

ACTIVITY, ARTEFACTS AND POWER: CONTRIBUTION OF ACTIVITY THEORY AND SITUATED LEARNING TO THE ANALYSIS OF ARTEFACTS IN MATHEMATICAL THINKING IN PRACTICE[1]

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*This paper explores and discusses the contribution that key concepts of activity theory and situated learning can offer to the analysis of the use of a mediating artefact – the calculator – in the distribution or power and control in social practices, using insights coming from the empirical field studying *ardinas*' practice[2] in Cape Verde. Drawing on activity theory and situated learning, we present the key concepts used to discuss the situated role of artefacts in the practice. The analysis of the use of a calculator by some *ardinas* in moments of the selling process opens room to discuss artefacts as resources for power and the relationships between power, technology of practice and shared repertoire.*

INTRODUCTION

Artefacts gain relevance when we seek to understand learning as a phenomenon emergent from participation in social practices. In fact, the dimension of the relations between resources or artefacts and power introduced by Giddens (1996) should be considered; resources are means through which social power is exerted. Thus, power should not be presented as a resource but as depending on the use of resources. On the other hand, artefacts constitute a technology of the practice or resources (Lave & Wenger, 1991) which include the repertoire of the practice (Wenger, 1998). Artefacts as part of the historical trace left by the reproduction cycles reveal the productive as well as the reproductive character of those cycles and the contribution to the constitution of the practice over time. Thus, “understanding the technology of the practice is more than learning to use tools; it is a way to connect with the history of the practice and to participate more directly in its cultural life” (Lave & Wenger, 1991, p. 101). In the following we will explore and discuss the contribution that key concepts of activity theory and situated learning can offer to the analysis of the use of a mediating artefact – the calculator – in the distribution or power and control in social practices, using insights coming from the empirical field studying *ardinas*' practice in Cape Verde.

CONCEPTS IN ACTION IN THE ANALYSIS

For Leontiev (1978), activity is a molar unit, not an additive unit in the life of the person but a system with its own structure, its transitions and its internal transformations, its own development. Here we can identify non-adding elements

linked to central concepts: activity (linked to motives), action (linked to goals) and operation (linked to conditions). The motive of the activity is intimately connected to the need felt by the individual – the form responding to that need. Activity may involve different processes – actions – that aim to produce certain results intimately related to the activity and in this way directing the activity. Action can be made concrete in different ways and forms – operations – according to the conditions available but always making sense in terms of the goal that is supposed to achieve.

In these terms, two methodological implications emerge: (i) activity cannot be reduced to a set of simpler stand-alone additive parts or processes, and (ii) its structural and functional unit can only be examined looking at the phenomenon in its active state. This perspective allows us, to identify elements of the activity and, to say that those elements have only a potential character, neither deterministic nor definitive, as activity can only be realized through a dynamic, transformative process of development.

Activity, artefacts and power

We will use central concepts from activity theory (Engeström, 1999; 2001) but concentrating on the artefacts, and in particular the links with the idea of mediation, one of the key concepts of the historical-cultural approaches.

A central principle of activity theory is that “a collective, artefact-mediated and object-oriented activity system, seen in its network relations to other activity systems, is taken as the prime unit of analysis” (Engeström, 2001, p. 136), the activity systems realizing and reproducing themselves through generation of actions and operations. Both individual and collective actions—conscious and intentional—and the automated operations they eventually become are fully understandable when considered against the entire activity system. This hierarchical structure of an activity system is permeated by its multi-voicedness character as participants in their different positions go along with their narratives carrying its history engraved in the mediating artefacts and rules. It is relevant to bring in here the notion of ‘ongoing activity’ coined by Jean Lave (1988) when she refers to activity as she readdresses our attention to the strongly fluid and dynamic character of activity. We need to keep present the local character of activity, developing here and now, with the resources and the constraints present in the situation for the actors in place. The ongoing character of activity seems consistent with Leontiev’s view that activity should be analyzed in its active state.

Referring to the non-definitive nature of activity, Engeström (1999) considers that none of the usual dichotomised forms of characterising artefacts are useful—tools and signs, or external and internal. In both cases it is the internal nature of the artefacts that is of interest, independently of the system of activity where they are used. Given the dynamic nature of systems of activity, artefacts’ functions and uses are in constant transformation and, accordingly, the elements that seem to be internal in a certain moment can be externalized in the next one. Similarly, external processes can

on one occasion be internalized. In any case, a dialectic relationship pervades the internal-external localizing of activity flux. Freezing or splitting the two processes seems to be a poor basis for understanding artefacts. Engeström (1999) proposes a differentiation in regard to the uses of artefacts:

The first type is *what* artefacts, used to identify and describe objects. The second type is *how* artefacts, used to guide and direct processes and procedures on, within or between objects. The third type is *why* artefacts, used to diagnose and explain the properties and behaviour of objects. Finally the fourth type is *where to* artefacts, used to envision the future state or potential development of objects, including institutions and social systems. (Engeström, 1999 p. 382, italic in the original)

A strong claim of the mediating role of artefacts is highlighted by Holland and Lave (2001) as they look with particular attention to the power of inscription of cultural forms—a notion close to Cole’s conceptualization of cultural artefact; Holland and Lave (2001) explicitly discuss “the materiality of cultural artefacts” (p. 63), the artefacts assuming an obvious material dimension and a conceptual or ideal aspect, an intentionality, whose substance is embedded in the world of its uses.

On the other hand, resources (or artefacts) can be conceptualized as ways of transformative relations which are incorporated in the production and reproduction of social practices (Giddens, 1996). This means that resources are intimately connected to power, be it seen in a broad sense as an ability that transforms activity or in a more specific sense of domination or ability to intervene. Resources are the basis and the vehicles of power. Given that resources are equally structural components of social systems, they become also the means through which the structures of domination are reproduced. It is within this framework that we can consider that exerting power is not a type of action; power is instantiated in action while a regular and routine phenomenon. In this sense, power is not a resource but it depends on resources.

THE EMPIRICAL FIELD: ARDINAS’ PRACTICE AT CAPE VERD

The participants observed were *ardinas*—boys aged between 12 and 17 years, half of them in 5th to 7th grade at school, who sold newspapers in the streets of Praia, the capital of the Republic of Cape Verde in Africa. The two weekly newspapers existing in Cape Verde during the time of the study were written in Portuguese, the official language[3]. The number of *ardinas* who sold the newspapers during the study varied from 19 to 32, all of them with no formal link to the institutions that owned the newspapers. However, selling newspapers in the city of Praia was done only in this way (on the street and by *ardinas*), so totally dependent upon the availability and interest of the *ardinas*.

There was no external sign that could identify an *ardina* in the street, except for the fact that he was carrying a number of newspapers under his arm. However, they were careful in their presentation and image on the selling days as this represented an important issue to gain access to certain places (eg. in state departments in Praia).

Most of the *ardinas* were motivated by the idea of getting some money to help their families and some were in this practice for a few years. These boys lived in the city of Praia or in the nearby small village of St Martinho.

The work of the *ardinas* developed in three phases: (i) receiving the newspapers from the agencies; (ii) selling them on the street; (iii) paying back the money to the newspaper agencies. The organisation of these phases was necessarily connected to the instructions of the agencies but the *ardinas* positioned themselves in that organisation in their own way.

In 1998 there was only one weekly newspaper available, *O Tempo*. Every Friday morning, as soon as the newspapers were printed, at the door of *O Tempo* the newspapers were delivered to Disidori, the man who was accountable to the newspaper agency and responsible for the whole process of selling and returning back the unsold newspapers. Disidori distributed immediately a number of newspapers to each *ardina* (between 50 and 150 units each) and wrote down a list to record the *ardinas* names and the number of newspapers given to each one.

After receiving the newspapers the *ardinas* run quickly to the usual areas for selling in the city, some trying to maintain their own selling place in the street. However, those places varied during the day according to the rhythm of selling and the rhythm of the activities in the city.

The price for one newspaper was 100 *escudos*[4] and, when the *ardinas* finished selling, they had to pay back to Disidori 87.5 *escudos* per newspaper sold, these amounts being defined by the newspaper administration.

Some time after the distribution of the newspapers, Disidori used to go to the central Square in Praia carrying with him a set of newspapers for those *ardinas* who were in school, and hence came later to the selling, or for those who sold out very quickly and asked for more newspapers. The central Square had a strategic role for the *ardinas* to integrate the newspaper selling into the socio-economic life of the city and it was the main point of convergence of the boys at several moments during the day: (i) as a selling place; (ii) as a lunchtime resting place, and (iii) when they finished selling and came to pay back.

As the *ardinas* finished the selling they started showing up for payment. Each *ardina* approached Disidori, saying how many newspapers were left; Disidori made the calculation with his calculator and showed the result on the calculator screen to the *ardina* who then gave him the money. Sometimes the more experienced *ardinas* made their own calculation with their own calculator or Disidori's. Usually, several operations were in progress: some of the *ardinas* were counting the newspapers left for returning, others were counting and organising the money, giving back newspapers to Disidori, observing the processes or giving the money to Disidori. The environment could seem confusing at a first glance as there were several boys present and a lot of money changing from hand to hand but when we observed in detail we

understood that everything was running in a certain order and that this allowed each *ardina* to see what was going on with the calculations – their own or those of the others.

This phase represented an important moment in the selling practice. The *ardinas* exchanged stories of the day, they had face-to-face discussions, and they organized the moment of making the final account with Disidori. It was also a very rich opportunity to observe how the *ardinas* interpreted and solved their problems. It is worth noticing the total absence of any attempt to make their calculation strategies explicit either through verbal explanation, deliberately showing, checking processes or anything we could classify as some sort of mathematical conversation.

In 1999—the second phase of field work—a second newspaper *O Espaço* came into the market being sold at the same time as *O Tempo* which provoked profound modifications in the whole structure and organization of selling. For instance, Disidori moved to this new newspaper with a new position. The majority of the *ardinas* were involved in selling both newspapers. New rules were in action: for each newspaper sold the *ardinas* would receive 20 *escudos*. But now they had to go to the *O Tempo*'s agency to receive the newspapers and go back there after selling in order to pay for the newspapers sold. For the new *O Tempo* the payment routine was similar to the previous year in the Square, but now with Manu—an experienced *ardina* playing the role of Disidori. This boy started helping Disidori in his relations to the *ardinas*, in particular in the distribution as well as in the support and control of what was going on in the Square including the reception of payment at the end of the day (all of this related only to *O Tempo*). At the end of the day Disidori used to go to Manu's home to make the final accounts checking the journals left and the money paid.

Although the second author was present during the whole process of distribution and selling, the payment phase in the Square was one of the best settings to collect data. There were plenty of opportunities to talk with the *ardinas* in a quite natural way videotaping informal interviews whose guidelines were mainly directed by the topics the *ardinas* wanted to talk about or the problems they were discussing among themselves.

THE POWER OF THE CALCULATOR AS A MEDIATING ARTEFACT

The *ardinas* use a variety of resources in the everyday practice of selling newspapers in the street. The forms of use and role of artefacts was one of the foci in our study its importance coming from the fact that in order to understand and characterize the processes of calculating-in-action it was relevant to identify the artefacts in use and to understand how those artefacts are constituted while structuring resources. We concentrated on who used the artefacts, how power was embodied in their use according to the emergent goals and motives in the activity. In doing so, we tried to highlight the way artefacts, as historical and mediating tools, were present in the

ways of acting and thinking. The focus of analysis here is the use of the pocket calculator in certain moments of the practice of selling newspapers in the street.

In several moments of the selling practice a calculator was used by Disidori, Manu and some of the other *ardinas*. A rather important issue here was that the calculator was one of the few tools present in the practice of the *ardinas* that was associated to mathematics[5]. The calculator was not an artefact present in the everyday life of most people and not used in school. Some people selling goods in shops used it but not in traditional selling such as street markets. It was a technological tool with a quite restricted and limited circulation and use in people daily practices in Cape Verde and in general it was associated to specific technical domains outside the range of the mainstream of the population.

This study took place in a period of the life in Cape Verde when ‘electronic technology’ was seen by most people as ‘magic’ and ‘automatic’, something that people in general did not really understand but that carried a strong degree of power and rightness, and a social connotation to ‘serious and important matter’. The calculator is placed within the category of desired and socially valued objects, although with a quite restricted access. Therefore, it was unnatural for *ardinas* to use the calculator when acting as *ardinas*. And in fact although the calculator was used everyday in the practice of selling, its use by the *ardinas* was very limited both in frequency and in forms of use.

The control mediated power of the calculator

In 1998 the manipulation of the calculator was mainly associated to the phase of payment. The forms of use of the calculator adopted by Disidori in the practice focused on its role as a mediating artefact in his interaction with the *ardinas* towards the control of the selling process. When paying back to Disidori the *ardinas* were immersed in a routine orchestrated by Disidori’s actions, and the calculator was an element always present and visible to the *ardina* he was addressing. It was through the mediation of the calculator that Disidori ‘organized’ his interaction with the *ardina*—a *how* artefact—turning possible for each *ardina* to see his particular situation represented.

He slowly typed in the numbers and operations:

X (newspapers delivered)
–
Y (newspapers not sold)
* 87.50
=
Z (to pay)



Figure 1. Final calculations taking place

At the same time, he was naming loudly each one, he transformed the calculator into a kind of ‘guarantee’—a *what* artefact—because in using it he described the specific selling situation of a particular *ardina*. While providing a certain degree of access to the *ardina* to follow the whole process of calculating, Disidori was offering a way not only of showing that he was not cheating—which entails a demonstration of the power of his managing role in the game—but was also introducing signs of care and honesty that Disidori found important for the development of the autonomy of the *ardinas*—the calculator playing the role of a *where to* artefact. Sharing the process (carefully taking each step of calculation) with the *ardina* clearly suggested Disidori’s will to reinforce confidence and transparency in relationships. The correctness and rigour of the results brought in by the calculator was reinforcing the power of Disidori to apply the rules of selling and contribute to legitimate his positioning in the practice.

When finishing the process of computation Disidori used to say out loud the amount that the *ardina* had to pay showing explicitly to him the calculator screen. The calculator was extensively used as medium for communication that allowed Disidori to offer to the *ardinas* different forms of representation of the amounts and this was important to those *ardinas* less experienced in school mathematics. In the frame of the social meanings associated to the technological tools (e.g. belief in the infallibility of the results produced) the calculator presented here the characteristics of a *why* artefact—if the numbers inserted were correct, the result would be correct.

However, the calculator was not present only as a resource for communication for Disidori. While organizing themselves in order to make the final accounts with Disidori, some of the older and more experienced *ardinas* used the calculator (their own or borrowing it from Disidori) for self-control, checking their previous mental computations. Thus, the calculator had here a status of a tool for confirmation of the final selling situation—a *why* artefact. Also important was the fact that using it in this way was also an affirmation of autonomy of the *ardinas* as it avoided a long interaction with Disidori. Again, the use of the calculator embodied power as it conveyed some degree of authority to the less experienced *ardinas*, being a *where to* artefact, a symbol of a particular *ardina* positioning and power.

The way Disidori had used the calculator gave rise to a variety of learning opportunities for the *ardinas*. For example, they enlarged their repertoire of forms of naming and representing numbers and operations and they had support in learning to respect hierarchy as the calculator was used by the *ardinas* with more and more autonomy according to their experience of selling.

The perception that each *ardina* had of their selling behaviour was mediated by subjective interpretation of the situations and the feedback that Disidori gave through several signs. On the other hand, the almost individual nature that framed the

payment phase was reinforced by the fact that Disidori used his selling records in a very private way and gave a central role to the calculator in the interaction with the *ardinas*. In addition, as the state of the account of each *ardina* was reconstructed for himself alone, and because the screen of the calculator was only visible to Disidori and the *ardina*, it was not possible in this process to compare his selling to that of another one. Finally, the way Disidori used the calculator reinforced the power of the institutional organization of selling while keeping the *ardinas* ‘dependent’ on the way they are considered by ‘authority’.

There is another side of the use of the calculator in the practice. The transparency embodied in the form of use adopted by Disidori during payment gave visibility to those *ardina* who was involved in the interaction during payment, but keeping invisible the specific forms of computation which produced the final account. Therefore, in relation to mathematical thinking inherent to the computations, the calculator was not transparent at all. The visibility was given mostly to the sequence of actions and this was obscuring the processes behind the results. It was apparent that the calculator had no impact in the ways the *ardinas* calculated, and it did not mediate their thinking in the computations. The *ardinas* who had almost no familiarity with the calculator, when challenged by the field observer to use it as a support to solve a question related with some selling situation, always started by trying to calculate their profit and they were not able to explore any other type of manipulation.

In 1999, the calculator became less of a resource for control and a marker of power. Manu used it mainly for his own calculations and not to interact with the *ardinas*, thus giving less visibility and less organizing role to the calculator[6]. At the same time, the close and affective relationships of Manu with the other *ardinas* made it difficult to develop the formality and the rituals that were the norm when Disidori was in charge. An additional issue was the smaller need to use the calculator given the amounts involved: 20 escudos of profit (instead of 12,5 escudos in 1998) and 80 escudos to pay back (instead of 87,5). As now most of the *ardinas* received 25 newspapers and sold them all, there was less variation in the situations. The calculator was a tool for computation rarely used and there was no evidence of its mediating role as artefact as it was noticed in 1998.

In terms of the whole activity in place, we should finish this section pointing out (i) the reinforcement of the hierarchical structure of the selling activity within the social world where it takes place (not only dealing with the cultural status that age represents but also with experience and responsibility as the *ardinas* are able to transform their object of activity into new forms along the time); (ii) the forms of talk and signs that become part of the repertoire of the practice of talking about the calculating-in-selling – decimal point (drop), operations (times, more), big numbers; (iii) the understanding of profit in the sequence of actions that allow earnings to happen (the remaining money after paying back which is not matter for verbalization

with Disidori); and (iv) the place and status of the common *ardina* in the hierarchy of power positions in the chain involved in the selling.

ARTEFACTS AND RESOURCES: HOW POWER PERMEATES THE TECHNOLOGY OF THE PRACTICE AND THE SHARED REPERTOIRE

The calculator was clearly the tool used more systematically by Disidori, in the moment of payment with all the *ardinas*. It was the best support for the dialogue with them reinforcing on one side the individual character that Disidori gave to participation of each *ardina*, and on the other side the visibility of his power and authority. Within this framework, the calculator assumed essentially a role of reproduction as it was used in order to regulate the participation of the *ardinas* and sustaining the established social order—strongly marked by hierarchy and empty of argumentative elements.

The way the artefact was used, while a mathematical-based tool, had a structuring role in the activity mainly in ‘paying back’ phase. It reinforced the importance of the act of paying back and the role of authority, and regulated the *ardinas*’ participation. However, the regulation made possible with the artefact did not come from the artefact itself but from the way it became present in the everyday and the power attached functions added by participants in the practice. The process of regulation was in accordance to aspects connected to the social world that framed the resources available, the activity, and the people who organized, managed and acted on it. The calculator in the hands of Disidori was introduced as a reified object, with associated strong social meanings, although serving the power and legitimating the actions of someone who did not in fact belong to the community of practice of the *ardinas* but was an officer of the institutional power. The calculator as artefact in the practice had an effect mainly reproductive of the social world.

We can conclude that this artefact, although not being appropriated in its totality by the *ardinas*, was a resource that had an important role in structuring their activity. There was a shared repertoire within the practice of the *ardinas* that reflected the attached nature of power of the calculator in the framework of the activity of selling. However, the repertoire used to compute-in-action was of a different nature[7] as it was based on elements (i) that emerged, on one side, in the structure of the broader social world where the activity was developed and, on the other side, in how people intervening in the activity coordinated it; and (ii) that reflected the motives that were behind their participation in the practice. What really was structuring the activity of the *ardina* was the ‘gain’ (called for the need of the *ardina*) while what was structuring the computation-in-action was ‘paying back’ (being honest). Perhaps we could hypothesise that there are sources of power and legitimation of the practice in both fields of the practice of selling and the issue is on the problems of border crossing.

It is the articulation of participation and reification within the practice that allows and orients the construction or re-construction of artefacts with potentialities of going on functioning as resources for new needs that could emerge in the evolution of the responsibilities of the participants. As Engeström (1999) puts it, the functions and use of artefacts are in a constant fluidity and transformation that goes along with the development of the activity. In this sense, the artefacts are not something fixed and external to the practices but are in the development of the practices; its usefulness is not revealed in the characteristics identified independently of its use in the practices where they are put in action. Artefacts are artefacts-in-the-practice; they should be understood in interaction with the forms of use that users develop in those practices.

The concept of technology of the practice introduced by Lave & Wenger (1991) refers to the set of elements, artefacts, which people act with, associating a certain practice to the existence of a particular technology. It is the cultural nature of artefacts which carry part of the cultural heritage and historicity of the practice and relate their use to matters of power and access in the context of the discussion of the problematic character of the reproduction of a practice. The notion of technology suggests a dynamic stability, accepting renovation and transformation while based in the history of the practice. Entering in a new space of participation is thus associated with learning about its history and its technology. The technology is appropriated by participants in forms that serve their needs and goals as well as the opening of affordances to the emergence of power and its manifestations. The calculator as a technological mediating artefact becomes a constitutive part of the practice and provides access to new forms of participant.

In addition, the idea of shared repertoire (Wenger, 1998) includes both a set of forms of doing, taking and acting, and a group of people who share them as resources. The very word 'repertoire' leads us to aspects different from those related to technology and closer to forms of talking, acting and doing, and to stories people tell and share. This refers to a broader spectrum beyond action that presupposes an audience to whom and with whom one acts. Such a collective entity shares constraints and affordances which involve action and interaction. And it is in that process that meanings, power and positioning are negotiated, reproduced and constructed. The notion of shared repertoire directs the attention to the dynamics of using, constructing and sharing certain resources and calls for a view of people as collective constructors and thus collectors of their own constructions. In doing so, it localizes knowledge on the collective and on the circumstances where the collective produces knowledge, uses and reproduces it. The shared repertoire, reflecting the coherence of the practice, emerges as a source of the coherence of the community of practice (Wenger, 1998).

The shared repertoire of a community of practice is permanently in construction *via* participation and side by side with reification. The technology of the practice includes the reified aspects of the practice that almost shadow the role of the practitioners in its construction, while maintaining a memory of its development.

Shared repertoire and technology of the practice can be conceptualized as complementary. Focusing on each one gives visibility to particular aspects, in one way to the process of construction (e.g. what facilitates or restricts the access to participation) and in another way related to the history (which allows or restricts access to meanings, comprehension and to the practice itself). In both concepts the key idea of participation is present and it is through participation that one contributes to construction and has access to history as sources of power.

The various artefacts analyzed in the original study (such as the calculator, the recording table, the school algorithms, certain forms of talk, etc.) (Santos, 2004) were present in the everyday of the *ardinas* as reifications; they made part of the technology of the practice of selling newspapers in Praia that every newcomer faced. The ways they were used in the practice gave visibility and reinforced the institutional order inherent to the social world where the *ardinas* activity was taking place. Through interaction with such artefacts the *ardinas* gained access to certain aspects of the practice of selling, sharing meanings of the inherent social world. The artefacts situated in the practice of selling constituted structuring resources although with less direct impact on the strategies of computations of the *ardinas* which were appropriate to their participation in the selling. Such a contribution was rather more visible in the forms of talking and in the social meanings developed by the *ardinas*. The mediating character of the calculator as an artefact in the mathematical-thinking-in-action of the *ardinas* was revealed in strong association to social meanings.

NOTES

1. This paper was prepared within the activities of Project LEARN: Technology, Mathematics and Society (funded by Fundação Ciência e Tecnologia (FCT), contract no. PTDC/CED/65800/2006 and Project PARTICIPAR (funded by Centre for Research in Education of the University of Lisbon). The research reported is based on a larger study developed for a PhD dissertation (Santos, 2004). A draft version of this paper was presented at the 2nd Socio-cultural Theory in Educational Research and Practice Conference: Theory, Identity and Learning, Manchester, 11-12 September 2007.
2. *Ardina* is the Portuguese word to refer to kids who used to sell newspapers on the street.
3. Although Portuguese is the official language, the actual language in use in everyday is the Creole.
4. 100 Escudos corresponds to €0.
5. A tool not so strongly interpreted as mathematical was the table used by Disidori to record the number of newspapers distributed, sold and returned by each *ardina*. An analysis of the use of this artifact is developed in Santos & Matos (in press).
6. Manu's major structuring artefact was a very detailed table he used as a record of the selling and which was always available during his interaction with the *ardinas*. See Santos & Matos (in press) for an extended discussion of the mediating roles of both the calculator and the table.

7. In Santos (2004) central structuring elements for the *ardinas'* computation during the selling activity were identified: (i) the monetary system; (ii) the selling price of each newspaper (100 escudos); (iii) the gain for each sold newspaper (12,50 or 20 escudos); (iv) the way how the newspapers were delivered (in groups of 25).

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