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Sand Drawing *versus* String Figure Making: Geometric and Algorithmic Practices in Northern Ambrym, Vanuatu

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1. Introduction

For a long time, indigenous societies have been excluded from the field of the history of mathematics (D’Ambrosio, 1985, 2001). Until a few decades ago, historians and philosophers of science have indeed left out of their field of study small-scale and/or indigenous societies—frequently endowed with an oral tradition. The prevalence of the evolutionist (Tylor, 1871) and “prelogical thought” (Lévy-Bruhl, 1910) theories, arguing that these peoples had a lesser ability to abstract and generalize than ours, appears to have durably impeded the recognition of genuine mathematical practices carried out in the various indigenous societies worldwide (Vandendriessche, upcoming-2021). At the turn of the second half of the 20th century, however, a significant epistemological change occurred on this issue, fostered through the work of anthropologist Claude Lévi-Strauss in particular (1962). The latter epistemological rupture seems to have prompted the development of studies—in the 1970s—that are now generally considered to be seminal works in the establishment of ethnomathematics (Vandendriessche & Petit, 2017).

The current development of this nascent interdisciplinary field of research contributes to further widen our perspective on mathematical knowledge and its history, while including in the picture all activities displaying mathematical characteristics carried out in social groups/societies within which they are (or were) usually not recognized as such. In the various indigenous societies of the planet, mathematics has not commonly appeared as an autonomous category of knowledge. However, as many ethnographies on “traditional” societies have demonstrated—throughout the 20th century—particular forms of reasoning/logic occur(red) within various practices of theirs, such as the making of calendars or ornaments, the establishment of camps and dwellings, textile production, navigation, games, the implementation of kinship relations, etc. (Rivers & Haddon 1902, Deacon & Wedgwood 1934, Austern 1939, Lévi-Strauss 1947, Pinxten *et al.* 1983, Gladwin 1986, MacKenzie 1991, Desrosiers, 2012, Galliot 2015...). A major epistemological issue tackled by ethnomathematicians is therefore to determine to which extent some of these practices relate to mathematical activities, and how.

In order to avoid being constrained by “Western connotations of the word mathematics”, Marcia Ascher (1935-2013), one of the founders of ethnomathematics in the 1990s, introduced the concept of “mathematical ideas.” Mathematical ideas are defined as any idea in which are involved “numbers, logic, and spatial configurations, and particularly the arrangement of these ideas into systems or structures” (Ascher, 1991: 3). Ascher has developed a methodology, based on the use of modeling tools, aiming to bring to light these systems and structures, related to

various activities practiced in “small scale or indigenous cultures”. However, like most ethnomathematicians, Ascher’s work consists in the analysis of second-hand ethnographic sources. By contrast, in the last decades, some ethnomathematicians have suggested that an ethnological approach should play a central role in ethnomathematics, while applying an ethnographic participant-observer methodology in particular (Chemillier, 2011).

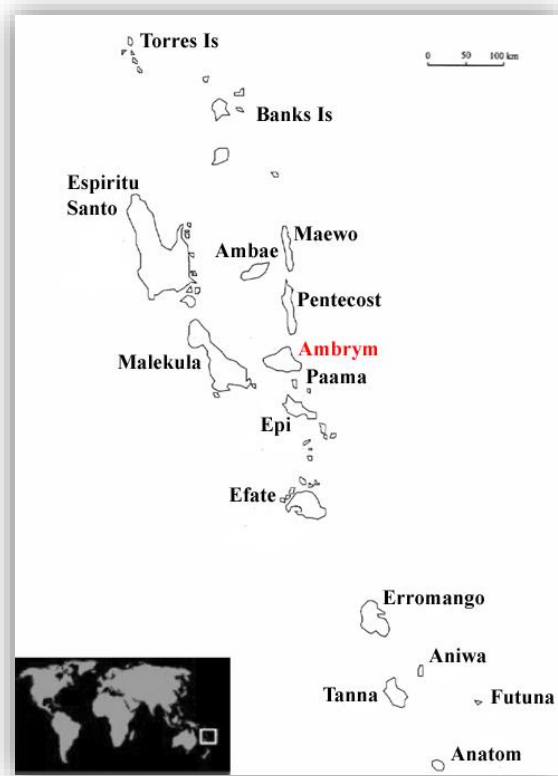


Fig. 1. Left: Map of Vanuatu. Right: Ambrym Island, Vanuatu

This should enable the collection of new data concerning activities that involve mathematical ideas/reasonings/logics. Meanwhile, long-term ethnographic fieldwork should lead to a better understanding of the cognitive acts that underlie these activities, and also the way in which they are embedded in the social organization and symbolic systems of the societies in which they are practiced.

With this theoretical and methodological framework in mind, I have undertaken ethnographic research that aims to compare two activities, described as string-figure making and sand drawing—both implying mathematical ideas—carried out in Northern Ambrymese society, on Ambrym Island, Vanuatu¹, South Pacific. String figure making consists in applying a succession of simple gestures to a string—knotted into a loop (made—in Vanuatu—of a slice of pandanus leaf), using mostly fingers and sometimes feet, wrists or mouth. This succession of operations, which is generally performed by an individual and sometimes by two individuals working together, is intended to generate a “final figure” whose name refers to a specific being or thing. For over a century, this practice has been observed by anthropologists in many regions of the world, especially in oral tradition societies (Rivers & Haddon 1902, Jenness 1924, Evans-Pritchard 1972, Braunstein 1992).

¹ Called the New Hebrides by the British navigator James Cook in the 1770s, this archipelago—located 1,750 kilometers east of northern Australia—was managed through a Colonial French & English Condominium from 1906, until its independence in 1980 and the foundation of the Republic of Vanuatu.

Fig. 2. Left: Mata (village of Fona) displaying the string-figure *mel* (fruits of the tree *limel* “trunk of *mel*” or *nakatambol* in Bislama, *Dracontomelon vitiense*), Vanuatu. Right: Buwekon (village of Topol) drawing *fanwochepu* (name of a village of the past) © Vandendriessche



In Vanuatu (ex-New Hebrides), string figure making has first been documented by anthropologist Lyle Dickey, who published in 1928 the instructions for making nine string figures collected from New Hebrides immigrants—mostly Erromango Islanders—living in Hawaii. Until very recently, no other collection of Ni-Vanuatu string figures had been published so far. In 2014, the lost collection of string figures collated by the anthropologist Arthur B. Deacon in the 1920s on Malekula Island finally reappeared and was edited (Deacon & Sherman, 2015)².

The practice of sand drawing consists in making a figure by drawing a continuous line with the finger—either in the sand or on dusty ground—drawn through the framework of a grid made of either perpendicular lines or dots, without retracing any part of the drawing, ending it (most of the time) where it has begun. Like string figures, the making of sand drawings has been observed in Vanuatu since the early twentieth century—notably by anthropologist Arthur B. Deacon (1934) and John W. Layard (1942)—and is still practiced widely in the center of the archipelago and in Northern Ambrym specifically.

Previous studies have shown that string-figure making practices are widespread throughout Melanesia (Landtman 1914, Hornell 1927, Maude 1978, Noble 1979, et al.). In contrast, and although we have scant evidence of such a practice in Papua New Guinea (Bell, 1935), sand drawing in the Melanesian area has mainly been observed in central Vanuatu. Accordingly, this

² Arthur Bernard Deacon (1903-1927) was a student of Cambridge anthropologist Alfred Cort Haddon. He died of blackwater fever (an acute form of malaria) on Malekula Island, New Hebrides, where he had carried out fieldwork in the years 1926-1927. His ethnographical field notes were published in 1927 and 1934 by another student of Haddon, anthropologist Camilla H. Wedgwood (1901-1955) (Deacon 1927, 1934, Deacon & Wedgwood 1934). We had evidence that Deacon focused on both string figures and sand drawings: an editorial footnote in Deacon’s monograph on Malekula (Deacon, 1934) indicates that Haddon and Wedgwood had hoped to publish his research on string figures (alongside his records of sand drawing) in a separate volume. Unfortunately, while the sand drawing records were published shortly afterward (Deacon & Wedgwood, 1934), the string figures have never appeared. The worst of it is that Deacon’s field notes on string figures had never been found. Recently, Mark Sherman, the president of “International String Figure Association” (<http://www.isfa.org/>), received a message from a stranger, explaining that he found a collection of documents on string figures from all over the world, through his late father’s effects, and looking to “give them a good home” (Sherman & Deacon, 2015). These documents were sent to Sherman, and Deacon’s field notes was one of those. This collection made of 32 string figures collected in the 1920s in the Islands of Malekula, Santo, Malo, Ambrym is of great historical interest, and shall be put in perspective—in upcoming works—with the whole corpus of string figures that I personally collected throughout the archipelago.

practice has become emblematic of Vanuatu cultural tradition. Moreover, it is noteworthy that sand drawings from Vanuatu have been listed, since 2008, by the UNESCO.

Nowadays, both sand drawing and string figure making practices are recognized—in the societies concerned and beyond—as a traditional graphic art with a mnemonic dimension. Involved in the recollection of ritual, mythological, geographical, as well as ecological knowledge, these two practices are considered as belonging to the so-called *kastom*; “a word that people in Vanuatu use to characterize their own knowledge and practice in distinction to everything they identify as having come from outside their place” (Bolton, 2003: xiii). Although, in Vanuatu, both sand drawing and string figure making practices appear as a transcultural activity, it nevertheless includes—in the Center/North of the archipelago—significant local characteristics, identified as genuine cultural markers (VKS, 2009).

As noticed by a few anthropologists, string figure-making and sand drawing practices are sometimes linked to one another, in the local mythology of different Ni-Vanuatu societies notably. About a century ago, anthropologist Layard observed the invention of new sand drawings in Malekula and suggested their relation to string figures:

Indeed, now that they are used as games of skill this tendency, as with cat’s cradles [string figures], with which they are probably allied, now serves to stimulate the creative ingenuity of the natives, who, while certain designs, of course, become traditional and are copied over and over again, constantly invent new ones as an intellectual pastime (Layard, 1942:654).

More recently, anthropologist Margaret Jolly collated a story of the *Sa* people, South Pentecost, which explicitly connects the two practices. The story is about a man, Barkulkul, who “put a taboo on his wife,” before paddling to the nearby Ambrym Island. He confined “his wife, placing two string figures, one on the door of the hut and the other on the woman’s genitals.” Despite these precautions, a man, Marelul, invited by Barkulkul’s wife, came into the hut. “They made love and the man left, and as he left he twisted the string figure which was across the woman’s genitals. He turned it around. He also twisted the string figure on the door. He turned it around.” “The husband returned home” and thought that “someone has come already.” Thereafter, Barkulkul asked Marelul to come with him to the shore, and “made drawings in the sand [...] the man who went into the hut made sand drawings and it was the right design [*i.e.* the same as the string figure]”. Barkulkul thus understood what happened and thereafter killed the adulterer³ (Jolly, 2003:199-200).

In North Ambrym, however, I was not told about such mythological links between string figure-making and sand drawing practices. Nevertheless, both activities are locally named using the same vernacular term. This suggests that both activities are perceived by the Ambrymese as conceptually linked to one another. The comparative analysis of Ambrymese string figures and sand drawings developed in this paper is based on a long-term ethnography aiming at collecting various types of data: 1) the procedures involved in the two practices under study, forming a corpus of 52 sand drawings and 60 string figures, 2) the vernacular (technical) terminology

³ A variant of this myth had already been collated in South Pentecost by missionary P.F. Tattevin (1929). More recently, in the 2000s, Stephan Zagala collated a version of this story on Ambae (typewritten letter entitled “String Figures”, Archives of the Vanuatu National Library).

linked with these activities, and 3) the oral texts and/or discourses which are sometimes associated with the latter. In the following, I will first describe the context in which are practiced both string-figure making and sand drawing among the Northern Ambrymese. The second part of this paper will be devoted to the comparative analysis of algorithmic and geometric properties of both practices, while illustrating how mathematical practices can be revealed in and through such ethnographic research. Finally, we will show how this study shall contribute to the ongoing debates conducted in Vanuatu for about a decade, regarding the use of traditional knowledge to improve the local mathematics curriculum, taking more account of the various cultural and linguistic contexts of the country.

2. Cultural and symbolic aspects of string figures and sand drawings: some elements of comparison

The Ambrymese refer to both string figure and sand drawing practices using the expressions “*tu en awa*” and “*tu en tan*” respectively. “*en awa*” and “*en tan*” mean “on a rope” and “on the ground” respectively, whereas “*tu*” is a verb translated by “writing”, “drawing”, “representing”. This suggests that these two practices are locally conceptualized as belonging to their “writing tradition”. At the same time, “*tu*” also means “discussing/debating/palavering” an issue in order to figure it out step by step, while organizing certain ritual events such as weddings or baptisms in particular. In the context of the practice of sand drawing and string figure making, this literal interpretation of the verb *tu* seems to echo the procedural aspect of this activity (*cf.* Section 3). This seems here to indicate a vernacular conceptualization of the making of these figures as procedural activities.

String-figure making is described by Northern Ambrymese as a female activity, whereas sand drawing is said to be a male activity. However, they are indeed practices shared by many people on the Island; almost everyone, including children, is able to perform a few of these figures. According to Ambrymese elders, string-figure making was generally practiced in the family, mothers or grandmothers often playing with their children. As for sand drawings, they were generally applied on the dance ground (*har*, or *nasara* in Bislama⁴)—where men used to meet at the end of the afternoon after a working day in the gardens.

Nowadays, as far as I have been able to ascertain, only a few women in each North Ambrym village are generally considered string figure experts. By contrast, it is mostly but a few men, either elders or young adults who are considered sand drawing experts. Furthermore, the practice of sand drawing seems to be more highly valued than the practice of string figure making, the latter being often described as a game or playful activity. Nevertheless, both practices have been a means of recording and expressing knowledge relating to specific mythological entities, rituals or activities involving humans, non-humans, or environmental elements.

For instance, the sand drawing *perrlio* represents one of the wood columns (*perr*) made from

⁴ The (pidgin english) Bislama together with French and English are the three official languages of the Republic of Vanuatu. This pidgin functions as a *lingua franca*, as there are about 120 vernacular languages in the country, for about 250,000 people. However, there is currently a creolisation of Bislama in Ni-Vanuatu’s cities, where speakers of many different linguistic areas are mixed. Consequently, Bislama has become the mother tongue of many Ni-Vanuatu children.

the trunk of the tree named *lio* (“red wud” in Bislama, *bischofia javanica*) of the *mel* “men’s house” (*nakamal* in Bislama) in the village of Olal (cf. Fig. 3a). It is a magical wood which has the diabolical power to catch and eat anyone who stands near to it. Similarly, *pelaperaoû* (name of a murderous device) is a highly complex drawing representing a (“bad”) person lying inside an underwater machine armed with long blades, cutting off the legs of people who swim on the beach of the North Ambrym village of Ranon (cf. Fig. 3b).

Fig. 3. Left: Sand drawing *perrlio* (magic wood columns). Right: Sand drawing *pelaperaoû* (murderous device)



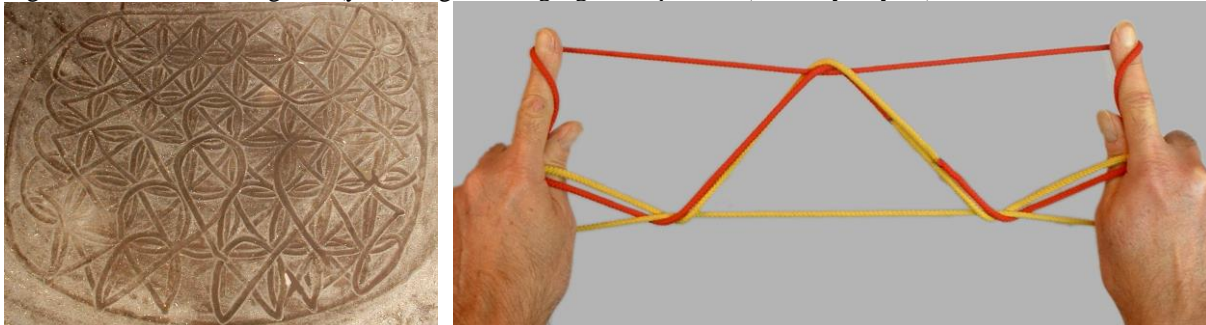
It is noteworthy that none of these entities are generally represented using both techniques. There are a few exceptions, though. For instance, the string figure and sand drawing named *bulbul algon* (literally “canoe lizard”) are both related to the story of Yaulon, one of this society’s mythical heroes (Guiart, 1951).

Fig. 4. Sand drawing and string figure *bulbul algon*.



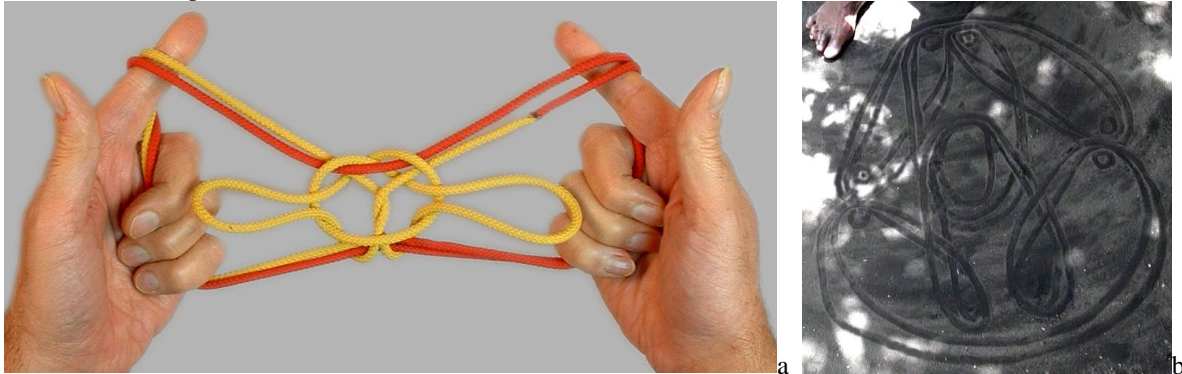
Bulbul designates this hero’s canoe, while *algon* (lizard) refers to the symbol of one of the fourth grades (*sagran*) of the chieftainship system (Patterson, 1981), whose conception is attributed to this local mythological hero. Another example is the representation of yams (cf. Fig. 5); tubers harvested in the Ambrymese gardens, and that have a key role in the goods exchange system which is at the heart of many rituals in Ambrym and more generally in Melanesia (Lanouguère-Bruneau 2000, Rio 2007, Coupaye 2013).

Fig. 5. Left: sand drawing *rem* (yam). Right: String figures *tapli rem* (the body of yam) © Vandendriessche



Some string figures and sand drawings are explicitly related to different ritual practices. The string-figure *malyel mweter lon turereoù* as well as the sand drawing *temarr ne luan* are one of those. *Malyel* designates a young man to be circumcised. *Mweter* “to look” and *lon tu rereoù* (literally “in a hollow little banyan”), refers to the position of the young boy, during the circumcision ritual, looking at a fixed point, in order to focus his attention elsewhere.

Fig. 6. Left: String figure *malyel mweter lon tu rereoù* (young man looking in a hollow tree). Right: Sand drawing *temarr ne luan* (spirit of *luan*) © Vandendriessche



Temarr ne luan (spirit of *luan*) also refers to the young men’s initiation ritual bearing the name *luan* “hiding”, which still took place in Northern Ambrym about two decades ago. A few young men were isolated from the community, for a couple of months, to be secretly enlightened. This initiation is described as rigorous, bringing prestige to the participants. The drawing *temarr ne luan* was painted on a piece of wood and placed at the entrance of the house (*mel*) sheltering the participants. The latter representation of the spirit (of the secret society) of *luan* carries a taboo and only a *luan* insider can make this artifact.

These two activities were part of the same prescription/prohibition system. A few decades ago, they were still preferably performed during the yam harvest, from February to July, while their practice is prohibited outside this period, the making of such figures being perceived as having a negative impact on the growth of the plant’s stem winding around the stake: it would favor the entanglement of the stem, slowing down the plant’s growth. Sand drawings and string-figures can both be analyzed as “entanglements” or “knots”. This prohibition seems to indicate that the Ambrymese perceive a link between the making of these “entangled figures” and the possible vegetal knots that can arise during the development of the stem. Therefore, one can thus hypothesize that the procedures leading to either sand or string patterns can interfere in the normal course of the vital process of growing⁵.

⁵ Such a ritual efficacy attributed to both sand drawing and string figure making practices was confirmed by practitioners from different Northern Ambrym villages. Nevertheless, it seems that this phenomenon does not concern the whole region. In some places, these practices are related to mourning: they would have been authorized only during the five days following the death of high rank people. Making such figures in the house of the deceased person would retain his/her spirit in his/her place for a while before going to the land of death.

Fig. 7. Yam growth and entanglements © Vandendriessche



In Northern Ambrym, as well as in the other societies where I carried out fieldwork, many people know how to perform numerous string figures, and I often had the opportunity to work with genuine “experts”⁶. Nevertheless, I have never met anyone with the ability or even the desire to invent a new string figure. Furthermore, it is generally asserted by the Ambrymese practitioners that string figures have been invented by their ancestors “a long time before”. In contrast, a number of sand drawings are assumed to be of recent invention. For instance, the sand drawing *poar* (white sea bird, “Pacific golden plover”, *puffinus pacificus*, cf. Fig.8a) would have been invented/created a century ago by the Ambrymese RirrRirr (village of Wow), inspired by a number of white sea birds sitting in a trench used for planting taro plants (*sitan*) in his garden.

Fig. 8. Left: Sand drawing *poar* (white sea bird). Right: Sand drawing *lengkon & paul* © Vandendriessche



Furthermore, a few young people do sometimes create novel sophisticated sand drawings after having learned the traditional ones from the elders. Since 2006, several knowledgeable sand drawing Ambrymese practitioners showed me the drawing called *lengkon & paul* (cf. Fig.8b), asserting that the latter has been created some years ago by a young man living in Northern Ambrym. Many years later (in 2019), I have finally met the man in question, Buwekon from Topol village, who confirmed that he imagined this new drawing, while thinking of it mentally for a whole night and finally succeeded in making it after a working day⁷.

⁶ By experts, I mean people who are recognized as the most knowledgeable in either string-figure making or sand drawing practices by the other members of the community. These practitioners generally know almost all the procedures known in the village and are able to perform them slowly, step by step, operation after operation.

⁷ Buwekon and myself have undertaken a (long term) collaboration aiming at studying how he actually proceeded

As the ethnomathematical study of both Ambrymese sand drawings and string figures suggests, it is most probably through an algorithmic practice, aiming at exploring the combinatorics of basic patterns that these complex procedures have been created in the past in central Vanuatu. Furthermore, as we will see in the next section, these two practices indeed share algorithmic and geometric properties, involving mathematical concepts such as operation, procedure, sub-procedure, iteration and symmetry.

3. Ethnomathematics of string figures and sand drawings

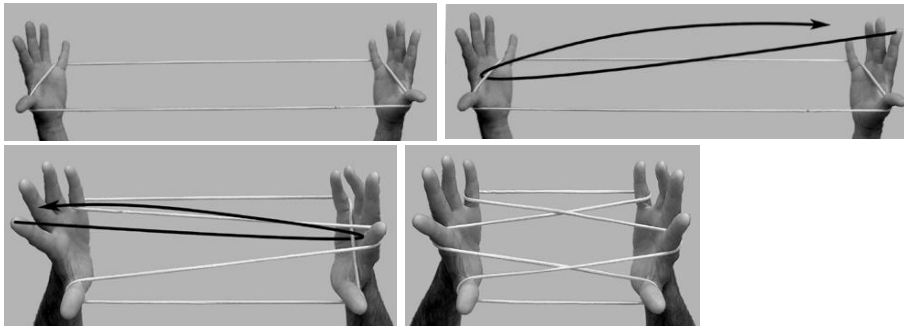
3.1 Algorithmic/procedural aspects of string-figure and sand drawing practice

String figure procedures

A string figure can be analyzed as the result of a “procedure” (or geometric algorithm⁸) consisting of a succession of “elementary operations”—, insofar as the making of any string figure can be described by referring to a certain number of these operations. Most of these elementary operations can be defined as “geometric” (or “topological”) operations which modify a given string configuration, transforming it into another (Vandendriessche, 2015).

The string passing around a finger forms a “loop”. Any string figure procedures of the corpus begin by a series of movements (or opening) aiming at making loops on fingers. Some of them are associated with technical vernacular expressions. For instance, *hu pokopreo* (pricking indices) corresponds to the movement that has been observed in many societies around the world, and named “Opening A” (*cf.* Fig. 9) by anthropologists Rivers and Haddon (1902).

Fig. 9. The Opening A



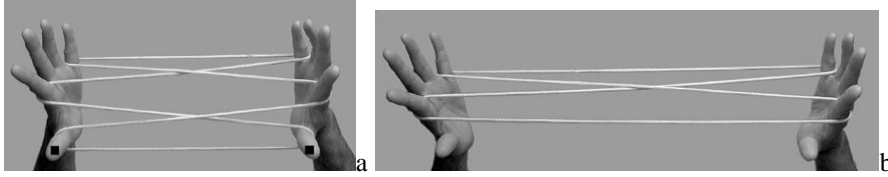
The following instructions/pictures illustrate the making of the Ambrymese string figure *wayu*

to invent this new sand drawing and the logical system involved in such creation processes in particular. Indeed, this sand drawing seems to have been inspired by some other drawings (*fanwochepu* and *perrlio* shown in Fig. 2 and 3 in particular), sharing some characteristic patterns with these traditional drawings. However, the latter patterns are combined in a different way, and basic motifs transformed into other ones (*cf.* Section 3.2, Transformation). Further (cognitive) research should be carried out to clarify this point.

⁸ We borrow the expression “geometrical algorithm” (“*algorithmes géométriques*”) from ethnomathematician Paulus Gerdes (1952-2014), thus indicating that the operations at work in the algorithm are of geometrical/topological nature (Gerdes, 1995).

(hairy yam)⁹ which starts with the opening A¹⁰.

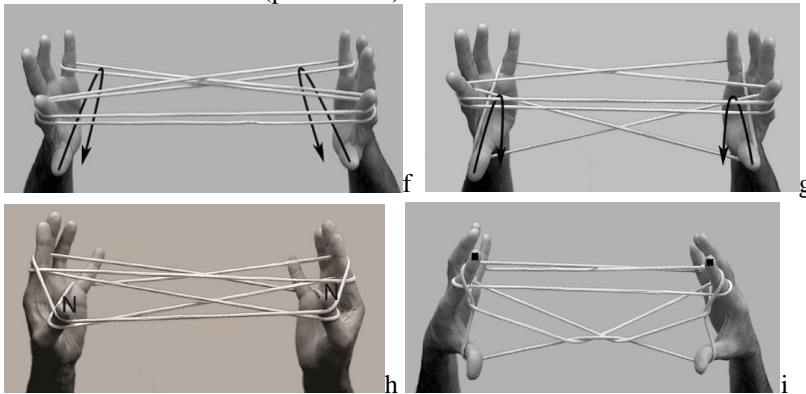
1. Opening A (picture a).
2. Release thumb loops¹¹ (picture b).



3. With right thumb, hook down both right index loop and near little finger string¹². With the right index hook up the far-right little finger string, and return to position (picture c).
4. Insert the left index into the upper right index loop, and return to position (palms facing each other) (picture d-e).



5. Pass thumbs under the index loops, insert them into little finger loops, from below, return with near little finger strings (picture f).
6. Insert thumbs from below into the upper index loops, pick up the upper near index string (picture g).
7. Navaho the thumbs¹³ (pictures h-i)



8. Release upper index loops (pictures h-i). Transfer thumb loops to indices (pictures j-k).

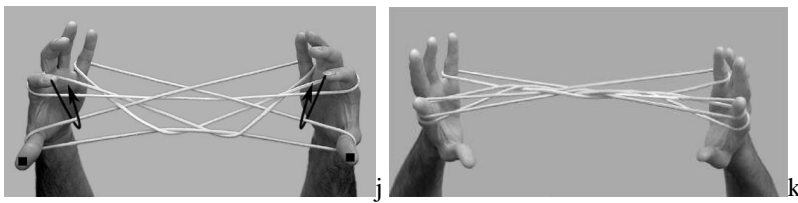
⁹ See also the description of this string figure on the website “String Figures: Construction Methods, Modelling, Cultural and Cognitive Aspects” (database of the project “Encoding and Transmitting Knowledge with a String: a comparative study of the cultural uses of mathematical practices in string-figure making (Oceania, North & South America) - ETKnoS” Project, 2016-2020): cf. <http://emergences.huma-num.fr/items/show/19>. The string figure *wayu* can be found (with little variations) in many published collections of string figures from Oceania (Vandendriessche 2015: 373-375). To my knowledge, it has been first recorded as “Ten Men” in 1902 in the Caroline Islands by anthropologist William Henry Furness, and published in 1906 by his sister, Caroline Furness Jayne (1962: 150-156).

¹⁰ From the first scientific studies on string figure-making practices—from the 19th century and onwards—a number of anthropologists/mathematicians have attempted to devise suitable and efficient nomenclatures to record the procedures involved in the making of such figures, cf. (Vandendriessche, 2015, 2019). The instructions of the procedure *wayu* are here adapted from the description of the string figure “Ten Men” made by Jayne (1962).

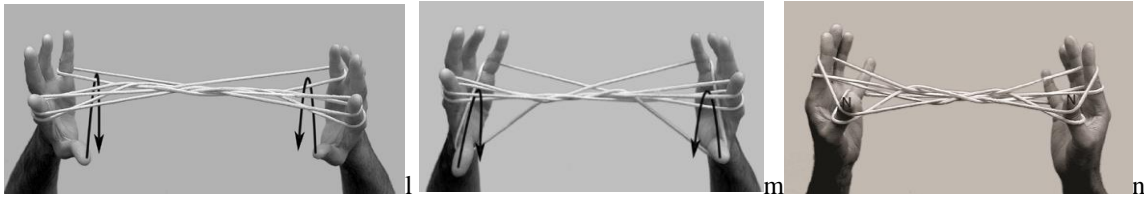
¹¹ The black square on the thumbs indicate the release of the string from the finger.

¹² A loop is made of two strings: the near string and the far string, with respect to the practitioners’ viewpoint, fingers pointing up and palms facing each other. When a finger carries two loops, we differentiate them by using the expressions “upper loop” and “lower loop”.

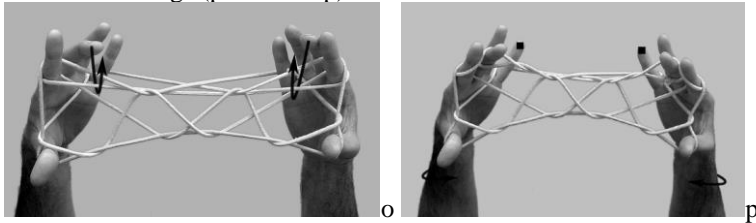
¹³ When two loops lie on the same finger the “Navaho” operation is implemented on this finger by passing the lower loop over the upper one, and then, over the fingertip where it is released. This movement is indicated on the Pictures with capital letter N. To my knowledge, the term “Navaho” (or more precisely the verb “Navahoing”) was first used in this context by Kathleen Haddon (A. C. Haddon’s daughter), in her book *Cat’s Cradle from Many Lands* (1911).



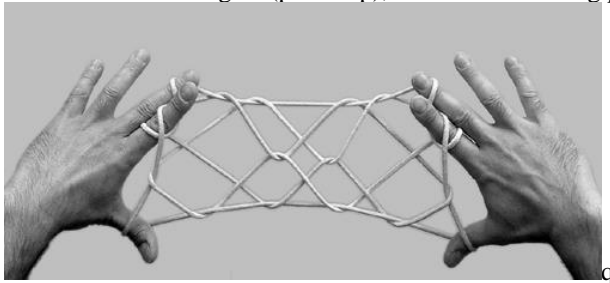
9. Repeat (5,6,7) (pictures l-m).



10. Pass middle fingers, over far index strings, insert them from below, into lower index loops, return with lower near index strings (pictures o-p).



11. Release little fingers (picture p), then extend turning palms away from you with fingers spread out (picture q).

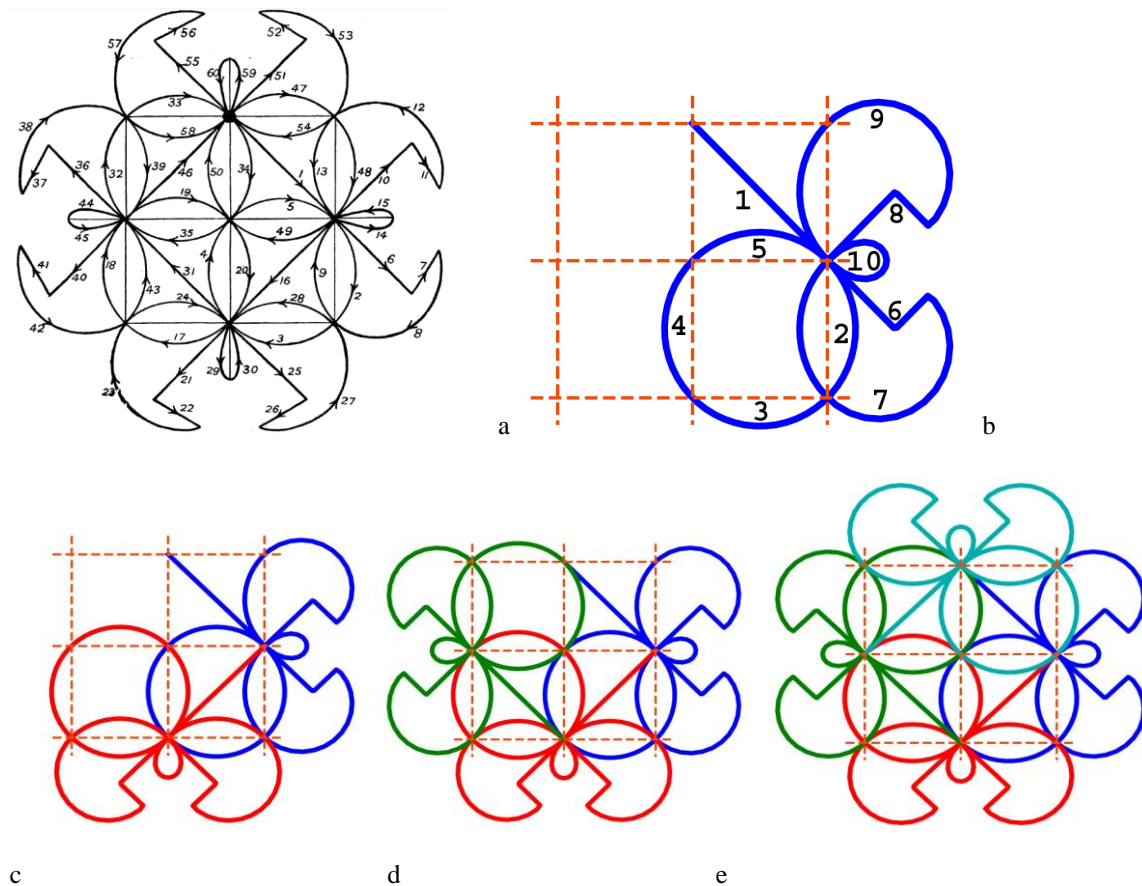


Sand drawings

As mathematician Marcia Ascher has first emphasized in the 1980s—while analyzing the sand drawings collected by Deacon (1934)—the making of a number of these figures consists in the implementation of an ordered sequence of “elementary transformations” applied to one or more patterns or “tracing procedures” (Ascher, 1988, 1991:30-65). The latter “tracing procedures” result from the organization of “basic patterns” into procedures (*cf.* Fig. 11).

If A and B denote two such tracing procedures, Ascher notes 1/ AB the procedure obtained by executing “A followed by B”, and 2/ A_T the procedure obtained by transforming A into another procedure through a given geometric transformation T. For example, if, starting from the end point of procedure A, one repeats the same drawing procedure, the “process” is identity, the resulting procedure will still be A, and the global procedure “A followed by A”, formalized by the expression AA. When each movement of procedure A undergoes a 90° clockwise rotation, the process is the 90° rotation, the new procedure is symbolized by A_{90} , and the global procedure is denoted by AA_{90} . For instance, Ascher (1991: 52-54) analyzes the sand drawing *nimbingge* (a variety of yam), collected by Deacon on Malekula Island, in terms of “tracing procedures” and “processes”: the choice of the initial procedure A (*cf.* Fig. 10) allows us to describe the global procedure as the iteration of the same pattern A, through the series of processes $AA_{90}A_{180}A_{270}$.

Fig. 10. (a) Sand drawing *nimbingge* (Deacon & Wedgwood, 1934: 148). (b) Tracing procedure A. (c-e) and the sequence of processes $A_{90}A_{180}A_{270}$ involved in the making of the sand drawing *nimbingge* © Vandendriessche & Da Silva¹⁴.



The latter drawing *nimbingge*, known as *peng* “troca”¹⁵ by the contemporary Ambrymese practitioners (cf. Fig. 24), like many other sand drawings in the same region, can thus be formalized/analyzed as an ordered sequence of “elementary transformations” (or “processes”) applied to one (or more) given pattern(s) (or “tracing procedures”). This conceptualization has indeed proven to be relevant in the analysis of a number of sand drawings (cf. sand drawings *fanwochepu*, Fig. 2 and *perrlio*, Fig. 3, as well as the sand drawing *konang lipang*, Fig. 16 below) that I have collected on Ambrym over the years.

Technical vernacular terminologies

Some vernacular expressions are used by practitioners to refer to the basic movements/operations involved in both activities. Although these vernacular terms usually differ from one activity to another, they are action verbs in both cases. For sand drawings, five verbs are thus used to designate the making of the (basic) patterns represented in the figure below.

¹⁴ Alban Da Silva is currently carrying out doctoral research under the author’s supervision. His ethnomathematical research aims at gaining a better understanding of the mathematical aspects of the practice of sand drawing in Vanuatu, and in North Pentecost Island in particular. As part of this project, Da Silva has created a digital modeling tool in order to rewrite the sand drawing procedures and display the final figures on a screen (Da Silva, up-coming 2021).

¹⁵ Trochus or “troca” is a gastropod mollusc from the *trochidae* family and characterized by its conic shape.

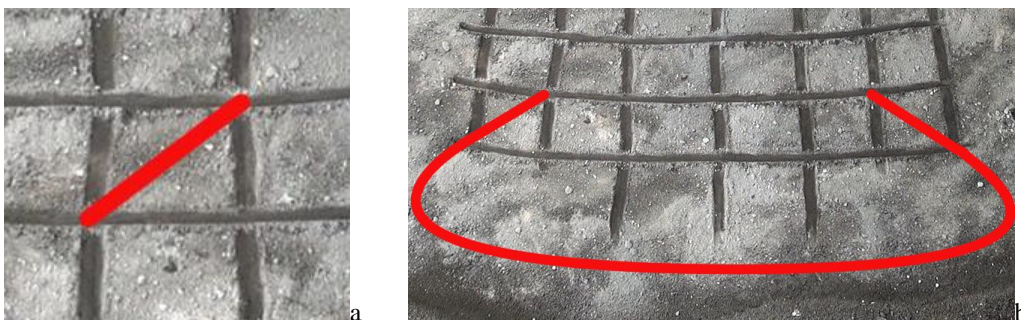
Fig. 11. The basic patterns : (a) *itel*. (b) *mli*. (c) *kuvür*. (d) *hupeng*. (e) *hu*.



Although, the verbs *mli* “to attach” (an object/animal to something), *kuvür* “to turn” (around something and returning to the initial point), and *hu* “to prick” (something with a stick) are used in other contexts, the two verbs *itel* and *hupeng* seem specific to the practice of sand drawing. The etymology of the verb *itel* would derive from the term *tel* “rope”, used—in particular—to tie breadfruits together with a knot for carrying them. As for the verb *hupeng*, it is a combination of the verb *hu* “to prick” and the noun *peng* “troca”.

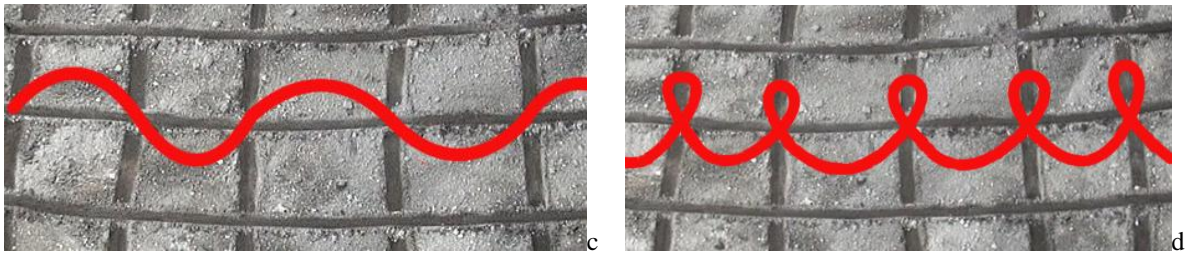
Some other verbs are used to designate particular drawing movements (cf. Fig. 12). For instance, the verb *tukor* “to cross” (a house or a garden for example) is used to indicate that the continuous line crosses one grid square diagonally. In other cases, the latter line sometimes has to pass outwardly through one corner of the grid, making a curve aiming at re-entering the grid again at the symmetrical corner. This movement is described by the verb *hoüre*, which designates the action of going out and then re-entering the same space (a house or a village, for example). The expression *roù lipi* (to wrap the trunk of the tree *pi*¹⁶) describes a sinusoidal line crossing several consecutive nodes of the grid. Finally, the verb *likete* “to maintain” refers to the movement consisting in joining several little loops (*mli*) drawn in a row on the same line of the grid. This suggests that the latter drawing movement is perceived as a link holding together the different lines (*yen/yeròù*) of the grid¹⁷.

Fig. 12. (a) Movement *tukor*. (b) Movement *hoüre*. (c) Movement *roù lipi*. (d) Movement *likete* © Vandendriessche



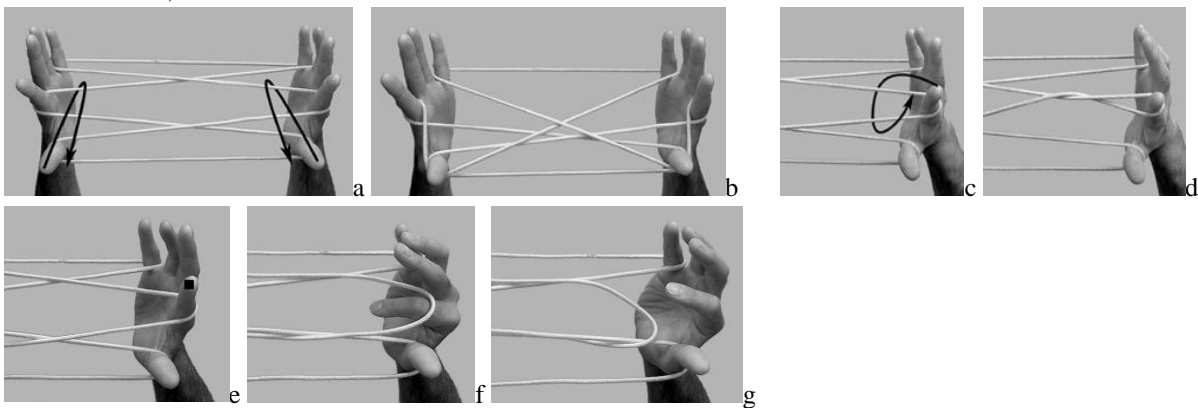
¹⁶ The tree *pi* belongs to the croton tree family (*codiaecum variegatum*). It has asymmetrical leaves; one of their edges having a sinusoidal curved shape.

¹⁷ The horizontal lines of the grid (from the practitioner’s point of view) are named *yeròù*, which also means “beams”, “lintels”, or “purlins” of traditional houses. The vertical lines are named *yen* “leg”, which also refers to the wooden posts supporting the houses. The use of these vernacular terms suggests that the grid is perceived as a framework supporting the drawing.



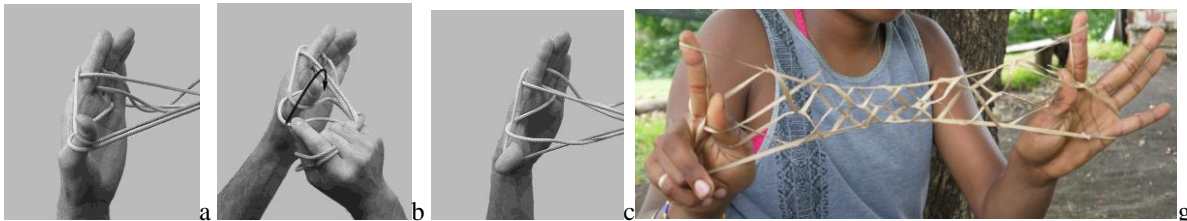
The verb *hu* “to prick” is also used while making string figures. For instance, the sentence *pokolam hu pokopreo* (lit. “thumb pricking index”) means that the thumb(s) pick(s) up (one of) the strings carried by the indices. The verb *tororro* is used to indicate that a finger must release its loop (for instance, *tororro pokopreo* “release index”). As for the expression *si kilhi* (lit. “turning/rotating, returning towards me”, it indicates a twist of a finger (or loop)¹⁸.

Fig. 13. (a-b) “picking up a string” (*pokolam hu pokopreo* “thumb pricking index”) ; (c-d) “twisting of a loop” (*pokopreo ro si kilhi* “turning the index returning towards me”) ; (e-g) “releasing a loop” (*tororro pokopreo* “release index”) © Vandendriessche

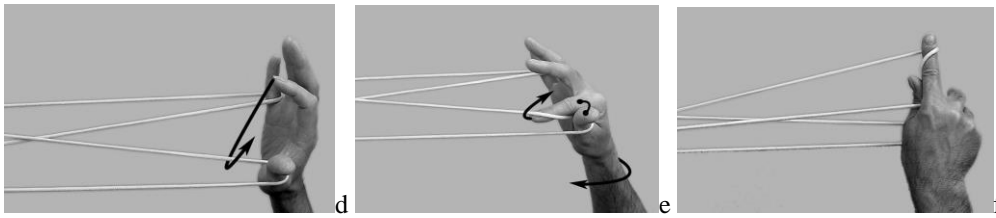


Some other expressions permit the designation of more sophisticated operations (made of several consecutive elementary operations). For instance, *cherrururu* is a term specific to string figure making practices referring to an operation known as “navaho” in the anthropological literature devoted the topic (cf. note 13). While the verb *wehe* “to kill” is used when the final figure is spread out through a specific movement called “Caroline extension” in the same literature (cf. Fig. 14).

Fig. 14. (a-c) Sub-procedure *cherrururu* ; (d-g) Sub-procedure *wehe* © Vandendriessche



¹⁸ We use the spelling introduced by linguist Michael Franjeh (2012), specialist of Ambrymese vernacular languages . The trill <r> is noted /rr/ and the retroflex <r> (used in the area of Fona, instead of the tap/flap <r> heard by Franjeh in the area of Rantvelam) is noted /r/. When these two <r>s are consecutive, /r/ always follows /rr/. Therefore, we will simply note ‘rrr’ this succession of <r>s. As for the sound [ʊ] and [y], they will respectively be noted /ù/ and /ü/.



All of these technical expressions associated with the practice of sand drawing and/or string figure-making in North Ambrym are used spontaneously by practitioners in action, in instances of transmission from one person to another in particular, although not consistently. In both cases, the procedures are indeed often taught or shown without any technical comments. However, the knowledge of this technical terminology seems to be shared by most Ambrymese, as it can be seen when the audience guides a hesitant practitioner. Finally, the existence of these expressions is an indicator of the perception by the actors of orderly sequences of operations, suggesting a local perception of the notion of elementary operations/basic patterns revealed by ethnomathematical analysis.

3.2 Shared mathematical properties

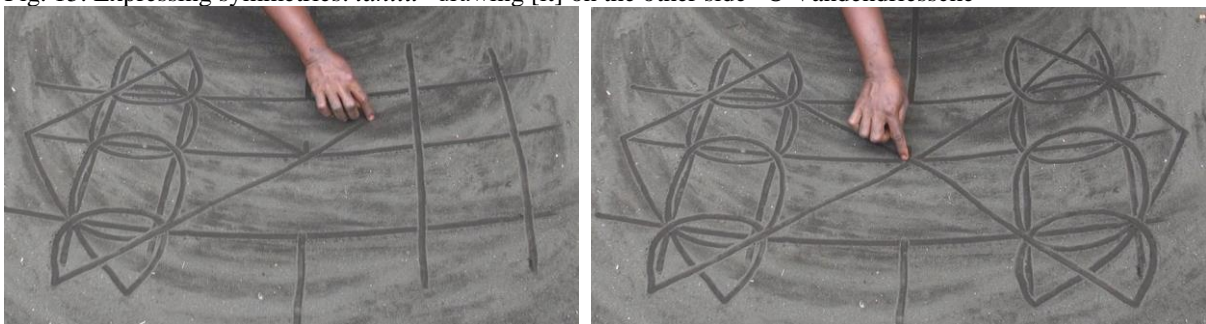
Cyclicity

The making of sand drawings, as well as that of string figures, seems to be perceived by the Ambrymese as cyclical processes. As often pointed out by practitioners, using the specific term *paritu*, literally “beginning” (*pari*) of the “action of drawing” (*tu*), it is indeed essential to end a sand drawing where it has begun. Similarly, a string figure is usually only shown for a few seconds, before being undone by the practitioner who thus obtains the original loop from which he started the procedure. This seems to indicate that a string figure is seen simply as a stage of the procedure. Moreover, the undoing of the figure appears to be included in the whole process of performing a string figure.

Symmetry

Most of the figures drawn either in the sand or with a string have at least one symmetry axis. In the practice of sand drawing, the term *tahitu* (lit. “drawing [it] on the other side”) refers to the action of successively making a given pattern on one side of the drawing and the symmetrical pattern on the other side.

Fig. 15. Expressing symmetries: *tahitu* “drawing [it] on the other side” © Vandendriessche



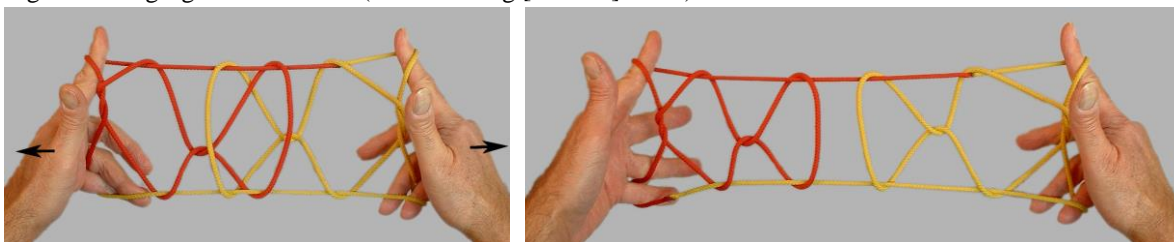
Remarkably, in the practice of string-figure making, when the same ordered sequence of operations has to be performed symmetrically on both hands, the practitioners most often proceed in two stages, performing the operations on one side, and then on the other. Either the expressions *tahitu* or *tahite* “the other side” are actually used to refer to this operational process.

Fig. 16. Left: *konan lipang* (banyan taboo). Right: *rom* dance, North Ambrym © Vandendriessche.



The ubiquity of symmetries is an important feature in both corpora of figures, and sometimes underlined by either the names given to the figures or the stories (or myths) which accompany the making of some of them. For instance, the sand drawing *konan lipang* (lit. “taboo banyan”) is accompanied by a narrative describing the birth of the Northern Ambrym *rom* dance¹⁹. The story starts with two women, sitting down on either side of a banyan tree, both weaving a mask for their children. Even though they could not see each other, the two women thereafter realized that they had made exactly the same mask.

Fig. 17. String figure *be mkor be* (shark hunting [another] shark) © Vandendriessche



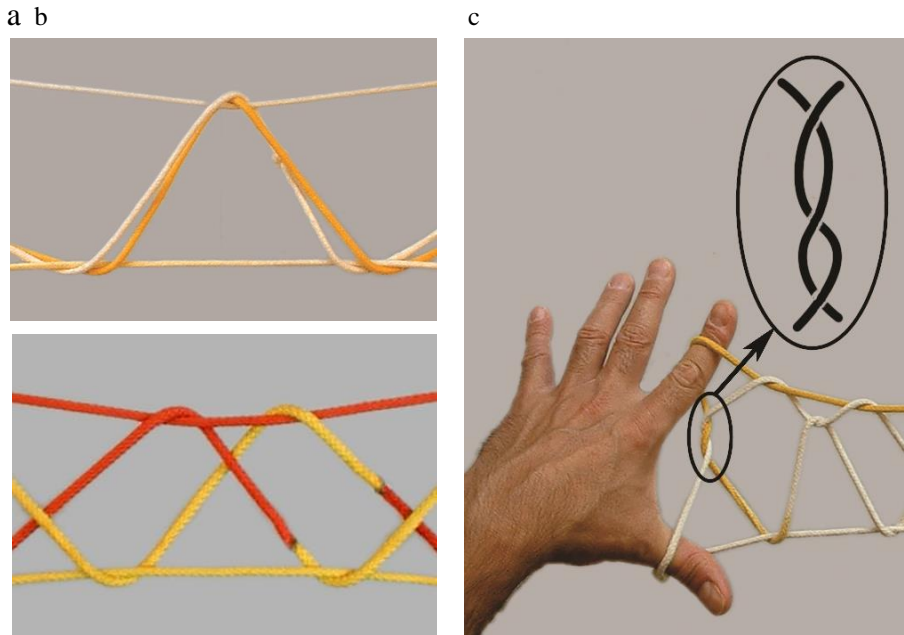
In the case of string figure-making, the symmetry of the final figure is sometimes related to the representation of the same object or being on both sides of the figure. This feature can be further emphasized through the vernacular name given to the figure. For instance, the string figure *be mkor be* (lit. “shark hunting shark”) represents two sharks symmetrically: a male and a female swimming away from each other.

Sub-procedures/algorithms

Our comparative analysis of both corpora of figures has brought to light numerous “sub-procedures” *i.e.* ordered sets of “elementary operations” or “basic patterns” either iterated within a given procedure or repeated identically within several different procedures of the same corpus. For string figure-making, these sub-procedures aim at making either basic string patterns or complex crossings (*cf.* Fig. 18), whereas for sand drawings, they allow the practitioner to draw different motifs made of several basic patterns (*cf.* Fig. 10 above) or to implement a specific algorithm for completing the grid (*cf.* Fig. 20 below). The currency of such sub-procedures in both corpora suggests comparable operational practices in the creation of sand drawings and string figures, which would have consisted in the organization of these elementary operations/basic patterns into procedures.

¹⁹ For further information about the *rom* dance, see (Guiart 1951: 68-69).

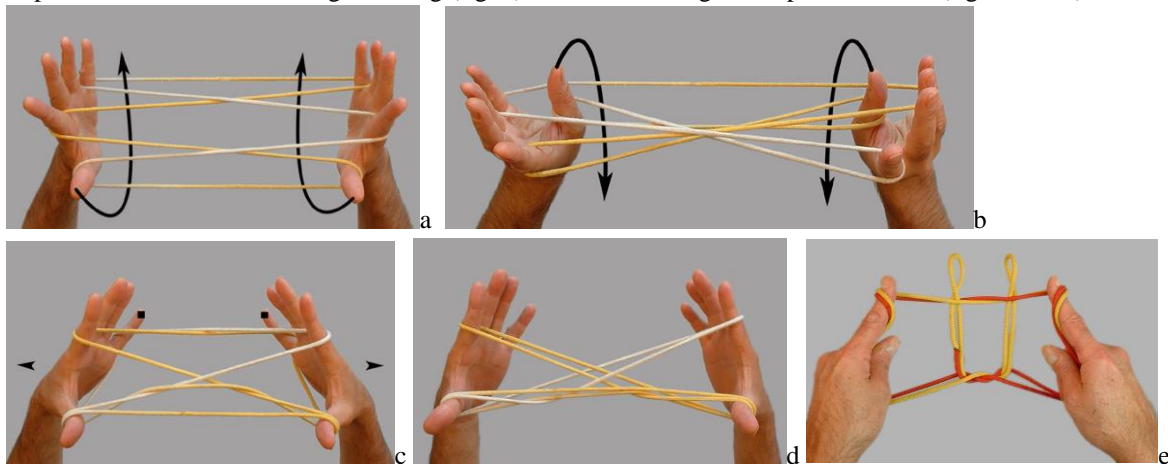
Fig. 18. (a-b) Two basic string patterns. (c) Complex (string) crossing © Vandendriessche



In a comparable way in both corpora of string figures and sand drawings from Northern Ambrym, some sub-procedures/algorithms have been used as a basis for creating new procedures. For instance, the three string-figure procedures *olol tamre* (lit. “coconut germ upward”), *warmupta* (bread fruit stem), and *rralngien burbur* (lit. “ears of *burbur*” [a little animal with a] tuft of hair/feather”)²⁰, all start with the same sub-procedure implemented after the “Opening A”, as described in Fig. 19.

Fig. 19. (a-d): Same sub-procedure involved in the string-figure procedures *olol tamre* (coconut germ upward, fig. e), *warmupta* (bread fruit stem, fig. f), and *rralngien burbur* (hearing [a little animal with a] tuft of hair/feather, fig. g).

Opening A. Pass both thumbs under all intermediate strings and insert them into little finger loops (fig. a), return to position with the far little figure string (fig. b). Release little finger loops and extend (fig. c. and d).



²⁰ See the ETKnoS project database: <http://emergences.huma-num.fr/items/show/82> ; <http://emergences.huma-num.fr/items/show/18> ; <http://emergences.huma-num.fr/items/show/110>



As for the practice of sand drawing, the same algorithm, say K, is involved in the making of different drawings. For the sand drawing *kil* “grasshopper” notably, this algorithm allows drawing the part which represents the body of the animal (cf. Fig. 20). This procedure—carried out here on a rectangular grid of 4 horizontal lines and 3 vertical lines (4×3)—requires following the diagonal lines of the grid; when the line goes out of the grid, it is re-entered through the nearest grid node; except if the line exits the grid through one of its four corners, and must, in this case, be re-entered inside the grid through the symmetrical corner (with respect to the vertical symmetrical axis of the grid—cf. movement called *hoùre*, mentioned above).

Fig. 20. Algorithm K: first part of the sand drawing *kil* “grasshopper” © Vandendriessche



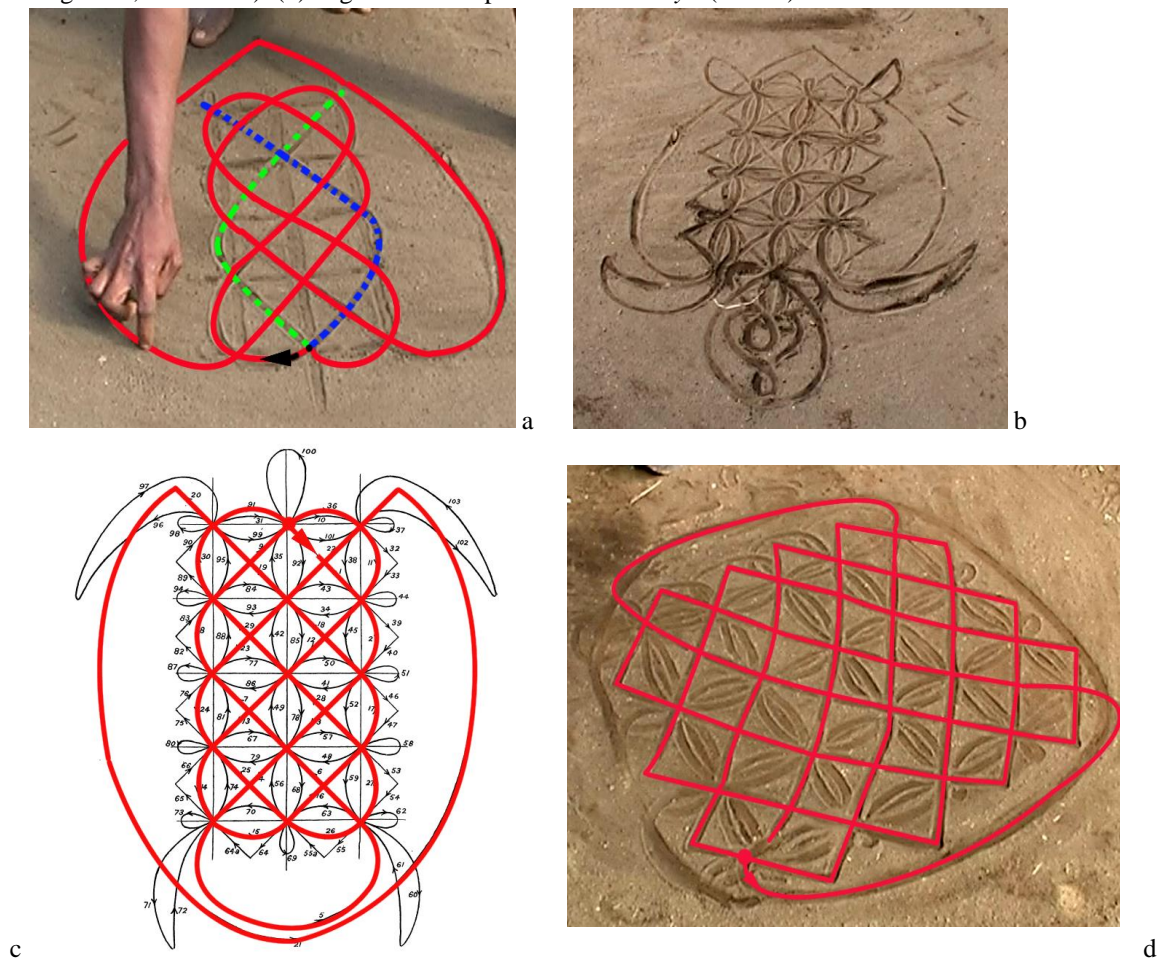
Video 1: drawing *kil* “grasshopper” by Lengkon (village of Fantan, North Ambrym) © Vandendriessche 2016

The same principle is used for the making of the sand drawings *vyu* “turtle” and *awuyil* (liana *yil*, *Epipremnum pinnatum*). Made on a 5×3 grid, the sand drawing *vyu* starts with the tracing of two short lines (cf. Fig. 21a). The figure is then completed by implementing (part of) the algorithm K, while deforming the upper big arc downward (movement *hoùre*) to draw the carapace of the turtle (Fig. 21a-b). About a hundred years ago, on Ambrym, Deacon actually collated a variant of the latter sand drawing *vyu*, for which the complete algorithm K was implemented (cf. Fig. 21c, Deacon & Wedgwood, 1934: 154).

As for *awuyil*—made on a 4×5 grid—this algorithm occurs in the last phase of the drawing. In the latter case, although the tracing principle is the same as for the sand drawing *kil*, the arcs—connecting the nodes outside of the grid—are replaced by broken lines (cf. Fig. 23, d-e); movement designated by the vernacular term *hu* “to prick”²¹.

²¹ The algorithm underlying the making of *kil*, *vyu*, and *awuyil* has been called “turtle algorithm” and further studied by Alban Da Silva, cf. (Da Silva, upcoming-2021). He has first observed this pattern as part of the sand drawing *hi* “turtle” already recorded by Deacon (Deacon & Wedgwood, 1934: 154). Consequently, I noticed that the same procedure is actually involved in different North Ambrym sand drawings.

Fig. 21. (a-b) Algorithm K implemented in *vyu* “turtle”. (c) Sand drawing *hi* “turtle”, adapted from (Deacon & Wedgwood, 1934: 154). (d) Algorithm K implemented in *awuyil* (a liana) © Vandendriessche.



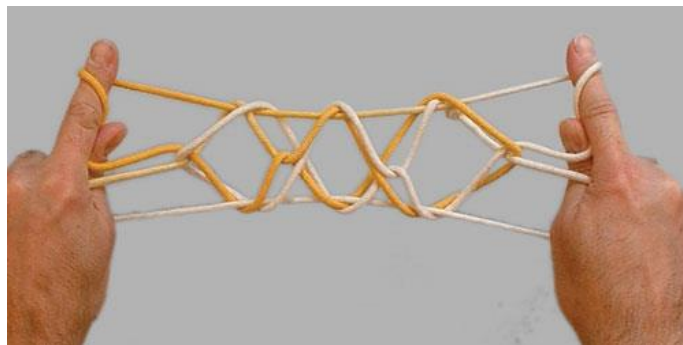
Iteration

The concept of “iteration” is ubiquitous in both corpora. In many string figures and sand drawings, we can analyze the iteration of a pattern as a consequence of the iteration of a sub-procedure: for string figures, an ordered sequence of operations, and, in the case of sand drawings, an ordered sequence of basic patterns. Furthermore, vernacular expressions—uniform in both activities—explicitly express the iteration of a pattern or a sub-procedure. As seen above, the sand drawing *peng* can be analyzed as the iteration of one pattern or tracing procedure (cf. drawing *nimbingge*, Fig. 10, and Video 2). Indeed, practitioners sometimes explain the making of this drawing by describing first the pattern to be iterated, and then making the three other patterns while saying *pe pa ru* “this one twice”, *pe pa sul* “this one three times”, *pe pa wir* “this one four times”.

As with many other string figures of the corpus, the making of the string figure *wayu* (described above, section 3.1) is also based on the iteration of a sub-procedure. We have seen that a series of elementary operations (cf. Steps 5, 6, 7) is repeated twice in the same way on different substrata/configuration of strings during this string figure process. Furthermore, as in the case of the making of sand drawings (cf. *peng* or *konang lipang*), the impact of an iterative sub-procedure is sometimes to iterate the same motif. For instance, the three “doubled lozenges” in a row of the string figure *meya* (inedible orange fruit) result from the iteration of the same

(iterative) sub-procedure (cf. Fig. 22)²².

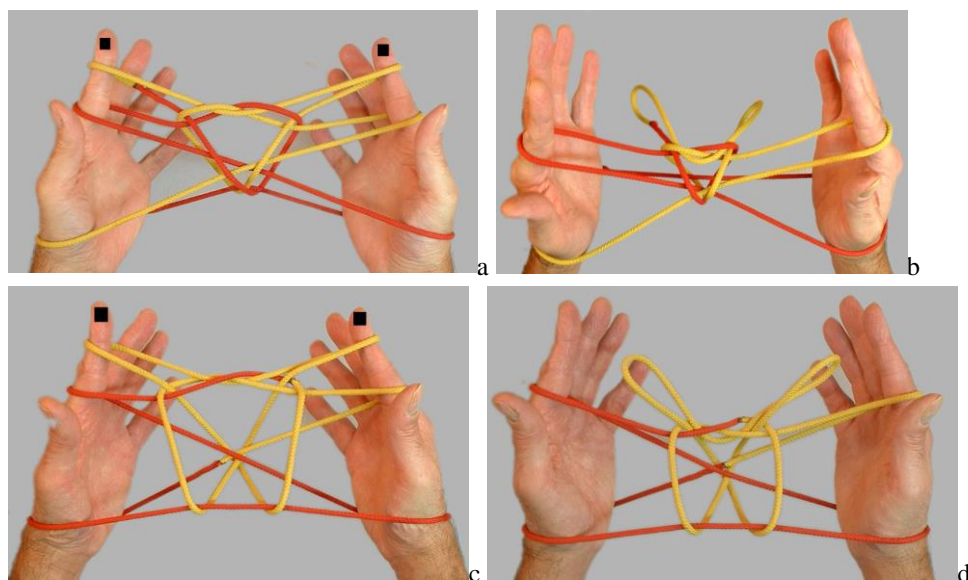
Fig. 22. String figure *meya* (inedible orange fruit), resulting from the iteration of a same pattern © Vandendriessche



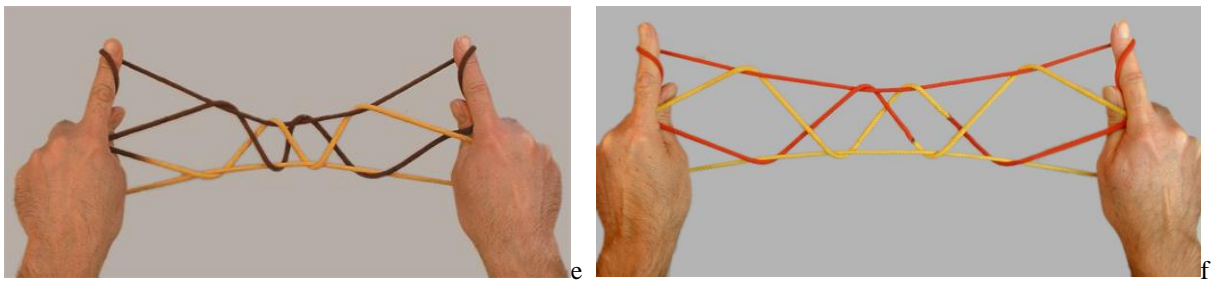
Transformation

Some examples suggest that string figures and sand drawings have circulated throughout the North Ambrym area (and beyond) while undergoing transformations at the level of procedures and/or final figures. First, some Ambrymese string figures suggest that practitioners have elaborated some procedures—or paths—leading to identical or very similar final figures. For instance, the string figure *ao mwiti lowon* (crab which defends itself with its claws) is the mirror symmetry of the string figure *blaol* (empty coconut). This property results from the exchange of the role of the thumbs and little fingers throughout the procedures, thus implying symmetrical movements of the loops. As for the procedures *silimri* (a tree) and *lopevi* (an island) they both lead to similar final figures made of four lozenges in a row (cf. Fig. 23, e-f).

Fig. 23. (a-b) String figures *ao mwiti lowon* (crab which defends itself with its claws). (c-d) String figure *blaol* (empty coconut). (e) String figure *silimri* (a tree). (f) String figure *lopevi* (an island).

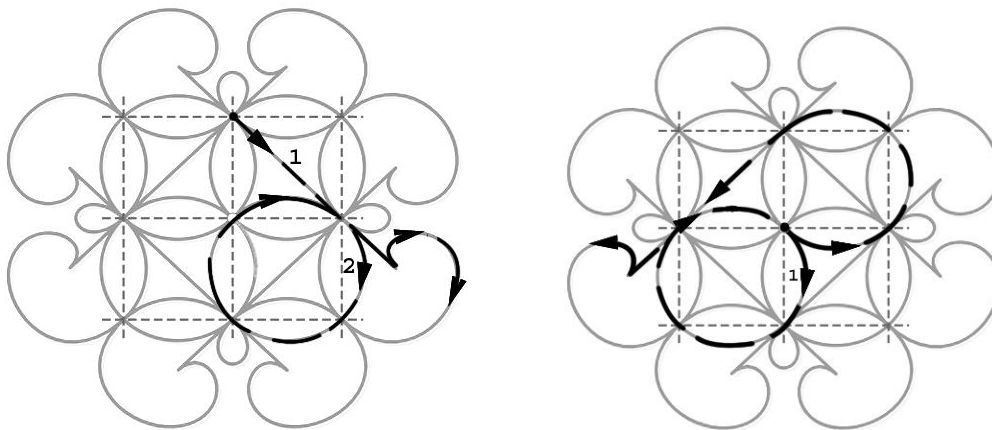


²² See the ETKnoS project database: <http://emergences.huma-num.fr/items/show/83>



Similarly, in the case of sand drawings, it can be shown that different paths have sometimes been created to obtain exactly the same final drawing, varying the order in which the various segments are drawn. For instance, there are at least two procedures used to draw the sand drawing *peng*: the procedure described above (cf. Fig. 10) and another procedure starting from the center of the grid and taking another route (cf. Fig. 24)²³.

Fig. 24. Two different routes for making the sand drawing *peng*.



Video 2: Drawing of *peng* “troca” by Bongrowo (village of Magam, North Ambrym) © Vandendriessche 2006

Vidéo 3: Drawing of *peng* “troca” by Limlim (village fo Likon, North Ambrym) © Vandendriessche 2006

This brings forward the interest that some practitioners had in procedures: if they had been only interested in the final figures (made either in the sand or with a rope/string), they probably would not have bothered devising different procedures, which display identical figures. In some cases, however, it is rather the final figure that one has sought to transform. Sand drawing procedures have thus been altered by adding and/or removing certain patterns from a given drawing. For example, the *konan lipang* procedure that I collated in Bahaltalam (a village near Fona), has also been recorded by linguist Mike Franjeh in the southern village of Ranvetlam. While the two drawings are very similar and have the same meaning (cf. Section 2.2. Symmetry), the Ranvetlam drawing shows two additional symmetrical patterns (cf. Fig. 25)—which represent the two women sitting on either side of the banyan tree—that are absent from the previous sand drawing.

²³ See these two variants of the sand drawing *peng*: [videos 2 and 3](#). In North Ambrym, *peng* actually consists in two parts. The first part is a simple continuous drawing and the second part is the drawing analyzed by Ascher.

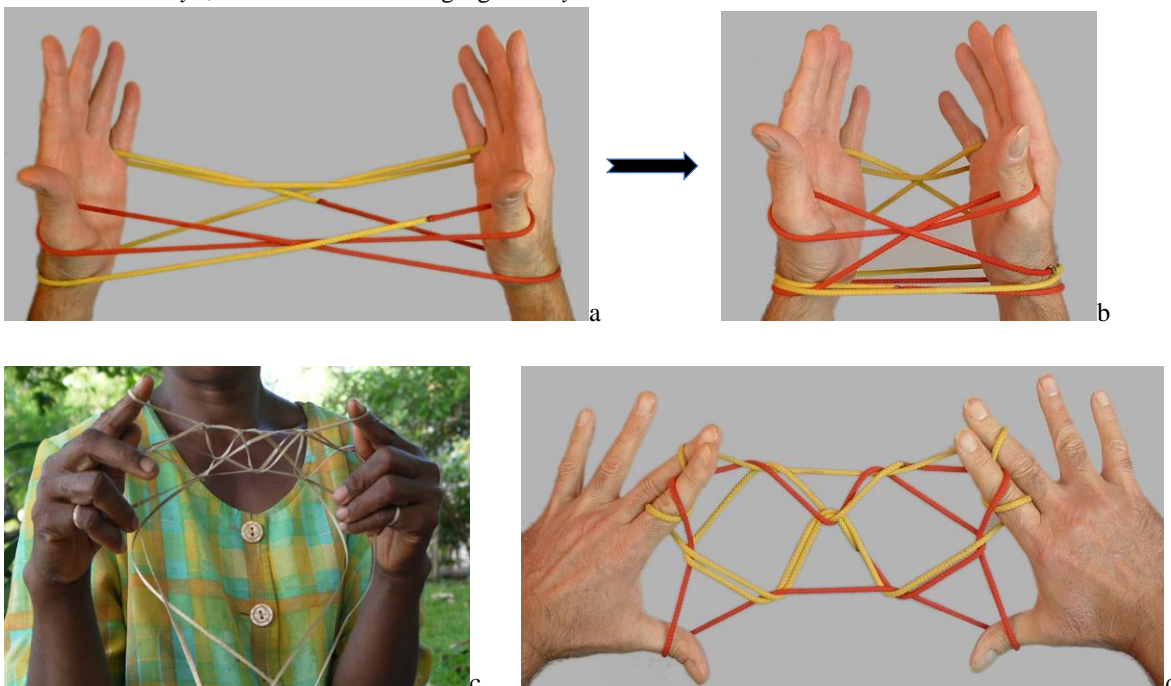
Fig. 25. Transformation of *konang lipang*. Left: *konan lipang* of Bahaltalam. Right: *rom* of Ranvetlam, variant of *konan lipang* © Mike Franjeh²⁴.



The same phenomenon occurs for string figures. For instance, the procedure *lipwim lalao mwecherkete wayu* (the roots of the tree *lalao* seize the hairy yam) is obtained by adding the picking up of two strings (the lower far index strings) within the iterative sub-procedure involved in the making of the string figure *wayu* described above (cf. section 3.1)²⁵. This alteration of the procedure leads to the transformation of the final figure (cf. Fig. 26d).

The string figure *titiman liseseo* (devil *liseseo*'s breasts) can also be analyzed as the transformation of the string figure *meya* (inedible orange fruit). However, in this case, it is done through the alteration of the starting position (cf. Fig. 26a-b), aiming at adding two long hanging loops (representing the breasts) to the final figure of *meya* (cf. Fig. 26c).

Fig. 26. (a-b) Transformation of the starting position of the procedure *meya*. (c) *titiman liseseo* (“The devil’s breasts”- represented by two hanging loops), variation on *meya* (red fruit). (d) Final figure of *lipim lalao mwecherkete wayu*, variation on the string figure *wayu* © Vandendriessche.



²⁴ Pictures extracted from (Franjeh, 2018) with the kind permission of Mike Franjeh.

²⁵ More precisely, Step 5 of the procedure *wayu* becomes “Pass thumbs under the index loops, insert them into little finger loops, from below, return with both near little finger and lower far index strings”.

4. In conclusion: from epistemological to educational issues

We have seen that the Ambrymese string-figure and sand drawing practices are both locally conceptualized as a way of representing things or beings, and are/were embedded in the same system of prescription/prohibition, related to their negative impact on the growth of yams. On another level, their creation very likely required an intellectual task of selecting “elementary operations” or “basic patterns”, and organizing them in procedures. Both string figures and sand drawings thus appear as the result of genuine algorithms. Moreover, these practices are both of a “geometrical” order, insofar as they are based on investigations into complex spatial configurations. Several recurrent phenomena confirm this point: specifically, the organization of basic operations in sub-procedures, the use of iterations, the transformation of final figures, and the search for different paths leading to the same figure, are ubiquitous in both practices.

As we have seen throughout this chapter, the comparison of the cultural and cognitive aspects of different practices comprising a geometric and algorithmic character (such as string-figure making and sand drawing) should lead to a better understanding of how these practices are locally conceptualized as well as correlated with one another in various ways, in their terminology for instance or through other cultural patterns. At the same time, the comparison of the combinatorial properties at work in these activities contributes to an improved understanding of the nature of mathematical knowledge and practices involved in these activities.

At another level, this ethnomathematical approach shall contribute to the discussions that currently occur in many indigenous societies worldwide, requiring a local education system and the development of a culturally based curriculum (Pinxten 2016, Vandendriessche 2017). For about a decade, the Republic of Vanuatu has undertaken a reform of the National Curriculum (inherited from the colonial period), taking more into account the various local cultures *i.e.* the 120 different vernacular languages as well as traditional knowledge and practices (such as sand drawing and string figures in particular) prompting their integration in teaching programs (VNCS, 2010). These new educational directives have already been implemented in the elementary schools where pupils now learn how to read and write in their mother tongue (vernacular languages in rural contexts and Bislama²⁶ in towns).

It is in this context of the revision of the National Vanuatu Curriculum (still in progress) that the “Vanuatu Cultural Centre”, the local institution working for the preservation and the promotion of different aspects of Vanuatu’s culture—drawing on my ongoing research on string figure-making and sand drawing—has given its (mandatory) assent for this project in ethnomathematics, provided it leads to pedagogical applications. As I have pointed out elsewhere (François *et al.*, 2018), beyond this institutional incentive, another motivation for undertaking such educational research is that the Northern Ambrymese communities welcome with interest the idea of using their traditional practices in the local curriculum. Whereas the purpose of ethnomathematical (theoretical) research is generally not clearly perceived as vital as we think it is, indeed, its educational valorization makes sense for these people. Aware of these practices’ decline in their community, and asserting that young people are no longer interested in traditional knowledge, they consider this valorization as a way of preserving their local culture.

²⁶ Cf. footnote 4.

However, the elaboration of teaching programs related to social and cultural concerns is still the subject of discussions in the country’s educational circles. Both the Ministry of Education and the Vanuatu Cultural Centre actually prompt Ni-Vanuatu as well as foreign researchers to take part in the debate, through their participation in conferences/workshops/trainings organized in the capital Port Vila in particular²⁷. Regarding the teaching of mathematics, Georges Tauenearu, Professor of mathematics at the “Vanuatu Institute of Teacher Education”-VITE teacher training, has been giving a course in ethnomathematics for about a decade. This course allows students to study seminal works in ethnomathematics, while being encouraged to use—as pedagogical materials—the local mathematical practices that they would be able to collate in the cultural/linguistic areas where they will be sent to teach in local secondary schools, throughout the archipelago.

Fig. 27. Bringing string figure making and sand drawing into the classroom.



In 2016, I was invited by Norbert Napong, the Head of Topol (Francophone) High School, North Ambrym, to present my research in ethnomathematics to the students and their teachers. On this occasion, I met Ambrymese mathematics teacher Frederick Worwor. Trained at the VITE, in ethnomathematics specifically, he had already introduced the practice of sand drawing as a mathematical activity into the classroom. Generously, he showed me his students’ productions and we planned to further collaborate in the development of teaching materials on both string figures and sand drawings. This collaboration was undertaken in 2019 through the elaboration of a sequence of three teaching sessions to be implemented in 6th and 10th year classrooms. We first agreed that this pedagogical sequence on both string figure-making and sand drawing should be elaborated in an attempt to experiment the use of these (ethnomathematical) practices “as such”, in and of themselves²⁸. Furthermore, their mathematical

²⁷ For example, a workshop in ethnomathematics (co-organized by Georges Tauenearu, Professor of mathematics at the “Vanuatu Institute of Teacher Education”-VITE, Pierre Metsan, Principal Education Officer-Higher Education division, and myself) was held at the VITE on Dec. 9-12, 2019, in order to discuss, with different education actors (Ni-Vanuatu mathematics teachers, teacher students at the VITE, PhD student in mathematics education at the National University of Vanuatu), the various issues raised by the elaboration of a culturally based mathematics curriculum in Vanuatu.

²⁸ A major critique of ethnomathematics (and its pedagogical implications) refers to the use of local/cultural artifacts as pedagogical tools which often serve as little more than a motivation or an “illustration” (Pais, 2011) when learning the official mathematics curriculum (using a particular pattern woven on a basket for instance to introduce Pythagoras’ theorem, *cf.* Gerdes 1992). The connection between such a pedagogical practice and cultural reinforcement is thus questionable. To overcome this contradiction, our proposal is thus to introduce these different “ethnomathematics” (or culturally-related mathematical practices) “as such”, in and of themselves (*e.g.* practicing string figure-making as well as sand drawing in “math class”, *cf.* François *et al.*, 2018), bringing into the mathematics classroom the cultural and cognitive complexity of these practices.

aspects shall not be isolated from the other forms of local knowledge embedded within these activities, with the intention of bringing into the classroom the cultural and cognitive complexity of these practices. In that perspective, the Ambrymese students would thus be incited to use their vernacular language for expressing the various operations involved in the making of these figures as well as the stories that often accompany them (*cf.* Section 2).

Ni-Vanuatu teachers use a standard preparation sheet in order to plan their pedagogical sequences. This document lists the objectives of the lesson, and divides it into different periods (introduction, tasks, results/conclusion, exercises to be done for the next session). Frederick Worwor and myself devoted a full day to create three such preparation sheets related to our project entitled “Jeux de ficelle, dessins sur le sable: des activités mathématiques ?” (String figure making, Sand drawing: mathematical activities?) Frederick suggested organizing the sessions in the classroom, in order to inspire the students to perceive the inclusion of these traditional activities in a more formal context. For the making of sand drawings, a couple of wood trays had been prepared and some ashes spread on them. As for string figures, long loops of pandanus leaves were ready to be woven. Basically, the sequence was carried out over a three month period: the first session consisted of 1/ explaining the project while discussing the idea of grouping the two practices in a single project 2/ working in groups of four or five individuals, where they have been asked to remember the making of 3 to 5 figures of each type, as well as their meanings (vernacular names, stories, etc.), making sure that all members of the group were able to do so by themselves, 3/ choosing one sand drawing and one string figure in the list, while describing the procedures/patterns as well as the symmetries and iteration of motifs in their mother tongue.

For the second session, we decided to concentrate on the concept of iteration at work in the making the sand drawing *peng* (*cf.* Section 3.1) and the string figure *meya* (*cf.* Section 3.2). The students were thereafter asked to identify other string figure/sand drawing processes based on the same principle. As for the third session, it was devoted to the analysis of the sand drawing *poar* and the string figure *wayu* (and its variation *lipim lalao mwecherkete wayu*, *cf.* Section 3.2), bringing to light the use of the concept of alteration in both practices. In the first case, the students tried to implement the procedure *poar* starting on grids with a different number of vertical lines (*cf.* Fig. 28). This led them to conjecture that the procedure works properly if and only if the later number of lines is an odd number²⁹. In the string figure case, the students readily realized that it is through the addition of a “picking up” (*hu*) operation that the final figure *wayu* is transformed into another figure. Consequently, they were able to find other examples of such phenomenon (alteration/transformation) occurring in the Ambrymese string figure corpus.

Fig. 28. Variations on the sand drawing *poar*



²⁹ The mathematical proof of this property will be published in (Da Silva, upcoming-2021).

Concerning the homework given to the students at the end of each session, they were asked to share all the procedures that had been demonstrated during the class. Furthermore, they had to identify the experts in string figure making and/or sand drawing in their own villages, with the objective of learning more from these people about “*tu en tan*” and “*tu an awa*”, and bring their findings back to the classroom. During this experiment, we quickly realized that although some students were well acquainted with one or both of the practices under study, others knew almost nothing about them. According to Frederick Worwor and Norbert Napong, an increasing interest for these traditional activities was perceptible on campus: some students spontaneously demonstrating (out of the classroom) the making of sand drawings and/or string figures collated in their own villages.

Although such an experiment obviously increases the transmission of these declining local activities to the younger generation, the impact of this pedagogical practice in the mathematics classroom remains an open issue (Pais 2011, François *et al.* 2018). The students involved in this educational experiment have readily connected both string figure making and sand drawing with mathematical practices through different analogies, comparing such practices with geometrical constructions or calculations that must be carried out with attention, step by step. Therefore, these sessions have emphasized that particular forms of mathematical practices/reasoning can be found in their close environment. The next step should be to evaluate whether a regular practice in the mathematics classroom, say during a year, of local activities with mathematical characteristics, “as such”, in and for themselves, might have an impact on the students’ skills in “academic” mathematics—as a few previous studies have suggested (Moore 1988, Murphy 1998, Lipka 1994, 2004). In other words, the issue would be to evaluate whether practicing/valorizing activities defined as *kastom* practices in Vanuatu—such as sand drawing, string figure-making, but also mat-making, basketry, housing construction, etc.—in a formal educational context could serve as a lever for increasing both the Ni-Vanuatu students’ interest and their abilities in practicing mathematics. The Vanuatu Educational Institutions currently promote such investigations notably by supporting doctoral research in mathematics education, carried out in the recently created National University of Vanuatu³⁰. Given the exceptional linguistic and cultural diversity of Vanuatu, this archipelago seems to be the perfect place to undertake such empirical research whose outcomes would be of fundamental importance for the entire ethnomathematics research community.

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³⁰ Pierre Metsan (Principal Education Officer-Higher Education division) is currently doing a PhD entitled « Apprentissage des mathématiques au Vanuatu : La culture comme levier de motivation et de réussite scolaire » (Learning mathematics in Vanuatu: culture as a lever for motivation and academic achievement), under the supervision of Pr. Catherine Ris (University of New Caledonia). The latter PhD is one of the first three doctoral researches carried out in the (recently created) National University of Vanuatu.

(“Encoding and Transmitting Knowledge with a String: a comparative study of the cultural uses of mathematical practices in string-figure making (Oceania, North & South America) - ETKnoS” Project, 2016-2021) and the “Institut des Sciences Humaines et Sociales” (InSHS) of the French National Center for Scientific Research (International Mobility Support program, 2019, “String figure-making, sand drawing, and mat making: a comparative study of (ethno-)mathematical practices from Vanuatu” project).

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