New Views on the Famous Ottoman Engineer Taqî al-Dîn

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Abstract. In the sixteenth century, the brilliant Ottoman scientist and engineer, Taqî al-Dîn wrote on arithmetic, algebra, geometry, astronomy, optics and mechanics. It has been claiming that while Taqî al-Dîn was carrying out these extraordinarily successful works, he obtained the most of his knowledge from Western scholars. Considering the basis of his work, his education and the atmosphere in which he lived, he rather appears to have carried out these successful works independently of Western scholars. This article argues that this nonreciprocal interaction could not have occurred owing to the scientific and technical relations between Europe and the Ottomans in the time of Taqî al-Dîn.

Keywords: Taqî al-Dîn · Ottoman Engineering · History of Technology

1 Introduction

Taqî al-Dîn was born in Damascus in 1521 according to his *Sidratu Muntahâ …* (The Limit of Skies Knowledge) [11] and after receiving education from his father, who was a teacher in Damascus, he travelled to Cairo, and continued his education in various subjects including mathematics and astronomy. He later continued his education in Istanbul, taking lessons from distinguished teachers of the period. He returned to Egypt in around 1555 and taught at schools in Cairo for some time. After periods of stay between Istanbul and Cairo, he finally returned to Istanbul permanently in 1570, where he remained until his death [6].

By attracting the attention of leading statesmen in the Ottomans with his astronomical and mathematical knowledge, he was appointed as the chief astrologer of the Palace in 1571. With the support of these statesmen, he persuaded the Sultan to establish an observatory in Istanbul, thus the Istanbul Observatory, one of the most important observatories of the sixteenth century, was established in 1579. Through this observatory celestial observations were made with the largest observation tools of the period. In 1583, after Ottoman conservatives convinced the Sultan that observing in the observatory would bring bad luck, the observatory was destroyed by cannon fire. Following this, Taqî al-Dîn continued his works personally until his death in 1585 [6] (Fig. 1).

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Fig. 1. Taqî al-Dîn working at the Istanbul Observatory

2 New Views on Taqî al-Dîn's Origin and Achievements

Various ideas have been put forward about whether he was from Syria, or Egypt and whether he was Arabic or Turkish. Turkish historian Ramazan Şeşen, depending on his genealogy given at the end of Taqî al-Dîn's book titled *Rayhânat al-Rûh*, determined that his sixth-line grandfather was one of the Turkish commanders of Salah al-Dîn Ayyubid (d. 1193) and his seventh-line grandfather was one of the Turkish commanders of Nur al-Dîn Mahmud b. Zangi's[1] (d. 1174) [11]. After the confusion regarding Taqî al-Dîn's origin and family was thus resolved by historical analysis of Ramazan Şeşen, the more significant remains over his work. Some historians (for example Avner Ben-Zaken) argue that his scientific studies were largely influenced by Western scholars, and his achievements in astronomy and mechanics especially, must be contextualized through the wider scientific achievements of the West.

As is known, Taqî al-Dîn wrote works in a variety of fields such as arithmetic, trigonometry, optics, astronomy, automata and astronomical instruments. For the first time he had applied decimal fractions to trigonometry and astronomy. And, most importantly, he corrected old astronomical tables and calculated new ones in the observatory he established.

The sources from which Taqî al-Dîn made his achievements, especially in the mechanics, has been met with suspicion. While making astronomical observations, he also developed celestial mechanics and it has been claimed that he laid the foundation for the new mechanical view of the universe that emerged in Europe [3].

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[1] Nur al-Dîn Mahmud (r. 1146–1174) was a member of the Zangi dynasty, which ruled the Syrian Province of the Seljuk Empire. He is regarded as an important figure of the Second Crusade.

There is evidence Taqî al-Dîn used the most advanced observational instruments in his observatory. He made most of these tools himself, yet there were also other tools imported from abroad, of this we are certain due to a miniature in the work titled *Şehinşahnâme* written in 1580.

Şehinşahnâme is a work that contains some of the most beautiful examples of 16th century Ottoman miniature art. It described the events of Sultan Murad III's reign between 1574 and 1581 in Persian verse. Ottoman sultans wished to leave their military victories, political successes and the important social events of their reign to future generations in the form of a glorious epic. For this purpose, a "Shahname-making" task was established [1]. That work (*Şehinşahnâme*) we have, been prepared for such a purpose.

One of the devices identified in the miniature in this work is a mechanical clock (Fig. 2). Taqî al-Dîn used the clock as an observational tool and thus aimed to achieve more precise results in his observations. How and where Taqî al-Dîn learned to build mechanical clocks has been met with suspicion, and it was thought that he acquired this knowledge from European craftsmen. It is believed that he acquired this knowledge from the watches and clocks sent as gifts to the Ottoman palace by European kings and from watchmakers in the entourage of the ambassadors of European states in Istanbul [3].

It is known that in 1547, the Austrians gave watches to the Ottomans as a form of tribute. This created a market for European watches in the Ottoman Empire and created a demand among Ottoman elite for these watches. In the 16th century some clockmakers made clocks for the sultan in a special place of the palace. Hasan Usta and Pervari Usta are two well-known Muslim watchmakers. It is understood that Frankish clockmakers also served in the palace between 1574 and 1595; 24 of the clocks made in the palace between these dates have survived to the present day.

As a result of this interest in European clocks, European watchmakers began to manufacture watches in Istanbul and Galata (the chief business section of Istanbul). However, the Ottomans, at this time, had not only begun using or assembling clocks, but were also in the phase of new inventions pertaining to watches, as in the case of Taqî al-Dîn. He wrote the only work of the period in Europe on mechanical watchmaking, titled *Al- Kavâkib al- Durriyya fî Vaz'al- Bankâmât al- Davriyya* (1556) [7, 10]. Its purpose was to determine prayer times and other matters without considering the movements of celestial bodies [12].

In *Al- Kavâkib al- Durriyya fî Vaz'al- Bankâmât al- Davriyya*, Taqî al-Dîn states that the Ottomans and Muslims in general were not interested in making clocks, and that the clocks made by Europeans, especially the Dutch, Hungarians, French and Germans, had come to Ottoman lands. He claims that he examined these types of clocks and watches in the treasury of Kılıç Ali Pasha (1500–1587)[2] and carefully analysed the tools of European masters. He notes that he has read and studied *Spherica* by Theodosius, Euclid's *Elements*, Archimedes' *Quadrilaterilazition* and papers on weighbridges, scales and mechanics since his childhood [12].

[2] Kılıc Ali Pasha was an Ottoman sailor who served as an admiral for 16 years between 1571 and 1587. He is of Italian origin and was born in the village of Le Castella in Calabria. His name prior to his conversion to Islam was Giovanni Dionigi Galeni.

Fig. 2. Miniature showing Taqî al-Dîn studying with his co-workers in the Observatory (from Âlât al-Rasadiyya bi-Zîc al-Şehinşâhiyya, Library of Istanbul University F1404, fol.57a.)

Further, Taqî al-Dîn describes clocks with wheels, clocks moved by weight, and clocks with a mainspring. He also described the manufacture of a spring-driven clock with a fusee drive. He describes several mechanisms that he invented, for example a new system for the striking train of a clock. He is known to have constructed an observatory clock and mentions elsewhere in his writings the use of the pocket watch in Turkey.

Mechanical clocks (the weight-driven clock) first began to be made in Europe around 1300, and the spring-driven clock was only invented in around 1430. The manufacture of watches began in Germany in about 1525 and in England sometime around 1580 [2]. In Medieval Islamic countries, time-measuring had reached a very high level. In fact, during the Middle Ages, Muslim scholars and craftsmen had been the world leaders in the construction of scientific instruments and automata. The Byzantine and Western Europeans learned these instruments from them. This important tradition of Islamic science and technology gradually declined and died for several reasons [14]. The mechanical watches developed by al-Jazari were forgotten in the Ottoman Empire, and few in the East showed any interest in watches developed in the West for more than 200 years. However, Sultan Mehmed the Conqueror, who conquered Istanbul, did show an interest in mechanical clocks and asked for a master who could make alarm clocks from Venice. Later, Sultan Suleiman bought a small but perfectly working watch made by a watchmaker named Giorgio (Capabianco) from Vicenza. This clock was placed in a gold ring and had a chime at the top of the hour [9].

During this period, European rulers began to send gifts for the purpose of establishing powerful Ottoman sultans, whom they feared. These gifts included clocks and other interesting mechanical devices. For example, during this period, a "planetarium" built under the Austrian Emperor Maximilian I's order was presented to the Sultan as a gift. This device was a silver machine combined with a clock that simulated the stars and the solar system in motion. However, in addition to showing the hours, it had a complex mechanism that worked with gears and weights and showed the movements of the Sun, Moon and planets. Sultan Suleiman was very pleased with this gift.

Following the Habsburg Peace in 1547, many mechanical watches with automatic components were sent to the Ottoman Empire as tribute from various Europe kingdoms and states. It had now become a tradition for European ambassadors to meet the sultan with latest designs in clock-making. In fact, European rulers were competing to send newer watches [15].

Despite the interest of the sultans, clock-making did not become a viable indigenous industry and the Ottoman world was soon being supplied with cheap clocks from Europe. According to Hill, however, Tagî al-Dîn's descriptions are lucid with clear illustrations, showing that he had mastered the art of horology [2]. Consequently, Taqî al-Dîn successfully continued this old tradition of his culture even though the current intellectual environment did not support it.

According to Avner Ben-Zaken, another network of circulation connected Taqî al-Dîn with Europe were pirates and their captives. Solomon Schweigger, the Habsburg envoy to Istanbul, closely witnessed the controversies that the observatory engendered, and in his journal covering the 1580s there are clues about the intellectual background of Taqî al-Dîn. Accordingly, conceivably, Taqî al-Dîn fell captive while sailing from Alexandria to Istanbul sometime either in the period 1549–1552 or during the 1560s. Salvatore Bono provides us with ample evidence of ships captured by Italian pirates. Meanwhile Malta provided encampment for thousands of Muslim captives who were sent as slaves to Italy. Moreover, the increasing missionary and economic interests in the Near East from the mid- 16th century led to the development of Arabic printing. Italian printers, aware of the popularity of printed works in the Islamic World, hoped to profit from Arabic versions of scientific classics. So, for example, they published Arabic translations of Euclid. As it was necessary to make use Islamic researchers in publishing these Arabic works. It is thought that Taqî al-Dîn also took part and task in this process in Rome when he was captured. The years in prison were determined by the rank of the captive. In that period kidnap and ransom exchanges became an active phenomenon, and in fact Sultan Murad III issued two royal decrees in 1592 concerning the exchange of captives with the Europeans [3].

Consequently, while Taqî al-Dîn was held captive in Rome, he worked in the service of a mathematician, and when he returned to Istanbul, he brought with him not only his mathematical knowledge and mechanical skills, but also a new mechanical worldview through which celestial bodies seemed like wheels of the cosmic machine.

As far as is known, the only person to write a work on automatic machines during the Classical Age (14th–17th centuries) of the Ottoman Empire was Taqî al-Dîn. He explained the production and working principles of tools and mechanisms like automats in his 1553 "Book of the Sublime Methods of Spiritual Machines." His engineering seems have benefited from his astronomical studies including making the instruments of observatory [6] (Fig. 3).

Fig. 3. Moon clock (benkâm) from "Book of the Sublime Methods of Spiritual Machines", fol. 9b-10a.

Scientific and cultural interaction has had various channels from East to West. Although these have been the subject of much debate, they are important historical determinations that should not be neglected. The Byzantine Empire comes first among these channels, and the mutual interaction of these two geographically neighbouring cultures was inevitable.

In a Byzantine arithmetic book written around the time that Istanbul was conquered by the Ottomans, it is documented that the Turks used decimal fractions, especially in commercial transactions [4]. The unknown author of this book refers to dealing with decimal fractions as a "Turkish Method". Since the Turks used decimal fractions around 1453, they must have been using it at earlier dates or passed it on from those who had introduced it to Turks. Simon Stevin (1548–1620), who introduced decimal fractions in Europe with his book *De Thiende* written in 1585, may have obtained this information perhaps from a Greek scholar or from Ogier Ghiselin, the Istanbul ambassador of Ferdinand I, who brought the Byzantine arithmetic book in question to Europe [4].

Another example of the Byzantine channel from East to West is the "School of Trabzon". Scholars belonging to this school participated in the activities of the Ilkhanid State's (1256–1335) observatories in Maraga and Tabriz from Trabzon and Constantinople and translated some of the mathematical and astronomical works of Muslims into Greek. These works, which were translated into Greek, were later used by Latin scholars, thus becoming an important channel for the transfer of (astronomical) knowledge from East to West [4].

Again, it has been observed that the values in the trigonometrical tables of scholars from different traditions such as Regiomontanus, Copernicus, Rheticus, Maurolico and Taqî al-Dîn, who lived in the 16th century, are remarkably similar. It seems that in the Middle Ages, the discoveries and innovations of Muslim scholars in trigonometry were taken by Orthodox scholars and carried to Latin scholars, especially in Italy. They also processed this information and put it into a new pattern [4]. In this case, it is understood that during the Renaissance, knowledge and practices took place not only from West to East, but also from East to West. Therefore, it seems reasonable to think that Taqî al-Dîn, who lived in the same period, already had the knowledge and was familiar with the techniques of the West in the cultural environment he was in.

Taqî al-Dîn himself says in his Optics: "Because he (Taqî al-Dîn) spent most of his life learning mathematics and natural sciences. He spent the most valuable years of his youth and adulthood to learn these sciences like money until there is no dark point left in his mind. … While I was struggling with these difficult problems (optical problems), I went through so much trouble that it would make me grow old. I relied on reason and experience in overcoming these difficulties" [13].

So, we can conclude, he successfully combined the theoretical and practical approaches of his Western counterparts and predecessors. In doing so, he would use his own knowledge and skill, and when he had the opportunity, he examined the practices and approaches of Europeans.

3 Conclusion

Bedayi'ül-Amel fî Sanayii'l-Hiyel, the first work on hiyal (mechanics) in the Ottoman Empire, written in Persian by Alâüddin el-Kirmani, a book concerning mechanical devices such as wall clocks, hourglasses and qibla numa (a kind of compass showing the direction of kible). It was presented to Sultan Mehmed the Conqueror who had always shown a great interest in works of science and mechanics [8]. Taqî al-Dîn too shares a distinguished place in this Islamic and Ottoman hiyal tradition and the history of technology, through the various books and articles he wrote about machines and scientific instruments.

Intercultural interaction is reciprocal. Influence can go from East to West, as well as from West to East. In the sixteenth century, commercial, military and financial relations between Ottomans and Europe were the basis of scientific and technical interaction. There is no evidence to support the claim that Taqî al-Dîn was captured by pirates and taken to Italy, where he acquired knowledge of European approaches to mathematics and astronomy from his mathematician master (we do not know his name) and introduced the European view of the mechanical universe. Moreover, we can explain how Taqî al-Dîn achieved his scientific expertise (he took lessons from the leading scholars of the time in Syria, Egypt and Istanbul, and read the books of the great scholars of ancient world such as Euclid, Archimedes and Theodosius).

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