

# The history of fire use and its effects on human sociality

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## Abstract

Fire, one of the earliest forms of technology, has been part of human culture for at least 1.5 million years. Initial interactions with fire and use of fire eventually turned into the control of fire. While non-human primates have a better relationship with fire than most animals, humans are the only species that control fire. Both the importance of fire and variety of purposes it served gradually increased through human history. This review summarizes the origins and early forms of human fire use. It analyses fire's effects on human life with the purpose of determining how fire use shaped human sociality. Fire use changed the human daily cycle by allowing people to stay awake during nighttime. This additional awake time was used primarily for socialization. It contributed to the development of language by fireside communication. Likewise, advanced human creativity and imagination by fireside storytelling. Undeniable parallels between fireside storytelling and contemporary mass media are uncovered. Fire use also necessitated the development of advanced human cooperation due to considerable costs of maintaining fire. Time spent awake during dark hours was first made possible by fire use. In terms of activities performed by both past and current societies, it is unique from both daytime and nighttime. This suggests that a third phase of the human daily cycle must be defined.

## Introduction

Fire is one of the oldest known human technologies. Human interactions with fire trace back to at least 1.5 mya. Fire requires organic materials serving as both fuel and combustible products. The earliest indicators of fire use are found in well-preserved archaeological contexts. These specimens are coal, burnt bones and stones that were exposed to fire (Chazan, 2017; Gowlett, 2016). Caution should be exercised when using expressions such as “human fire use” and “control of fire.” The cognitive extent of fire use is doubtful until findings that prove systematic fire starting and continuous maintenance of fire such as hearths start appearing in the archaeological record. Human interaction with fire cannot be considered as evidence of fire control. Likewise, the presence of fire is more difficult to determine than other types of Lower Palaeolithic technology such as stone tools (Gowlett, 2010). Thus, archaeological record is not always able to explain earliest forms of human-fire interactions.

One method to improve the reliability of investigating human fire use is “microcontextual approach.” This method focuses on microscopic scale analysis of fire related material in the archaeological record to interpret connections to human activity. In archaeology, different materials found in the same context are considered to be culturally related to each other. Minimizing the size of the context using microcontextual approach enables establishing more precise connections between burnt material and human activity (Goldberg et al., 2017).

Existing research on connection between fire use and human sociality is mostly focused on the role of fire in the development of language and cooperation between individuals. Changes to the circadian cycle are recognized but usually not evaluated beyond the extension of waking hours. This article addresses the questions of how fire use shaped our daily cycles beyond sleep-wake schedules and whether additional time spent awake is the only contribution of fire use towards human sociality. In this work, firstly the origins of humans’ relationship with fire is presented. Then, it is discussed whether the behavior of modern primates can provide insights about the origins of human fire use. The process starting from earliest forms of human-fire interactions leading to widespread use of fire is explained. Finally, the connection between fire use and human sociality is analyzed.

## Origins of human-fire relationship

The first encounters of hominins with fire were through wildfires. Early hominins frequently encountered natural conflagrations in African savannas. Small wildfires occur due to causes such as thunderbolts or spontaneous combustion (Clark and Harris, 1985). Flames may spread to larger areas and turn into forest fires. Other less frequent causes, such as volcanic eruptions can also introduce people to natural fire. However, bushfires are the source of natural fire that humans first interacted with (Gowlett et al., 2017). Humans have long been aware of the properties of natural fires and their ability to change the environment. A model in which our early ancestors are first affected by the environmental changes caused by fire and then try to manipulate the fire to benefit from it should explain the beginning of fire use. It is likely that first humans to benefit from fire consumed food sources cooked by natural fires. Likewise, it also became possible to collect small animals that were killed or lost their habitats due to natural fires. It is possible that in later phases of human-fire interactions, people deliberately attempted to imitate the effects of natural fires by carrying burning branches or other burning material to their living areas.

Evidence for early human controlled fire use could be divided into four categories: Archaeological evidence, fossil evidence, demographic evidence and paleoenvironmental evidence (Twomey, 2013). Throughout most of the Lower Palaeolithic period there is no evidence

for control of fire. Fire use was limited to only benefiting from fire. People used fire for various purposes, but for a long time did not develop the ability to control and maintain fire for extended periods. During the Middle Palaeolithic period, complete control of fire, conscious fire-starting practices and hearths emerged. When the history of fire use is examined, it is seen that most of the key developments leading to fire taking a vital role in human activities (including but not limited to first conscious fire starting and fire use becoming widespread) are associated with *Homo erectus* (Gowlett and Wrangham, 2013). When examining the earliest history of fire use, it is necessary to search for precise connections between hominin behavior and archaeological materials related to fire (Goldberg et al., 2017). Nevertheless, it is difficult to reach a precise determination whether evidence points towards deliberate fire use. Human-fire interactions existed long before hearths. However, evidence of early fire use is difficult to find as the introduction of fire to human culture is a multi-staged process (Pruetz and LaDuke, 2010; Gowlett, 2016).

## Interactions between primates and fire

Twomey (2013) claims that fire use implies cognitive features distinctive of humans that are not evident in other animal species. These features are episodic memory, working memory and social cognition. While no species other than humans have the ability to control fire, some primate species are observed to understand certain properties of fire. Non-human primates such as chimpanzees can adapt their behavior according to natural fires (Parker et al., 2016). Savanna chimpanzees of Fongoli were observed as showing no signs of stress or fear even in short distances from bush fires. Their behavior towards fire is described as “predictive rather than responsive” and they appear to understand the spreading pattern and speed of fire. Furthermore, in one instance they only reacted to fire by moving away when it reached a proximity enough to make human observers uncomfortable (Pruetz and LaDuke, 2010). Additionally, Fongoli chimpanzees were frequently observed to ignore fire or spend considerable time in burnt areas (Pruetz and Herzog, 2017). Their ability to predict the movement of fire enables these chimpanzees to be comfortable around fire and live in a fire prone area.

Chimpanzees are the closest living relatives of humans. While their relationship with fire does not directly indicate how human fire use started, it suggests potential forms of human-fire interactions before first archaeological evidence of human fire use. Furthermore, it is unclear how much, if any of chimpanzees understanding of fire properties is inherited from their last common ancestor (LCA) with humans. However, the ability to coexist with fire, which the chimpanzees have, is the most important prerequisite to eventually control fire.

Palaeoenvironmental reconstructions reveal a certain shift in East African landscape starting around 7 mya. Dense forested areas were gradually replaced by savannas and around 1.8 mya the extent of savannas peaked. Hominins thrived on savannas that are more prone to wildfires than forests, while other apes, regardless of how much they understand the properties of fire stayed in the forests (Wood and Harrison, 2011; Parker et al., 2016). While control of fire likely does not go far beyond 1.5 mya; it is a possibility that understanding the properties of fire is an ability our LCA with chimpanzees possessed.

## History of early human fire use

Oldest archaeological hints for human fire use date to approximately 1.5 mya. In the Kenyan site of Koobi Foora, part of the sediment was burnt and reddened after exposure to 200-400 °C fire. Fractured and heated stones were also found. Burned material and non-burned material at the site are at spatial relationship with each other (Hlubik et al., 2019). At another Kenyan site

Chesowanja, large piles of heated clay cooked at 400 °C heat, dating back to approximately 1.42 mya are found (Gowlett et al., 1981). Heated clay at the Chesowanja site is spatially related to Oldowan tools and faunal remains. While evidence of fire at Koobi Fora and Chesowanja sites is certain, it is debatable whether the origin of fire in both sites is anthropogenic (Gowlett, 2016). However, the fact that burnt spots and heated material were found spatially related to non-burned artifacts give the impression of deliberate fire use.

More convincing indicators of fire use were found at the Swartkrans Cave located in South Africa and date to at least 1 myr BP. Around 270 burnt bones of different animal species were found. These bones were burnt at temperatures consistent with experimental campfires from branches of the most common tree (*Celtis africana*) in the area (Brain and Sillent, 1988). Another cave in South Africa, Wonderwerk presents earliest archaeological evidence of the control of fire. Among the findings dating back to 1 Ma; charred plant remains, burnt bones and remains of grass and leaves used to feed the fire were found (Berna et al., 2012). While evidence of human ability to start fires does not exist 1 mya, it is clear that fire had great importance for early humans. They made great efforts for feeding and controlling fire.

790 kya, at the Gesher Benot Ya'aqov (GBY) site in Israel widespread use of fire is seen for many different functions. GBY represents the earliest example of domestic fire use. Coal and burnt wood are present in multiple layers. In addition, burnt remains of fruit, wood and seeds belonging to plant species used as food were unearthed. Among these remains are burnt wood belonging to six different plant species. Three of those species (olive, wild barley and wild grape) provide edible products (Goren-Inbar et al., 2004). Additionally, burning in the soil is focused on certain locations in the GBY site. It is not possible to claim that these spots are the remains of the first hearths as no evidence for special construction exists. However, they can be considered as proto-hearths in terms of both settlement planning and technology (Goren-Inbar et al., 2004). Another important feature of the GBY site is the first evidence of conscious and continuous cooking. In areas of the site reserved for fire use, fish teeth belonging to certain species that had been exposed to high amounts of heat were found among burnt stones. This discovery revealed that fish was cooked and consumed in the GBY site 790 kya (Zohar et al., 2022).

The Zhoukoudian site in China, dating back to at least 400 kya has two important features regarding the early use of fire by humans. Firstly, it is the oldest example of extensive fire use outside of Africa and Levant. The second important feature is the abundance of diverse types of artifacts associated with the use of fire (Weiner et al., 1998). Evidence for fire exists at multiple layers and multiple areas. Burnt bones are in spatial relationship with unburnt bones and stone tools. Ash, charcoal and burnt stone tools were also found. There are burnt areas in the soil similar to the GBY site. While claims about Zhoukoudian site containing the oldest hearth example are questionable; extensive evidence for use, control and maintenance of fire exists (Weiner et al., 1998).

The use of fire by humans has become more common around MIS 11 or 400 kya. Since then, evidence for fire use started appearing in many sites in various parts of the world such as Europe, Middle East, Africa and Asia (Gowlett, 2016). Evidence of human dispersal into middle latitudes predate fire use in these regions. However, the lack of evidence for earlier fire use in middle latitudes doesn't prove that fire wasn't necessary for humans to disperse into colder regions. This lack of evidence could be due to sampling limitations. Use of fire isn't the only cultural adaptation humans developed in order to survive in cold climates. The increase of fire use does coincide with the emergence of *Homo heidelbergensis*, a species with bigger brain size than earlier hominins. The social brain hypothesis suggests that larger brains are connected both with increased dietary costs (made easier to fulfill by cooking) and larger social network sizes. Therefore, fire use might be more closely aligned with human sociality than adaptation to colder climates (Macdonald, 2017; Gowlett, 2006).

It is suggested that the rapid increase of fire use around 400 kya is caused by cultural diffusion and cooperative interactions between different human populations (MacDonald et al., 2021). Domestic fire gradually becomes more common after 400 kya. During this time period hearth start to appear much more frequently. A large hearth used repetitively for a long time was found in the Qesem Cave in Israel (Shahack-Gross et al., 2014). In another cave in Israel, Tabun large fire marks appear in the soil indicating regular fire use (Shimelmitz et al., 2014). In the Beeches Pit site in England, large hearths were found on the banks of the river. Burnt bone, flint, seashells with burn marks and stone tools that had certain parts exposed to fire were found (Preece et al., 2006). In the Terra Amata site in Southern France an extensively designed hearth structure was found dating to 380 kya. In addition to a large amount of ash, indicating regular fire-starting behavior; a small stone wall was also built in order to protect the fire from wind (James, 1989). By the end of the Lower Palaeolithic, both geographical distribution and the purposes for which fire was used became widespread. This makes it possible to start investigating the effects of fire use on human sociality. Earliest uses of fire are thought to be practical and there are difficulties identifying cultural use of fire from the archaeological record. Fire use as a cultural trait can be archaeologically observed as early as the Gravettian (Alzate-Casallas et al., 2025).

## Effects of fire use on human sociality

### *Shift of the circadian rhythm and nighttime socialization*

Sociality is directly associated with the length of time people stay awake and how this time is organized. Human sociality was reorganized by the control of fire and use of hearths. Continuous cooking of food was first made possible by campfires. Cooking reduces the time spent preparing and eating food. Non-human apes spend 4-7 hours per day chewing food. For humans, cooking reduced the daily chewing time to under 1 hour. Likewise cooking increases the digestibility and caloric value of most human food sources; reducing the amount of food required to feed one person (Wrangham and Carmody, 2010). These differences enabled humans to allocate more time for non-essential activities such as socializing.

In non-human primates, total sleep time varies between 9 and 17 hours. Adult modern humans are diurnal and on average they sleep for 7 hours and stay awake for 17 hours every day. Humans are the primate species with the shortest total sleep time at 7 hours (Nunn and Samson, 2018). The short sleep duration of humans is a phylogenetic outlier. Ideal human sleep duration was calculated using the phylogenetic prediction method as 9.55 hours (Nunn and Samson, 2018). Humans are active throughout much of their awake time but most aware during early evening hours. In contrast, chimpanzees and gorillas, closest living relatives of humans are active between sunrise and sunset. The daily schedule of non-human apes is more closely aligned with sunlight than their sleep patterns. Use of fire has significantly changed the human biological clock (Wiessner, 2014). Biological clock regulates which parts of the day and how long one stays awake or sleeps. The apparent difference between the biological clocks of humans and other primates was caused by human fire use as a source of light and heat (Wiessner, 2014).

Exposure to firelight shifted the human biological clock. The reason humans stay awake longer is that the use of fire extends the “daylight” hours (Burton, 2009). Fire lit by humans is the first artificial light source in human history and it shortens time spent in darkness. However, firelights are never as useful as daylight. In addition to only providing light to an extremely limited area, its quality is not adequate for anything more than the simplest form of toolmaking (Dunbar, 2017). Daylight hours are sufficient to source vital necessities such as foraging. Therefore, additional awake time made possible by fire was used almost entirely for social purposes (Gowlett, 2016). Human communication before speech depended mostly on visual cues.

However, gestures, body language and facial expressions are at their most useful during clear daylight. By campfire, sounds such as grunts or laughter carry much more importance than visual cues. Remarkably, the only step required to go from grunting to voiced speech is establishing a cognitive connection between sound and meaning. Assigning society-wide meaning to certain sounds is an early step towards language (Dunbar, 2017).

### *Fireside conversation*

It is not possible to know for certain what people gathered around campfires in prehistoric societies talked about or how they socialized. However, some current pre-industrial hunter-gatherer societies that have closer lifestyles to past societies could give some ideas. Small-scale, partially isolated groups that do not participate in formal education can partly represent past societies. While these groups cannot provide direct evidence on the behavior of prehistoric societies, the role of fire in human sociality and fireside activities should be to a certain extent comparable to past societies. !Kung people live in the south of the African continent and has a hunter-gatherer subsistence pattern. Wiessner extensively studied the Ju/'hoansi tribe of the !Kung people using the participant observation method and recorded daytime and nighttime conversations (2014). Her research uncovered that in the Ju/'hoansi tribe, daytime and nighttime conversations are drastically different. While daytime conversations are centered mostly on daily and ordinary subjects, during the night storytelling and ritualistic conversations by campfire are common (Wiessner, 2014). Dunbar emphasizes that daytime conversations are functional and nighttime conversations are social (2014). Fireside social activities during the evening hours are also observed among Hadza hunter-gatherers (Samson et al., 2017). These findings reveal that at least for contemporary hunter-gatherer tribes, human behavior and activities are completely different under firelight compared both to daytime and nighttime. From these results, it could be interpreted that time spent under artificial light is not an extension of daytime, but it is a new phase of the human daily cycle in addition to night and day. While campfires enabled the beginning of this new phase, they are far from the only form of artificial light source that could be used to shorten nighttime anymore.

Among the Ju/'hoansi tribe, there are famed expert storytellers. By campfire; stories about living people, stories that have supernatural content and stories of ritual value are all told (Wiessner, 2014). Storytelling can only occur if three basic conditions are met. These conditions are vocal language, childhood learning and the beginning of fireside talks (Lauer, 2022). It is remarkable that campfires influenced the development of both language and human imaginative culture through storytelling. Storytelling opportunities provided by campfires created significant changes in the lives of the earliest people who stayed awake for part of the night. The purpose that stories serve for these people is similar and comparable to media in today's post-industrial societies. Time periods when people in current post-industrial societies most frequently access media content such as movies, TV series, news and sports are after sunset and before sleep, peaking between 9 pm and 11 pm. This content consists of both fictional and non-fictional products (Tana et al., 2020; Rigby et al., 2018; Bentley et al., 2019). The time period which media content is most accessed in current post-industrial societies is not dissimilar to fireside storytelling in the Ju/'hoansi tribe. There are also undeniable similarities between hunter-gatherer storytelling and contemporary mass media in terms of the balance between fictional and realistic content.

The effect of fire use on human sociality can largely be explained by how nighttime awake hours are used for or can be used for. Individuals of different ages and genders gather around campfires. In societies where division of labor is based on gender and age, individuals often interact and socialize with their own age and gender groups while performing tasks. The use of campfires and gathering of all members of a certain society around fire is an important



opportunity for people that would otherwise have minimal time socializing with each other (Dunbar and Gowlett, 2014).

### *Fire and human cooperation*

Significant changes have occurred in human cooperation with the use of fire. Making fire was a costly behavior for early humans. Fire making (or fire starting) is the most cognitively demanding feature of human fire use. Starting, feeding, controlling and protecting fire are all difficult tasks and require both extensive planning and a division of labor. Planning in advance ensures that sufficient fire supplies are acquired in a timely manner and is necessary against adverse contingencies (Twomey, 2013). Existence of fire use implies long term planning as the benefits of fire aren't immediate. Thus, extended working memory capacity is required. The cognitive demands of controlled fire use suggest that human cognition has evolved gradually since the divergence from our LCA with chimpanzees (Barnard et al, 2007; Twomey, 2013). Furthermore, without complicated division of labor costs of fire would outweigh its benefits. Regularly starting and maintaining fire would only become beneficial in larger groups with well-developed cooperation (Henry et al., 2018). In cases where fire was lit in the same place for a lengthy period, eventually it would become necessary to collect the materials to feed the fire from long distances as resources close to the fire run out. It has been suggested that the best solution to overcome these difficulties is a comprehensive division of labor based on age and gender, in which grandparents and children also participate to increase efficiency (Twomey, 2014). While contemporary approaches towards prehistoric division of labor mostly reject categorization based on gender, a complicated system of cooperation, perhaps with less clear boundaries than previously thought is advantageous (Panter-Brick, 2002). Advanced, long-term cooperation is required to maintain fire and to take precautions against free riding. A division of labor involving all members of society improves both efficiency towards the cost of fire and cooperation (Twomey, 2013). The division of labor in starting, maintaining and protecting fires increased both the productiveness of grandparents and the amount of communication between them and younger members of their society. Contribution of elderly people towards the costs of fire helped the formation of "three-generation society" (Duyar, 2023). The development of human cooperation makes fire use much more efficient and its costs more worthwhile. Cooperation enables sharing the costs of fire among individuals. It also has the potential to elevate the evolutionary success of members of society more inclined to cooperate with others (Twomey, 2014).

### **Conclusion**

Our fascination towards fire might even go further back than the earliest humans. Natural fire simultaneously presents opportunities and danger for anyone attempting to benefit from it. Understanding the properties of natural fire enabled humans to first take advantage of it and eventually control fire. In a utilitarian point of view fire use could be interpreted as a technological step in human evolution. Nevertheless, the benefits of fire use go far beyond technology. Campfires completely reshaped the human daily cycle, extending the awake period. Time spent around campfires was used mostly for socialization, contributing towards the beginning of vocal speech which in turn led to the development of language. Fireside storytelling is a factor that contributed towards the development of human creativity through its influence on the development of language and imaginative culture. Thus, a new type of entertainment which originates from the use of nighttime hours for non-essential activities was developed. Current small-scale pre-industrial societies are observed to practice storytelling in the time period after sunset and before sleep. During the same time period current post-industrial

societies frequently access digital mass media. While it is difficult to claim that prehistoric hunter-gather storytelling eventually led to contemporary mass media, some parallels are clearly observable. Activities done under artificial light during time spent awake at night are unique compared to both daytime and nighttime activities. This pattern can be observed in both current societies and past societies since the widespread use of campfires began. Thus, a third phase of the human daily cycle; a phase that takes place under artificial light defined by socialization and creativity was established.

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