Who was "Central" in the History of Chinese Buddhism?: A Social Network Approach

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Abstract

Hidden in the Buddhist biographical literature on eminent monks is a large amount of information about who knew whom. It is especially rich for the time between 300 and 1000 CE, when the four major collections of "Biographies of Eminent Monks" (gaoseng zhuan) *allow us to date and locate the relationships of individuals to a degree unimaginable for the religious history of Europe or India in that period.*

Using open data from the Gaoseng Zhuan *projects conducted between 2007 and 2012 at Dharma Drum Mountain, Taiwan, this article applies centrality measures to identify key players in the currently available data. The dataset connects actors with places and other actors; often connections can be dated. The version of the large, undirected network used here contains ca. 6,500 actors and ca. 13,000 links. The largest component contains ca. 5,500 actors connected by ca. 10,000 links.*

Comparing the set of key players based on Degree Centrality with those indicated by Betweenness Centrality, a meaningful constellation appears. Degree based centrality yields a list of translators and important patrons. Translation teams constitute cliques that contribute to the high degree value of their leader. Imperial patrons interface with monastic leaders as well as with the secular domain, moreover, records of such interactions are privileged in the sources. Betweenness Centrality, on the other hand, yields famous Chan masters of the late Tang and early Song Dynasty. This reflects both the rising importance of the lineage paradigm in Chinese Buddhist historiography as well as the seminal position of these figures between earlier and later forms of Chinese Buddhism.

Key words: Historical Social Network Analysis, *Gaoseng zhuan* 高僧傳 Literature, Centrality Measures, Chinese Buddhism, Biographies of Monks and Nuns

Introduction

Statistics and data science have developed a wide number of measures to tackle the notion of centrality. The *mean* and the *median* of descriptive statistics are part of the high-school curriculum. Statistics 101 introduces additional measures such as *range*, *percentile*, *mode*, *standard deviation*, and *z-scores* to explore given distributions. In graph theory, still other forms of centrality are used to determine which nodes (= actors) are "central" to a network. Here basic measures are e.g. *Degree*, *Betweenness*, *Closeness* and *Eigenvector Centrality.*[1] Each measure captures different aspects of centrality, and different measures will often identify different sets of nodes as most "central." The following is a first attempt to apply centrality measures to a historical social network of Chinese Buddhism.[2] One aim is to identify quantitatively who was important in the history of Chinese Buddhism and, more fundamentally, what kind of importance such measures reveal. Another aim is exploratory: can we discover actors whose importance/centrality have hitherto gone unnoticed? Methodologically, we want to explore which measures are most suitable for the analysis of our particular dataset that spans several centuries.

The Dataset

The bulk of the data was collected between 2007 and 2012 at Dharma Drum as part of a larger project to markup biographies of eminent monks.[3] Most actors in the network are Chinese Buddhists – monks, nuns and lay-people – who appear in the biographical literature on eminent monks or nuns,[4] but the network also includes antagonistic figures who are mentioned for their role in persecutions.[5] *Gaoseng zhuan* collections form the single most important source for the study of Chinese Buddhism in the first millennium.[6] In the markup, which identifies dates, person and place names with the help of authority databases, we have created "nexus points," i.e. computable statements expressed in TEI/XML, that express where and when people interacted. As of March 2017, the total number of nexus points is ca. 17,800.[7] Many of these connect only one single person to a place or a point in time, which is relevant for GIS or timeline-based analysis. For SNA we can only apply the ca. 7,800

nexus points which involve two or more actors. The nexus point construct does not contain semantic information about what the actors did, but simply that they are mentioned in a source as interacting with each other or being in the same place at the same time. Due to the nature of the sources this means that they knew each other, met, or were otherwise in contact (e.g. through correspondence).

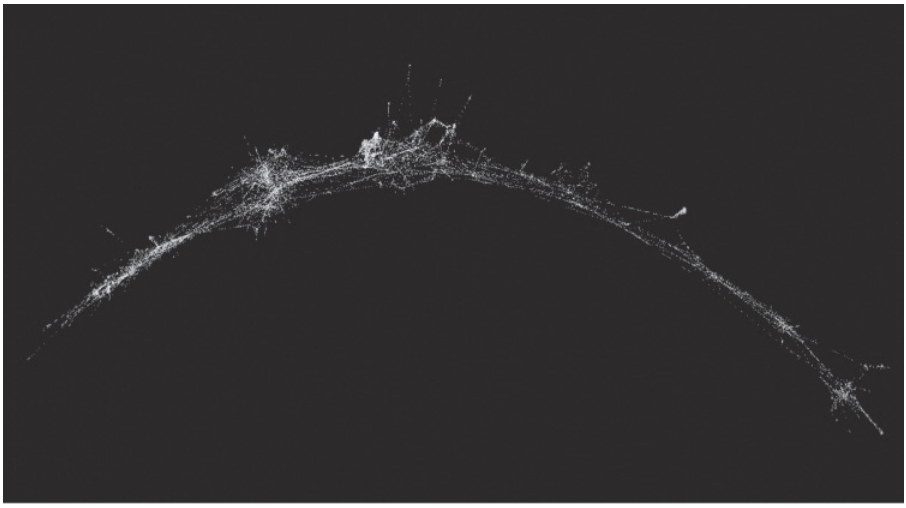
The data we have for this network is thus undirected, but there is the general, generational directedness of the historical network. It is therefore, in principle, possible to model the information flow through the network, since in diachronic, historical networks information (and influence) is transmitted along a timeline from earlier to later generations.[8]

Network Size

The network dataset ("GSZ-HSNA_version_2018-01.gexf") that is used here has 6,470 nodes (actors), and 13,257 edges. Filtering out 277 small unconnected components, the largest connected component with 5,505 nodes and 12,414 edges remains. The network diameter (longest path) of the giant component is 33, its average path length is ca. 10.61. Below, "network" refers to the giant component of this version of the dataset.

Layout

This historical network represents interactions that took place between ca.150 CE and ca.1650 CE. Any network that extends across several generations has natural limits regarding to which actors could have interacted. A visualization should take this into account and the result should resemble the Milky Way rather than a furball. Below the elongated "Milky Way" network is rotated such that it approximates a timeline, with the first clusters to the left corresponding roughly to the second to fourth centuries and the right-most nodes representing actors that lived in the seventeenth century.



[Figure 1]
Network layout: Main Component of *GSZ-HSNA_version_2018-01.gexf* (produced in Gephi (0.9.2) using ForceAtlas2)

Limitations

Temporal coverage: The dataset in principle covers the period between ca. 100 to ca. 1650 CE.[9] However, there is a strong bias toward the first millennium.[10] For the largest component we know the death year for ca. 3280 actors (ca. 60 percent of all nodes). The death year of ca. 2700 (ca. 84 percent) of these falls on a date before 1000 CE. Assuming actors with unknown death year are distributed evenly over the network, this means that ca. 85 percent of the interactions recorded in the current dataset took place before 1000 CE. This only to be expected as the sources from which the data is derived are mainly concerned with that time. Most nexus points come from the *Tang* and the *Song Collection of Biographies of Eminent Monks* authored in the seventh and tenth century respectively. The available information about the second millennium in the dataset used here is limited to the nexus points recorded in the *Ming Collection of Biographies of Eminent Monks* (dated 1600) and the *Supplementary Collection of Biographies of Eminent Monks* (dated 1647).

Edge weights: As the information in the sources overlaps—a fact stated in one source (e.g. the CSZJJ) might be repeated in a later one (e.g. the GSZ)—

different links might simply be duplicates of the same event. Thus, edges might have a stronger weight not because more interactions took place, but because these interactions have been recorded multiple times. Ideally, if A and B met twice, the edge between them should have a corresponding value. However, in case their first meeting was reported four times in different sources (or several times within the same source), the weight of the edge would be five rather than two. Thus, edge weight in our data is not a reliable indicator, neither of the number nor of the variety of encounters, they simply reflect how often interactions between two actors are mentioned in the sources. For this reason, we will (for now) work with simple Degree Centrality instead of Weighted Degree Centrality.

Degree, Betweenness and other Centrality Measures in the Network of Chinese Buddhism

In the following I suggest that SNA centrality measures are a useful heuristic means to discover influential actors in the historical network of Chinese Buddhism. I do not want to suggest that we can expect centrality measures to return all influential players. Based on his research about support networks for persecuted Jews during the Holocaust, Düring (2016, 100) finds that "centrality measures are useful to narrow down the list of potentially influential actors in a network, but will always fail to detect those ca. 20–30 percent of actors whose influence does not correspond with above average connectedness." Thus, the below is a first step towards discerning a macro-historic outline view of Chinese Buddhism, rather than a statement about the exact importance of individual actors.

Degree Centrality

Degree Centrality is the most basic centrality measure in that it simply looks at the number of links of an actor. Degree Centrality is a "local" measure in the sense that it is mainly indicative about the importance of a node in its immediate environment, which in our case means also in its own time. For a historical network this reflects the phenomenon that there are figures who were important in their generation, but not beyond.

Betweenness Centrality

The importance of Betweenness Centrality rests on the assumption that goods and information tend to move through a network on the shortest path. Nodes that are situated on many shortest paths have a high Betweenness Centrality. This is important for historical networks because Betweenness Centrality might turn out to be an indicator for the information flow between generations. In our case a shortest path between any two figures of different periods does not necessarily imply actual transmission, but this network can and should be seen as communication network, in which information about Buddhism unfolds in China. In that sense the sum of shortest paths between actors over different generations is relevant.[11]

Betweenness Centrality is often used to identify bridge actors – nodes that, though they are neither strongly connected themselves (Degree Centrality) or to important players (Eigenvector Centrality), are on a large number of shortest path between different parts of the network. We found that whereas Degree Centrality, as a local measure, is fairly robust, Betweenness Centrality is sensitive to false positives. One single wrong connection can increase the Betweenness Centrality for a node disproportionately, if it causes the node to link two otherwise distant sections of the network.[12] This is in line with research in the robustness of centrality measures, which found that global measures (e.g. Betweenness Centrality) are "more sensitive to measurement errors than local measures" (such as Degree Centrality).[13]

Closeness and Eigenvector Centrality

The usefulness of Closeness and Eigenvector centrality for larger networks has been questioned. Closeness Centrality is based on a node being close, i.e. having short paths, to all other nodes. This can be useful when deciding in which city to build a warehouse, or in measuring the maximum speed with which information passes through a large computer network. In a historical social network, however, actors can only socially interact with contemporary actors and applied to the network as a whole Closeness Centrality is therefore not really helpful to indicate anything. If applied, Closeness Centrality strongly favors actors in the middle of the period covered by the network. In contrast to a non-historical network here centrality is not indicative of influence, but simply

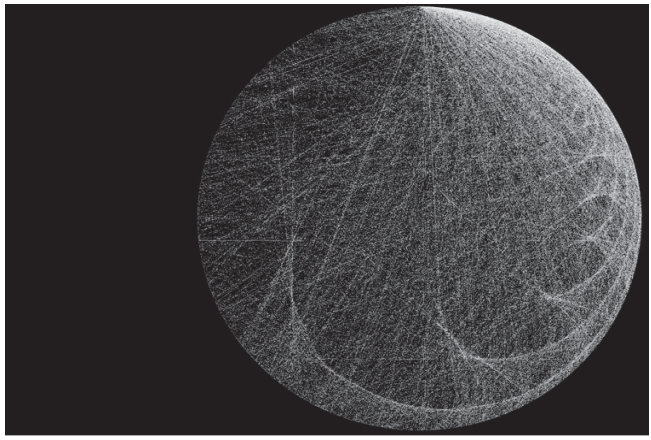
incidental to the actors' position in time. Indeed, when sorting by Closeness Centrality all 20 most central individuals were born between 509 and 709 CE, a relatively narrow band compared, compared with a spread of birth years between 314/738CE for Degree, and 418/1263CE for Betweenness Centrality.

Eigenvector Centrality differs from Degree Centrality in that it does not only measure a person's connectedness, but also takes into account whether he or she is connected with other highly connected people. It attempts to capture an actor's influence within a network based on the idea that important nodes need connections to other highly connected nodes in order to exert influence. Someone might wield great influence by being connected to only a few highly connected individuals and thus an actor's Eigenvector Centrality can be larger than its Degree Centrality suggests. But the same restrictions as with Closeness Centrality apply, and for the network as a whole Eigenvector Centrality is not very useful. Eigenvector Centrality has an even narrower band of birth years (611 to 688) mainly, it seems, due to the overwhelming weight of the cliques described in data for the early Tang. Nevertheless, it should be noted that it does successfully identify the industrious Seungjang 勝莊 (fl. 651–714), a Silla monk, who has no biography of his own, but was extremely well connected, having worked in several translation teams and known many influential patrons. That Eigenvector Centrality highlights Seungjang as the "most well-connected monk" in our dataset, shows how historical SNA can bring interesting and important actors into view that traditional Chinese historiography has so far failed to identify as "central."

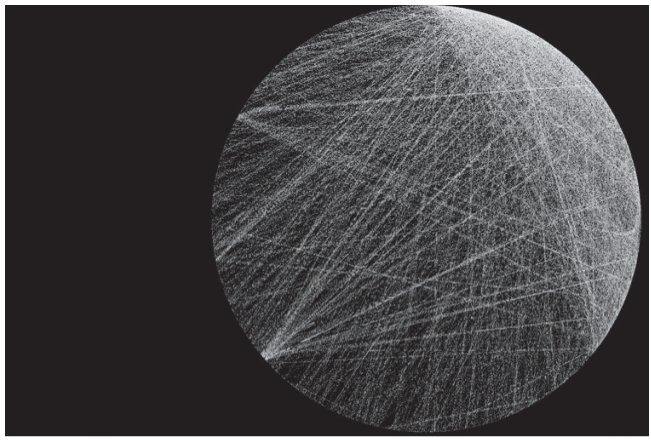
Visualizing Three Types of Centrality

One way to visualize how different forms of centrality order the network is to compare how the network looks when the nodes are arranged in an ordered circular layout. The node with the highest value for Degree/Betweenness/Eigenvector Centrality is placed at 12:00 o'clock, the nodes are ordered according to the respective measure clockwise along the circumference of a circle. [Figure 2.1.]

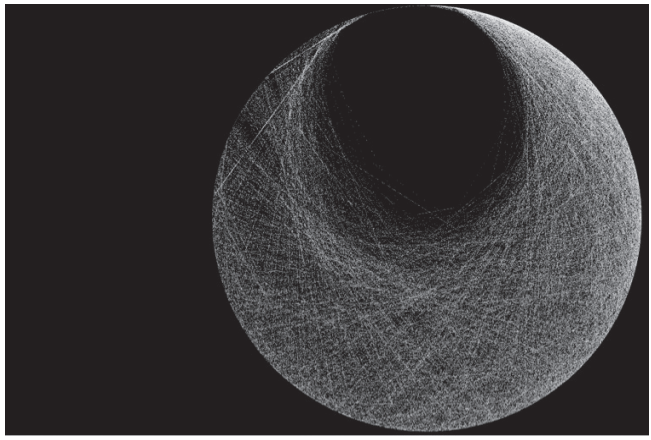
The hatching effect that appears in a circular layout ordered by Degree Centrality, is a "naturally" occurring pattern that depends on this order. Pretty and meaningless beyond the fact that it is dependent on the ordering of nodes with many connections (=lines) in the same segment of the circle, it merely reflects how patterns can arise on the basis of sorting rules.



[Figure 2.1.]
Nodes of the Main Component sorted clockwise by Degree Centrality



[Figure 2.2.]
Nodes of the Main Component sorted clockwise by Betweenness Centrality



[Figure 2.3.]
Nodes of the Main Component sorted clockwise by Eigenvector Centrality

In contrast, the "chaotic" effect that appears in the circular layout sorted by Betweenness Centrality is due to the fact that the number of connections for each node is not directly related to the sequence of the nodes on the circle. The "busy" nodes at 7:30 and 10:00 o'clock indicate actors which have relatively many connections with actors who have a higher Betweenness Centrality (and are thus situated between 12:00 and ca. 4:00). Such anomalies are good starting points for exploration. Another study might reveal who these actors are and whether this pattern is historically interesting. [Figure 2.2.]

The characteristic opening or hole that appears below 12:00 o'clock when the circular layout is sorted by Eigenvector Centrality [Figure 2.3.] exists because those actors who are well-connected to other well-connected actors are not, in general, also connected to the least connected. In other words, if someone in the least well-connected segment (at 11:55–11:59) would be connected to a player in the most well-connected segment (at, say, 12:01–12:05), they would not be among the "least connected."

Visualizations such as these help to understand the particular character of centrality measures as pertaining to this dataset. The patterning can also help to identify individuals or groups which deserve further research.

Results

Below are two tables that list the top twenty actors (out of ca. 5,500) according to Degree and Betweenness Centrality. These lists correspond roughly to the nodes on the first second (12:00–12:00:01) in the circular layouts in Figure 2.1 and 2.2 above. The ID numbers in the first column refer to the Dharma Drum Buddhist Person Name Authority Database.

[Table 1] Top 20 actors Degree Centrality

Name & ID	Dates (fl.)	Degree	Notes
楊堅 Yang Jian A004324	541~604	121	= Sui emperor Wen 隋文帝 (r. 581–604), First Emperor of the Sui Dynasty
玄奘 Xuanzang A000294	602~664	83	India pilgrim and translator

Name & ID	Dates (fl.)	Degree	Notes
楊廣 Yang Guang A004413	569~618	80	= Sui emperor Yang 隋煬帝 (r. 604–618), Second Emperor of the Sui Dynasty
蕭子良 Xiao Ziliang A002655	460~494	76	Prince Wenxuan of Jingling, poet, patron of Buddhism, organizer of the "Eight Friends of [Prince] Jingling"
勝莊 Seungjang A001179	651~714	68	Korean translator monk Seungjang, who worked with students of Xuanzang, with Yijing and Īśvara. A "student" of the Silla monk Woncheuk 圓測
鳩摩羅什 Jiumoloshen A001583	344~413	64	= Kumārajīva. Translator
張說 Zhang Yue A002473	668~731	62	Chancellor, writer & patron
彥琮 Yancong A000829	557~610	55	Translator
慧遠 Huiyuan A001204	334~416	55	Student of Daoan, founder of the White Lotus society
僧旻 Sengmin A001595	467~527	54	Author of commentaries
伊舍羅 Yisheluo A002107	659~724	52	= Īśvara. Translator
智顗 Zhiyi A001301	539~598	52	Founder of the Tiantai School
慧遠 Huiyuan A002000	523~592	51	= Huiyuan of Jingyingsi 淨影寺慧遠. Author of commentaries Influential teacher. Not to be confused with his namesake (above A001204), the student of Daoan.
義淨 Yijing A001470	635~713	49	India pilgrim and translator

Name & ID	Dates (fl.)	Degree	Notes
文綱 Wengang A002468	636~727	49	Vinaya master, student of Daoxuan
澄觀 Chengguan A001755	738~839	49	Author of commentaries on Huayan texts, member of Amoghavajra's translation team
蕭衍 Xiao Yan A002098	464~549	49	= Liang emperor Wu 梁武帝 (r. 502–549), one of the "Eight friends of [Prince] Jingling" 竟陵八友
道安 Daoan A001503	314~385	48	Organized translation teams, teacher of Huiyuan (A001204)
曇一 Tanyi A004177	692~771	47	Vinaya master
李隆基 Li Longji A000291	685~762	47	= Tang emperor Xuanzong 唐玄宗 (r. 713–756)

The dataset used here reflects the information about Chinese Buddhists that is preserved in *Gaoseng zhuan* literature. Due to overlaps between the *Liang* and the *Tang Gaoseng zhuan*, as well as between the *Tang* and the *Song Gaoseng zhuan* most information concerns relationships that have formed between the sixth and the ninth centuries.

For the sake of our study, it is significant that Degree Centrality highlights translator monks (7), famous patrons (4 emperors, 1 prince, 1 chancellor), authors of commentaries (4), and Vinaya masters (2). No Chan figure is on the list and among the Pure Land masters only Huiyuan (A001204) appears prominently. The other Huiyuan (A0020000) too wrote commentaries on Pure Land texts, but significant Pure Land figures such as Tanluan 曇鸞 (ranked 1572/5500 by Degree Centrality), Daochuo 道綽 (ranked 909), or Shandao 善導 (ranked 2843) are not on the top-20 list, although they were active in the period for which our dataset contains most information.[14] All three of these "patriarchs" play an important role in the Pure Land narrative in many modern histories of Chinese Buddhism.[15] The relative lack of information about their social

networks, however, well reflects the fact that the Pure Land patriarchate was created retrospectively by Tiantai Buddhist historians during the Southern Song.[16]

[Table 2] Top 20 actors Betweenness Centrality

Name & ID	Dates (fl.)	Deg.	Betweenness Centrality (rounded)	Notes
馬祖道一 Mazu Daoyi A003623	709~788	41	50578	Chan master, student of Nanyue Huairang. 143 known students.
法眼文益 Fayan Wenyi A000174	885~958	22	47873	Chan master, 62 known students.
楊廣 Yang Guang A004413	569~618	80	47660	= Sui emperor Yang 隋煬帝 (r. 604–618), Second Emperor of the Sui Dynasty
南嶽懷讓 Nanyue Huairang A004015	677~744	11	44138	Student of Huineng 慧能, teacher of Mazu Daoyi 馬祖道一.
慧安 Huian A010232	582~709	10	44065	Chan master, student of Hongren 弘忍
南泉普願 Nanquan Puyuan A003889	748~835	11	37219	Chan master, student of Mazu Daoyi 馬祖道一, teacher of Zhaozhou Congshen 趙州從諗.
趙州從諗 Zhaozhou Congshen A004475	778~897	4	35115	Chan master, Student of Nanquan Puyuan 南泉普願
蓮華峯祥 Lianhua Fengxiang A017895	10th –11th century	5	23612	Chan master, Student of Fengxian Daoshen 奉先道琛

Name & ID	Dates (fl.)	Deg.	Betweenness Centrality (rounded)	Notes
奉先道琛 Fengxian Daochen A020463	10th century	6	23108	Student of Yunmen Wenyan 雲門文偃 (864–949), Teacher of Lianhua Fengxian 蓮華峯祥
鐵山瓊 Tieshan Qiong A021356	11th century	5	22580	Chan monk, student of Shishuang Chuyuan 石霜楚圓 (987–1040) and Lianhua Fengxian 蓮華峯祥
百丈道恆 Daoheng A014282	d. 991	3	21702	Chan master, Student of Fayan Wenyi
棲賢澄湜 Xixian Chengshi A020702	10th –11th century	4	20871	Chan master, Student of Daoheng
高峰原妙 Gaofeng Yuanmiao A004700	1238~1296	6	19020	Chan master
普覺慧南 Pujue Huinan A003921	1002~1069	22	17639	Chan master, 53 known students
智文 Zhiwen A005233	509~599	25	16284	Vinaya master, grandson of Ruan Tao 阮韜
慧則 Huize A011638	835~908	7	15729	Vinaya master
皎然 Jiaoran A008833	737~806	25	14906	Poet, painter monk
圓悟克勤 Yuanwu Keqin A001411	1063~1135	38	14128	Chan master. One of the "Three Buddhas of the Northern Song." Compiler of the Blue Cliff Records, 50 known students

Name & ID	Dates (fl.)	Deg.	Betweenness Centrality (rounded)	Notes
阮韜 Ruan Tao A005019	d. 484	5	13918	Powerful official during the Liu Song Dynasty
希覺 Xijue A010005	864~948	7	13009	Vinaya master

The immediate finding here is that analyzing the same data for Betweenness Centrality returns a quite different set of actors who were "central" to the historical network of Chinese Buddhism. Viewing the network from this angle it is a group of Chan monks, some famous, some not, who tie together the two millennia of Chinese Buddhism. Although much in our data for the first millennium is about patron and translator networks, the longitudinal aspect of information flow through the network into the second millennium rests on the transmission lines of the Chan School. This accords well with the fact that since the Song Dynasty most larger monastic institutions had to identify as belonging to a Chan lineage, and the abbotship could as a rule only be filled by a monk who had received official transmission in an established lineage. The success of Chan to become the preeminent institutional form of Buddhism after the Song Dynasty stands in contrast to other doctrinal formations such as the Huayan and Faxiang (Yogacāra) schools, which were not able to build enduring institutions.

Also remarkable in the result of applying Betweenness Centrality is the role of Vinaya masters some of whom are included in the "Top 20" of Table 2. Obviously, though often overlooked, Vinaya masters would have assumed a central function in the long-term transmission flow of the Buddhist community, because they organized ordinations and maintained the discourse on monastic law, which was an crucial factor in the maintenance of institutional Buddhist identity.

Finally, one wonders how other Buddhist formations that are known to have survived the end of the Tang, such as Tiantai, esoteric Buddhism, and Pure Land practices, are represented in the network. The actors that transmitted these might not be among the (somewhat arbitrary) set of the "Top

20," but their transmission lines too must show up in the network and could be studied with its help.

Conclusion

This study is a first attempt at applying centrality measures to a SNA dataset based on *Gaoseng zhuan* literature and to assess their usefulness for historians. Comparing the top actors measured by Degree and Betweenness Centrality, respectively, two distinct categories appear: Degree Centrality favors translators and patrons, while Betweenness Centrality returns Chan and Vinaya masters.

The difference illustrates the slow and truly fundamental change that occurred when Chinese Buddhism started to organize its institutions and perceive its own history as a lineage system modeled on family genealogies. The change in historiography, but also in organizational structures, becomes apparent when different measures of centrality are applied to a model – our dataset – of Chinese Buddhist history. Two objections might be raised here, one regarding the role of Buddhist historiography, the other regarding the quality of the current data.

History or Historiography?

First, does the difference between the two sets of key players that is revealed by Degree and Betweenness Centrality reflect a change in history or historiography? Are the different views on centrality merely a optical illusion that is caused by different ways of writing history, or do they indeed reflect a difference in the social, institutional reality? In English the word "central" can be joined by a number of different prepositions. A player can be central to a game, in a game or for a game. Using quantitative centrality measures we have, conservatively speaking, shown merely what nodes are central in the graph—a social network visualization of Chinese Buddhist history. This type of "central in" is derived arithmetically and changes with the data. When the data is expanded or corrected, we might find a different permutation of names at the top. But does "central in the graph" translate into "central for the history of Chinese Buddhism"? The Chan school, after all, is known for defining itself as a network of lineages. Lineages as graphs are tree structures, and in tree

structures nodes closer to the root will naturally be on many shortest paths and therefore have high Betweenness Centrality.

This is all true, but the appearance of major Chan figures as key-actors is nevertheless remarkable, because our data is reliant on a relatively small number of historiographers that wrote and/or collected biographies on eminent monks and nuns in a genre that formed before the lineage narrative firmly took hold in Buddhism. The data used here is by no means based on the vast historiography of the Chan School, which is encoded in "Lamp Transmission Records" (*zhuandenglu* 傳燈錄) and "Recorded Sayings" (*yulu* 語錄), genres which are quite different from the *Gaoseng zhuan* format. Significantly therefore, the turn towards Chan lineage in the social structure of Chinese Buddhist history is indicated by sources that are in no way partial to Chan.[17]

Data Quality and Scope

A second objection one might make is regarding the quality of the data, which, as mentioned above, is rather weak for the second millennium. This leads to a constellation where the more recent parts of the network are relatively thin compared to the bulk of the data that covers the fourth to the tenth century. One could assume that the Chan figures in Table 2 merely join the otherwise weakly connected pre-Song and post-Song regions of the network and *only because of this* are therefore identified as important when applying Betweenness Centrality. However, there are reasons to think that this is not the case.

Firstly, as the table shows, Betweenness Centrality does highlight important Chan masters, but does not do so exclusively. The official Ruan Tao, the poet monk Jiaoran and some Vinaya masters belong to the pre-Chan period. Other actors with high Degree Centrality, such as Sui Yangdi, Xiao Yan, or Xuanzang, appear further down the list (but still in the Top 30) when calculating Betweenness Centrality.

Secondly, based on our current understanding of Chinese Buddhist history, between the late Tang and the Southern Song there indeed occurred fundamental changes in institutional practice, in doctrinal discourse, in the production of new texts genres, canonical collections, as well as in historiography. That some of these changes appear in an analysis of social networks based on information purely drawn from the particular genre of *Gaoseng zhuan* literature, merely confirms the pervasiveness of these trends and

their embeddedness in the social fabric of Chinese Buddhism.

Thirdly, I have one more reason to believe that the different views on history that centrality measures reveal are indeed factual and not merely an artifact of data bias. A currently ongoing research project dedicated to expanding second millennium data, although still in its early stages, already shows Chan lineages have even greater weight in the second millennium and that the centrality (dare we say "importance"?) of figures like Mazu Daoyi, can indeed be confirmed by a larger and more temporally balanced dataset.[18] This proves that centrality measures do correctly reflect the historical information that we use to build our model.

Other sources that could provide denser information about who knew whom in Buddhist history are the corpus of Buddhist temple gazetteers (Bingenheimer 2015), and the *zhuandeng* and *yulu* literature of the Chan school. As for more recent material the humongous para-canonical *Xinxu gaosengzhuan* 新續高僧傳 (1923) in 65 fascicles, provides rich, *zhuan* style biographies for monks of the Song, Yuan, Ming and Qing periods, but is rarely used by researchers of late imperial Buddhism. Furthermore information from secular histories, as well as archaeological, epigraphic, and art historical data would be helpful, but so far no efforts have been made to digitize these sources as structured data.

Nevertheless, as more and more computable data becomes available, this first exploration of centrality measures in the study of Chinese Buddhism is but a beginning. Next steps might include determining group centrality (identifying influential cliques), edge betweenness (identifying especially important connections), experimenting with multi-modal networks that relate multiple sets of social network(s),[19] such as citation networks, and (next on *my* list) the integration of the wider network of Chinese history available from the Chinese Bibliographic Database (CBDB).[20]

Notes

1 There are numerous other measures. An outline is Wassermann and Faust (1994, 169–219).

2 For an example of the successful use of historical SNA which touches on centrality measures see the by now classical study by Padgett & Ansell (1993) on the rise of the Medici. Recent years have seen research on Byzantine Egypt (Ruffini 2008), ancient Greek (Collar 2011), medieval Sicily (Engl 2014) to name only a few. For a critical appraisal of the use of centrality measures in historical social network analysis see Düring (2016).

3 Where not otherwise stated the visualizations and lists in this paper are derived from "GSZ-HSNA_version_2018-01.gexf." The markup design for the corpus and how the data can be derived from it has been explained in detail elsewhere (Bingenheimer et al. 2011). The marked-up *Gaoseng zhuan* texts with the nexus points are available at and https://gitlab.com/dila/biographies and http://buddhistinformatics.dila.edu.tw/biographies/gis/. The Dharma Drum person authority that provides dates and additional information on the actors is available at http://authority.dila.edu.tw/docs/open_content/download.php. The analysis below is based on these two sources. I make merged versions of the data for immediate use in GEPHI available at http://mbingenheimer.net/tools/socnet/.

4 *Chu sanzang jiji* (Part 5: Biographies) 出三藏記集 (列傳部) by Sengyou 僧祐, completed 510–518 (=CSZJJ); *Biqiuni zhuan* 比丘尼傳 by Baochang 寶唱, dated 516 (=BNZ); *Liang gaoseng zhuan* 梁高僧傳 by Huijiao 慧皎, dated 519 (=GSZ); *Tang gaoseng zhuan* 唐高僧傳 by Daoxuan 道宣, dated 665 (=TGSZ); *Song gaoseng zhuan* 宋高僧傳 by Zanning 贊寧, dated 988 (=SGSZ); *Mingseng zhuan chao* 名僧傳抄 (X.1523), by Sōshō 宗性, 13th cent. (=MSZC); *Ming gaoseng zhuan* 明高僧傳 by Ruxing 如惺, dated 1600 (=MGSZ); *Buxu gaoseng zhuan* 補續高僧傳 by Minghe 明河, dated 1647 (=BXGSZ).

5 For instance the official Du, who, as her biography tells us, grievely injured the nun Zhixian (T 2063, 935a).

6 This, of course, is not to say that they are always reliable witnesses. Detailed research, often drawing on surviving epigraphy and other sources, has repeatedly revealed contradictions, mistakes and misinterpretations in the biographic record. Kōichi Shinohara and Jinhua Chen especially have demonstrated how the *Gaoseng zhuan* accounts can and must be corrected in light of other sources (e.g. Shinohara 1988; Chen 2007, 36–39).

7 Nexus points per source: CSZJJ: 474, BNZ: 375, GSZ: 1790, TGSZ: 5410, SGSZ: 4994, MSZC: 188, MGSZ: 591, BXGSZ: 3976.

8 Based on life dates we can visualize the network dynamically. For first attempts see a sample at http://mbingenheimer.net/tools/socnet/. One problem is that the life dates for many actors are not available and must be extrapolated from existing connections to

actors with known dates. The construction of dynamic networks with this data is a rich field for experimentation which, however, exceeds the scope of this paper.

9 The earliest death year of an actor is 65 CE, the latest 1684 CE.

10 Currently, a project is underway to address that imbalance. After including biographic data on Ming-Qing dynasty monks compiled by Hasebe Yūkei and others, the second millennium will be better represented in future SNA datasets.

11 From the point of view of information too Betweenness Centrality is an important measure because a signal will suffer from less distortion the fewer nodes it traverses, thus, again very generally, the shortest paths across generations is the one which promises the least lossy transfer of information.

12 Analyzing for Betweenness Centrality, I had to correct several mistakes in earlier versions of the data, which are corrected in the outputs available on my website. Thus, the use of certain centrality measures can help with error detection.

13 See Zemljič and Hlebec (2005, 73). Already Wassermann and Faust (1994, 215) have remarked that Betweenness Centrality values show the strongest variance.

14 The wide difference in their rank is not significant. Beyond the first ca. 500 positions the number of degree connections is less than 12 and ranking by degree ceases to effectively differentiate actors.

15 See e.g. Lai (2010, Vol.7, 383–400).

16 Getz (1999, 477).

17 Zanning (919–1001), the first *Gaoseng zhuan* author aware of Chan, was, according to Albert Welter, "disturbed over assertions of Chan's institutional autonomy. According to Zanning, there was no basis for distinguishing independent Chan monasteries from regular vinaya monasteries." (Welter 2008, 37) None of the major *Gaoseng zhuan* collections does display a particular bias in favor of the Chan narrative.

18 We are currently digitizing data about monastic lineage networks of the Ming and Qing gathered by Hasebe Yūkei (2008). This includes information on more than 4,700 monks and nuns, who lived from 1368 CE until 1911 CE. Compared to the data from the *Gaoseng zhuan* corpus, the data from Hasebe's tables is relatively "flat," in that it is mainly arranged along the lineage framework and does not record events and encounters. It will go a long way, however, to address the imbalance between the first and the second millennium. The new data is made available provisionally at http://mbingenheimer.net/tools/socnet. Once the project is concluded the data will be archived at Zenodo.

19 For such extensions of centrality measures see Everett and Borgatti (2005).

20 I am grateful for the support of the Chung-hwa Institute of Buddhist Studies, esp. Director Venerable Guojing, for funding the data collection and sharing the data under an open access license. Much of the information in the current dataset has been painstakingly collected and encoded by Mr. Boyong Zhang without whose collaboration this project would not have been possible.

Abbreviations

T *Taishō Shinshū Daizōkyō* 大正新修大藏經 [Revised Buddhist canon compiled during the Taishō reign period], eds. Takakusu Junjirō 高楠順次郎 and Watanabe Kaikyoku 渡邊海旭 et. al., 100 vols., Tokyo: Daizōkyōkai, 1924–1935.

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