Different stones: the weight of colour in ancient near Eastern glyptic

Pedras diferentes: o valor da cor na glíptica do Oriente Próximo antigo

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Abstract

The cylinder seals of ancient Western Asia are a category of artefacts with a wide range of characteristics and implications. Their use was both administrative and bureaucratic, but they were ornamental and apotropaic objects too, thus acquiring diverse symbolic and cultural values. Moreover, they were mostly experienced by their owners and users by being kept in close contact with their bodies. This means that the physical characteristics of the seals (colour, conductivity, weight, etc.) probably had some importance for the ancient societies using them. Thanks to widespread and precise digital technologies, the recording of the data of seals has grown significantly in recent years. In this preliminary work, primary and secondary visual data and the metadata thus obtained have been collected, and statistical analyses have been carried out with the objective of testing the possibility of mapping the general colour trends of ancient Near Eastern glyptics.

KEYWORDS
Cylinder seals
Colours of artefacts
Ancient Western Asia
Principal component analysis
Quantitative methods

Resumo

Os selos cilíndricos da antiga Ásia Ocidental são uma categoria de artefactos com uma ampla gama de características e implicações. O seu uso era administrativo e burocrático, embora também fossem objetos ornamentais e apotropaicos, adquirindo assim diversos valores simbólicos e culturais. Além disso, eles foram experienciados principalmente pelos seus proprietários e usuários, mantendo-os em contato próximo com seus corpos. Isto significa que as características físicas dos selos (cor, condutividade, peso, etc.) provavelmente tiveram alguma importância para as sociedades antigas que os usaram. Graças à difusão e precisão das tecnologias digitais, o registo de dados de selos cresceu significativamente nos últimos anos. Neste trabalho preliminar, foram recolhidos dados visuais primários e secundários e os metadados obtidos, tendo sido realizadas análises estatísticas com o objetivo de testar a possibilidade de mapear as tendências gerais de cores dos glípticos do Oriente Próximo antigo.

PALAVRAS-CHAVE
Selos cilíndricos
Cores de artefactos
Ásia Ocidental antiga
Análise de componentes principais
Métodos quantitativos

Introduction: studying ancient cylinder seals

The use of cylinder seals is documented in ancient Western Asia, and especially in Mesopotamia, from the Chalcolithic period (around 3500 BCE). The first appearance of this type of artefact seems largely linked to the technology of writing and the emergence of the first forms of state administrations and complex societies [1-6] (Figure 1 and Figure 2). It was then rapidly adopted, albeit unevenly and in different periods and with different modes, in other areas and by other cultures of the Eastern Mediterranean and Western and Central-Western Asia. Among these were also less or differently literate cultures, such as those of Egypt, the Aegean, Anatolia, the Indus Valley, etc. The spread of the cylinder seal led in most cases (but not always and not everywhere) to the disappearance of the stamp seal [7; 8, pp. 5-7; 9, pp. 14-19].

It has often been emphasised that the cylinder seals had other functions in addition to their administrative use, that could have been acquired even before the first large-scale production and use: the seal became an amulet and an ornament, sometimes as part of its owner's clothing. Although it is possible that in its earliest use, and in some later cases, it had been linked to an office rather than to a person, it is likely that it was soon linked mostly to individuals. As such, it could be worn on clothing, as a pendant or as part of a bracelet or other pieces of jewellery. It is possible that, at least in some historical periods, the cylinder seal was also an explicit mark of high social status [4; 10-13; 14, pp. 16, 22-24, 229-230; 15; 16, pp. 57-60].

As far as we may now understand the daily life of the peoples who used them in antiquity, cylinder seals were perceived and experienced primarily through their peculiar corporeality, both when being used as administrative tools and when being manufactured or worn. Nevertheless, when publishing cylinder seals in scholarly works or catalogues, it has been common practice for many years to show their complete (and carefully produced) aseptic modern impression, so that their entire iconographic apparatus is shown in an easily understandable representation. However, such a display has no real equivalent in the actual ancient use of seals. Similarly, when seals are exhibited in museums, they are usually shown alongside their modern impression: in fact, a very poor representation of meaning and impact in ancient societies. As a rule, in both cases – i.e. museum exhibitions and printed publications – little information is provided about the physical characteristics of the seal, usually limited to height and diameter, while other interesting features are neglected (see, for example, the observations of Asher-Greve and Stern [17-18]). This means that very little information regarding cylinder seals has been recorded which could be truly useful for an investigation focusing on their nature as a cultural product. The perceptual characteristics associated with their intense physical relations with the bodies of their ancient makers and active or passive users also remain unexplored. Only in recent years have some research groups taken advantage of the recording and reproductive potential of digital technologies to expand the range of available information regarding ancient glyptic specimens [19-29].

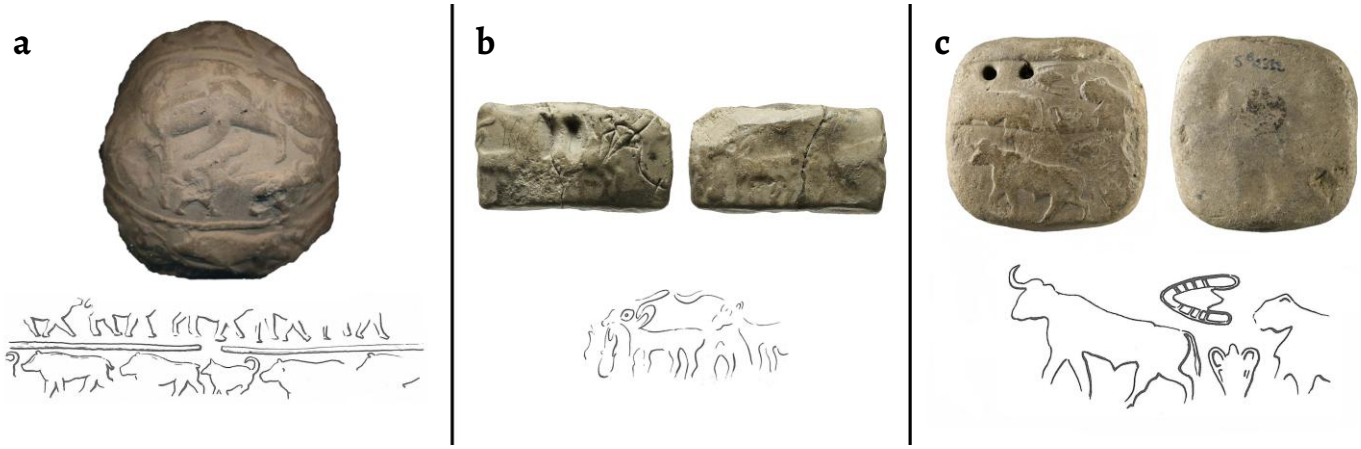

Figure 1. Fourth millennium sealed artefacts: *a)* Bulla from Susa (Louvre: SB 6295); *b)* Protohistoric administrative tablet (obverse and reverse) with numeric and pictographic signs (Louvre: SB 6349, from Susa); *c)* Protohistoric administrative tablet (obverse and reverse) with numeric signs (SB 2312, from Susa) [30].

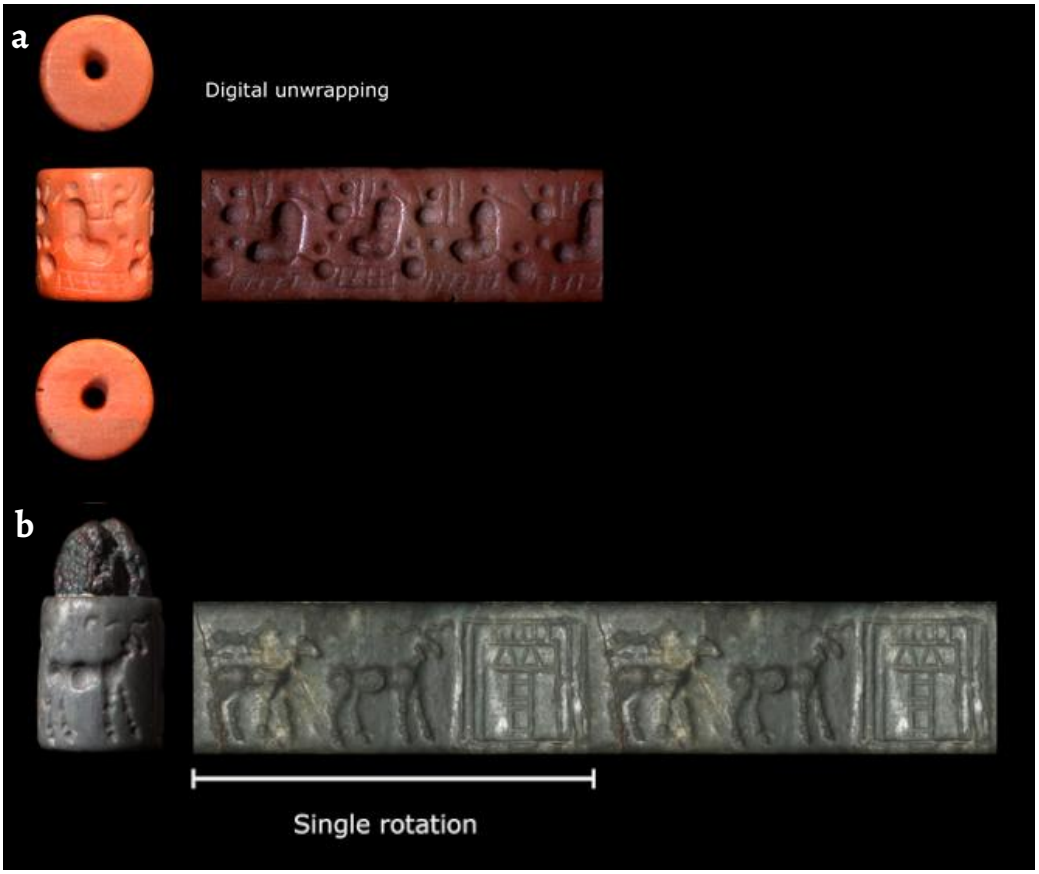

Figure 2. Two cylinder seals of the Late Uruk period: *a)* CDLI P502513; *b)* P476472, BnF Paris et Université de Nanterre (photography: N. Ouraghi for the SESPOA Project [31]).

This contribution illustrates research into the colours of cylinder seals, one of their physical features which has thus far been largely neglected in literature and research. It is worth recalling that most – though not all – known cylinder seals are made of stone, as are most of the seals used in this study, except for a few made of faïence.

This work and its development are based on – and have been made possible thanks to – four main components: the availability of a pre-existing independent open archive of digitised seals; a dataset based on this archive specifically developed for this research; open algorithms for the examination and analyses of colour in digital images; exploratory data analysis methods, such as principal component analysis (PCA). Our objective was to provide a preliminary step in a broader study on both colours of cylinder seals and on possible clues to the phenomena underlying their perception and choice. We have focused on two topics: the changes of the colours of cylinders during the historical periods when these artefacts were in widespread use (ca. 3500-300 BCE), and the possible relations between the colours of the seals and the iconographic subjects carved on them.

The structure and building of the data set

In order to build a dataset that would fit the aims of this investigation, specific information consistently recorded for a large number of artefacts is necessary. Such information must relate to three main features at least, namely: the colours of the seals, the subjects carved on their surface, and the historical period of manufacture.

The historical period of each seal's manufacture has been identified considering both iconography and carving style, while the subjects represented on the surfaces of the cylinders were recognised and named according to the traditional terminology used in literature (such as

"contest", "presentation", et sim.) or through a simple description ("geometric motifs", "animals", etc.). As sometimes more than one theme is shown on a seal, both primary and secondary themes have been recorded for each specimen, with possible inscriptions recorded as secondary themes too.

Identifying the colour of seals is not a trivial matter, as surfaces often show complex mixtures of shades or a dense juxtaposition of very different hues. Furthermore, as colour is the result of a subjective visual perception of the type of diffusion of light by a particular surface, a consistent perceptual response is needed to record and compare colours. The solution to this problem has been found in recently developed research projects. Indeed, various experiments have been carried out over the last twenty years which seek to optimise the documentation and representation of cylinder seals in scientific publications with the help of digital technologies [19-29, 32-36]. One of the most recent projects of this kind has been developed as an international initiative involving several research institutions, SESPOA-SIANE [31, 37]: using a structured light scan, a large number of digital representations of cylinder seals with consistent colour reproduction could be produced. Structured light is a system that projects a pattern of light onto an object: this pattern of light is distorted by the profile of the object's surface [28], such that it can be further analysed in its constituent parts. The team of SESPOA-SIANE used the same setup for capturing the images necessary to obtain the digital rollout – and possibly the 3D model – and consistently carried out post-processing of the images obtained, at least for the digital rollouts, made possible by calibration measurements made on the scanner. On the other side, the two bases and the single pictures of the sides of the cylinders shown in the archive sometimes – especially in the earliest phases of the project – had been taken separately with a digital camera: as a result, they may look a bit different in colour in the final display. For this reason in this work we took into account the colour data resulting from the digital rollouts. As numerous images of seals obtained through structured light scan are published on the freely accessible SESPOA website as images together with the "digital unwrapping" of their surface, we could take advantage to use these for our experiments (Figure 3).

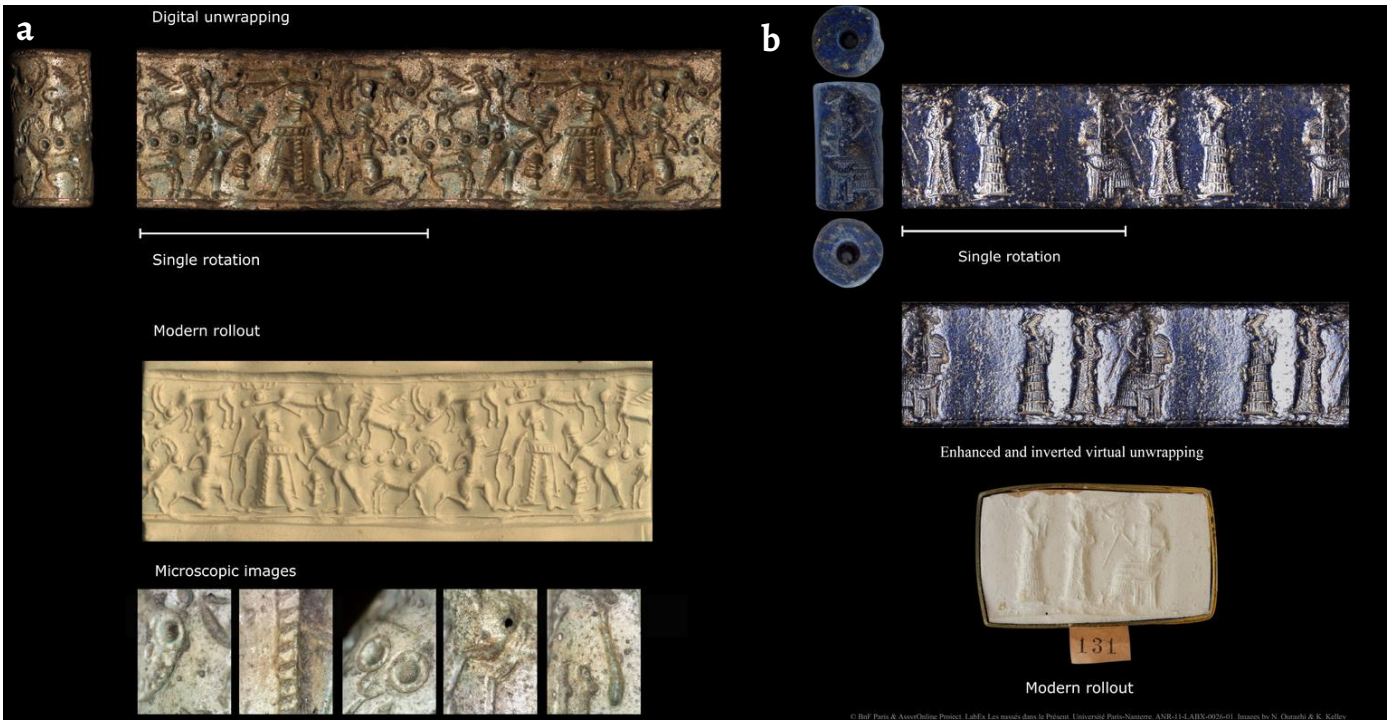

Figure 3. Two examples of scans published on the websites of SESPOA and CDLI: *a)* P502856; *b)* P502611, BnF Paris et Université de Nanterre (photography: N. Ouraghi for the SESPOA Project [31]).

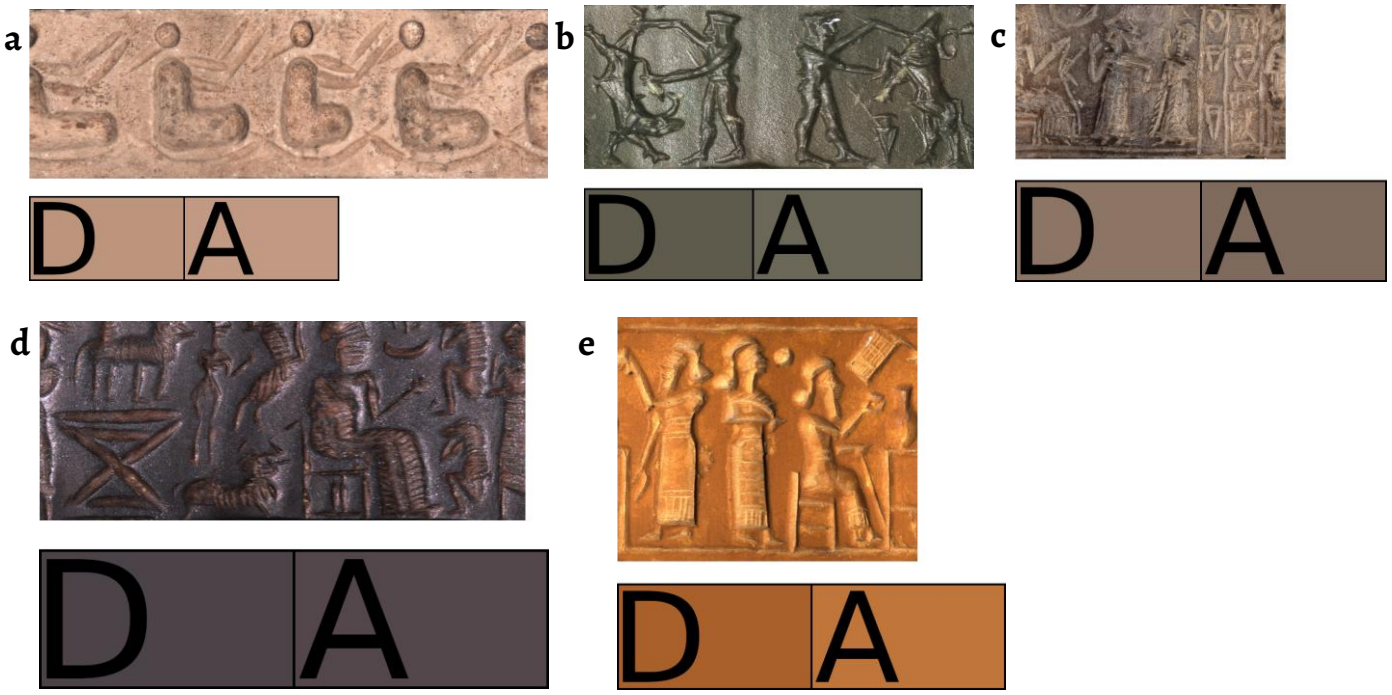

Figure 4. Examples of *Dominant* (D) and *Average* (A) colours recorded on some cylinder seals. The triples of values refer to the RGB coding of each colour (dominant; average): *a)* Jemdet-Nasr period working women (daily life): 189, 148, 124; 194, 154, 131; *b)* Akkadian contest: 95, 91, 76; 107, 104, 90; *c)* Ur III presentation: 140, 117, 100; 127, 107, 93; *d)* Old-Assyrian presentation: 75, 67, 72; 84, 71, 75; *e)* Neo-Assyrian banquet (daily life): 170, 96, 42; 192, 118, 58.

Nowadays, various strategies exist for measuring the colours present in a digital image, from client free or proprietary software to various web applications. Of course, the selection and consistent use of a single tool or set of algorithms is essential for a study comparing the colour values of images. In our case, the calculation and description of the RGB colour values of the images of the artefacts was performed using the image analysis web tool *Image Average Color Finder*, available on the DevPicker website [38]. This particular tool was chosen because it is easy and quick to use and has the advantage that the image analysis can be visually interacted with and controlled, making it well suited to the production of a large dataset. The *Square Root* and *Dominant* analyses were used to obtain the RGB values of the average and dominant colour for each specimen, respectively. Note that to measure the average colour *Square Root* proved to be more accurate and reliable than the *Simple* analysis.

Based on the values obtained from DevPicker, we created a dataset of the recordings of 639 seals, each consisting of 10 entries: 1) the unique identification number of the seal, linked to both the corresponding accession number of the collection and the identification number of CDLI [39]; 2) the historical period, made up of twenty possible values representing a range of periods from Late Uruk to Hellenistic; 3-4) the primary and secondary themes, entered as nine and seven formalised codings respectively; 5-7) the average and 8-10) the dominant colours, each recorded as the values of the three Red-Green-Blue (RGB) components, ranging from 0 to 255 respectively (Figure 4 and Table 1-3).

All the codings included in this first step refer to seals belonging to the collection of the Bibliothèque Nationale de France (Paris). They are based on the image archive published on SESPOA website [31], also present in the CDLI archive.

We were aware of the possible drawbacks of using a dataset largely based on artefacts from the antiquarian market and so ruled out any risk by careful visual inspection. In the corpus recorded in the dataset, forgeries or overly eccentrically coloured artefacts are absent. The latter were not excluded on purpose: this could be verified after completing the dataset, and thanks to the useful observations by Margaret C. Root (on the international congress *Archaeology of Colour*, 2024). However, not all seal images published by SESPOA were considered. About 35 % of them (hundreds) were excluded as a precaution, either because they

appeared to have been recorded according to different parameters than the others, or because the artefacts were too badly preserved to recognise their theme and period. As with a few other seals which were heavily damaged, but still clearly showing the carved theme, their profile was adjusted to avoid the possible influence of "empty" spaces on the analysis. A similar treatment was applied to the very few specimens in which light was reflected in an exaggerated manner.

Table 1. Composition of the dataset, according to historical periods.

Coding	Period	Number of specimens
Lt-Uruk	Late Uruk	18
JN	Jemdet Nasr	14
EDII	Early Dynastic II	16
EDIII	Early Dynastic III	26
Early Syr	Early Syrian	14
Akk	Akkadian	54
UrIII	Third Dynasty of Ur	44
Isin-Larsa	Isin-Larsa	36
Old Bab	Old Babylonian	123
Old Assy	Old Assyrian	32
Old Syr	Old Syrian	58
Cyprus	Cypriote Late Bronze	15
Kassite	Kassite	13
Middle Assy	Middle Assyrian	18
Mitanni	Mitanni	20
Egypt	Egyptian Late Bronze	16
Neo Bab	Neo Babylonian	23
Neo Assy-Sy	Neo Assyrian	57
Persian	Persian	30
Hellen	Hellenistic	12

Table 2. Composition of the dataset, according to themes.

Coding	Theme	Number of specimens
Inscription	Inscription (or legend)	12
Pres deity	Presentation before a deity	228
Daily life	Scenes of daily activities	56
Pres	Presentation	117
Deities	Deities	27
F-f-g	Floral, faunal or geometric motifs	22
Contest	Contest scene	122
Hunt	Hunting scene	37
Animal	Animal(s)	18

Table 3. Composition of the dataset, according to secondary themes.

Coding	Secondary theme	Number of specimens
Absent	Secondary theme is absent	426
Daily life	Scenes of daily activities	4
Animal	Animal(s)	40
Pres	Presentation	13
Inscription	Inscription (or legend)	126
Deities	Deities	7
Contest	Contest scene	23

The methods

The data analysis was essentially based on principal component analysis (PCA [40-41]), a very well-known tool for exploratory identification of the main features of a data set. PCA seeks the most informative graphical representation of the numerical data at hand through a transformation (singular value decomposition [42]) in which the units are represented on new uncorrelated variables – the principal components – along which most variation occurs. Since principal components are those most correlated with the original variables, their direction can be interpreted through them, leading to an optimal representation in reduced dimensional spaces of both the units and the numerical variables, in which the most relevant features of the data can be observed. On the same graphics, each value of the nominal characters – in the following, addressed as "level" – may be represented as a supplementary unit, situated in a central position with respect to the units showing such value. More precisely, these levels are set as "centroids", i.e. points whose coordinates are the average of the considered units. As such, both their absolute position and that with respect to the other levels may show to what extent the corresponding groups of units may be characterised by the average values of the original variables. All calculations were performed with the R package [43].

The results

The PCA was performed on the values of the two groups of three components of the digital RGB colour model recorded for each specimen, representing its average and its dominant colour, respectively.

On the three extracted components, accounting for 98 % of total variation – an outstanding amount –, all levels of period and themes have been projected as average of the seals grouped by each level. As expected, dealing with all positive values, the first component explains about 85 % of total variability, the second about 9 %, and the third more than 4 %.

A very important aspect of the results, particularly clear in the graphics, is the actual degree of distance or proximity between plotted items, which are generally expressed with the association or opposition along an axis, i.e. a straight line where the items' coordinates correspond to a principal component. For instance, two items are opposed on an axis if either lies on the positive and the other on the negative side of the axis. Moreover, the further they are from the axes' origin – the point where the axes cross, the center of gravity of the cloud of points – the larger is their opposition as well as, in general, their distinction from a very common item. For the interpretation of the axes, their correlation with the original variables – in this case, the six colour components – is considered and represented in the circle of correlations, where the angle between variables and axes approximates their correlation.

According to this representation (Figure 5), the resulting oppositions along the axes are the following: Axis 1, light (on the positive side) and dark colours (on the negative side); Axis 2, lighter average colours (on the positive side) – corresponding to higher values of the RGB components – opposed to dominant colour (on the negative side); Axis 3, higher values of Blue (on the positive side) as opposed to Red components (on the negative side), Green which comes out as average.

Note that, in addition to the colour hue, the first two axes also show the ability of the stone to reflect light. Therefore, however controlled and accurate they may be, image acquisition operations through structured light scanning and further processing could not avoid light reflections produced on the stones of which some of the seals are made [31]. In our case this happened with very few seals, but proper pre-processing of data, and counterchecking with the recording of both the average and dominant colours in the dataset helped us to minimise the effects of this introduced bias.

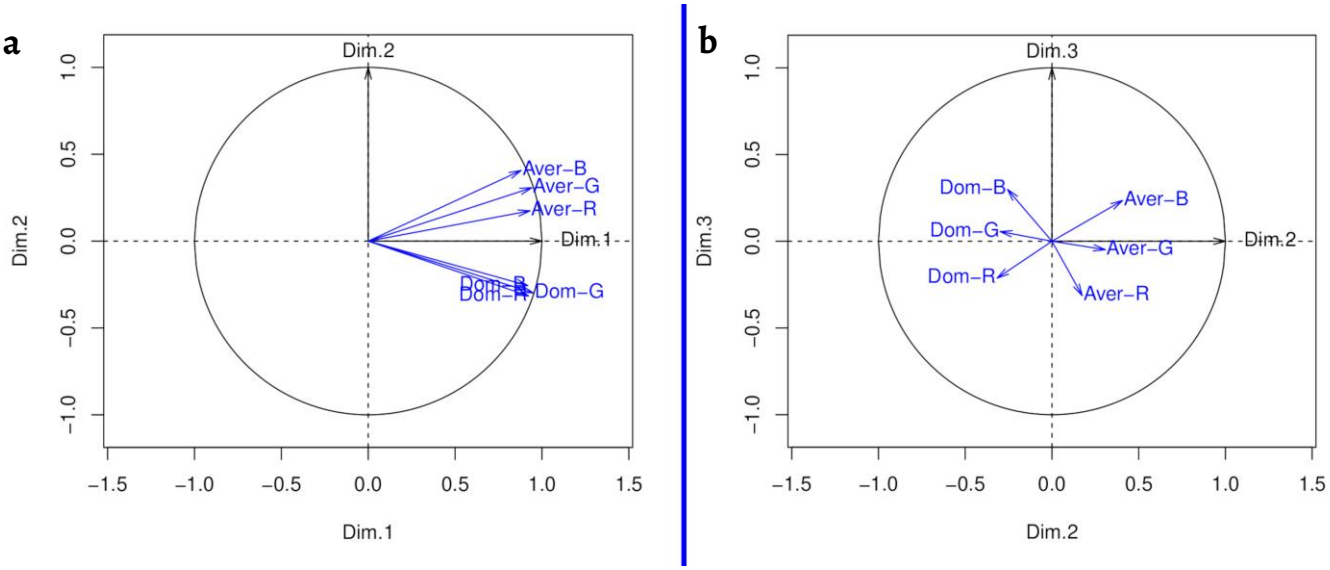

Figure 5. PCA results: the circles of correlations with respect to the axes 1-2 (a) and 2-3 (b). Note the positive correlation of all colour's components with axis 1 (hence interpreted as intensity), the opposition between average and dominant colours on axis 2, and the clear distinction between Blue, Green, and Red on axis 3.

Seal colours and historical periods

The representation of supplemental items on the graphics as a three-dimensional cloud of points, allows them to be interpreted according to the agreements-oppositions along the three axes of the space of representation.

On the plane spanned by axes 1-2 (Figure 6a), the cloud of historical periods suggests that the earliest Mesopotamian seals were made of stones of relatively homogeneous and intense colours and a shade of colour which gradually changed from moderately light to very light: this is suggested by the position of the levels of chronology Late Uruk (Lt-Uruk) and Jemdet Nasr (JN). These features seem to have been maintained in Mesopotamian glyptic until the middle of the third millennium BCE, apart from the fact that colours tend to become slightly brighter from Early Dynastic II (EDII) and darker in Early Dynastic III (EDIII). In the following centuries, i.e. in the Akkadian (Akk) and Third Dynasty of Ur (UrIII) periods, Mesopotamian cylinder seals tended to be darker and more homogeneous in colour, but apparently also shinier. This picture is confirmed and further explained by looking at the distribution of periods along Axis 3 (see the plane spanned by axes 2-3 in Figure 6b). From the early historical era (Late Uruk) to Early Dynastic III, the general development of colour is from greenish-reddish to yellowish with a general prevalence of the dominant colour, while in the second half of the third millennium, first in the Akkadian period and then under the Third Dynasty of Ur, the colours seem to become more balanced, with a prevalence of the blue component in quite dark and slightly shiny stones. The Early Syrian production (Early Syr) – which in this case can be chronologically paired with the late Early Dynastic III and Akkadian periods in the Land of the Two Rivers – differs markedly that of Mesopotamia, as it has lighter colours and a clear predominance of the red component.

Lower Mesopotamian glyptic production of the Middle Bronze age (represented in the graphics by "Isin-Larsa" and "Old Bab") shows a strong chromatic homogeneity, with a moderate balance of the three components (RGB) and significantly darker stones when compared to the earlier periods. Old Assyrian figures (Old Assy) are very similar, and the same is true for Old Syrian seals (Old Syr), if it was not for the significantly lighter colours of the latter.

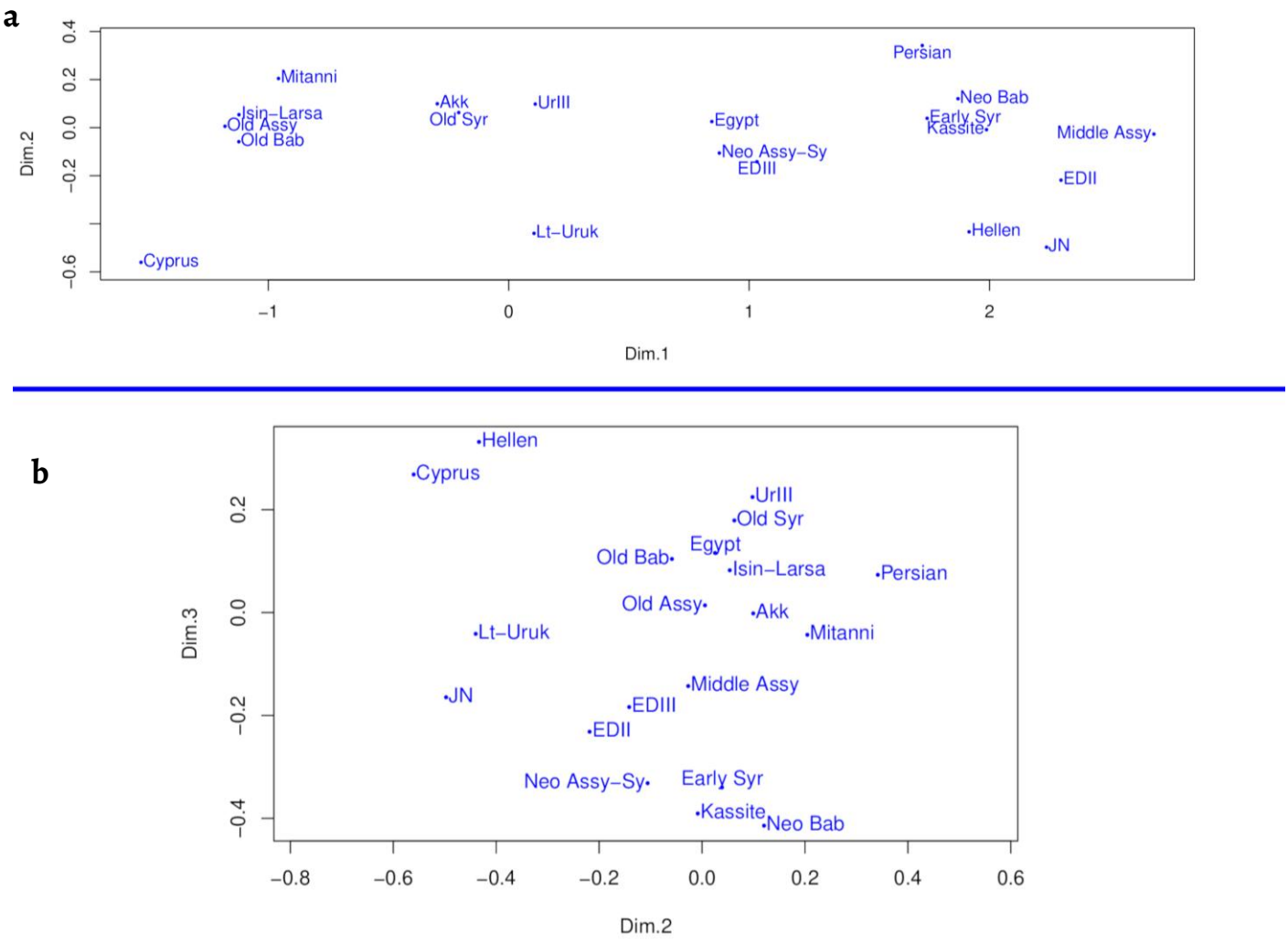

Figure 6. PCA results: representation of the historical periods on to the planes spanned by the axes: *a)* 1-2; *b)* 2-3.

In the Late Bronze Age regional and cultural-chronological distinctions emerge clearly, and with sharp oppositions. Kassite and Middle Assyrian (Middle Assy) specimens tend to be quite light in colour, relatively dull and with a marked prevalence of the red component – especially the Kassite seals. Mitannian production (Mitanni) seems brighter, much darker and with a good balance of the three components, while the specimens of Late Bronze Cyprus show extreme values on all axes, with a clear prevalence of the blue component on Axis 3 and a tendency towards dull (Axis 2) and dark colours (Axis 1). The Egyptian cylinders included in the dataset are not very numerous and can be dated to a period across Late Bronze and Early Iron Ages. They are essentially quite light in colour, with the blue component clearly predominant and the green component present to a small extent only.

In the first millennium the seals from Mesopotamia show a clear tendency towards lighter colours. The Neo-Assyrian (Neo-Assy-Sy) and Neo-Babylonian (Neo Bab) specimens share a predominance of the red component, but the former are somewhat darker and less bright. Later periods, i.e. Persian and Hellenistic (Hellen), are opposed on Axis 2, with the Persian production being brighter, but both showing a tendency towards light colours and a predominant blue component, especially the latter.

The general framework that can be established on the basis of these results has been summarised in Figure 7. This synthetic overview allows a quick diachronic comparison since it shows, and juxtaposes graphically, average RGB values recorded for the dominant (Dom) and average (Avg) colours of the seals of each period (Figure 4).

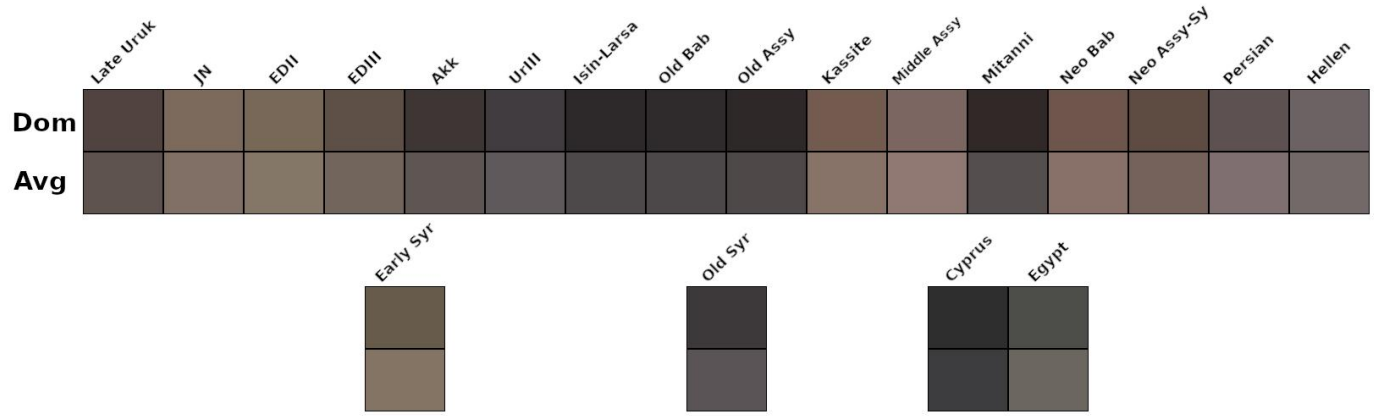

Figure 7. Synthesis of the average values of dominant (Dom) and average (Avg) colours of cylinder seals in different historical periods. The continuous series shown above represents Mesopotamian periods, or periods partly related to Mesopotamia. The discontinuous series below similarly represents the contemporary periods related to other regions of Western Asia. The upper half of each series shows the RGB rendering of the average of seals' dominant colours (Dom) for each period, while its lower half shows the RGB rendering of the relevant average of average colours (Avg).

Such a global view of the results shows remarkable diachronic changes in the colours of Mesopotamian cylinder seals from late fourth millennium to the early second half of the third. This seems an accurate reflection of the nature of changes that took place in the Early Bronze Alluvium in the realms of visual culture and regional political balances. The transition from the late Early Dynastic "proto-imperial" phase to the Akkadian empire is represented by changes in the colour of the seals that would characterise glyptic production until the end of the third millennium. The many cultural, political and organisational affinities that existed between Akkadian rule and Ur III are well reflected in the figures that emerge from this analysis, despite the differences in glyptic themes and iconographies. Geographical differences appear to emerge as early as the second half of third millennium when looking at the values for Early Syrian production.

The Middle Bronze Age is very homogeneous across different regions, with Lower Mesopotamian, Syrian and Old Assyrian productions showing great similarities. This can perhaps be interpreted in cultural and commercial terms (i.e., trade in raw materials) rather than in a political manner considering the diffusion of the Amorite peoples throughout these regions, often in leading socio-political positions, and the growing number of (mainly territorial) entities that played independent roles in international trade and politics. Such homogeneity could be due to trade networks that seem to have facilitated the fulfilment of demands for certain raw materials, though the general political situation, characterised by discontinuous international balances, may have rather favoured a differentiation between the political entities involved in terms of their internal structure and organisation. Indeed, this is much more evident when considering the iconographies of the seals rather than their colours. Looking at the figures of the analysis, it seems that the colours of Late Bronze Age seals reflect not only the changes in the local politics of most regions, but also a clear-cut cultural differentiation among these regions and a profoundly altered international political framework. It is only between the productions of Lower and Northern Mesopotamia that some traces of affinity can be identified, despite major differences in the iconographic tradition.

The general picture of the first millennium fits well with the historical-political situation, with appreciable – while not huge – differences between Neo-Babylonian and Neo-Assyrian productions and, later, the Persian and Hellenistic seals: these differ clearly only in that they are opposed on Axis 2, but not on axes 1 and 3. The colours of Persian seals seem to be in continuity with the developments of the Neo-Babylonian seals, and during the Hellenistic period many of their features are retained, while a tendency emerges to use duller stones.

Seal colours and iconographic themes

One of the aims of this research is the investigation of the possible relations between the colours of seals and represented subjects. This study was only partially carried out because, in addition to the interpretation of the carvings, it also involves their categorisation into thematic groups which is a complex and delicate question which could increase the degree of arbitrariness of the investigation.

The ideal association of the themes represented on different seals may be fairly solid and well-grounded in some cases, and also within the same historical period. However, it can become difficult and lead to the misleading coding and interpretation of data when formal similarities between different cultural or historical productions are very tempting. We have decided to limit the study to a few themes for which an ideal definition – based not only on compositional and formal features, but also on past research and literature – may reasonably be adopted.

One of these is the category of the so-called "presentation scenes", where the focus of the presentation or act of homage is a deity or a human being [16, 44]. This category of subjects ("Theme_pres deity" and "Theme_pres"), which is mainly attested in the late Early Bronze and Middle Bronze age, is associated with dark colours and a predominant blue component. In general, seals with "presentation scenes" seem to tend slightly towards being associated with shiny stones (Figure 8).

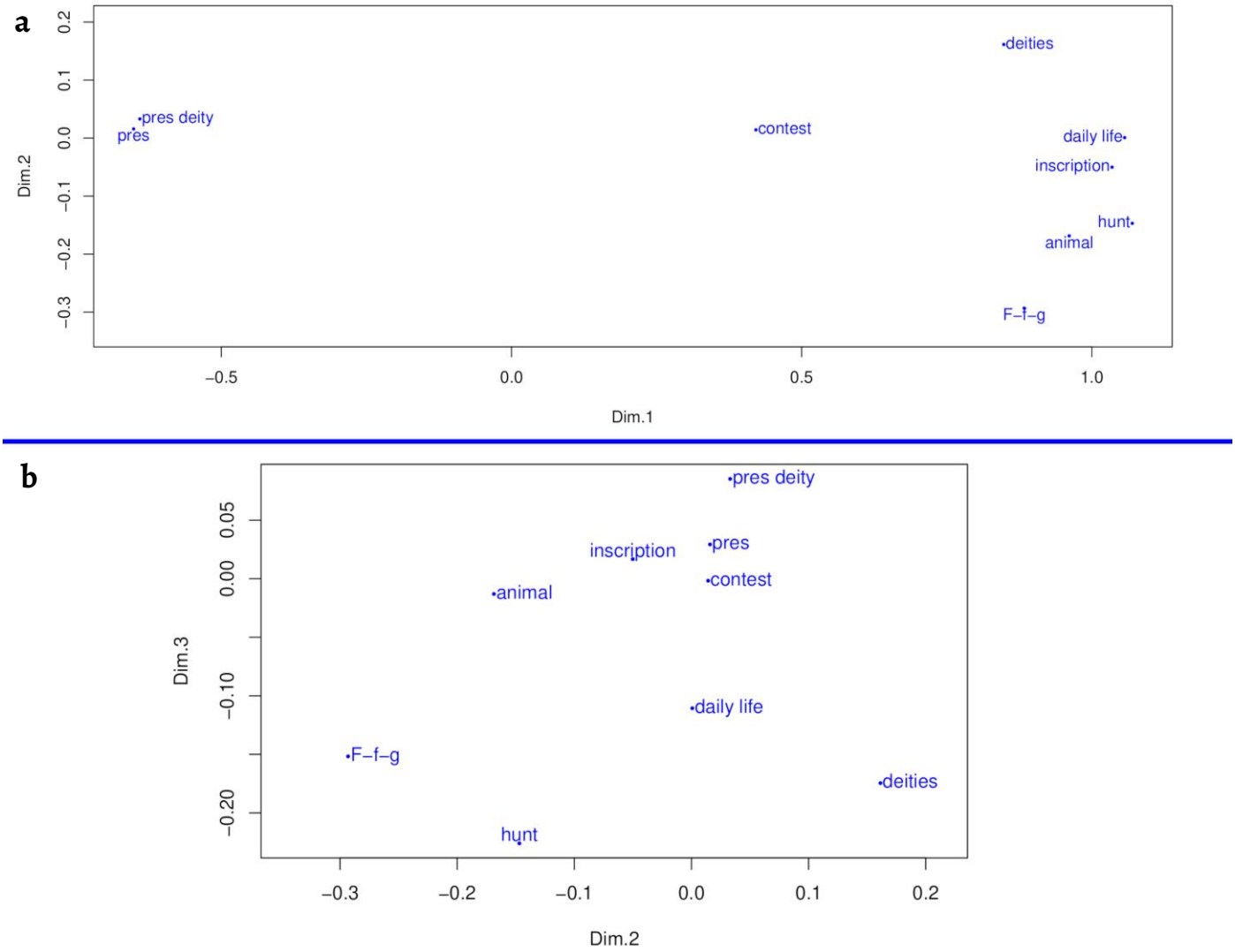

Figure 8. PCA results of the representation of the iconographic themes on to the planes spanned by axes: *a)* 1-2; *b)* 2-3.

Another group of subjects that can be considered fairly homogeneous is largely linked to the earliest historical periods: the combination of elements or patterns rhythmically distributed on the surface ("Theme_F-f-g"). These may include geometric motifs and floral or faunal elements. This category is in clear opposition to the presentation scenes on all three axes and is generally represented on light-coloured seals which tend to be dull, with a predominant red component. The nature of the occurrence of the hunting theme ("Theme_hunt") is very similar, but the logical and semantic internal homogeneity of this group does not seem solid enough at the moment to consider this a real clue for interpretation.

Apart from being easily recognisable, both the "presentations" and the "F-f-g" patterns are largely homogeneous in terms of their own chronological development. Their clear-cut opposition in the graphics might be due to the different historical periods and conditions in which they were mainly produced and used, but also to the fact that they were probably tied to different administrative uses and to different understandings of the relation between the seal and its owner.

Closing remarks

The perception and use of colour in the cultures of ancient Western Asia are very stimulating, but also largely unexplored research topics (except for comparatively few works, see e.g., [45-47]), particularly with regard to stone artefacts. This is not surprising considering how difficult it is to collect and interpret data on these issues. We must not forget that the various cultures of antiquity perceived and classified colours differently from us and from each other. It is possible, though unlikely at large scale, that none of the colour distinctions we make correspond to any kind of implicit or explicit classification of the cultures that produced cylinder seals. On the other hand, one must consider the possibility that the colour distinctions we find for a class of artefacts correspond to other significant differences in perception, construction or choice of materials.

The study presented here is merely a preliminary exploratory step of research which hopes to develop in a number of directions: the first stage focuses on understanding when and to what degree the colours of cylinder seals changed, and, consequently, whether there may have been any relation between seal colours and iconography or historical phenomena of any kind. At the moment, the perspective is too general and the stage of research too early to include the investigation of specific reasons behind the choice of colours and possible links to social, political, economic issues, or questions of contemporary fashion. Therefore, at present, the central subject of this research is seal colours, considered independently from their materials and other physical factors.

Significant opportunities for this study arise from the fact that cylinder seals are fairly well – and in large numbers – documented and known. For our investigation, it is essential to have a dataset of seal colours containing a good number of records (we plan to expand it significantly) and which has been built with due attention to the representation of different periods and production types. These starting conditions can lead to a well-grounded and solid picture of general chromatic developments in ancient glyptic craftsmanship, if one uses the proper methodologies to obtain information adequate for a representative synthesis. In the study presented here, PCA proved to be a suitable tool for identifying and graphically representing similarities and differences in the colours of seals according to their historical periods and, to a lesser extent, depending on the theme depicted.

The main weaknesses of this work and its procedures are – as has already been mentioned – the degree of arbitrariness in the definition of iconographic themes engraved on the cylinder seals and the fact that the original data we can presently use are only those already collected in research projects by scholars and institutions not involved in this work.

Although the type of data available limits the possibilities for expanding the dataset, the future substantial increase in number of records should in itself reduce possible biases and help to achieve the goal of a correct representation of the specimens for different periods and cultures. A higher number of seals coded and included in the dataset would also allow a more refined differentiation of periods, and thus a bettergrounded classification of the themes represented in glyptic.

Needless to say, the following steps of this research will start with an increase of the dataset in two directions: the number and variety of records and the number and quality of variables included. With such an approach, the possible biases caused by an excessive presence of artefacts from the antiques market in the dataset will further be limited. Other statistical methods are considered too, in particular to carry out analyses allowing the assessment of the degree of variability within historical periods or geographical areas. Together with a cautious and careful use of recent studies on colours in ancient Western Asia [48-49], this would help in the interpretation of the results.

Acknowledgements

The authors are very grateful to the creators and developers of the SESPOA, SIANE and CDLI projects for publishing their data in an open and freely accessible archive. In particular, we thank Kathryn E. Kelley, Bertrand Lafont, Jacob L. Dahl and David Young for the additional information with which they provided us. We are also grateful to Margaret C. Root and the two anonymous reviewers for their helpful comments for refining this work and for the future developments of this study.

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RECEIVED: 2024.5.10
REVISED: 2024.10.6
ACCEPTED: 2024.10.7
ONLINE: 2025.4.26