	1,24	0,12
3B	5	0,49	0,04	0,44	0,03	1,07	0,09
3A	6	0,61	0,08	0,43	0,06	1,90	0,13
3B	6	0,53	0,03	0,42	0,04	1,83	0,18
3A	8	0,48	0,04	0,38	0,05	0,98	0,13
3B	8	0,45	0,02	0,37	0,06	0,87	0,13
3A	9	0,63	0,05	0,59	0,04	0,60	0,07
3B	9	0,67	0,17	0,59	0,03	0,60	0,18

Absolute Dimensions of Restricted Containers

Thickness of walls (Table 9)

In our preceding study, the index of shaping regularity was shown to be pertinent in distinguishing the different stages of apprenticeship, or mastery of wheel. This index, represented here by the square of the differences between the right and left median thicknesses of the pot, differentiates the 3B group of potters from groups 3A and 2B. The containers produced by group 3B present the lowest differences, which demonstrates the capability of this group to throw the most regular walls.

Table 9: Means and standard deviations of the squares of the differences between the left and right thicknesses of the restricted vessels (calculated in millimetres), distributed according to the shape and to the stage of competence of the potters.

STAGE	N* (n=7)	av	σ
2B	1	23	20,19
3A	1	9	13,30
3B	1	4	6,16
2B	2	27,14	24,21
3A	2	6,28	6,10
3B	2	4,14	4,56
2B	4	24,16	25,55
3A	4	13,43	18,34
3B	4	10,57	17,83
2B	5	22,71	21,50
3A	5	7,28	9,51
3B	5	8	9,41
3A	6	35,71	38,82
3B	6	13,71	9,51
3A	8	17,71	16,57
3B	8	7,42	8,50
3A	9	4,42	6,02
3B	9	22,14	22,13

The absolute values in relation to the norms given in the instructions will now be examined. Table 10 presents the means of the margins between the measurements of the experimental pots and the dimensions given in the instructions, listed according to pot shape and stage of competence of the potters. The means are positive or negative, reflecting measurements above or below the norm.

Height

The instructions were, in every case, to make pots 20-cm high. The results show that the potters tended to make pots whose height is above the norm when the diameter was equal to or greater than 20 cm (containers Nos. 2, 4, 8 and 9). This tendency reduces the difficulty of the ratio H/MD. Group 3B gave the best results since the dimensions of the containers mentioned are closest to the norm.

Diameter

Given the instructions to make vessels with a diameter equal to or greater than 20 cm (containers Nos. 2, 4, 8 and 9), the potters tended to make pots with a diameter below the norm. The difficulty of the ratio H/MD was thus reduced. The best potters, i.e. those who had best mastered this ratio in throwing containers Nos. 2, 4 and 8, belonged to group 3B.

Base

The instructions were to make bases less than 10-cm wide (containers Nos. 4, 5, 6 and 8). The potters tended to make pots with a base above the norms, in order to reduce the difficulty of the ratio BA/MD. Group 3B yielded the best results in terms of measurements closest to the norm, except for container No. 8.

Table 10: Means and standard deviations (given in millimetres) of the differences between the dimensions given in the instructions and the dimensions obtained by experimentation of the restricted vessels, distributed according to the shape and to the stage of competence of the potters.

STAGE	N' (n=7)	HEIGHT		DIAMETER		ORIFICE		BASE	
		av	σ	av	σ	av	σ	av	σ
2B	1	1,42	18,41	0	7,63	-3,28	6,77	-6,85	5,98
3A	1	7,42	17,84	2	11,09	-0,85	5,61	0,28	2,75
3B	1	12	12,79	13,28	9,72	8,57	6,26	5,42	5,88
2B	2	15,71	11,23	-3,85	15,24	-2,57	5,59	-13	8,56
3A	2	26,71	12,48	-0,42	13,81	-3,14	7,33	-2,14	11,49
3B	2	12,42	7,54	8,14	12,48	-4	11,34	-1,57	7,25
2B	4	-3,33	12,04	6,83	11,51	23,33	11,55	30,5	5,04
3A	4	1,14	13,71	12	24,52	17,28	15,07	34	9,30
3B	4	0,71	11,71	13,42	13,58	12,57	9,50	24,57	8,61
2B	5	18,57	15,09	-14,85	12,40	30	8,34	33	10,87
3A	5	26	25,14	-17,14	15,77	14,71	13,58	28,28	11,49
3B	5	12,85	11,96	-1,71	8,47	17,71	8,92	28,14	5,45
3A	6	-1,42	12,43	24,57	8,71	15,42	5,65	33,14	5,08
3B	6	3,28	14,45	31	5,85	16,85	3,76	28,85	3,43
3A	8	21,85	12,19	-30,71	29,49	-2,14	7,55	21,42	10,29
3B	8	18,71	19,10	-7,14	33,02	3,57	16,47	23,57	12,48
3A	9	16,28	20,30	-42,71	23,52	-9,28	16,42	4,57	16,47
3B	9	4,85	19,14	-44,85	60,92	27,28	63,63	10,57	9,16

This analysis of the relative and absolute dimensions of the experimental production reveals that group 3B gave the best results. It was the most competent group. In this sense, the indigenous classification is an empirical reality: the information given orally corresponds to actual throwing difficulties, based on which the competence of potters can be differentiated.

Group 3A is barely distinguishable from group 2B, which is not surprising. The greater competence of group 3A over group 2B lies in the ability of these potters to raise 30-cm high vertical walls. Given the fact that the experimental production called for only 20-cm high containers, the difference in competence of the two groups could not be clearly demonstrated.

It should be noted that had the measurements of the experimental production been considered in terms of their strict proximity to the norms given in the instructions, the production of group 3B would not have stood out. According to the oral survey, a normalized production can be obtained after

6 essays, since it entails the habit of throwing rather than particular competence.

We distinguish here between *normalized* and *standardized* production on the basis of standard deviations from the mean absolute dimensions of a pot. In the case of *normalized* production, the values of the standard deviations have a tendency to be high. They correspond to the fact that in this situation the constraints imposed by the demand, or the utilization of the product, are low. Thus the flower pots made in Delhi present approximate dimensions while concomitantly meeting certain norms, because there is no obligation for the dimensions of this product to be executed within one millimetre. Hence a normalized production can be made very rapidly by potters of ordinary competence, for whom it is not necessarily a full-time activity. Some potters of Haryana or Rajasthan are both agriculturalists and potters; they possess ordinary competence (judging from the quality of their products) and produce lids and vessels whose measurements actually correspond to norms.

On the other hand, a *standardized* production presents pots that are strictly identical in dimensions, and therefore standard deviations from the mean with low values. The main implications of this type of production are expressed in terms of time and specialization. Indeed, to manufacture pots with identical measurements, the gestures and pressures on the clay must be perfectly controlled. Such control implies, first of all, that the gestures are executed slowly, which enables the potter to apply precisely the pressures required to transform the clay into the exact form desired. Secondly, these gestures must be executed often so that the potter is capable of producing in an identical manner, the pressures which apply to a particular shape, and only to that particular shape. Thus the phenomenon of standardization is significant of competence and specialization: it presupposes that the potter often produces objects which require time and skill.

The distinction between normalization and standardization should thus be made, because each term implies different socio-economic inferences. In an earlier study (Roux, 1989), we wrote that the production of standardized products could be executed as well by specialists as by non-specialists (the term "specialist" being defined relative to the economic resources of the artisan who may or may not be an agriculturalist). This earlier study pertains, in fact, to ethnographic observations on products which are normalized and not standardized. Let us repeat that the latter, opposed to the former products, are, in fact, significant of specialization.

4.2. Manufacturing time

The thinning and shaping operations (the principal phases in constructing a pot) of the different vessel shapes were timed in video recordings. The time during which the potter stops throwing in order to restart the wheel, has not been taken into account. The results (see Table 11) show that the manufacturing time decreases with respect to the degree of competence of the potter and increases with respect to the degree of difficulty of the vessel shape. These

results corroborate the foregoing observations, namely, that group 3B possessed a mastery of the wheel superior to that of the other groups. Compared to group 2B, group 3A gave better results due to their training.

Table 11: Means and standard deviations of the thinning, shaping and total time (given in seconds), distributed according to the vessel shape and to the stage of competence of the potters.

STAGE	N' (n=7)	Thinning time		Shaping time		Total time	
		av	σ	av	σ	av	σ
2B	1	53	15,62	99,14	30,17	152,14	24,89
3A	1	46,85	14,46	74,85	31,02	121,71	35,57
3B	1	42,85	10,31	73,71	18,11	116,57	24,95
2B	2	75	21,69	153,14	42,56	216,71	49,17
3A	2	42,28	5,00	94	31,36	142	34,14
3B	2	43,14	11,40	75,28	25,91	118,42	34,40
2B	4	64,28	40,03	115,85	22,32	174,42	24,11
3A	4	49,42	11,81	78,14	35,87	127,57	33,82
3B	4	36,14	7,82	82,85	20,08	119	23,49
2B	5	56,28	12,26	155,42	38,08	206	45,30
3A	5	44,42	6,86	89,42	27,32	133,85	31,00
3B	5	38,28	9,33	86	22,81	124,28	27,08
3A	6	48,14	11,30	72,28	33,03	120,42	39,35
3B	6	39,42	10,90	81,14	17,96	120,57	27,59
3A	8	39,42	8,63	116,57	32,43	156	39,68
3B	8	37,85	6,57	97,71	13,05	137	14,11
3A	9	63	16,56	130,85	38,62	193,85	42,16
3B	9	58,67	7,49	109	11,67	166,14	17,17

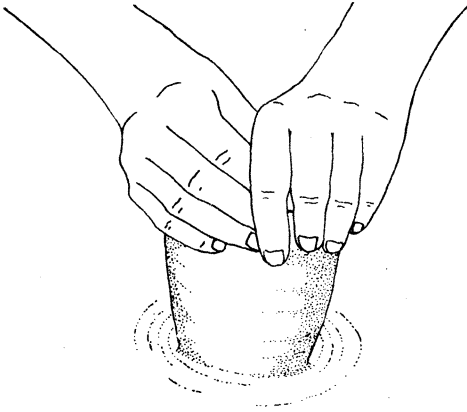
4.3. Thinning and shaping: gestures, number and duration

The potter's gestures were studied on videos which were analysed on the basis of the descriptive grid set out in the course of our preceding study. The description was restricted to that of thinning and shaping gestures: these are the two main fashioning operations. Let us recall that thinning differs from shaping in the pressures applied to the walls, which are stronger and which radically transform the clay after the passing of each gesture. For each container thrown by the potters, a study was done on the number and nature of the gestures used during these fashioning operations. The aim of the study was to examine, firstly, whether the throwing difficulties peculiar to the different vessel shapes come under a set of gestures specific to each pot, and, secondly, whether the practise of each set of gestures is a question of competence.

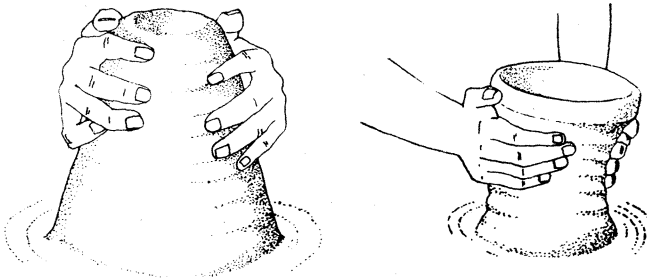
Thinning Operation

An analysis of the gestures revealed that in Haryana and Rajasthan, the thinning of a pot can be done according to five types of two-handed activities:

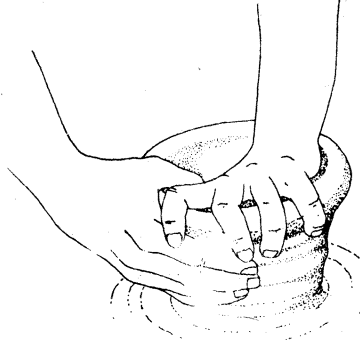
Type A1: Symmetrical bilateral movement. The two hands, equidistant on either side of the axis of rotation of the wheel, simultaneously stretch the clay from the base up to the top by pressing it between the fingers and the thumb (the thumb is placed inside the pot, and the fingers on the outside). The clay rises vertically (vertical displacement of the pressure) in relation to the central axis of the wheel. The fingers exert pressure either on the whole pot (type A1), or on the upper part (type A1a), or on the lower part (type A1b).



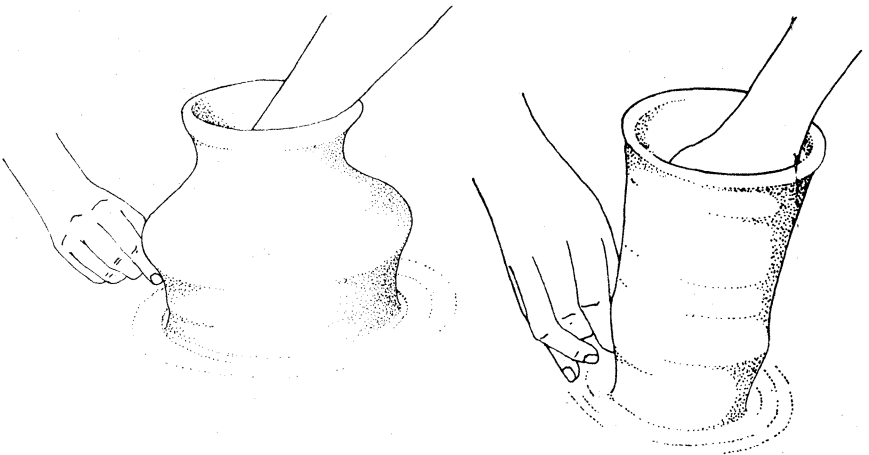
TYPE A2: Symmetrical bilateral movement. The two hands, placed equidistantly on either side of the axis of rotation of the wheel, exert an internal horizontal pressure on the outer face of the cylinder, from the base towards the top. The walls rise up either in a cone (the cylinder is narrowed) (type A2) or vertically (type A2b). The movement A2 may be followed by an opening of the top of the cone with the two fingers which act as claws (type A2a).



TYPE 3: Combined movement of the two hands acting in their respective hemiplanes. The left hand supports the clay and the right hand stretches it vertically from below upwards by pressing it between the fingers and the thumb (type A3). When the role of the hands is inverse, the thinning operation is called type A3a.



TYPE A4: Combined movement of the two hands acting in the right hemiplane of the subject. The index fingers of the right and left hands either flexed or extended exert a combined pressure on either side of the clay wall, on the right of the axis of rotation of the wheel. When the pressure is applied along the entire length of the clay wall, the movement is of type A4. When the pressure is applied only to the upper or lower part, the movement is respectively A4a or A4b.



TYPE A5: Combined movement of the two hands acting in the right hemiplane of the subject. The right palm works on the outer face of the clay wall and exerts a horizontal internal pressure, whereas the index finger of the left hand, either flexed or extended, works on the inner face of the wall and exerts an equivalent pressure, which makes the clay rise vertically.



The different sequences of thinning gestures relating to the type of pot and the group of potters are presented in Table 12. By sequence of gestures, we mean the series of gestures followed to thin the lump of clay. The primary sequences, that is, the sequences used most often regardless of the group of potters or vessel shape, consist of two (depicted in Figure 7). These sequences present variants that essentially consist of the addition of one or two thinning gestures (see Figure 8). The secondary sequences, that is, sequences which are rarely used, are characterized either by the omission of the thinning gesture A2, or by the use of gestures A5 or A2b at the beginning of the sequence.

The description of the gestures used to thin the different vessel shapes reproduced experimentally shows, first of all, that the *sequences of gestures* followed do not present major intra-individual differences relative to the vessel shape. In most cases, the subjects have a preference for one of the two primary sequences of gestures that may be identically repeated for every pot. One of the differences between sequences may consist in changing the first thinning gesture with respect to these three vessel shapes: No. 6, the first thinning gestures are always A1, A2a; Nos. 8 and 9, the first gestures are always A3 and A2a. The other variations observed consist in the addition of thinning gestures in the primary sequences regardless of the vessel shapes. As for inter-individual differences, these are minimal since most of the subjects use the same sequences of gestures with minor variations. Thus, the three groups of potters are not distinguishable with reference to sequence of gestures, which is illustrated by Table 12. This Table shows, for example, that the sequence "A3, A2a, A4" is used to thin containers No.1 as well as No. 9, whether made by potters of stage 2B or stage 3B.

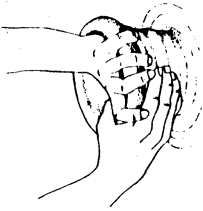

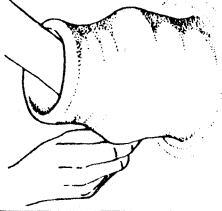
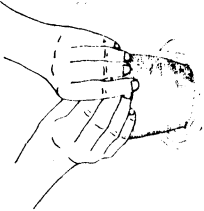

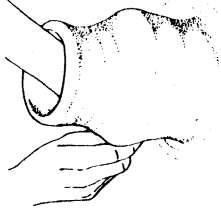
SEQUENCES OF THINNING GESTURES			
A3, A2a, A4			
A1, A2a, A4			

Fig.7 : Primary sequences of thinning gestures used by the potters of Ultram Nagar.

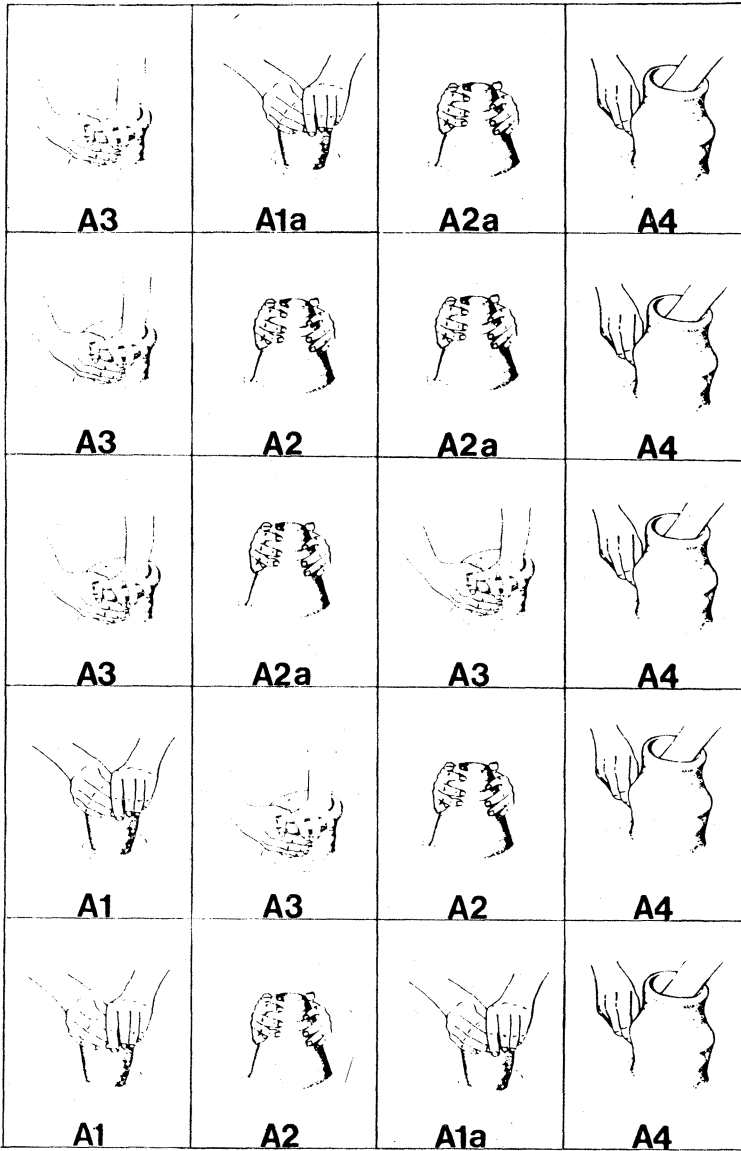


Fig.8 : Main variants of the primary sequences of thinning gestures used by the potters of Uttam Nagar.

Table 12: Frequency of utilization of the sequences of thinning gestures according to the groups of potters and to the shape of containers.

Shapes of containers Groups of potters (n=7)	1			2			4			5			6			8			9			
	2B	3A	3B	2B	3A	3B	2B	3A	3B	2B	3A	3B	2B	3A	3B	2B	3A	3B	2B	3A	3B	
Sequences																						
A3, A2a, A4 (or A4a and/or A4b)	2	3	2	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
idem + A3a or A1a or A4 (a,b)	1	2	-	-	2	-	-	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
A1, A2a, A4 (or A4a and/or A4b)	2	1	3	-	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2	1	3	2
idem + A3a or A1a or A4 or A2b	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A3, A1a, A2a, A4 (or A4a and/or A4b)	-	-	-	1	-	-	2	1	-	1	-	-	1	-	-	-	-	-	-	-	-	-
A3, A2, A2a, A4 or A1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A3, A4, A2a, A4 (or A4a and/or A4b)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A3, A2a, A3, A4b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A1, A3, A2, A4 (or A4a and/or A4b)	-	-	1	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A1, A2, A1a, A4 (or A4a and/or A4b)	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A1, A4, A1a	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
A1, A1, A4, A4b	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
A1, A4, A4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A1, A3, A4, A3a	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
A5, A2a, A4a	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
A5, A1a, A2, A2a, A4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
A2b, A2a, A4b, or A1a	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-

The *number of thinning gestures* (Table 13), i.e. the length of the sequences, is likewise dissociated from pot shape and potter's level of competence. This is evidenced by the fact that intra- or inter-individual variations are minimal.

On the other hand, the *thinning time* (Table 11) decreases proportionate to the potter's level of competence (the most competent potters are the most rapid) and increases with the making of container No.9. The thinning time depends, in fact, on rapidity of execution of movements, taking into account the skill of the potter in controlling his pressures, the size of the lump of clay to be thinned, the shape of the pot, and the diligence of the potter in obtaining regular walls.

These observations are corroborated by the number of gestures executed and the thinning time taken by Har Kishan in the manufacturing of containers numbered 1 through 28 (Table 14). He executed the same number of thinning gestures for Nos.1 and 28, but took twice as much time to make No. 28 because of the amount of clay to be worked. Nos. 19 and 25 required the greatest number of thinning gestures due to their size, both in terms of height and diameter. However, No. 25 was the quickest to be thinned because its ratio H/MD is easier to execute than that of No. 19.

Table 13: Means and standard deviations of the number of thinning and shaping gestures distributed according to the vessel shape and to the stage of competence of potters.

STAGE	N*	Number of thinning gestures		Number of shaping gestures	
		av	σ	av	σ
2B	1	3,28	0,45	7	2,20
3A	1	3,57	0,49	6,71	2,49
3B	1	3,57	0,90	5,57	1,98
2B	2	3,42	0,49	8,14	3,09
3A	2	3,28	0,45	8,85	2,41
3B	2	3,14	0,34	6,42	1,76
2B	4	3,40	0,48	8	3,46
3A	4	3,42	0,49	6,14	3,31
3B	4	3,14	0,34	6,57	2,19
2B	5	3,28	0,45	8,57	1,98
3A	5	3,71	0,69	7,85	2,35
3B	5	3,14	0,34	6,57	2,38
3A	6	4	0,53	5,42	3,11
3B	6	3	0,53	6	1,60
3A	8	3,14	0,34	9	2,61
3B	8	3,14	0,34	7,14	1,12
3A	9	3,42	0,49	9,71	3,61
3B	9	3,71	0,88	8,85	3,09

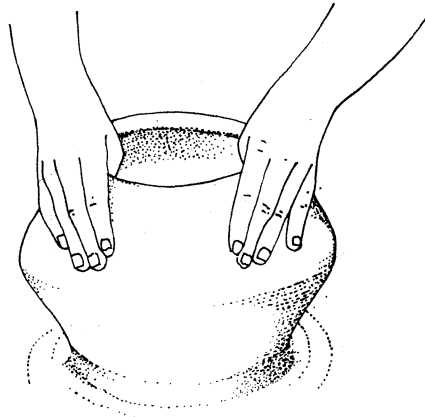
Table 14: Number of thinning and shaping gestures and corresponding time (given in minutes) achieved by Har Kishan for manufacturing the containers comprised between n°1 and 28.

N°	Thinning		Shaping	
	Number	Time	Number	Time
1	5	1,01	3	1,24
2	3	1,09	6	1,56
4	3	0,53	2	1,24
5	3	1	4	1,34
6	4	0,58	5	1,46
8	3	0,46	7	1,33
9	5	1,07	12	2,09
11	4	0,54	7	1,52
12	4	1,04	6	1,55
13	3	1,26	4	1,39
14	4	1,18	12	2,26
15	5	1,22	11	2
16	3	1,11	8	2
17	3	1,05	11	2,50
18	4	1,16	8	2
19	7	2,08	9	3,17
20	5	1,27	9	2,33
21	5	1,39	8	2,46
23	5	1,58	9	2,51
24	5	1,47	9	2,58
25	8	1,46	5	1,52
27	6	1,37	6	1,58
28	5	2,07	3	0,59

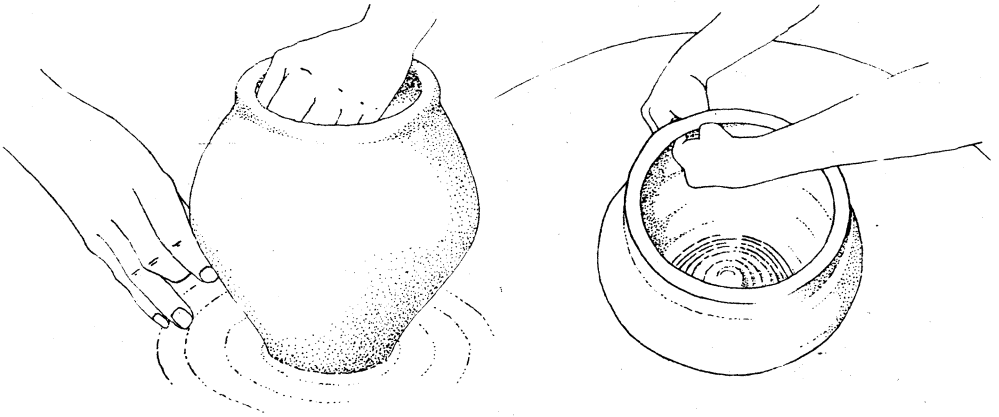
Shaping

Vessel shaping is done by three types of two-handed movements.

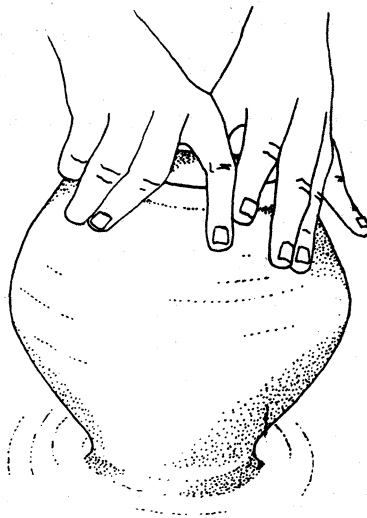
TYPE M1: Symmetrical bilateral movement. The two hands act simultaneously in pinching movements. Pressure is exerted from below upwards with the fingers and the thumb on the upper part of the pot. This movement is used to widen (type M1a) or to narrow (type M1b) the orifice.



TYPE M2: Combined movements of the two hands which act in the right hemiplane of the subject. The index fingers of both hands are either flexed or extended and exert a combined pressure on either side of the clay walls, to the right of the axis of rotation of the wheel. The pressure is continuous and is applied from below upwards or from above downwards, either along the entire length of the walls (type M2a) or to the median part (M2b), or to the lower part (M2c).



TYPE M3: Symmetrical or asymmetrical bilateral movement of the hands. The upper part of the pot is shaped either by the pressure of the fingers and the thumb of both hands which act symmetrically on either side of the axis of rotation of the wheel, or by pressure of the fingers and the thumb of the right hand while the left hand supports the clay.



In contrast to the thinning operation, shaping presents no primary sequence of gestures. The variants are numerous at the intra-individual scale as well as at the inter-individual scale. These differences do not distinguish the groups of potters from one another, and it is clear that the *sequences of gestures* are dissociated from the vessel shape and the level of potter competence. They depend on each individual and on the form taken by the container in the course of throwing. As for the *number of shaping gestures*, this depends on the following:

- Level of competence of the potter, or rather, of the thinning operation and its success with regard to required vessel shape. During the thinning phase, if the shape obtained is close to that desired, the number of shaping gestures will be minimal. In the contrary case, the number will be high.
- Diligence of the potter in finishing a container more or less perfectly.
- Shape of the container and the possibility of obtaining the desired shape at the time of thinning. Thus, containers Nos. 8 and 9 present a large number of shaping gestures due to the ratio H/MD, which cannot be obtained during the thinning operation.

The numerous shaping gestures executed by Har Kishan (Table 14) are essentially due to a concern for perfection. Nos. 27 and 28 present few shaping gestures because they were made under different experimental conditions, when Har Kishan was in a hurry.

The *shaping time* (Table 11) is directly related to the number of shaping gestures, or again to the degree of difficulty of vessel shape, and the degree of competence and diligence of the potter.

From this analysis of the gestures involved in the thinning and shaping operations, it is apparent firstly, that the gestures do not vary in relation to pot shape and, secondly, that levels of competence are not distinguishable from this point of view. This observation indicates not only the existence of a set of gestures specific to the potters of Haryana and Rajasthan, but also indicates that the throwing difficulties of a vessel shape do not arise from the sequence of gestures or the type of gesture to be executed. Rather, these difficulties are actually the application of pressures to the clay, whose control is more or less problematical depending on the shape of the pot desired and the degree of plasticity of the clay. This point is important because the mastery of pressures is a sensorimotor ability whose acquisition may be presupposed as an individual aptitude, independent of cultural context. The throwing difficulties perceived by the Indian potters would correspond, therefore, to the difficulties caused strictly by the practise of motor activities with regard to the constraints of the clay, whose force varies according to the shape of the pot.

To study to what extent the acquisition of the pressures required in throwing different pot forms depends on individual capability rather than cultural context, we examined the dimensions of the experimental production after the thinning and shaping operations respectively.

To obtain these dimensions, we studied the video films, stopping them after each thinning and shaping operation executed by a potter, to make a tracing

of the lump of clay on the video screen. Thus the design of every container was obtained at each phase of its making (Figures 9 and 10). The films had been shot according to a horizontal stabilizer, which permitted us to calculate the scale of each pot by reference to the known dimensions of Har Kishan's wheel (91 cm in diameter).

These aspects were studied:

- Vessel measurements after thinning;
- Margin between these measurements and measurements of containers after shaping.

In both cases, the study was carried out with the measurements recorded from the video screen. The dimensions retained were: height, maximum diameter, and orifice. The base was not considered because it is determined at the time of hollowing the lump, and its width does not vary during the course of subsequent fashioning operations.

Table 15 presents the means of the measurements of the thinned containers, listed according to pot shape and potter's stage of competence.

Table 15: Means and standard deviations of the dimensions, noted from the TV screen and given in centimetres, of thinned restricted vessels distributed according to the shape and the stage of competence of the potters.

STAGE	N' (n=7)	HEIGHT		DIAMETER		ORIFICE	
		av	σ	av	σ	av	σ
2B	1	20,77	1,72	12,78	0,76	10,68	0,90
2B	2	22,72	1,81	15,32	0,64	11,78	0,85
2B	4	18,70	1,20	12,93	0,77	9,33	0,73
2B	5	21,53	1,35	14,93	0,90	10,60	0,98
3A	1	21,16	1,28	13,11	0,65	10,03	0,69
3A	2	23,4	1,28	16,19	1,37	12,36	1,72
3A	4	19,47	1,84	12,70	0,81	8,55	1,72
3A	5	22,56	1,86	16,49	1,84	10,90	1,34
3A	6	17,97	1,46	13,68	4,18	7,50	1,93
3A	8	23,17	1,17	18,70	1,53	12,07	1,01
3A	9	25,67	2,04	24,25	2,02	16,82	2,09
3B	1	21,82	1,35	12,99	1,89	10,39	0,91
3B	2	23,13	2,03	17,67	1,16	12,65	1,27
3B	4	20,19	2,84	13,51	2,03	9,82	0,94
3B	5	22,03	0,99	15,72	1,55	11,06	1,19
3B	6	17,78	0,94	10,76	0,67	9,35	0,68
3B	8	22,63	1,04	20,27	1,54	12,62	0,73
3B	9	25,31	3,20	27,04	1,97	16,70	2,51

Two points are discernible:

- Measurements of the various vessel shapes present values comparable from one group of potters to another. Only the values of containers Nos. 8 and 9 of group 3B have a tendency to be higher than those of groups 3A and 2B.

- 1
- - 2
- . - 3

SCALE : 1/1,8

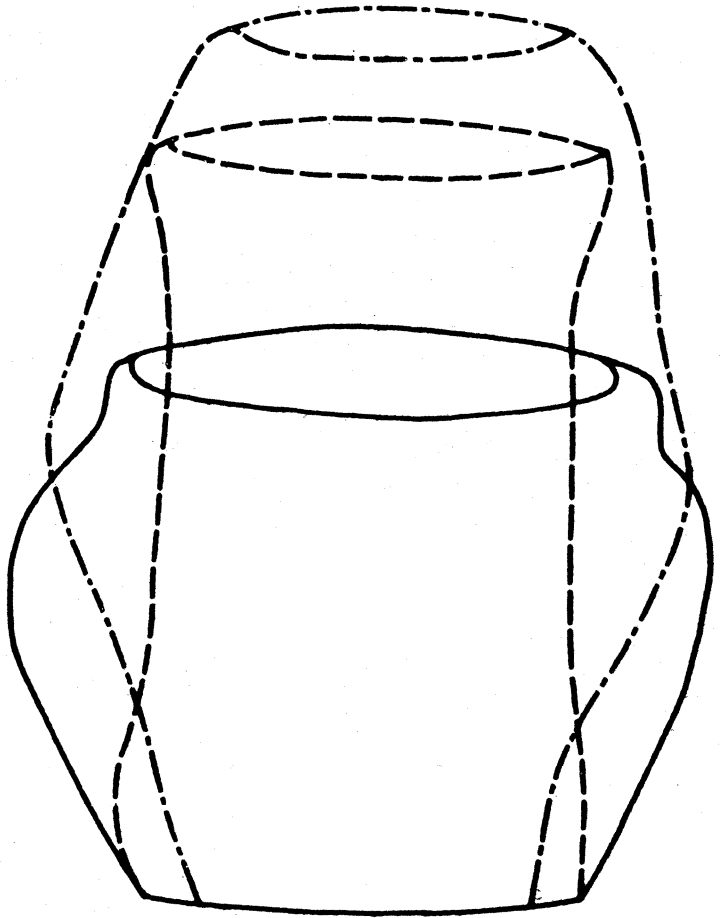


Fig.9: Shapes that the lump of clay takes after each thinning gestures

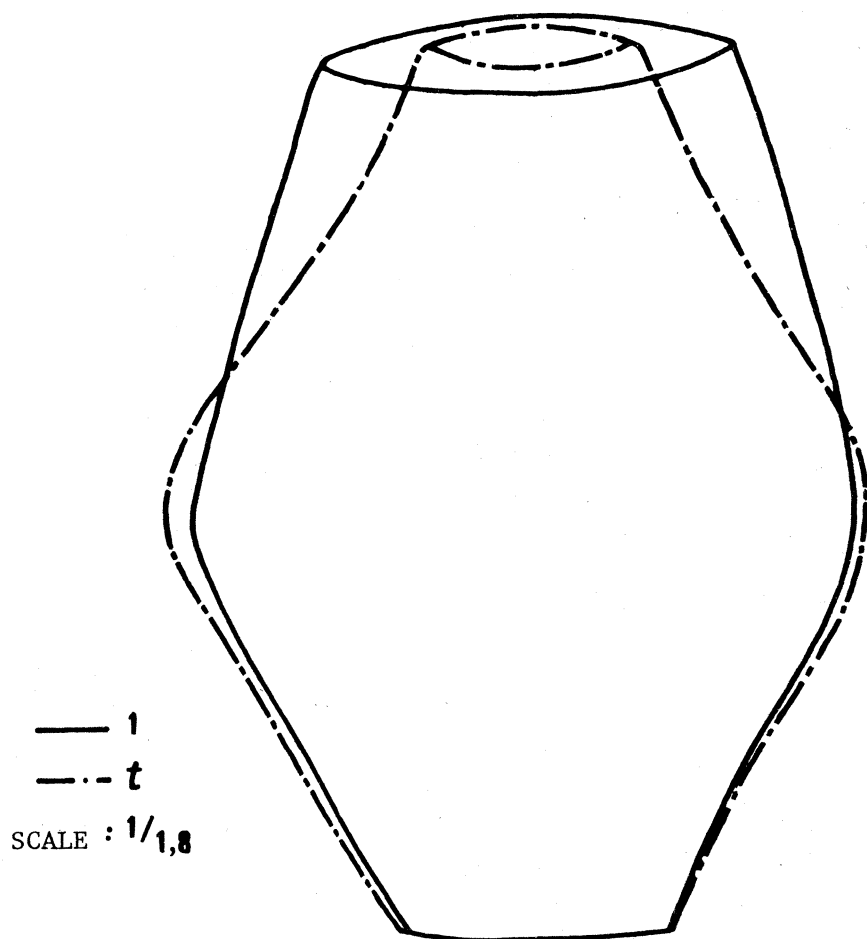


Fig.10: Shapes that the lump of clay takes after the first and the last shaping gestures.

- These measurements vary from one vessel shape to another for the same proportions in the three groups of potters. Thus, the height decreases regularly according to the order of the following containers:

Nos. 2, 5, 1, 4 (for groups 2B, 3A, 3B);

Nos. 9, 8, 6 (for groups 3A and 3B).

The diameter decreases regularly according to the order of the following containers:

Nos. 2 and 5, 1 and 4 (for groups 2B, 3A, 3B);

Nos. 9, 8, 6 (for groups 3A and 3B).

The orifice likewise decreases according to the following containers:

Nos. 2, 5 and 1, 4 (for groups 2B, 3A, 3B);

Nos. 9, 8, 6 (for groups 3A and 3B).

Thus the measurements of the containers after the thinning operation do not enable us to differentiate the three groups of potters. It was seen earlier that the sequences of gestures executed during this throwing phase were standardized. Pressures on the clay are standardized as well.

Table 16 presents the means of the square of the differences between the measurements of the thinned pots and those of the shaped pots. Analysis relative to the measurements obtained after thinning revealed three points:

- Values of the height of the various pot types varied among the potter groups according to the stage of competence.
- Values of the diameter of the various pot types also varied among the potter groups according to the stage of competence, except for containers Nos. 5 and 6. Variation in the diameters of containers Nos. 8 and 9, from stage 3A to stage 3B was expected since the thinned vessel measurements noted for each of these two groups differed.
- Values of the orifice of the various pot types varied among the potter groups according to the stage of competence, except for container No. 1.

A comparison of the productions obtained during the thinning and shaping operations reveals the form of the acquisition of control of the pressures required in throwing different vessel shapes. It is during the shaping, and not during the thinning operation, that the final shape of the container is given, and hence the potter's competence assessed. Yet during this operation the sequences of gestures are not standardized and the pressures applied to the clay are weak, i.e., not perceptible to the naked eye. This implies that the subject acquires the control of application of pressures neither by repetition of gestures, nor by visual observation. The development of the sensorimotor skills essential to the control of pressures takes place through trial and error during the course of apprenticeship according to idiosyncratic paths, i.e. individual experience. Therefore, the following hypothesis may be posited: the perception of throwing difficulties by Indian potters is not defined by a specific mode of throwing, but by the constraints of different forces present in biomechanical terms (physiology and mechanics of the human body) and physical terms (constraints imposed by the clay). It is quite likely that the difficulties entailed by the acquisition of the motor skills associated with these constraints are transcultural. These difficulties are indicated by the shape of the containers. The taxonomy may, consequently, present a transcultural character.

Table 16: Means and standard deviations of the square of the margins between the measurements of the thinned and shaped restricted vessels, noted from the TV screen and given in centimeters, distributed according to the shape and the stage of competence of the potters.

STAGE	N' (n=7)	HEIGHT		DIAMETER		ORIFICE	
		av	σ	av	σ	av	σ
2B	1	0,74	0,94	1,39	1,62	1,99	2,77
2B	2	1,58	1,64	10,96	8,19	8,45	5,24
2B	4	1,98	1,38	2,32	3,53	6,62	4,55
2B	5	2,24	2,24	5,87	2,48	1,95	3,55
3A	1	0,57	0,60	0,87	1,15	1,21	1,00
3A	2	0,58	0,68	14,32	16,50	7,88	7,21
3A	4	1,69	1,49	2,07	2,43	8,15	7,44
3A	5	1,39	1,20	4,84	4,33	6,20	6,68
3A	6	3,82	4,11	0,76	0,66	14,08	10,04
3A	8	3,15	3,68	15,19	10,25	10,89	7,79
3A	9	3,19	5,37	63,99	43,78	18,95	18,62
3B	1	0,20	0,23	1,35	2,37	1,41	1,65
3B	2	1,60	1,66	4,87	4,81	3,05	5,04
3B	4	4,04	7,43	5,08	5,98	15,65	0,41
3B	5	0,18	0,22	5,94	6,45	9,01	8,73
3B	6	6,26	4,71	0,45	0,42	23,22	8,75
3B	8	2,79	3,24	11,51	10,35	15,00	9,74
3B	9	5,91	9,25	53,21	33,34	29,03	25,82

4.4 Conclusion

The results presented by the vessel measurements as well as the total throwing time and the number of shaping gestures, enable us to consider the proposed techno-morphological taxonomy as founded. Not only do these results attest to the existence of the throwing difficulties indicated during the oral survey, but furthermore distinguish between the potters' different levels of competence on the basis of these difficulties.

The interpretation of the taxonomy is, by construction, univocal within the given corpus, but only within this corpus. Now we had to assess its validity for application to other ceramic corpus. An analysis of the gestures permitted us to suppose that the taxonomy has a strong possibility of presenting a transcultural value, since the throwing difficulties on which the taxonomy is based fall under mechanical constraints, which are dissociated from the socio-cultural factor. To study the validity of this hypothesis, an investigation was conducted with French potters.

5. EVALUATION BY FRENCH POTTERS

Professional potters, capable of evaluating the techno-morphological taxonomy established earlier, were needed. This led us to Cluny (Burgundy) where

several pottery workshops have been established. Kick wheels and mechanized wheels are used here. The morphological series was first scrutinized by these potters, who were then requested to classify the various containers in ascending order of throwing difficulty. Next, they were questioned about the reasons given to justify this classification and, the validity of the reasons given by the Indian potters.

5.1. Measures of throwing difficulties

The French potters considered the explanations of the throwing difficulties given by the Indian potters correct. Their own, more rationalized perceptions of the problems made a synthesis possible. According to them, the wheel-throwing difficulty of a pot is assessed against the following factors.

1) *Weight of clay above the maximum diameter.* This weight may be relatively estimated on the basis of (a) the distance between the tangents at the maximum diameter and the tangents at the points of the base and the orifice, and (b) the distance between the maximum diameter and the orifice. An increase in weight of clay above the maximum diameter corresponds to an increase in both distances. This factor implies that all pots with a maximum diameter in the lower part of the body are more difficult to throw than pots with a maximum diameter located in the upper part. It further implies a correspondence between the difficulty in throwing a pot and its size, and the fact that a container such as No. 19 is particularly difficult to throw on a wheel.

2) *Quantity of clay to throw.* This determines the throwing difficulty of pots because its increase requires an ever-increasing mastery of the clay. Few potters would be capable of centring more than 6 kg of clay. This factor permits us to differentiate pots that are not distinguished by the criterion "weight of clay above the maximum diameter". It also explains why containers with a base 25-cm wide, or an orifice wider than 40 cm, present problems at the time of throwing. In both cases, the problem is to master an ever-increasing quantity of clay, which has a greater tendency towards deformation because the centrifugal force increases with augmentation of the distance between the walls of the vessel and the axis of rotation of the wheel.

3) *Height.* Clay is a soft material which has a tendency to collapse. Height is therefore an important variable in the assessment of the throwing difficulties of a container.

4) *Base.* If the base is too narrow, a problem of balance arises, which is illustrated by container No. 6. The potters of Cluny considered this pot an aberrant case.

5) *Presence of carination.* In this case, there is a point of juncture at which two forces are exerted: the force of gravity which tends to slump the lower part towards the outside and the force which tends to slump the upper part by dragging the point of juncture towards the inside. For this point of juncture to be resistive, the clay must be sufficiently thick. Continuous body pots are easier to make because they present no point of rupture.

5.2. Techno-morphological taxonomy

The French potters considered it justifiable to distinguish classes within groups of restricted containers of the same height, and unrestricted containers of the same orifice.

For the restricted containers, they considered the definitions of the six techno-morphological classes significant. According to them, these classes mark out different degrees of difficulty with respect to weight of clay to throw, and weight of clay to balance above the maximum diameter. The ratio of diameter to height corresponds to the problem of weight of clay to throw, while the ratios BA/MD and OR/MD correspond to weight of clay to balance. We obtained this assessment of the value of the techno-morphological classes by requesting the potters to point out, among the 20-cm high containers, those forms that marked transition from one level of difficulty to another. The replies yielded this order: containers Nos. 1, 5, 7 and 9.

Nos. 2 and 3 were grouped with No. 1. These three containers were thus regarded on the one hand as equal in throwing difficulties and on the other hand as the easiest in the series to be thrown. In our taxonomy, these three containers belong to the same class, class I. This class is representative of the pots that are the easiest to throw. It is characterized by a maximum diameter less than or equal to the height, and relative dimensions with high indexes.

No. 4 was grouped with No. 5. No. 6, considered an aberrant case, was nevertheless placed immediately after No. 5. In terms of manufacturing difficulties, these three containers come after No. 1. In our taxonomy, they belong to the same class, class II, which is distinguished from class I on the basis of relative dimensions that are more difficult to execute.

No. 7 was considered definitely more difficult than No. 5. This container belongs to class III, which is distinguished from the two preceding classes on the basis of ratio between maximum diameter and height: here, the maximum diameter is between once and twice the height. However, No. 8 was not considered more difficult than No. 7, whereas, in our taxonomy, it belongs to a different class, class IV. The classes III and IV are differentiated on the basis of indexes presented by relative dimensions. The thresholds of classification retained are arbitrary. Therefore, it is not surprising that containers Nos. 7 and 8 were not considered distinctly different because the indexes of their ratios BA/MD are 0.50 and 0.34 respectively. The index 0.50 represents the threshold of differentiation; No. 7 is therefore a borderline case between classes III and IV.

No. 9 was considered definitely more difficult than Nos. 7 and 8. It belongs to class V, which is differentiated from the others on the basis of a maximum diameter that is greater than or equal to twice the height.

The throwing difficulties of container No. 10, contrarily, were not assessed as particularly greater than those of No. 9. Vessel No. 10 belongs to class VI, which is distinguished from class V on the basis of the index of relative dimensions. Like Nos. 7 and 8, Nos. 9 and 10 present relative dimensions whose indexes are too close to the thresholds we have defined to be distinctly

differentiated from one another (their ratios BA/MD present the indexes 0.55 and 0.45 respectively).

According to the same procedure, the classes of unrestricted containers were considered significant, as was the general classification, i.e., the organization of classes relative to size and type of container (restricted/unrestricted).

The classification of the morphological series proposed by the French potters thus parallels that defined by the Indian potters. The plausibility of our hypothesis is reinforced, namely that the different degrees of difficulty according to which the containers are arranged, come under *mechanical constraints* which are more or less easy to master according to the vessel shape, regardless of the cultural context of the potter.

5.3. Technical gestures

According to the oral survey, it seems that the observations made in India are of general value. Whatever the set of gestures followed, the gestures and their sequences do not vary relative to the vessel shapes. These shapes are achieved through the application of pressures on the clay, and their throwing difficulties are assignable to mechanical constraints presented by the clay, irrespective of the nature of the gestures to be executed.

5.4. Type of wheel

The Indian and French potters work on different types of wheel—the stick and the kick wheel.¹ Yet, the explanations of wheel-throwing difficulties given by these two groups of potters are identical. These difficulties do not vary, therefore, with respect to type of wheel; this is not surprising since the speed

¹In Asia, these two types are distributed to the West and East of the Indus Valley respectively (for the kick wheel, see Rye and Evans, 1976; for the stick wheel, see Saraswati, 1978 and Saraswati and Behura, 1966). Two features differentiate these types of wheels:

1) The speed of the revolving table (the wheel head) of the kick wheel is maintained by activation of the flywheel, which is operated by the foot. Contrarily, the wheel of a stick wheel is spun by means of a stick, with the wheel mounted on a pivot; since the speed of the wheel is constantly diminishing from the moment propulsion ceases, this necessitates frequent interruptions of work to re-start the wheel. Continuous maintenance of wheel speed by means of the foot is a definite advantage as it eliminates interruptions in throwing.

2) On cessation of movement, the revolving table of the kick wheel presents a work surface that is horizontal and stable, while the wheel of a stick wheel presents an oblique, unstable surface. A stick wheel mounted on a tripod is a recent technical innovation, whereby the wheel remains horizontal when motionless. The major advantage of a stable work surface is apparent when throwing large-sized vessels. With a wheel mounted on a pivot, it is difficult to raise high walls, whether at one go or by successive addition of coils. In the first case, the walls are distorted when they reach a height of about 35 cm. Such a height requires strong thinning pressures, which retard wheel speed. Pressures are thus exerted on a pot that turns irregularly or on walls that whirl. In Orissa, it was only after the introduction of the tripod wheel that potters began to throw pots higher than 35 cm. If the walls are raised through the successive addition of coils, which are then thrown by means of centrifugal force (e.g., throwing of jars in Pakistan; Rye and Evans, 1976), a problem of equilibrium arises because the stick wheel, upon stopping or when in slow motion, is not in a horizontal but an inclined position. Indian potters obtain large-sized pots by throwing rough models whose dimensions are then increased through the beating (padding) technique.

of the wheel is adjustable, whatever the type. This observation implies that our taxonomy may be applied to all wheel-thrown ceramic assemblages, regardless of the type of wheel used and, therefore, independent of its identification.

6. CONCLUSIONS

At the end of this study, it appears that (a) the proposed taxonomy is founded on measurements that express throwing difficulties related to biomechanical and physical constraints, independent of a local or individual set of gestures, and (b) Indian and French potters perceive these constraints and the related throwing difficulties in a similar manner. Now, the following aspects need to be investigated:

- a) To what extent are the problems of acquisition of the motor skills required for making various vessel shapes not affected by cultural context.
- b) To what extent does the common perception of the Indian and French potters correspond to a formal invariance of functioning, i.e. to an identical treatment of constraints at the perceptive level, independent of the socio-cultural context. Could the Indian and French perceptions be considered representative of any *Homo sapiens sapiens*' perceptions?

After such studies, the taxonomy could be considered transcultural from the two points of view it seeks to transcribe: competence (the requisite sensorimotor skills) and performance (perception of the throwing difficulties). Meanwhile, the hypothesis of a transcultural taxonomy is plausible because based on an experiment conducted in two different cultural milieus. Thus this taxonomy enables us to realize the objectives set forth in the introduction.

One objective was to define a threshold beyond which the wheel-throwing technique could be considered mastered and, consequently, pottery activity as specialized. To define this threshold, reference may be made to both oral data and the techno-morphological taxonomy. According to the former, the wheel-throwing technique is considered completely acquired with the throwing of 30-cm high restricted pots and 40-cm orifice unrestricted pots. Consequently, and with reference to our taxonomy (Figure 6), the following division is proposed:

- Assemblages consisting of pieces belonging to classes comprising I-20 to I-30, i.e. 20-cm to 30-cm high restricted pots from classes I to IV (Nos. 1 to 8), 30-cm high restricted pots from class I (Nos. 11 to 13), and finally the 20-, 30-, 40-cm orifice unrestricted pots from classes VII, VIII, IX and X (Nos. 30 to 40). These may be considered the work of craftsmen in the course of mastering the wheel-throwing technique. The interpretation of their socio-economic status requires criteria other than that of the ceramic-fashioning technique.
- Assemblages consisting of numerous pieces belonging to classes comprising I-30 to V-30, i.e., any piece more difficult to make than those mentioned above. These may be considered the work of craftsmen who have mastered the wheel-throwing technique and are therefore specialized.

- Finally, assemblages consisting of intermediate pieces, for example, most pieces belonging to classes comprising I-20 to I-30, and simultaneously some pieces belonging to classes comprising I-30 to V-30. These are of non-decisive value for inferring the competence of potters and therefore of pottery specialization. For these assemblages, it is necessary to refer to other descriptive criteria such as the standardization or regularity of wall fashioning to define the degree of mastery of the wheel-throwing technique.

To realize the other objectives, archaeological material ought now to be analysed according to the techno-morphological taxonomy and the oral data on apprenticeship. In a perspective analysis of the genesis of the wheel-throwing technique, it is important to keep in mind, for example, the difficulties inherent in a change in vessel shape in terms of development of new sensorimotor skills. To illustrate: on his arrival in Delhi, Har Kishan knew only how to throw rough models meant to be beaten. It took him several months to learn how to throw flower pots in the required dimensions, i.e., with 1-cm thick regular walls, even though this type of container is considered easy to throw.

The archaeological data of the Indus Valley (Casal, 1964) or of Mesopotamia (Van der Leeuw, pers. comm.) seem to show that the process of integration of the wheel-throwing technique into the socio-economic systems was slow. The first containers which present a throwing technique look as though they were made on a tournette. They are small and the throwing is crude. In the sequence of Amri (Casal, 1964), containers thrown on a fast wheel seem to replace them, and their size as well as their shape complexity to increase through the centuries. This picture, though succinct, gives rise to many questions: What was the role of the socio-economic milieu in this evolution? What was the role of the difficulties caused by the genesis of the technique itself? What was the spatial and temporal diffusion of this technique? And so forth. So many of the questions we posed in the introduction can be answered not only by an analysis of the ceramic techno-morphological evolution through space and time, but also by a study of the correlations between this evolution and the corresponding techno-economic and socio-demographic systems. These correlations would be all the more significant as precise measurements, similar to the one elaborated here, will enable us to describe the evolution of these other fields in an equally detailed manner.

In conclusion, it may be said that an analysis of the technical know-how and its transmission is a particularly fecund approach to the problems posed by the introduction of a new technique, the conditions underlying its evolution, and its maintenance or regression. Such an approach is particularly fruitful since the interpretation is given with reference to ethnographic analyses of material facts. These analyses enable us to highlight analogies between ethnographic and archaeological facts, and to define the context in which the interpretation of the first can be transferred to the second. In our study, ethnoarchaeology and experimental archaeology joined hands in the field not only to elicit a better understanding of the material facts, but also to collect data which enable us to verify the validity of our interpretative propositions.

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