For the Pottery and for the Potters: an Ergonomic Approach to Pottery Production in Italy (8th–1st Century BC)

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Spatial analysis has been applied in different forms to pre-Roman pottery production in Italy as well as in the whole Mediterranean for the same period (8th–2nd century BC).[1] The dynamics of interaction between craftsmen and productive structures can only be partially detected in the archaeological record, which has hence often been supplemented with ethnological parallels.[2]

The present contribution provides a methodological focus and discusses the possibility to reshape the spatial analysis of pottery production within the methodological frame of ergonomics, the discipline studying the relationships between worker and working space in the dynamic of workflow.[3]

Ergonomics offers a suitable set of methodological tools to understand the impact of social and political systems on the balance between workers' needs and the workshops' productivity and to build a general model to compare different workshops and production systems. In approaching ancient pottery production contexts, we are dealing with paraergonomics or intuitive protoergonomics.[4]

Ergonomic categories have already been intuitively applied by archaeologists to pre-Roman production: e.g. Ninina Cuomo di Caprio has pointed out that the variations within a standard range in the dimensions of *praefurnia* of the Hellenistic kilns of Morgantina are a compromise between functional needs, the space available for their construction and the expertise and knowledge of the potters.[5]

In this article, I will establish some parameters to rationalize an ergonomic approach to the archaeological dataset and make it suitable for comparative analyses. Ergonomics has an evaluative function, which analyzes the human factor in the spatial organization of the workflow, and a proactive function, which aims to improve the efficiency of the production system and the workers' quality of life. The analytic function will be tested here in a case study of an Archaic Etruscan pottery workshop in Florence, while the proactive function will be presented as a potential of the archaeological modelling.

Ergonomic Analysis

An ergonomic evaluation in pre-Roman pottery production can be conducted on three levels[6] of the workflow[7]:

a. Spatial and dimensional relationships within a single task of production;
b. Spatial organization of work and workshop-layout;
c. Community ergonomics of a workshop embedded in a production and social system.[8]

Published in: Nadin Burkhardt – Robinson Peter Krämer (Eds.), Organizations of Production and Crafts in Pre-Roman Italy, Panel 3.7, Archaeology and Economy in the Ancient World 11 (Heidelberg, Propylaeum 2022) 31–45.
DOI: *https://doi.org/10.11588/propylaeum.873.c11381*

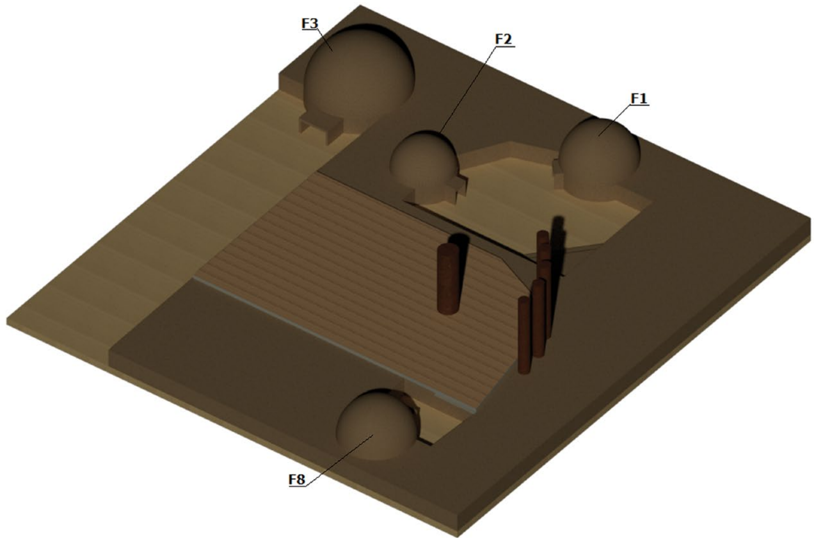
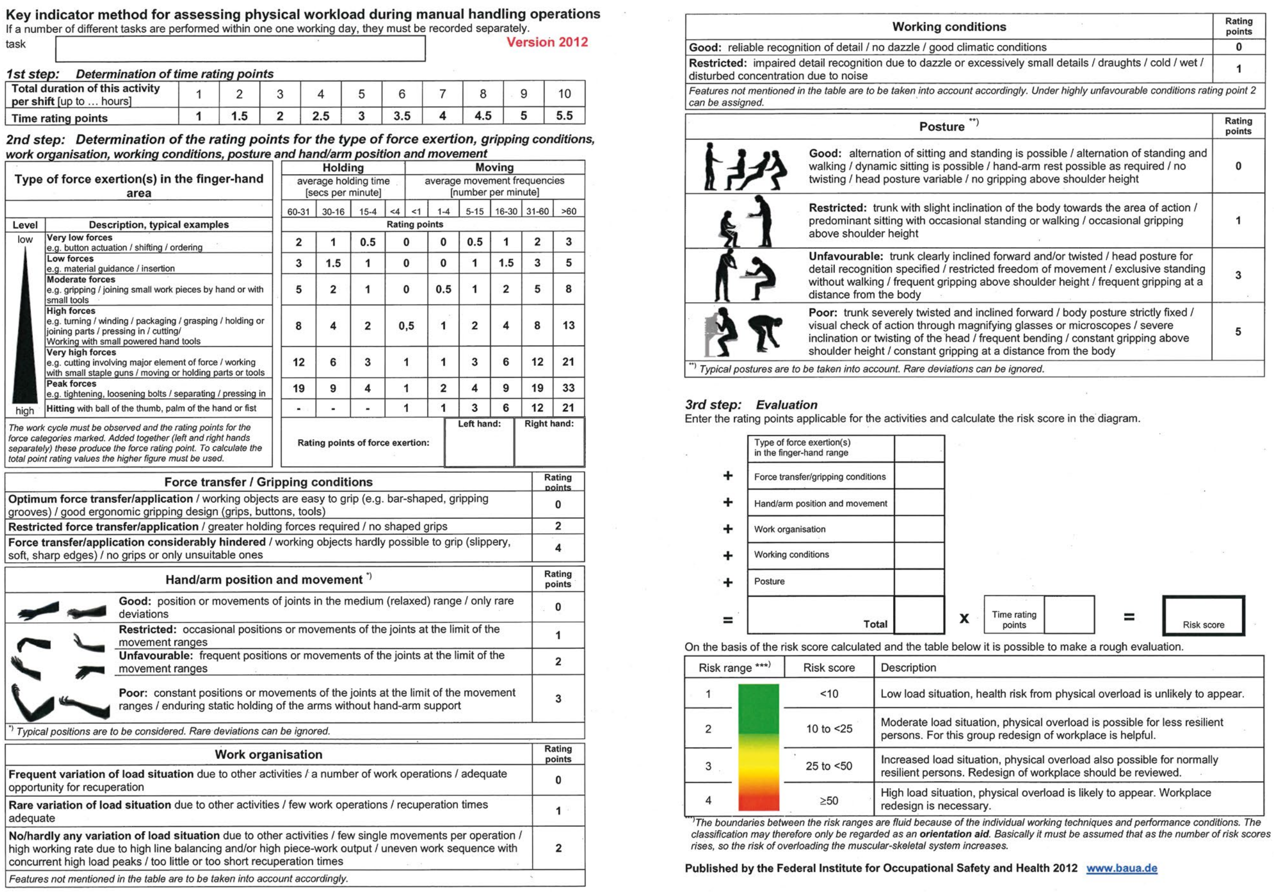


Fig. 1: Pottery Workshop of Florence, via Nazionale, cinema Apollo: reconstruction of the last phase in AutoDesk AutoCAD-Architecture.

The possibility of applying complex ergonomic analyses depends on the conditions of preservation of the ancient contexts. The available sources for the first level of ergonomic analysis in pre-Roman Italy are mostly kilns and more seldom working areas for the potters' work and basins for clay preparation (attestation level 1). The sources for the second level are workshops with attestations of many phases of production (Attestation level 2). The sources for the third level are workshops, which can be plausibly linked to an urban context or a commodity chain (Attestation level 3). The dataset of pre-Roman workshops presents an unbalanced distribution of the attestation layers, with many isolated or single kilns, few workshops with at least partial operational sequences and very few cases of topographic entanglement of the workshops, most of them located in Magna Graecia and in Etruria.[9] As a pilot test, an ergonomic evaluation of the Archaic pottery workshop of Florence, via Nazionale, Cinema Apollo[10] (fig. 1) has been conducted through a Hierarchical Task Analysis (HTA)[11]. A structured heuristic Ergonomic Evaluation of the complex tasks of pottery production has been indicated with a multi-aspect physical load assessment method, the KIM (Key Indicator Method for manual handling operations), which takes into account posture-based and bio-mechanics analysis, allowing the evaluation of static and dynamic ergonomics (fig. 2).[12]

Ergonomics of the Firing Process (fig. 3–4)

The ergonomic evaluation of the firing process is suitable for all layers of attestation, since single kilns can be isolated or be part of a workshop, and deals with immediate risk of injury, as well as long-term health risks.



Key indicator method for assessing physical workload during manual handling operations

If a number of different tasks are performed within one one working day, they must be recorded separately.

task

Version 2012

1st step:* *Determination of time rating points

Total duration of this activity per shift [up to … hours]	1	2	3	4	5	6	7	8	9	10
Time rating points	**1**	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**	**4.5**	**5**	**5.5**

2nd step:* *Determination of the rating points for the type of force exertion, gripping conditions, work organisation, working conditions, posture and hand/arm position and movement

Type of force exertion(s) in the finger-hand area		**Holding** average holding time [secs per minute]				**Moving** average movement frequencies [number per minute]				
		60-31	30-16	15-4	<4 / <1	1-4	5-15	16-30	31-60	>60
Level	**Description, typical examples**	**Rating points**								
low	**Very low forces** e.g. button actuation / shifting / ordering	**2**	**1**	**0.5**	**0**	**0**	**0.5**	**1**	**2**	**3**
	Low forces e.g. material guidance / insertion	**3**	**1.5**	**1**	**0**	**0**	**1**	**1.5**	**3**	**5**
	Moderate forces e.g. gripping / joining small work pieces by hand or with small tools	**5**	**2**	**1**	**0**	**0.5**	**1**	**2**	**5**	**8**
	High forces e.g. turning / winding / packaging / grasping / holding or joining parts / pressing in / cutting/ Working with small powered hand tools	**8**	**4**	**2**	**0,5**	**1**	**2**	**4**	**8**	**13**
	Very high forces e.g. cutting involving major element of force / working with small staple guns / moving or holding parts or tools	**12**	**6**	**3**	**1**	**1**	**3**	**6**	**12**	**21**
	Peak forces e.g. tightening, loosening bolts / separating / pressing in	**19**	**9**	**4**	**1**	**2**	**4**	**9**	**19**	**33**
high	**Hitting** with ball of the thumb, palm of the hand or fist	**-**	**-**	**-**	**1**	**1**	**3**	**6**	**12**	**21**

The work cycle must be observed and the rating points for the force categories marked. Added together (left and right hands separately) these produce the force rating point. To calculate the total point rating values the higher figure must be used.

Rating points of force exertion: **Left hand:** **Right hand:**

Force transfer / Gripping conditions	**Rating points**
Optimum force transfer/application / working objects are easy to grip (e.g. bar-shaped, gripping grooves) / good ergonomic gripping design (grips, buttons, tools)	**0**
Restricted force transfer/application / greater holding forces required / no shaped grips	**2**
Force transfer/application considerably hindered / working objects hardly possible to grip (slippery, soft, sharp edges) / no grips or only unsuitable ones	**4**

Hand/arm position and movement *)	**Rating points**
Good: position or movements of joints in the medium (relaxed) range / only rare deviations	**0**
Restricted: occasional positions or movements of the joints at the limit of the movement ranges	**1**
Unfavourable: frequent positions or movements of the joints at the limit of the movement ranges	**2**
Poor: constant positions or movements of the joints at the limit of the movement ranges / enduring static holding of the arms without hand-arm support	**3**

*) *Typical positions are to be considered. Rare deviations can be ignored.*

Work organisation	**Rating points**
Frequent variation of load situation due to other activities / a number of work operations / adequate opportunity for recuperation	**0**
Rare variation of load situation due to other activities / few work operations / recuperation times adequate	**1**
No/hardly any variation of load situation due to other activities / few single movements per operation / high working rate due to high line balancing and/or high piece-work output / uneven work sequence with concurrent high load peaks / too little or too short recuperation times	**2**

Features not mentioned in the table are to be taken into account accordingly.

Working conditions	**Rating points**
Good: reliable recognition of detail / no dazzle / good climatic conditions	**0**
Restricted: impaired detail recognition due to dazzle or excessively small details / draughts / cold / wet / disturbed concentration due to noise	**1**

Features not mentioned in the table are to be taken into account accordingly. Under highly unfavourable conditions rating point 2 can be assigned.

Posture **)	**Rating points**
Good: alternation of sitting and standing is possible / alternation of standing and walking / dynamic sitting is possible / hand-arm rest possible as required / no twisting / head posture variable / no gripping above shoulder height	**0**
Restricted: trunk with slight inclination of the body towards the area of action / predominant sitting with occasional standing or walking / occasional gripping above shoulder height	**1**
Unfavourable: trunk clearly inclined forward and/or twisted / head posture for detail recognition specified / restricted freedom of movement / exclusive standing without walking / frequent gripping above shoulder height / frequent gripping at a distance from the body	**3**
Poor: trunk severely twisted and inclined forward / body posture strictly fixed / visual check of action through magnifying glasses or microscopes / severe inclination or twisting of the head / frequent bending / constant gripping above shoulder height / constant gripping at a distance from the body	**5**

**) *Typical postures are to be taken into account. Rare deviations can be ignored.*

3rd step:* *Evaluation

Enter the rating points applicable for the activities and calculate the risk score in the diagram.

	Type of force exertion(s) in the finger-hand range	
+	Force transfer/gripping conditions	
+	Hand/arm position and movement	
+	Work organisation	
+	Working conditions	
+	Posture	
=	**Total**	

x Time rating points = Risk score

On the basis of the risk score calculated and the table below it is possible to make a rough evaluation.

Risk range ***)	Risk score	Description
1	<10	Low load situation, health risk from physical overload is unlikely to appear.
2	10 to <25	Moderate load situation, physical overload is possible for less resilient persons. For this group redesign of workplace is helpful.
3	25 to <50	Increased load situation, physical overload also possible for normally resilient persons. Redesign of workplace should be reviewed.
4	≥50	High load situation, physical overload is likely to appear. Workplace redesign is necessary.

***) *The boundaries between the risk ranges are fluid because of the individual working techniques and performance conditions. The classification may therefore only be regarded as an **orientation aid**. Basically it must be assumed that as the number of risk scores rises, so the risk of overloading the muscular-skeletal system increases.*

Published by the Federal Institute for Occupational Safety and Health 2012 www.baua.de

Fig. 2: Interactive Worksheet for KIM calculation (version 2012).

The immediate risk depends on different factors: the possibility of crushing injuries caused by a kiln collapsing due to defective construction; the inhalation of toxic products, due to the materials used or an imperfect firing process; the risks of serious flash burns and consequent infections. The archaeological sources for an analysis of these parameters are the following: dimension of kilns, dimensions and position of their mouths (regulation of fire); rapport mouth/*praefurnium* (regulation of air circulation); numbers and positions of the aeration holes (aeration system) and in some cases destruction layers caused by the spontaneous collapse of the kiln.

In the case study (fig. 4), the kilns have a diameter of about 1 m, the mouths are c. 0,40 m large and 0,50 m high, giving access to short *praefurnia* (about 0,30 m deep). Information about the regulation of aeration on the vault is lost. The risks linked to collapse of the kilns were very low, since combustion chambers were quickly completely dug into the ground and the vaulted firing chamber in clay was both light and stable, presenting more risks of implosion than of explosion.

Long-term health hazards depend on a variety of factors: muscular and joint damage due to carrying and moving loads, repetition of unhealthy or un-ergonomic movements,

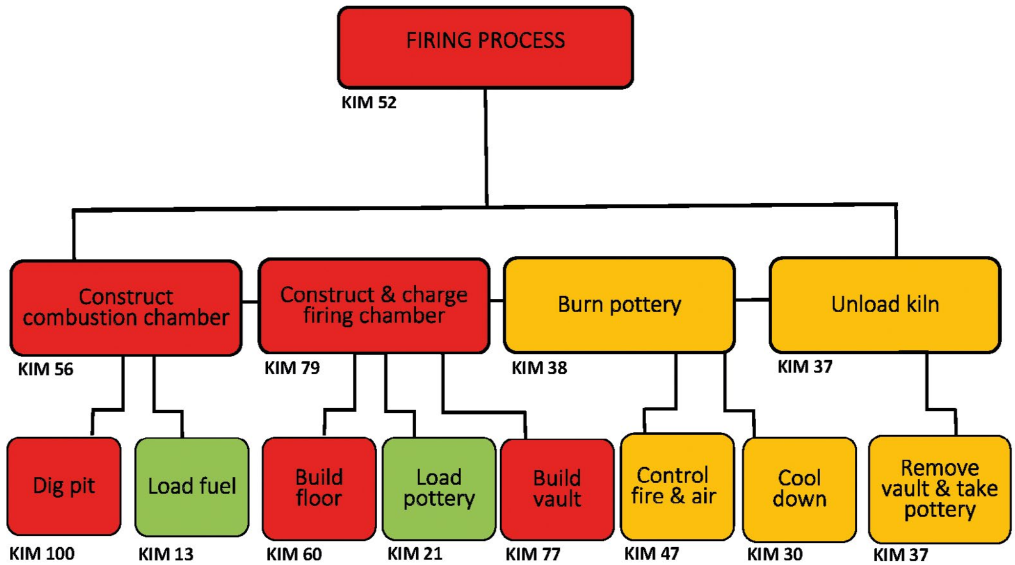


Fig. 3: HTA of firing task for the Pottery Workshop of Florence, via Nazionale, cinema Apollo, with KIM-Number calculation.

such as bending down and straightening up or twisting the back by carrying heavy loads; skin being exposed to dangerous materials or elements; the respiratory system being exposed to particulates. The archaeological sources permit only the ergonomic numeric evaluation of mechanical risks: height/diameter of the combustion chamber (need of fuel alimentation); height/diameter of the kiln floor (charging/discharging); position of the kiln-mouth relative to the ground level of the workshop (possibility to sit or stand while controlling the fire). In the case study, the application of this first level of ergonomic evaluation on the kilns shows different KIM values in the tasks related to the firing process (fig. 3), higher for the construction of the kiln and of the floor of the firing chamber, built by leaning clay bars on a central mobile pedestal[13] and in the delicate phase of charging and discharging. Handling of heavy objects was sporadic, e.g. when positioning the about 20 kg heavy stone to close the kiln's mouth to cool it down slowly, and consequently has a lower impact.

Ergonomics of the Workshop-Layout and of the Workflow (fig. 5–7)

The workshop-layout is structured to economize movements within the workflow and to complete them rapidly to increase the efficiency of production. In the analysis of the workflow, the possibility of multifunctional spaces, especially open-air spaces, calls for the combination of space analysis with an analysis of the operational sequences.[14] Workflow analysis further requires a dataset of a complete workshop or at least of a consistent part of it.[15]

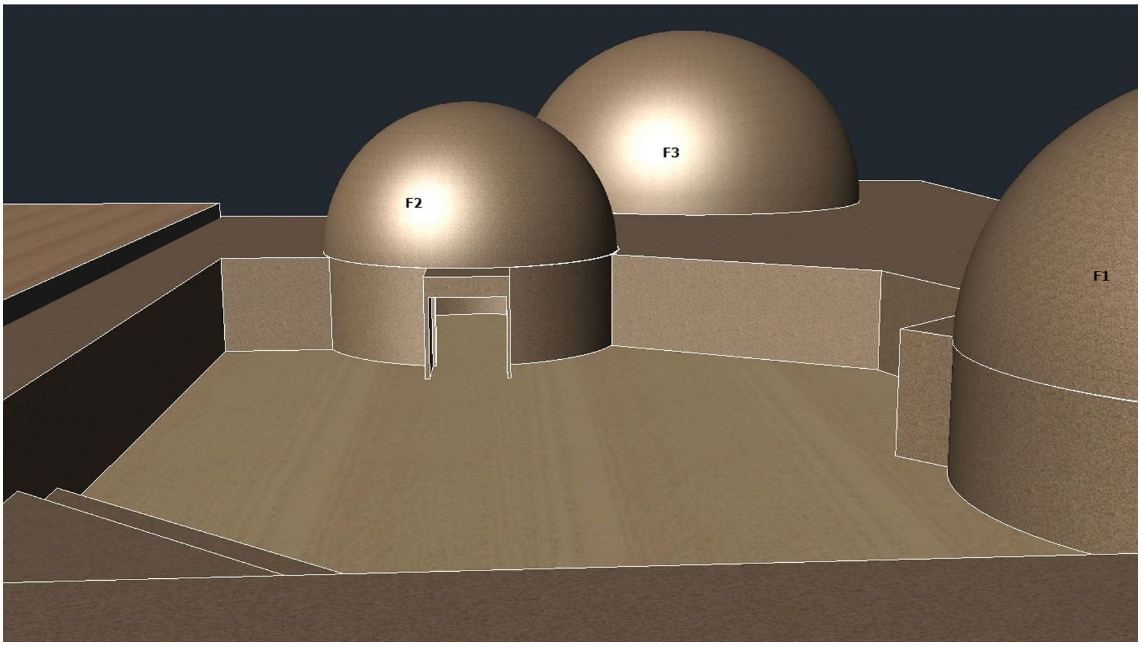


Fig. 4: View of kilns F1 and F2 as a 1,65 m high person, reconstructed in AutoDesk AutoCAD-Architecture.

Given the available sources, the ergonomic parameters of the workflow are the following: path from storage/preparation of raw materials to working place; path from working place to drying/decorating place; path between drying place and firing place; path between firing place and storage. The paths are evaluated based on frequency of use, distance, angles of movement within the working-path; differences in ground level, resolved with inclines or steps. Parameters linked to light and visibility are for the most part inaccessible, because the original height of the buildings is lost.

These parameters are based on the following archaeological data: workshop surface (sqm); access path analysis for different working stations and working-path reconstruction based on the phases of the operational sequence; position of the kilns.

In our case study, the workshop produced different materials: tiles, small pots (*ollae*) and large food containers (*pithoi*, jars). Technique, form and weight of different products affect especially ergonomics of forming, drying, decorating and stocking. Even if the workshop was not specialized, some kilns show a trend towards specialization, e.g. the kiln F8, where only fragments of tiles have been found. This kiln is also the one nearest to the working and drying area. The position is probably linked to the delicate phase of charging and stocking these materials, which are the heaviest and most likely to be deformed and crushed in transport (fig. 7). The paths, described as weighted ties in the HTA, do not present particular high values in the ergonomic evaluation, since the differences in ground level are very small (30–50 cm). The proximity of two kilns (F1-F2) with a common working area is a way to save energy in the production process (fig. 4).

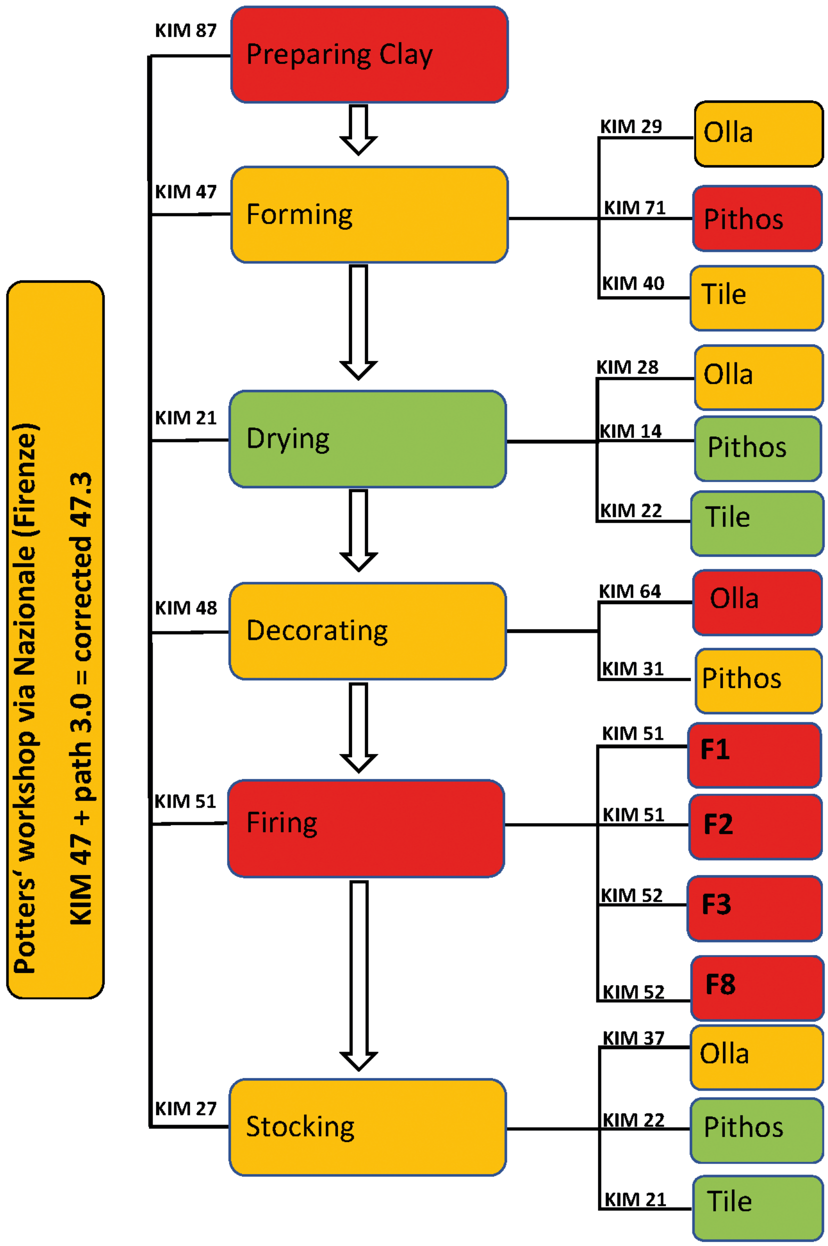


Fig. 5: HTA of the operational sequence of Pottery Workshop of Florence, via Nazionale, cinema Apollo, with KIM-Number calculation.

Since the borders of the working area are only partially preserved, it is not possible to prove how kiln F3 was accessed, though it was probably also accessible from the central working-area, as were all other kilns (fig. 6). The ergonomic evaluation of the path within the operational chain is very low and does not affect the general KIM number (fig. 5).[16]

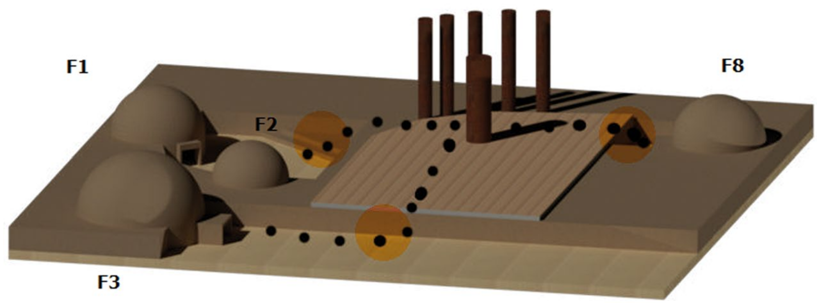


Fig. 6: Pottery Workshop of Florence, via Nazionale, cinema Apollo: reconstruction of the working path in AutoDesk AutoCAD-Architecture, inclines and steps are indicated with orange circles.

Community Ergonomics

There are very few documented examples of workshops in pre-Roman Italy, which can be integrated into a social and environmental structure, as well as in a complex commodity chain. The workshop location gives some indication as to its role within the commodity chain as well as in the human and urban landscape,[17] but nevertheless a broader dataset is necessary to frame it correctly and permit us to understand the workshop within a conceptual framework of 'intersubjective and embodied habitus'[18] of production and consumption.

This conceptual framework of chaînes opératoire is the object of analysis in community ergonomics.[19] The main parameters that have to be taken into consideration for community ergonomics are the time required to reach the workshop from the residential area, the supply of raw materials, the facility's access to a redistribution system, its access to common services,[20] as well as the position of the workshop in the commodity chain, in particular its connections to the sources or distribution hubs of raw materials and re-distribution routes or structures (marketplaces, harbors and docks).[21] The required large-scale analysis shows a high degree of complexity (fig. 8). A dataset complete enough for this level of analysis is still unknown, though there are already some good cases, which could be suitable for community ergonomics evaluation, as e.g. in Lokri Epizephyrioi, Naxos, Selinunte and Veio Campetti.[22] For the case study of the kilns of Cinema Apollo, this level of ergonomic evaluation is yet missing.[23]

Toward a Construction of an Ergonomic Index for Pottery Production in Pre-Roman Italy

The proactive function of ergonomics can be adapted as useful tool for the archaeological modelling of human behavior. It is possible to empirically develop an ergonomic index in pre-Roman pottery workshops and study cultural or contextual

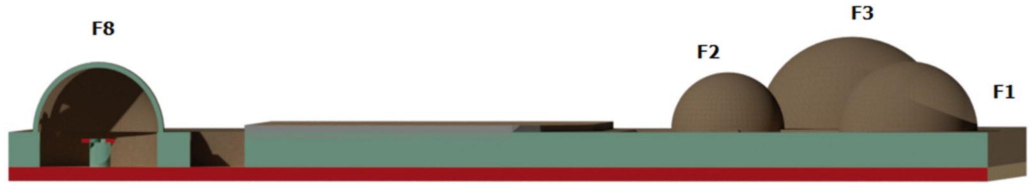


Fig. 7: Reconstruction of the section of F8, view standing from South-East.

reasons for deviations from the standard. Since Vladimir Stissi's analysis of the layout of potteries in Greece and Magna Graecia revealed evidence for a lower impact of geo-cultural variability on the workshop-layout,[24] the use of ergonomics can help to highlight subtle differences.

The workflow for an ergonomic evaluation can be generalized, parametrizing the application to empiric data, in a way to realize an ergonomic model for each level of analysis, progressively including the models of the sub-levels (s. ergonomics of firing process in fig. 1 and in fig. 5). This model can also be calibrated on the base of the source material preserved by introducing a correction parameter to weight the number and the importance of the available parameters.

To create an ergonomic index starting from the ergonomic model, we need to be able to quantify and qualitatively compare the ergonomics values collected by applying the model to a larger dataset, which could be archaeological as well as ethnological.[25]

The ergonomic index should include static and dynamic measurements calibrated on the anthropometric data of inhumations unearthed in local necropoleis.[26] Using the same dataset, it should in the future be possible to integrate 3D-CAD reconstructions of the working space of ancient workshops with Human Digital Modelling based on anthropological observations of the inhumations found in the same geographic area.[27]

Ergonomics – do we really need that?

Ergonomics shares some research questions with the studies on contextualized chaînes opératoires, such as spatial insertion and access pattern analysis.[28] The ergonomic evaluation is based on the observation of material remains, in terms of productions structures, production organization and economic space. Therefore, ergonomic evaluation of pottery workshops differs from spatial analysis by focusing on human factors and introducing the human body as a dimension of the working space.

The individuation of ergonomic patterns can be useful to detect differences in the social organization and in the exploitation of labor in workshops with different modes of production, from individual household production to nucleated workshops industries for mass production.[29] Ergonomics can thus be harnessed to study the

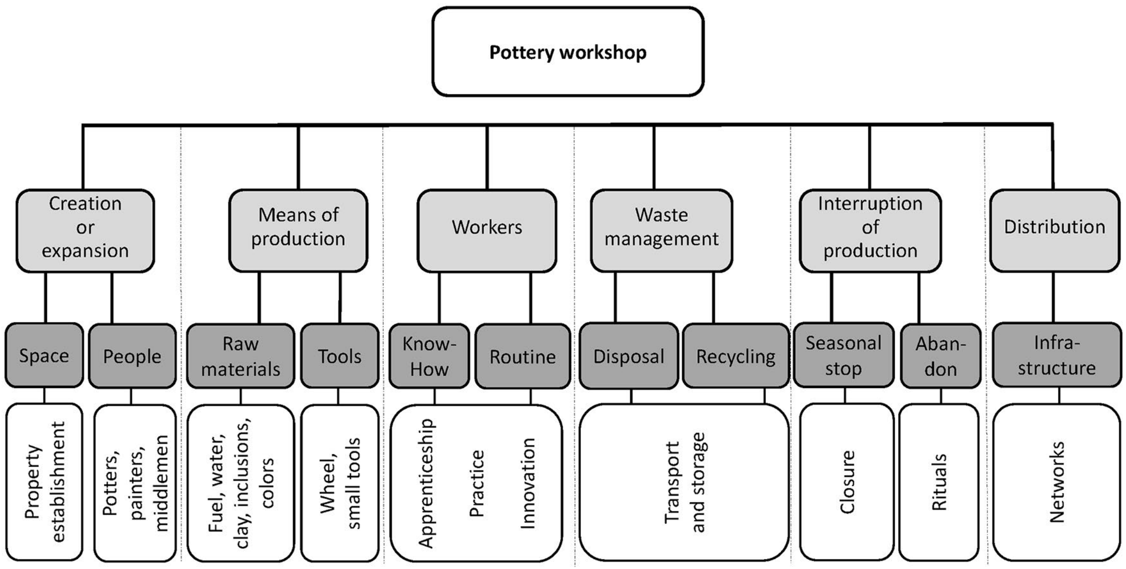


Fig. 8: Proposal of HTA for Community Ergonomics of Pre-Roman Workshops.

impact of production systems and their structural needs on the healthy and life quality of potters.

Moreover, despite the lacunary documentation of many contexts, an ergonomic evaluation of pottery workshop, modulated on three attestation levels, can detect cultural patterns while remaining sensitive to chronology and cultural geography: this 'ergonomic footprint' can then be considered an indicator of specific ceramic traditions or communities of practices as well as technological boundaries.[30]

A research focus on human work and work organization, proper to social archaeology, finds in ergonomics a means of bridging the gap between the reconstruction of structure and social interaction in ancient societies and the functionality of teleological acts in the production process.[31]

Acknowledgments

My gratefulness gives to the organizers of the Convention and in particular to the organizers and editors of the session, Nadin Burkhardt and Robinson Peter Krämer. A special acknowledgment is given to Albert Nijboer and Eleni Hasaki, who were discussing the topic with me during and after the presentation in Bonn and gave me very useful bibliographic indication on their works on the integration of ethnographic studies.

I also wish to warmly thank Henry Heitmann-Gordon for the stylistic editing of the paper.

Notes

[1] In ancient Greek pottery workshops in particular by Heleni Hasaki (Hasaki 2011, for further bibliography s. note 5. 13). An application of spatial analysis to ancient production contexts, to analyze the social implications of work has been e.g. presented by Monteix 2016, 171–173 and Monteix 2018, 133–150 for Pompeian bakeries.
[2] For a review of the ethnographic approaches to pottery production: Nijboer 1998, 18. 50–78; David – Kramer 2001; for an application to pottery workshops in Tunisia: Hasaki 2011, where the ethnographic parallels are applied "to extrapolate the spatial requirements and configurations for ancient workshops": Hasaki 2011, 13.
[3] The formalized definition of ergonomics is: "the theoretical and fundamental understanding of human behavior and performance in purposeful interacting socio-technical systems, and the application of that understanding to design of interactions in the context of real settings": Wilson 2000, 560. The term was coined in 1949 by a group of scientists working in the fields of Psychology and Engineering (Murrel 1958, 602). In the 1960s, the progressive digitalization of the work extended the semantic field of the terms and the potentiality of the scientific application of ergonomics, in the branch of cognitive ergonomics (Green – Hoc 1991). Up to the 1980s, ergonomics focused on sociotechnical systems (Macroergonomics: Berlin – Adams 2017, 5) and cognitive ergonomics on large-scale logical systems (Yoon 2001).
[4] Many studies on ergonomics in modern production contexts allude to ergonomics in historical and archaeological contexts: Taveira – Smith 2012, 275. A definition of protoergonomics is given by Jerezy Charytonowicz: "From prehistory, man has always taken care of their comfort and convenience by making the first tools and successively transforming the material environment, in order to adjust them to their own needs and thus subconsciously initializing paraergonomic activities. The time from prehistory to the second half of the 19th cent. can be described as a period of intuitive ergonomics or subconscious ergonomics." (Charytonowicz 2009, 450).
[5] Cuomo di Caprio 1992, 50. 51.
[6] The three levels are an adaptation of the levels of ergonomic interaction formulated by Livy 1974, 89.
[7] Defined as a teleological motion towards the goal of pottery production.
[8] Community Ergonomics (CE) is a part of (macro-)ergonomics, dealing with the global ergonomics within communities and their social organization: Newman – Carayon 1994, 738–741; Bayeh – Smith 2001, 1201. In the case of pottery production, community ergonomics takes into account how workshops were embedded in the local social structures and the regional and supra-regional commodity chain, including topographical and structural information (Yoon 2001, 254).
[9] The workshops attested by sporadic markers of production, such as traces of firing, misfired pottery or production tools, are not suitable for ergonomic evaluation. In pre-Roman pottery workshops, the firing phase, individuated by kilns, is best attested, while the other phases are badly underrepresented: of the 511 sites of production in middle and south Italy collected by Gloria Olcese (Olcese 2012), only 43 are suitable for the application of criterium A. For criterium B, only 10 sites are available. The same lack of documentation has been mentioned by Eleni Hasaki and by Vladimir Stissi for Greek pottery workshops (Hasaki 2006, 225; Hasaki 2011, 14–17; Stissi 2012, 205).
[10] The workshop, dated on the basis of stratified ceramic fragments to the end of the 7th – first half of the 6th cent. BC, presents many phases of frequentation/use. The last one was attested by four kilns (F1–F3.

F8) type I of Cuomo di Caprio 1985, 140–142) and a working area with chopper-pavements: Cianferoni – Da Vela 2015; Da Vela 2019.

[11] HTA consists in the individuation of tasks directed towards a goal (in our case the production of pottery), in the analysis of their interactions and in breaking them down into sequential chunks: Berlin – Adams 2007, 132. 133.

[12] The KIM evaluation number derivates of derives from a calculation in an interactive sheet, where different movements and postures required by the working tasks are associated to a numeric scale. The interpretation of the ergonomic number is established in the KIM-Method as follows: n<25 absence of risk (color green in the HTA); 25<n<50: minor risk (yellow in the HTA); 50> high risk (red in the HTA): BAuA 2012.

[13] For its shape: s. Cuomo di Caprio 2007, 543–545. For the control of the fire and the cooling down in the case study: Da Vela 2019, 36. 37.

[14] For the differences in the operational chain of household and industrial workshops, referring as well to the implications of specializations: Nijboer 1998, 30. 31. 52–54. For the standardization of the operational space in pottery workshops: Hasaki 2011, 24.

[15] The operational sequences of the workflow of pottery production are based on the possibility to individuate spatially organized structures for each station of the working process: Nijboer 1998, 50–73; Orton–Huges 2013, 121. 122; Santacreu 2014, 60–108.

[16] The present paper presents a modification of the HTA diagram, evaluating the ergonomics of the paths represented as linking edges within the traditional tasks sequence.

[17] This aspect in particular has been analyzed by Vladimir Stissi for the location of Greek pottery workshops: Stissi 2002, 38–48.

[18] Dobres 2010, 52.

[19] Community Ergonomics aims to study the ergonomics of the whole production system (Taveira – Smith 2006, 286).

[20] For potters' residential areas and shared infrastructures in potters' quarters: Stissi 2002, 52–54.

[21] For the impact of the human factor, resources and viability on the choice of the workshops location: Stissi 2002, 38–48.

[22] Lokri Epizephyrioi: Stissi 2012, 201–205; Naxos: Stissi 2012, 207–209; Selinunte: Bentz et al. 2013; Veio, Campetti: Belelli Marchesini 2017, 111–115.

[23] Camporeale 2015, 42. 43.

[24] Stissi 2002, 55.

[25] An ergonomic model of the pottery production in particular could be developed based on ethnographic comparisons. s Nijboer 1998, 18 with preview literature.

[26] Ergonomic models are based on the normal distribution of anthropometric measurements for men and women: Berlin – Adams 2017, 65–82.

[27] Digital human models are male and female manikins with different anthropometric measurements and weight, which are used to reproduce the three-dimensional movement of people at work: Berlin – Adams 2017, 162–173. There is some specific software which allows for the modelling of production ergonomics, such as Tecnomatix® Process Simulate Human and the JackTM Software of Human Simulation by Siemens.

[28] Taveira – Smith 2012, 275–277 present ergonomics as embedded in the sociotechnical system, since the balance between improvement of the production and conditions of the workers is strongly affected by the political and social views of the societies in which the production takes place.
[29] For the definitions of these different scales of production: Nijboer 1998, 50–54.
[30] Technological skills and related cognitive patterns result from apprenticeship processes in communities of practices: Roux 2011, 81. 82; Hasaki 2012, 194–196. In particular on the impact of the social structure in cognitive processes of apprenticeship: David – Kramer 2001, 311–316; Santacreu 2014, 56. 212–216; for the concept of persistence of traditional patterns of production as technological boundaries: Roux et al. 2017.
[31] The relationship between variation of the ergonomic parameters and social and cultural changes is studied e.g. by Rubio 1991, 85, who pointed out how social differentiation and change in work organization can change the ergonomics of a workshop. The possibility to integrate space syntax analysis, studies on the chaîne opératoire and cognitive studies permits us to overcome the traditional separation between specific functionalist, cognitive and sociopolitical explanatory approaches to the organization of pottery production (s. Costin 2005, 1043. 1044). For the impact of cognitive patterns in the workflow: Green – Hoc 1991, 294. 295 "mental aspects, even in a very repetitive physical action must be carefully considered. The increasing interest in cognitive aspects of work is determined by the development of tasks which have important cognitive features as well as the theoretical progress of several sciences in dealing with these features."

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Fig. 1. 3–8: by author. – Fig. 2: from Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, <https://www.baua.de/DE/Themen/Arbeitsgestaltung-im-Betrieb/Physische-Belastung/Leitmerkmalmethode/pdf/KIM-manual-handling.pdf?__blob=publicationFile&v=2> (17.08.2019).

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