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Nature as the Time Teller: Indigenous Mathematics of Time Calculation in Nepal

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Abstract

Mathematics of time calculation has remained an indigenous asset of different Nepali societies since time immemorial. In this work, we aimed to discover the indigenous ways of time calculation in Nepal in terms of time telling, estimation of time, estimation of seasons, and the way people transferred their indigenous knowledge to their further generations. Employing the phenomenological design of qualitative research, we used unstructured interviews as the tool for data collection. We interviewed seven people from different ethnic and cultural backgrounds using an interview guideline. We also used folk song called 'Sita jee ko bhalaulo' popular in district Baitadit of Sudur Paschim Province. We analyzed the information retrieved from those open-ended interviews. From the analysis, we concluded that people in Nepal used to observe the natural entities in their vicinity to estimate the time. While doing so, they used to observe the celestial bodies, shadows cast by the sun, and the visible changes in nature, as well as behaviours of animals. Likewise, they depended upon astrological calculations, and some provisions made by the state to inform people about time.

***Keywords*:** astrological calculation, observation, time-keeping in Nepal, time zone, vedic evidence

Introduction

History of time calculation dates almost 30 thousand years back when early human groups recorded phases of the Moon. Later, about 20 thousand years ago, people gained the idea of a month by observing the repetition of the lunar phases (Atkins & Koth, 2020). Later, Babylonians developed the idea of 24 hours a day (Roy, 2003). They divided the Sunlit portion of the day into 12 intervals and the remaining dark potion into 12 as 12 is mystically significant in the ancient Babylonian culture (Atkins & Koth, 2020). Babylonians developed a sexagesimal (base 60) system for astronomical counting which was later adopted by the Greeks who divided each of the the12 equal intervals of a day into 60 smaller units (Dame, n.d.). Almost four hundred years ago, the concept of minute was gained and almost half a century ago, the human race became able to count a billionth of a second (Atkins & Koth, 2020).

A sophisticated system of time calculation was developed in the Indian subcontinent also. The ancient manuscript that mentions the concept of time calculation methods was *Vedanga Jyotisha*, which was orally transferred for a long in *Guru-Shishya* tradition and formalized during 1200 to 600 BC (Hariprasad, 2018; Sarma, 1991). This book introduces the mathematics of calculation of a day and year. According to the text, a civil day counts the time from one sunrise to another sunrise, and the year was divided into two *Ayanas* one from the brighter half of the month of *Magha* to the end of the darker half of the month of *Ashadha*, and other from the brighter half of the month of *Sravana* to the darker half of the month of *Pausha* (Sarma, 1991).

In the ancient texts of Hindus, such as *Vedas, Puranas,* and *Upnishads,* several examples of time calculations are found. People used to use sundials and water clocks. Further, they used to observe the celestial bodies at night. In the treatise of astronomy, the expansion of time is compared to the infinite expansion of the universe (Kak, 1999). Some of the Vedic evidences show that people started meteorological observations and estimated three seasons in a year to ease agricultural practices (Roy, 2009). In the Vedic scriptures, the significance of tripartite time dimensions as past, present, and future have been significantly marked. This markedness is depicted in the ancient architectural structures where designs were influenced by the Vedic time calculation method. Many of such architectures, building blocks depict the *yuga cycles* (cyclic repetition of the Yugas [world ages], i.e.; *Satya, TretāDwāpara, and Kali*), the solar year, the lunar year, the *mandalā* (the circular representation of universe), and its transformation of time, and, the solar year and lunar time cycles with reference to the *Mount Meru* (Kak, 2002).

Regarding time calculation, the Vedic scriptures mention micro level time unit, smaller than a second to the unit that consists thousands of years. The categories of time calculation in the Vedic texts range from a *Paramānu* (equivalent to 16.8 microseconds) to a day, which comes as the 16th category of time calculation (Sanskriti, 2015; Sharma & Agarwal, 2021). A very large unit of Vedic time calculation is a *Manvantara* (equivalent to 306,720,000 years). In a *Manvantara* 71 *Chaturyugas* repeat, *Kalpa* is even the bigger unit, which is made up of 14 *Manvantara* (Sanskriti, 2015; Sharma & Agarwal, 2021).

Similarly, in the ancient Greece too, water-clock or clepsydra was a common tool for time measurement. Apart from it, they also used to use the sun-dials. They had a twelve-month year like in the other parts of the world. However, the names of the months were different in the different city states (Lahanas, n.d.). Almost similar were the practices in Egypt, Rome, and other parts of the Near East, where people mainly used three methods of time calculations; i.e.; using sundials, using water-clocks and observing celestial bodies (Cartwright, 2012).

Time-keeping in Nepal: The Historical Overview

The first historical evidence that officially mentioned date is the inscription of Mandeva at Changu Narayan dated, 464 AD (Gautam, 2019). It contains the details of the year, day, and the auspicious hour (muhurta) the inscription was placed; i.e.; on the auspicious hour (muhurta) '*Abhijiti*' with the constellation *Rohiṇī* accompanied by the moon on *JyeṣṭhaŚuklaPratipadā, Samvat 386* (Bajracharya, as cited in Rajopadhyay, 2014). This shows that astronomy was well developed in the early days of the Lichchavi era. Some folk tales of different indigenous groups (DR, 2015) aslo show that the concept of time, the difference between day and night had been depicted in the myths in the antiquity which are still orally transferred via generation to generations. The Tamang story of genesis (Dangbo Serab) has a beautiful portrayal of creation of the day and night. According to the story, the God created some of the animal before he created the sun and the moon, therefore, these animal can see in the night too (DR, 2015). This mythological explanation shows that people noticed the difference in the nature of life due to the differences of the day and night.

Use of the sundials and water-clock was common in the past for the astrological purpose too. During the Malla period, residents of Kathmandu developed their own mathematics for telling the time. They used the pond near *HanumānDhokā* for the purpose of time calculation. Government officials kept *palas*(bowl shaped pottery used to light the oil lamp) with small hole at the bottom in such a way that a *pālā* would submerge in water exactly in 24 minutes. People went there to see how many *pālās* have submerged since the dawn. There was an official

assigned the duty of the time keeper and s/he had to tell people the exact time. In 1884, Nepal adopted the Western time keeping system. At that time, Nepal used Indian Standard Time zone, used in India and Ceylon. It 1956, Nepal set watches to Nepal Standard Time, setting its meridian to Mount Gauri Shankar (Gurung, 2003). The wrist watches were not so commmon as those are now in the past, thus, it was difficult for the common folks to know the time. Therefore, in 1901, the then Prime Minister Dev Shamsher started a tradition of noon cannon firing to remind the citizens that it was afternoon (Pokharel, 2018).

Even after the watches came, people kept using their indigenous concept of time keeping because it was not only an integral part of their lives but cost efficient too, hence watches were expensive luxuries. Participant A shared his interesting experience, "When a baby was born in the village, people had to run to find one who wore a wrist watch to know the time because the exact time of birth was necessary to make exact horoscope of a baby".

Before people had watches, they used the indigenous knowledge of time keeping. Though people have been practicing the methods of time calculation that their ancestors invented in the distant past the indigenous mathematics of time calculation has not particularly been studied. Thus, this study aims to explore some ways of time calculation used by Nepali people. For that, we basically focused on the research questions such as the way of estimating time by indigenous people when watches were not in frequent use, the way of estimation of the seasons especially focused on agriculture and other necessary works, and the way they transferred their indigenous knowledge to the coming generations.

Methods and Procedures

We, with the epistemological positioning that people's perspectives contain data, tried to explore their experiences regarding time calculation in their respective communities. For this, we opted phenomenology, a qualitative research methodology, which is concerned with the lived experiences of people on particular phenomena (Fochtman, 2008; Given, 2008) as it is experienced by human beings (Brinkmann et al., 2014). As we come from the clusters our participants do from, we have embedded our personal experiences too to make meanings of the data we retrieved. Thus, we adopted the Heideggerian perspective of phenomenology which believes that as human beings, our meanings are co-developed in the collective life experiences through our experiences in the world we live in (Byrne, 2001).

We collected data from seven individuals selected using purposive sampling it ensures the selection of people appropriate for the study (Gill, 2020). We used in-depth unstructured interviews for data collection. Considering the ethical issues,

we have concealed the identities of our participants and denoted them here by pseudonyms. Participant A, Participant B, and Participant C represent from Bahun-Chhetri community and come respectively from Sudur Pashchim, Gandaki, and Bagmati provinces; Participant D and E are from the Newar community. Similarly, Participant F and Participant G were respectively from the Limbu and the Gurung community. Due to the corona-virus restrictions, we took telephone interview and one interview on Zoom. We transcribed the data and coded them. After this we organized the codes into categories and finally drew themes from the categories to draw the meanings of the data. Apart from this, we used a time related folk song, *Sitājee ko bhalaulo* (The morning song of Sita), from the Sudur Pashchim province as secondary data.

Results and Discussion

We organized the information acquired from the data into four themes. Though the locality of the informants stretches from the far eastern hills to the far western ones, there is a significant commonness in the information regarding the time calculation in all the areas. Therefore, we have blended the information together to make the data meaningful.

Observation of Celestial Bodies

People used to observe the position of celestial bodies. At day time they observed the position of the sun, and at night they observed the moon and the stars. All the participants said that there was a practice of observing the sun, the moon, or the stars to guess the time in their locality, when watches were not common. This observation not only provided the time of a particular day but they also could estimate the season or the month. According to Participant B, observing the height of the sun in the sky was a common practice to estimate the time of the day. Similarly, she said that people watched constellation in the sky to guess how much night had passed.

Measuring a Shadow in the Sunlight

It was a common practice in the villages to measure the shadow of a previously set fixed signpost such as a house, a hill, or a tree to measure the maturity of a day. Seniors kept noticing the shadow's location and determined whether it is time for taking the cattle for grazing or sending daughters-in-law to the grass meadows to cut the grass, or to go to the field to plough or to reap the crops. Participant B said, "We usually took the shadow of our house as the indicator of time. My grandmother used to measure the shadow with her steps and then said other people whether it is late for going to a particular place or not." The similar

information was given by Participant A and Participant F. Participant A noticed that people used to guess the time observing the shadow of a *Peepal* tree in the village and Participant F said he too has heard about people observing the shadow to guess time.

Women who had to travel hours to get grass for the cattle used to notice the shadow of a particular hill to know that it is the time now to return home. Participant A said, "There was a *Peepal* tree down to the hill, it remained sunny there all day long, and it used to be late if the tree comes under the shadow of the adjacent hill. We had to hurry then to return home."

Sometimes, people watched their own shadow to estimate the time. Participant F said, "Shadow watching was easy way to see the time. In the morning it is long and extended westward, at the noon it is shortest, almost beneath your feet, and as time passes in kept stretching eastward until the sunset. After the sunset you could not use this trick!" Measuring time by observing shadow is a widely practiced time calculation technique in the world. It is a simple science that the length and direction of the shadow changes as per the sun advances over the sky. People still use this technique when they do not have a watch (Sloane, 2017). This practice is evidence that people have the concept of the position of the sun in the sky and this indigenous knowledge is being transferred from generation to generations. In the ancient Greece, Rome, Egypt and India, the methods of the sun observation reached to further advancement (Cartwright, 2012; Kolivand et al., 2011; Tatavarthy & Lanka, 2016) where the observation further leads to the astronomic calculations.

Observing the Altitude of the Sun

People observed the sun in the sky to estimate the time. Normally when the sun advents high enough above the head, it is the midday. It is scientifically proven technique to estimate time, season, and geographic regions (Jenkins, 2012)**.** Participant B said, "I remember mothers and aunties saying "Oh my God! The sun is high enough to go to the *Melā*, when will we cut grass, and when will we return?"

Apart from this, the sun's changing spectrum, bright to pale is also an indicator of the time for indigenous people. Still people rely upon the solar observation for time estimation. It has great significance in people's lives, this may be the reason that in many of the old religions of the world, the sun has been exalted to the level of gods. Participant C said that she heard people referring the pale spectrum of the sun to indicate the sunset. The same is the experience of Participant A.

Observation of the Moon and Stars

Another practice of estimating the time by observing the celestial bodies is observation of the moon and the stars (Sarma, 1991). As per the responses of the participants, people observed the position of Jupiter, Venus and *Tin-Tārā* in the sky to estimate the time in the night. As Participant B said, "we used to watch the sky. If the *Teen-tārā* constellation was over the head, it is time to go to bed, and if it was inclined westward, the night has almost passed and the dawn is near." Another, observation was related to the Jupiter, which appeared as big star in the sky. People took it as a signpost to estimate the time (Rogers, 2008).

Similarly, observing the Venus, which is called the morning star in the morning and the evening star in the evening, is another technique for the estimation of time (Rogers, 2008). Participant A and Participant B said that is called *Bihānitārā* (the morning star) in their communities and people estimate the daybreak or falling of the night from it. Participant A who keeps some knowledge n astrology explained that it appears as the brightest star in the sky and appears in the evening sometimes after the sun sets, when other stars are not visible. In the morning also when other stars have disappeared it keeps shining in the sky. Watching this too people estimated the time.

The moon is another celestial body people watch to estimate the time. Participants said that they estimated the lunar day as well as the time in the night observing the phases and position of the moon. Further, people knew whether it was the dark half or bright half of the month. It gave them sign to the seasonal changes too. For different seasons, the brightness and spectrum of the moon keep changing.

Observation of Animal Behaviours

People estimate time observing animal behavior too. Four of the respondents (Participant A, Participant B, Participant C, and Participant F) expressed that in the past, people estimated time by observing the behavior of animals, birds and insects. This topic has been discussed in the following sub-themes.

Behaviours of the Birds

Different birds also give the hint of time and seasons. People took help from the behaviours of such birds to know the time. Interpreting a cockcrow as the signal of the dawn is a common practice in Nepal. All the respondents agreed that they had heard that people still take a rooster's crow as the signal of daybreak. Both participant A and Participant B mentioned that in the past, poultry was not kept at Brahmin family homes, even though they said they noticed rooster crow from the neighbouring *Toles* (settlements). People call it a *Ghadicharā,* (a clock bird) as it

tells time like a clock. Participant B said, "We did not have one at our house, but our mothers said — when the rooster of the neighbouring family gave the third crow, it was the time to get up now!" Participant G also said that people in the Gandaki reason have given a name '*Ghadi Chara*' to a rooster

Another interesting fact was disclosed by Participant B and Participant F about the behaviours of *Karyāngkurung* (migrant cranes). They said the appearance of these birds signals the beginning of the rainy season. Participant B said, "In our childhood we used to chant '*Karyāngkurungāye, kānkrāpharsiropa*' (Migrant cranes have come, sow the seeds of cucumber and pumpkin)". According to Participant F, in Limbu community of the Eastern hills, the appearance of the migrant cranes was seen as the beginning of rituals like *SisekpāTamnāng*, the festival of Chasing the famine away. This falls on the first day of the month of *Saun* and celebrated as *Sāune Sankranti* by majority of Nepalis. Similarly, owls signal night, cuckoos spring seasons and, the migrant cranes, the coming of monsoon. Participant A, Participant B, Participant D and Participant F verified this.

Behaviours of Livestock

According to Participant Ait was the defection time of a cow or a buffalo in the morning that gave hint to housewives that it is the time to get up. Similarly, milking cows moo when it is the time to milk them. He disclosed a very interesting fact that cattle behave abnormally when some natural calamities are to hit. Calves playfully jump and run when it is either going to rain or there is a storm upcoming. Animals such as dairy cattle some insects indicate seasons.

Similarly, Participant A said that apart from signalling of the morning by a rooster, people used to observe the behaviour of their cattle which indicate the crack of dawn. A bell is worn around the neck of cattle in Nepal. When it is right before the first light cattle get up from their inactive rest and shake their body giving the cowbells a ring. This was used as the signal of the daybreak specially in the families where cockcrow not a facility. There have been studies to explain this type of behaviour shown by animals.

Participant A commented, "The morning is indicated by a cockcrow but having chicken at home was considered a taboo for we Brahmins, so we rarely heard a cock crow". He added, "If the village host families from different communities, one is not restricted to listen a cock crow. But we lived at a village which only have Brahmin houses, so my grandfather said they guessed the time listening the bulls shaking its body in the morning and making the bells ring".

People associated the concept of time with the biological clock of animals, a routine that is supposed to regulate diverse rhythms in the body such as body temperature, sleep, hunger etc. (Jiang & Turek, 2018). A study found that due to change in the flow of nitric oxide synthase (NOS) in the blood during the active and resting period of animals causes contraction of blood vessels causing dip or rise in their blood pressure which cause them behave particularly (Denniff et al., 2014). Animal husbandry is an inseparable part of Nepal's country life as animal count outnumbers the human. This fact is supported by the argument by (Bhatta et al., 2018) that about 25.68 per cent of the total population is still directly involved livestock and it covers 32% of agricultural GDP and about 11.5% of the national GDP. People have accustomed their lives with the routine behaviors of the domestic and non-domestic animals living in the human proximity.

Observation of Insects

The chirp of *Jhyāukiri*, a sub-species of cicada in the evening is the indicator of evening. This becomes more significant on a clouded day when the time calculation is impossible by measuring the shadow or the altitude of the sun. Participant E said "still in the villages chirp of *Jhyāukiri* is understood as the beginning of evening."

Bee keeping is a common part of the pastoral life in Nepal. Bees also indicate time. Participant A said, "You can easily observe their lunch time". They indicate spring season too. Participant A added bees split in different colonies in the spring season. Participant F tried to clarify "it is their mating time too".

Colonies of ants indicate the rainy season. People use it as a major indicator of weather and season. Similarly, nuptial flights of the ants can be observed at the end of monsoon. Participant A said, "We call them *Dhan Putali*. I remember- how enthusiastically we chanted a song—*Dhan putalidhān de, kodegadobān de!* (Oh, flying ant give us paddy, and let us sow millet in the fields)". Similarly, appearance of leech in the swampy area indicates maturation of the monsoon season. Participant A said leeches are seen in the rainy season.

Apart from these animals, fishes also indicate seasons. According to Participant F people in the eastern hills take swimming downward stream of *Tite māchhā,* a local species of stone carp, as the termination of the monsoon and beginning of the winter. He said, in rivers like the Arun, when *Tite māchhā* start swimming downwards people begin preparation for the winter season. He added, "People interpret the downstream swimming of *Tite māchhā* as the end of the rainy season and beginning of the winter, the season of festivals". Similarly, appearance and disappearance of snakes is also taken as the indicator of winter and non-winter seasons. Participant A said, "Snakes hide in the winter and appear when the winter ends".

Astronomical Calculations

Astronomical and astrological calculations are common mostly for the auspicious occasions such as marriages and festivities. However, mainstream astrological practices are not the integrated part of all the indigenous cultures. Basically, in Hindu and Buddhist communities, astronomy was on advent and astrological calculations are commonly practiced since antiquity (Mohan, 2015). Auspicious hours and moments are calculated through the observation and interpretation of the fixed stars, the Sun, the Moon, and the planets (Pingree, 2019).

Participant A and Participant B from Brahman-Chetri community and Participants D and E from Newar community said that there is a practice of *Jyotisha* consultation for the festivals and auspicious occasions. In the eastern tradition of astrological calculation, the day counts from the sunrise to the next sunrise (Sarma, 1991). Similar was the practice in Harranians from the ancient Mesopotamia (Pingree, 2019). Participant A, who hails from Brahmin said, "For the calculation of propitious time, astrologers count *barsa, ayan, mahinā, paksha, tithi, haptā, bār, prahar, ghadi, pala, bipala,* and set the time for the auspicious rituals". Participant B and C added that those astrologers used some devices like water-clock and the sun-dials to calculate the time.

Other Observations

People calculated time of a day or a year by observing several entities in the nature as well as other various things. Participant A shared an interesting information that women in the past estimated the morning time when they felt their jewelries or clothing cold. He told, "There were no watches, yet women got up early in the morning. They used to wear jewelries like ear rings, bangles, or nose rings. In the morning temperature goes down and these jewelries feel colder than in normal times." This is depicted in the folk song *Sitājee ko bhalaulo* too. The song depicts that Sita gets up early in the morning to bring water from the well/spring, Ram asks her, "Great! Like an owl, how did you know the secrets of a night? (*Dhanna bijāikhānikosedi ki jāṇerāt ki bāt*)" On this Sita answers, "When the *Nathiyā* (nose ring) of my nose felt cold, I knew the secrets of the night, when the metal bangles of my wrist feel cold, I knew the secrets of the night! (*nāk-ki nathiyā meri thannalāgitabajānyārāt ki bāt, bauli-kākhaduwāmerāthannalāgi tab jānyārāt-ki bāt*)*"*.

In Newari culture also people used water clocks (*pānighadi*) to calculate time. Use of water clock at night and the gnomon (sun-dial) have been popular in India and Mesopotamia since antiquity. (Pingree, 1973) estimates this method of time calculation was imported to India from Mesopotamia sometimes in the first

millennium BC, however, this theory has been denied and countered by Falk (2000) pointing at the methodological flaws in the observations of Pingree. However, regardless of its origin, it had become an integrated part of human life in different societies and so is in Nepal. Apart from it, people estimate the season by observing the leaves of trees. Participant A, Participant B, and participant F said that when trees sprout new leaves it is the spring season and when the leaves of the trees get pale or fall, it is the autumn

Another method of estimation of season is the observation of the stones at the bank of rivulets. Participant F said "people estimated time observing the things around them. Even the stones at the bank of the rivulets show the season. When the winter begins the stones get black as the water level of the rivulets descends and the algae on the stones began drying". This was verified by Participant A too.

Flowers and other plants also indicate time. Blossoms of rhododendron, marigold, cherry or peach or other flowers indicate specific time. Participant A pointed out, "even the pine pollen with blowing with wind gives symbol of Holi festival coming". Not only this, even diseases are season specific. One can guess the season by observing breaking out of the diseases. Participant A added, "in the summer skin infections, in the monsoon water-borne diseases, and in the winter influenza; diseases also tell time". Participant B and Participant D and F also verify this.

The findings of people's observation have been orally transferred to the new generations. Such knowledge has been transferred from generation to generations mainly in two ways. The first is transfer from the senior members of family or society to the junior members. In this regard, mainly grandparents and parents seem to transfer knowledge to their siblings and Mother in laws transfer it to their daughter in laws. Participant A told us that he got a great deal of information from his grandfather and grandmother. Similarly, Participant B said she knew about such information from her seniors in the family and society. She got the idea of time associated with shadow from her grandmother and mother. She used to chant the song "*Karyang-kurung aye…*" in her childhood and she learned it from her peers and seniors of the society. Mothers and mothers-in-law taught them about such duties which also included time keeping.

Likewise, folk literature is another strong means of such transfer. In the districts of Far Western hills people have two specific folk narrative songs to indicate the start of the day and the night. They sing *Bhalaulo*, the song of dawn and *Sanjhyāwāli*, the song of the dusk. Housewives had to get up early in the morning in the past as they had several domestic responsibilities. In the folk song *Bhalaulo*

of Sudur Pashchim the features of dawn are depicted in the poetic form which have been transferring generation to generation (Bhatta, 2017).

Conclusion

People have their own methods of time calculation which are not only common throughout the country but in the far away countries too. For example, observation of the celestial bodies, shadows, water-clocks have been a common practice in ancient Greece, Egypt, or in Mesopotamia. However, the units and practices are identical to a particular religion and culture. From their consistent observation of the nature for centuries people drew the conclusions for the symbols indicating time in societies like in Nepal.

From the study, majorly four ways of time calculations have been found; i.e.; observation of celestial bodies, observing animal behaviour, astrological counting and observing other miscellaneous things in the surroundings. From the study it is concluded that, people have drawn conclusion after generations of observations and shared those findings beyond their cultural, ethnic boundaries. Because of this there is a great deal of commonness in the methods of time calculations in various cultures.

The indigenous time-keeping skills of people have not become an academic issue yet in Nepal. It has not been embedded to any discipline specific research. Thus, there is plenty of scope for the further research in this field. Scholars of history, anthropology, history of mathematics, and even education can find several researchable issues in this field.

References

Atkins, W. A., & Koth, P. E. (2020). *Measurement of time.* Retrieved September 30, 2020, from Encyclopedia.com: https://www.encyclopedia.com/science-and-technology/mathematics/mathematics/measurement-time#3407500302

Bhatta, B., Kaphle, K., & Yadav, K.K. (2018). Situation of livestock, production and its products in Nepal. *Archives of Veterinary Science and Medicine, 1*(1), 1-8. https://doi.org/10.26502/avsm.001

Bhatta, K.R. (2017, October 14). *Manasi Lok-sahitya-ma Bhalaulo*. Retrieved from Prasasan: https://www.prasashan.com/2017/10/14/44709/?fbclid=IwAR0l4foULMS-_Jn43eItkB6vj_RyZUF_DI7QNhoBa41mvuSQeL835qQI-04

Brinkmann, S., Jacobsen, M. H., & Kristiansen, S. (2014). Historical overview of qualitative research in the social sciences. *The Oxford handbook of qualitative research*, 17-42.

Byrne, M. M. (2001). Understanding life experiences through a phenomenological approach to research. *AORN journal, 73*(4), 830-830. https://doi.org/10.1016/s0001-2092(06)61812-7

Cartwright, M. (2012, August 12). *Ancient timekeeping*. Retrieved from Ancient History Encyclopedia: https://www.ancient.eu/Timekeeping/

Dame, J. (n.d.). *Why is a minute divided into 60 seconds, an hour into 60 minutes, yet there are only 24 hours in a day?* https://tf.nist.gov/general/pdf/2209.pdf

Denniff, M., Turrell, H.E., Vanezis, A., & Rodrigo, G.C. (2014). The time-of-day variation in vascular smooth muscle contractility depends on a nitric oxide signalling pathway. *Journal of Molecular and Cellular Cardiology, 66*, 133-140. https://doi.org/10.1016/j.yjmcc.2013.11.009

Falk, H. (2000). Measuring time in Mesopotamia and ancient India. *Zeitschrift der Deutschen Morgenländischen Gesellschaft, 150*(1), 107-132. Retrieved from https://www.jstor.org/stable/43380202

Fochtman, D. (2008). Phenomenology in pediatric cancer nursing research. *Journal of Pediatric Oncology Nursing, 25*(4), 185-192.

Gautam, B.N. (2019). Emergence of the Lichhavis in Nepal and societal transformation. *National Development, 32*(2), 51-63. http://jndmeerut.org/wp-content/uploads/2020/09/Volume-32-No-2-Winter-2019.pdf#page=56

Gill, S.L. (2020). Qualitative sampling methods. *Journal of Human Lactation, 36*(4), 579-581. https://doi.org/10.1177/0890334420949218

Given, L.M. (2008). *The Sage encyclopedia of qualitative research methods* (Vol. 1 & 2). Sage Publications.

Gurung, T. (2003, July 25). 15 minutes of fame. *Nepali Times* (155). Retrieved from Nepali Times: https://web.archive.org/web/20110725100005/http://www.nepalitimes.com.np/issue/155/Heritage/10013

Hariprasad, P.P.S. (2018). *How ancient are Vedas, Vedanga Jyotisha and Surya Siddhanta?* CrossAsia-Repository.

Jenkins, A. (2012). The Sun's position in the sky. *European Journal of Physics, 34*(3), 1-20. https://doi.org/10.1088/0143-0807/34/3/633

Jiang, P., & Turek, F.W. (2018). The endogenous circadian clock programs animals to eat at certain times of the 24-hour day: What if we ignore the clock? *Physiology & behavior, 193*, 211-217. https://doi.org/10.1016/j.physbeh.2018.04.017

Kak, S. (1999). Concepts of space, time, and consciousness in ancient India. *arXiv: History and Philosophy of Physics*. Retrieved from https://cds.cern.ch/record/381232/files/9903010.pdf

Kak, S. (2002). Space and Cosmology in the Hindu Temple . *Vaastu Kaushal: International Symposium on Science and Technology in.* New Delhi. Retrieved from https://www.ece.lsu.edu/kak/Time2.pdf

Kolivand, H., Amirshakarami, A., & Sunar, M. S. (2011). Real-time projection shadow with respect to sun's position in virtual environments. *IJCSI International Journal of Computer Science Issues, 8*(6), 80-84. Retrieved from https://core.ac.uk/download/pdf/78911896.pdf

Lahanas, M. (n.d.). *Ancient Greece : Measurements - length, weight, time*. Retrieved from Hellenicaworld.com: http://www.hellenicaworld.com/Greece/Technology/en/Measurements2.html

Mohan, C. (2015). *The story of astrology in India.*

Pargiter, F.E. (2011). The telling of time in ancient India. *Journal of the Royal Asiatic Society, 47*(4), 699-715. https://doi.org/10.1017/S0035869X00048796

Pingree, D. (1973). The Mesopotamian origin of early Indian Mathematical astronomy. *Journal for the History of Astronomy, 4*(1), 1-12. https://doi.org/10.1177/002182867300400102

Pingree, D.E. (2019, Jnuary 10). *Astrology*. Retrieved from Encyclopædia Britannica: https://www.britannica.com/topic/astrology

Pokharel, U. (2018, August 18). *History of time keeping*. Retrieved from My Republica: https://myrepublica.nagariknetwork.com/news/history-of-time-keeping/

Rajodhyay, A.D. (2015, January 15). *Creation of universe - GENESIS (Tāmāṅg folktale) [Blog Post]*. Retrieved from Folk Tales from Nepal. http://folktalesnepal.blogspot.com/2015/01/creation-of-universe-tamang.html

Rajopadhyay, A. D. (2014, November 3). *Mānadeva's Inscription at Cắgu Nārāyaṇa (Side I) - 464 AD [Blog post]*. Retrieved from Inscriptions of Nepal: http://inscriptionsofnepal.blogspot.com/2014/11/changu-narayan-inscription-464-ad-mandev.html

Rogers, L. (2008). *A brief history of time measurement*. https://nrich.maths.org/6070

Roy, M. (2009). Agriculture in the Vedic period. *Indian Journal of History of Science, 44*(4), 497-520. Retrieved from https://insa.nic.in/writereaddata/UpLoadedFiles/IJHS/Vol44_4_2_MRoy.pdf

Roy, R. (2003). Babylonian Pythagoras' theorem, the early history of zero and a polemic on the study of the history of science. *Resonance, 8*(1), 30-40.

Sanskriti. (2015, February 1). *Concept of measurement of time in vedas*. Retrieved from Sanskritimagagine.com: https://www.sanskritimagazine.com/indian-religions/hinduism/concept-measurement-time-vedas/

Sarma, N. (1991). Measures of time in ancient India. *Endeavour, 15*(4), 185-188. https://doi.org/10.1016/0160-9327(91)90125-U

Sharma, C. K., & Agarwal, S. (2021). The Vedic time system: An explanatory study. *Journal of Indian Research, 9*(3 & 4), 25-31.

Sloane, C. (2017, April 24). *How to tell time with your shadow*. Retrieved from Sciencing: https://sciencing.com/tell-time-shadow-8318540.html

Tata, S.P. (n.d.). *The Vedic calculations of time and creation*. Retrieved from Astro Jyoti: https://www.astrojyoti.com/vedictimecalculations.htm

Tatavarthy, B., & Lanka, R.S. (2016). Surya Siddhantha Division lll Time, the position of places and directions called Triprasna. In *Surya Siddhantha [Sun theory] – Cosmological analysis- The basis for astrology.* https://doi.org/10.13140/RG.2.1.2553.8969