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Reflections on the Use of Social Networking Sites as an Interactive Tool for Data Dissemination in Digital Archaeology

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ABSTRACT

Based on a case study, the paper analyses the possibilities of social media as a tool for science communication in the context of information and communication technology (ICT) usage in archaeology. Aside from discussing the characteristics of digital archaeology, the social networking sites (SNS) Twitter, Sketchfab, and ResearchGate are integrated into a digital research data dissemination tool. As a result, above-average engagement rates with few impressions were observed. Compared with that, status updates focusing on actual fieldwork and other research activities gain high numbers of impressions with below-average engagement rates. It is believed that most of the interactions are restricted to a core audience and that a clearly defined social media strategy is obligatory for successful research data dissemination in archaeology, combined with regular posts in the SNS. Additionally, active followers are of highest importance.

1. Introduction

This paper presents a case study concerning the use of the social networking sites (SNS) Twitter, Sketchfab, and ResearchGate as an integrated tool for digital science communication in archaeology. Although this combination seems to be characterised by means of a distinct heterogeneity among the different SNS, the interlocking of the various sites will be highlighted and its importance outlined. Therefore, the basic workflow for combining a microblogging service with a 3D content sharing site and a scientific social network shall be delineated within the framework of science communication.

Disseminating data digitally can be handled in different ways, both actively and passively. An active manner can be the triggering of a social media war: in general, *war* might be seen here as *permanent adversity* between at least two parties. This adversity can arise for various reasons and take different courses on different intensity levels (Kekes 2010). Expanding the meaning of *war* to include digital conflicts within the realm of information and computer science, this *permanent adversity* can be easily combined with *social media*, specifically the *social web*, as an integral part of *Web 2.0* (*e.g.* Conole, Dyke 2016; Ebersbach *et al.* 2016, pp. 11–33; Neal 2012; Rheingold 1993; O'Reilly 2005; Stephens 2007; Zuppo 2012). Accordingly, war may have various definitions within social media: Firstly, a *social media war* may mean a public disagreement on a certain question which is outrageously debated using social media (*e.g.* Woolston 2015). Secondly, and more indirectly, a social media war may also describe a fight between two or more opposing social media services themselves (*e.g.* Ganahl 2013). Thirdly, the complex and quite well-known case of using social media as a toolset for history, memory, propaganda or even as a weapon – in the manner of symmetric and asymmetric warfare – has to be considered too (*e.g.* Comunello, Anzera 2012; Jones, Baines 2013; van Niekerk, Maharaj 2013; Farwell 2014; Klausen 2014; Lawson 2014;

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Lähteenmäki, Virta 2016; Patrikarakos 2017). Social media wars also occur in the free web-based social messaging and microblogging service *Twitter*, which is used to send short posts (so-called *tweets*) with originally 140 characters and (since November 2017) 280 characters in some countries (*e.g.* Rosen 2017; Richardson 2012; 2015; Williams, Krause 2012, pp. 105–113).

Originally, it is likely that Twitter wars (in their broadest sense) have become a digital phenomenon in the context of the Israeli-Palestinian conflict, and thus became known to a wider public during 2012 (Ball 2013), considering the role of social media in modern warfare (Sutter 2012). Hence Twitter war initially belongs to the above-mentioned third definition, incorporating the metaphysical meanings of real and virtual war, but may have adopted additional meanings besides. Thus, a Twitter war may also belong to the first type of social media war. In today's Twitter lingo (slang) a *Twitter war* may describe in detail a quick public dialogue based on tweets between at least two parties for several hours. The parties involved are addressing each other mainly using the so-called retweet- (*RT*) as well as replies- (*Replying to*) and mentions-functions (@) on Twitter (Twitter 2017a; 2017b).

A quick review of last months' tweets mentioning the combined terms "Twitter" and "war" reveals the characteristics of a Twitter war in general (Twitter 2017d). Twitter wars seem to be declared by either one of the two parties or even a third party without following any formal rules. Through simply announcing an explicit statement as well as directly mentioning the other party/parties, the Twitter war starts. Here, one party refers to a certain position while the other party/parties take/s an opposite one. The other party/parties respond/s to this statement with a similar but differing statement more or less immediately. Afterwards, the first party responds again, *etc*. Other recipients of the dialogue within this Twitter war can comment on individual tweets and may therefore be addressed by the opponents afterwards. This special type of discussion may be conducted as friendly banter but also as a serious debate, depending on the parties involved.

Regarding the rhetoric of Twitter users, *#twitterwar* as well as *#TwitterWar, #Twitterwar,* and *#TWITTERWAR* are used, although the term may be also used without any hashtag (*e.g.* Kehrberg 2015; Twitter 2017d). A hashtag thereby serves as a freely definable visual emphasis of the particular word, as well as a linking tag inside the service that enables users to filter the millions of different messages based on a selected keyword by just clicking on it or searching for it (*e.g.* Bruns *et al.* 2016; Enli, Simonsen 2017; Small 2011; Twitter 2017c).

The main reason to start a Twitter war may be to stimulate public attention on a large scale. Furthermore, a Twitter war is a social media marketing strategy which gains the attention of customers for all parties involved. It is important that only equal competitors start a Twitter war and that the involved parties treat each other with respect during the whole confrontation (Alaimo 2017). Otherwise a Twitter war could quickly become something else, like a case of internet "trolling", *i.e.* the attempt to provoke the counterpart and to outrage him/her, or even flaming *(e.g.* Kohn 2015). Additionally, Twitter itself sometimes encourages such activities (*e.g.* @TwitterNotify 2017). Users may further formerly invite or provoke each other to start a Twitter war through using a matching hashtag in a corresponding post, although this kind of request usually would not have the desired effect.

An example of a Twitter war is the "conflict" between Denmark and Sweden in 2016: On July 7th, a Twitter war broke out between the Danish Foreign Ministry and the Swedish Institute and lasted for several hours (@denmarkdotdk 2017; @swendense 2017). It all started when the Danish Foreign Ministry quoted a post from the Swedish Institute about special aspects of Swedish taste in interior decoration, which primarily was meant for the amusement of the Swedish Twitter community (@denmarkdotdk 2016b; Podhovnik 2016; @swendense 2016b). The Swedes responded to that tweet, then the Danes countered and the whole conversation culminated into an alternating struggle for amusement (@denmarkdotdk 2016a; @swendense 2016c). As the Swedish Institute stated during the discussion repetitively, the whole conversation was meant as "friendly rivalry" (@swendense 2016a).

All in all, a Twitter war may be one concept (among others) of gaining attention of a vast group of interested users as a first step to sell one's product to this target group. It is a specialised marketing strategy which uses digital information and communication technology (ICT) to gain success in getting noticed. ICT is more important than ever nowadays, mainly due to the high availability of the internet in many parts of the world, although a significant digital divide still exists (Cancro 2016; Mano 2012, pp. 30–31; Walker 2014). Nevertheless, ICT has a very serious impact on society, and thus the effect of ICT on archaeology can also be observed (*e.g.* Henson 2013).

The strategy presented here may be settled in a more passive setting and Twitter wars are hard to find in the field of archaeology. Maybe the archaeological Twitter community is too small and homogenous, or "big players" within this community are not big enough for occurrences like Twitter wars to appear regularly in archaeology. Considering the wider field of cultural heritage management, a recent example from digital museology may be the Twitter war of two British museums in 2017: On September 13th, in the course of the *#AskACurator*-campaign by Mar Dixon, another Twitter war occurred between the Science Museum and Natural History Museum in Great Britain, because of the question posed by Twitter user Bednarz O'Connell regarding which museum would have the best exhibition (@bednarz 2017a, 2017b; Dixon 2013). While this Twitter war was actually started by an individual non-museologist, there are concepts which try to facilitate mutual as well as pluralistic activities on Twitter in archaeology, like the first CAA Twitter Conference (#CAATCO 2018). Furthermore, it is questionable whether an active and possibly even aggressive marketing concept like that conducted during a Twitter war is suitable for archaeology.

This paper seeks to evaluate the role of SNS regarding their function as platforms for science communication in the context of *digital archaeology* (*e.g.* Kansa *et al.* 2012; Watkins 2016). In contrast to a Twitter war, the general concept presented here is, in a sense, passive, because although information is actively disseminated, it must also be received by other Twitter users who are not actively involved. A Twitter war, however, is active in all aspects, as not only information is disseminated, but other users are also actively involved. Founded on the evaluation of a case study, it is examined whether it is necessary to start a Twitter war to successfully disseminate information in archaeology. To do so, recent Twitter data received from an official university's account will be analysed.

2. Digital archaeology

Digital archaeology itself is an integral part of today's archaeological practice and a broad area encompassing various aspects, methods, and ideas (*e.g.* Hagmann 2017a; 2017b; 2017f; Langendorf *et al.* 2017; Morgan, Eve 2012; Trognitz *et al.* 2017). However, digital archaeology seems to be neither an archaeological sub-discipline nor its own specialisation, but rather a pool of different theoretical and practical aspects of information technology and their corresponding applications within archaeology (Costopoulos 2016; Huggett 2017). Applying digital methods in archaeology expands the possibilities of creating insights and generating knowledge (Zubrow 2006). In this sense, Zubrow (2006) defines digital archaeology as the usage of "[…] future technology to understand past behaviour […]". Therefore, theory and practice of combined digital input, digital information management, digital analysis, and digital publication are immanent for digital archaeology.

In regard to the above, Daly and Evans (2006) mention in their fundamental compilation about digital archaeology that this field of study "[…] explores the basic relationships that archaeologists have with Information and Communication Technology […]" – a situation, which may be also found in the digital humanities (*e.g.* Jannidis *et al.* 2017). The relationship between archaeology and ICT, as well as the term *digital archaeology* itself, have different names, such as *archaeological informatics* (*Archäoinformatik* in some German-speaking countries), *cyber archaeology, virtual archaeology*, and so on (*e.g.* Djindjian 2015; Hookk 2016; Levy 2014; Reilly 1990). There are no clear-cut borders and, according to Grosman (2016), one can state that the varying nomenclature is due to "many groups of scientists worldwide, [which] almost concurrently recognized the immense power of computer technology". Additional digital neighbouring "disciplines" also exist, such as the highly independent, do-it-yourself and mainly self-funded *punk archaeology*, as well as *digital geoarchaeology*, *digital history*, *digital literary history*, *digital musicology*, or *digital philology* (*e.g.* Ghilardi, Desruelles 2009; Graham *et al.* 2016; Gregory 2014; Murrieta-Flores *et al.* 2017; Nichols, Altschul 2012; Pugin 2015; Richardson 2017; Schofield 2017; Siart *et al.* 2017).

Depending on one's personal definition of *archaeology*, digital archaeology may be defined – at least in a taxonomic view – as an integral part of the digital humanities (*e.g.* Burdick 2012; Warwick *et al.* 2012). However, it seems difficult to treat digital archaeology and digital humanities as equivalent (*e.g.* Reiche *et al.* 2014): considering the research history of both fields, it seems that there are only a few points of interaction between digital humanities and digital archaeology. Indeed, digital archaeology may have evolved nearly on its own (Thaller 2017b; Zubrow 2006, pp. 12–21). At most, these two fields have only merged recently through individual projects which offer a few zones of overlap (*e.g.* dha 2017; Kaplan 2015). Actually, digital humanities mainly seem to encompass varying methods of digital text analysis in the broadest sense, the development and usage of various database applications, open access, studies in metadata, image classification research, as well as long term data archiving (*e.g.* Bair, Carlson 2008; Berry 2012; DHd 2018 Köln 2017; Diao, Hernández 2014; Funkhouser *et al.* 2011; Manovich 2012; Röhle 2012; Thaller 2017a). In this case, one should question if incorporating digital archaeology into digital humanities would not solely be a matter of taxonomy, regarding their highly diverse characteristics and the role of interdisciplinarity in archaeology (*e.g.* CAA International 2017; Hirst 2008). However, if one defines archaeology as a social science instead of assigning it to the humanities or cultural studies, these interconnections may be completely altered again (Smith *et al.* 2012).

Comparing digital archaeology and digital geoarchaeology may show that these different digital "disciplines" are more formally divided than they practically are. Recently, it was claimed that the use of digital methods and applications derived from geomatics in an archaeological context would define digital geoarchaeology (Siart *et al.* 2017). Nonetheless, spatial analysis using geographic information systems (GIS), for example, is inherent to archaeology, geology, geomatics, geoarchaeology, digital geoarchaeology, as well as digital archaeology (*e.g.* Djindjian 1998; Schörner, Hagmann 2015; Verhagen 2017; Zubrow 2006, pp. 16–21). In other words, it should be considered if it is even possible to make a precise distinction between a geoarchaeologist and a digital archaeologist while they are doing fieldwork and using GIS. So, it seems that such a definition might be valid only if rigid boundaries are defined between these different fields – a state that is quite atypical for archaeology (*e.g.* Sinclair 2016). Moreover, the number of disciplines using even the *same* digital methods and tools is not limited to digital geoarchaeology and digital archaeology. For example, digital dissemination strategies such as open access publishing, repositories, wikis, blogs, photo and video platforms are of highest importance for digital archaeology as well as for nearly *all* other scientific disciplines nowadays (Bauer *et al.* 2015; Morgan 2015; Richardson 2017; Xia 2012). Furthermore, the question is if an autonomous discipline arises because of the usage of

digital methods. One must consider if topics like ICT in archaeology and the neighbouring branches require their own digital archaeological disciplines and sub-disciplines, or whether one should think of something else, especially considering previously neglected aspects (Huggett 2015a; 2015b).

Consequently, ICT seems to be situated in between *all* disciplines. So, digital archaeology as the theory and practice of the complex use of ICT *throughout* archaeology may be positioned more likely on a meta-level than being its own specialisation or discipline. The same can be assumed for digital zooarchaeology, digital Judaic studies, digital classics, etc. (*e.g.* Betts *et al.* 2011; Campbell 2015; Schubert 2015). One might therefore suggest that sophisticated digital practice based on ICT within a given specialisation creates the corresponding digital meta-discipline.

3. Research data dissemination

As mentioned above, social media have an important role in today's society and in archaeology (*e.g.* Gennaro 2015; Richardson 2014; Rocks-Macqueen 2016; Sedlacik 2015; Laracuente 2016; Wolf 2017). Twitter, especially, can be regarded as an influential SNS, serving as a platform for individual messaging as well as for elaborate science communication. Innovative projects like the *Public Archaeology Twitter Conference* show the high potential of this service for science communication (#PATC 2017).

Different kinds of social media, such as microblogging services like Twitter, and research networks like Academia.edu, can be integrated for more effective outreach, for example to enhance public reception of a newly published research paper (*e.g.* Shuai *et al.* 2012; Thelwall, Kousha 2014). Going one step further, the combination of the various abilities of social media can create a holistic digital scientific communication tool. Thus, it is a question of the integration of different kinds of social media to form an interactive tool for archaeological research data dissemination – with all its innovations, advantages, disadvantages and problems (*e.g.* Perry, Beale 2015; Huvila 2013). *Research data* may be defined here as every kind of digital information available in archaeology, including digital objects like texts, tables, and photos, as well as ready-made publications such as research papers and monographies (Brin *et al.* 2013). Such a digital archaeological communication tool is settled at a point of disciplinary intersection and strongly overlaps with public archaeology "[…] viewed through the lens of the internet" (Lake 2012, p. 476). So, the role this tool plays in digital research data dissemination should also be considered (*e.g.* Denning 2004; Miles 2004). The tool may be used online, (mainly) without restriction world-wide, interactively, and may be comprised of numerous forms of social media, such as online wikis, blogs, photo as well as video platforms, and social networks (*e.g.* Scholz 2017). Because of its bidirectional nature, the tool allows enhanced use and reuse of data made available on open access and other online repositories and the sustainable publication of the meta-data via the internet, enabling a public digital discourse and evaluation of the data (Kansa *et al.* 2014; Niyazov *et al.* 2016). Through these means, the idea of open science or, more precisely, open archaeology, can be realised (Lake 2012; Morgan, Eve 2012; Zhu, Purdam 2017).

Due to the heterogenous characteristics of social media, the SNS used should be chosen precisely: for example, Instagram, a (primarily) mobile application, mainly focuses on photos, videos, and GIFs and is mostly used as a sophisticated marketing tool for individuals as well as for organisations in various fields (*e.g.* Firsching 2017; Moon *et al.* 2016; Sheldon, Bryant 2016). Controversially, however, this SNS is even used for e-commerce and trafficking of cultural heritage, including human remains (Huffer, Graham 2017). Apart from this, Instagram is not perfectly suitable for archaeological research data dissemination. For instance, there is currently only the possibility of adding non-clickable hyperlinks in combination with a single post. Without using paid features or additional applications, clickable hyperlinks are available on one's so-called bio (*i.e.* personal account description) only (Kobilke 2016).

Twitter is arguably a more important tool for information dissemination and communication. Posts are received very directly and can reach wide audiences and gain numerous interactions within a very short time. Not surprisingly, Twitter is also extensively used in several scientific disciplines aside from archaeology. Here, Twitter is mainly used for information dissemination, but also serves as a data source for different types of Big Data analysis (*e.g.* Cavanillas *et al.* 2016). Disciplines like economics, medicine, educational research, or architecture, as well as professionals like journalists, are using Twitter and its data, based on the interactions of hundreds of thousands of users and millions of data-sets to examine numerous kinds of research questions. Examples include optimised customer service conversations, the behaviour of people with traumatic brain injuries, or urban land-use (*e.g.* Ahmad 2010; Evans 2014; Oraby *et al.* 2017; Soliman *et al.* 2017; Vobič *et al.* 2016; Workewych *et al.* 2017).

4. Methodology

Twitter is a suitable tool for specialised research data dissemination, using hyperlinks, one of the most essential components of the internet (Berners-Lee *et al.* 1994; Berners-Lee 1997). One of these workflows is described through a basic example here: a 3D model of trench 2/2014 from the Roman excavation at Molino San Vincenzo in Tuscany/Italy was uploaded to the 3D content sharing platform Sketchfab (Hagmann *et al.* 2015; Lloyd 2016; Sketchfab 2017). The model, hosted on this platform, was embedded in a tweet: one can view the embedded model interactively within the tweet or follow the reference to Sketchfab (@rrl_univie 2017c; Hagmann, Reiter 2016c). Additional information is provided there too and offers further content through linking

to other webpages, for example, the overall-project website, Google Maps, the website of the excavation project itself, or the author's personal homepage (Dominik Hagmann 2017; Google Maps 2017; Molino San Vincenzo 2017; Roman Rural Landscapes 2017). Importantly, the data of the 3D model is provided on ResearchGate as a data repository and linked to the model (Hagmann, Reiter 2016a, 2016b; Kowalczyk 2014; Thelwall, Kousha 2015). The data can be retrieved as 3D geometries (COLLADA) and textures (JPEG) and all files are citable through digital object identifiers (DOIs; Agisoft PhotoScan 2017; COLLADA 2017; JPEG 2017; DOI 2017). ResearchGate is used in this special case as a repository mainly because of the high level of awareness of this platform within the scientific community and the possibility of assigning DOIs to digital resources. Long-term data archiving will be performed using the institutional repository *Phaidra* of the University of Vienna, and it is easy to link the digital objects on ResearchGate and Phaidra (Borrego 2017; Jeffrey 2012; Nicholas *et al.* 2016; Solodovnik, Budroni 2015; Thelwall, Kousha 2017; Yu *et al.* 2016). The mentioned websites have a (mostly) barrier-free, responsive web design and there are mobile applications for devices like smartphones and tablets available (*e.g.* Bernacki *et al.* 2016; Kerkmann, Lewandowski 2015). These technical specifications also help to dissolve the digital divide, at least partially.

At the Department of Classical Archaeology at the University of Vienna, selected (scientific) social media platforms are used for digital public outreach. Twitter serves as an official channel for various forms of science communication pertaining to the research activities of a newly established and specialised cluster of projects called Roman Rural Landscapes (RRL). These projects mainly focus on settlements in the Mediterranean and Central European countryside during ancient times (*e.g.* Banks *et al.* 2017; Gabellone 2015; Pinfield *et al.* 2014; Papmehl-Dufay, Söderström 2017; Richardson, Dixon 2017; Rocks-Macqueen 2016; Williams, Atkin 2015; Zuanni 2017).

Within this framework, Twitter activities started on May 15th, 2017, operated by the author. On December 22nd, 2017, the account had a quite small audience of 165 followers. The data-set analysed below is formed by the contents and metrics of all tweets (n=46) from June 1st to September 22nd, 2017, retrieved from Twitter Analytics between July 31st and November 10th, 2017 (Hagmann 2017c; Twitter Analytics 2017). The account had 145 followers during this time (averaged due to slight fluctuations). The tweets mainly contained various status updates with associated scientific background. 21 tweets within this period were themed to the excavation project *Molino San Vincenzo* and thus represent the majority of the posts (Hagmann *et al.* 2015). Therefore, two additional data-sets (obtained from Twitter Analytics on September 9th and October 12th, 2017), representing the subset of the excavation-related tweets described above, containing all tweets (n=23) from the period August 2nd to August 30th, 2017 are also analysed (Hagmann 2017d, 2017e). Descriptive analysis was performed on selected qualitative and quantitative aspects of these Twitter metrics (*e.g.* Bol 2010): aside from the published content of the tweet as text, general technical details like the unique identification number of the tweet or the permanent URI are among them. Further aspects, like the timestamp or the number of times how often embedded media (photos, videos, GIFs, embedded models *etc.*) within the tweet were shared with other Twitter users were regarded too. Attention was paid to the number of times the tweet was shown to a Twitter user (*i.e. impressions*), as well as the interactions (*i.e. engagements*), and the *engagement rate* (*i.e.* the impressions divided by the engagements). For their part, the engagements are composed of various kinds of special actions, like retweets, replies, likes, profile clicks, link clicks, hashtag clicks, detail expands, and media interactions (Twitter 2017e). No paid Twitter *Ads campaigns* for increasing the performances of the tweets through promotion were used – only so-called organic activities are considered (@buster 2014; Twitter 2017f). Aside from simple calculations, the standard deviation (std. dev.) as well as the arithmetic mean and median were calculated using MS Excel (Excel 2017a, 2017b, 2017c). MS Excel and Adobe Illustrator were used for the visualisation of the data and for generating the charts (Adobe 2017; Microsoft 2017). The datasets are licensed under a CC BY 4.0 International License (Creative Commons 2017).

5. Results

During the period of 114 days, 46 tweets were posted, which means 1 tweet per *c.* 2.5 days on average (Figure 1): 11 tweets were posted in June, 7 tweets in July, 25 tweets in August and 3 tweets from September 1st to 22nd, 2017. The tweets have 609.2 (std. dev. 1140.8) impressions on average, with a minimum of 75 and a maximum of 5497 impressions per tweet. The average number of engagements is 12.1 (std. dev. 14.1) with a minimum of 1 and a maximum of 82 (Figure 2). The average engagement rate is 0.03 (std. dev. 0.01), or 3%, with a minimum value of 0.004 (0.4%) and a maximum value of 0.08, respectively 8% (Figure 3). The median engagement rate is 0.03 (3%) (Hagmann 2017c).

Comparable values can be observed for the subset of tweets (n=23) from August 2017, which were received from Twitter Analytics on September 4th, 2017 (Figure 4): per tweet, 784.7 (std. dev. 1349.9) impressions are recorded, with a minimum of 105 and a maximum of 5497 shares. On average, the tweets have 16.0 (std. dev. 18.1) engagements (minimum: 2, maximum: 82) and a mean engagement rate of 0.03 (std. dev. 0.01), also 3%. The minimum average engagement rate is 0.004 (0.4%), the median engagement rate is 0.03 (3%), the maximum average engagement rate-value is 0.08 (8%) (Hagmann 2017d).

Regarding impressions and engagements, the most successful tweet, no. 892754365618028544, was published on August 2nd, 2017. It is an informal status update mentioning the preparations for the 2017 season at Molino San Vincenzo in Tuscany. The message gained

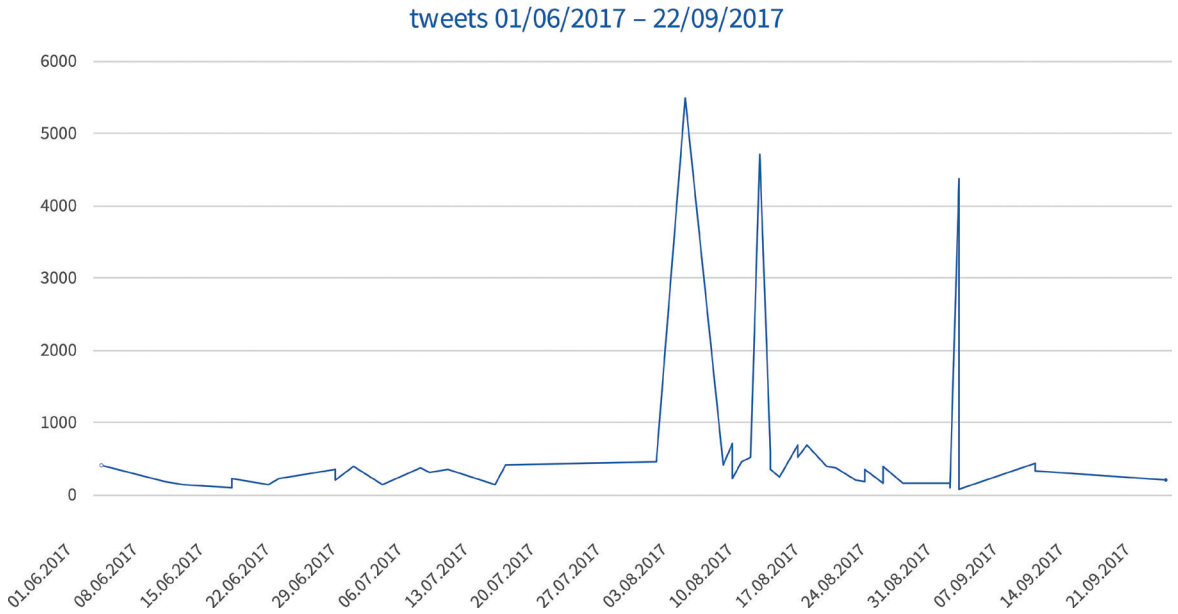

Figure 1. Impressions of the tweets (n=46) from 2017-06-01 to 2017-09-22 (Dominik Hagmann 2017. Data received from Twitter Analytics).

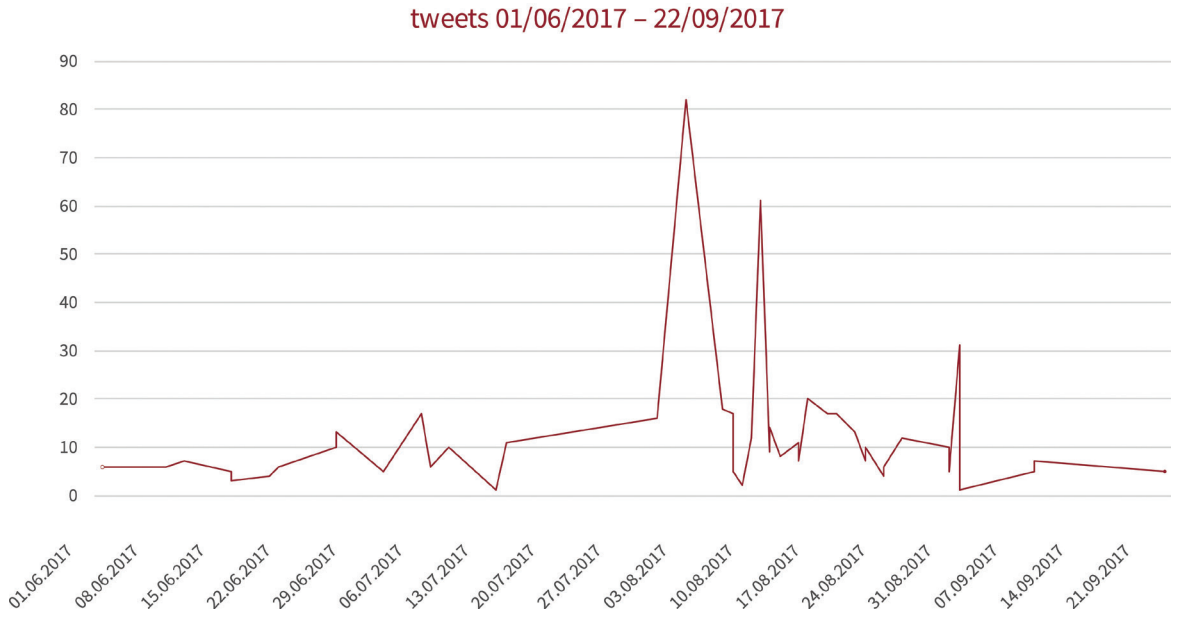

Figure 2. Engagements of the tweets (n=46) from 2017-06-01 to 2017-09-22 (Dominik Hagmann 2017. Data received from Twitter Analytics).

5497 impressions and 82 engagements (@rrl_univie 2017a). The least successful tweet, no. 902917404883394560, is from August 30th, 2017. It gained 105 impressions and 5 engagements, and relates to the publishing of a 3D model according to the data dissemination workflow mentioned above (@rrl_univie 2017b). With regard to engagement rate, however, the reverse conclusion can be drawn: tweet no. 902917404883394560 achieved a better rate of *c.* 5% than tweet 892754365618028544 (*c.* 2%) (Hagmann 2017d).

The metrics for the same subset of Twitter data from August 2017, received on October 12th instead of September 4th, 2017, are little changed compared to the previous values (Figure 5). On average, 856.1 (std. dev. 1345.3) impressions (minimum: 193, maximum: 5558) and 16.0 (std. dev. 17.9) engagements (minimum: 2, maximum: 81) are recorded. The average engagement rate is 0.03 (std. dev. 0.01, minimum: 0.004, maximum 0.06) or 3%, the median engagement rate 0.02 (2%) (Hagmann 2017e).

Based on Twitter data derived from the period between November 23rd and December 22nd, 2017 and received from Twitter Analytics too, the Twitter audience target group of the RRL Twitter account can be described as followed: based on the interests of 165 followers on December 22nd, 2017, the top interest (for 83% of followers) is within the category "science news", followed by "books-news and general info" (71%) and "business and news" (60%). Twitter followers are

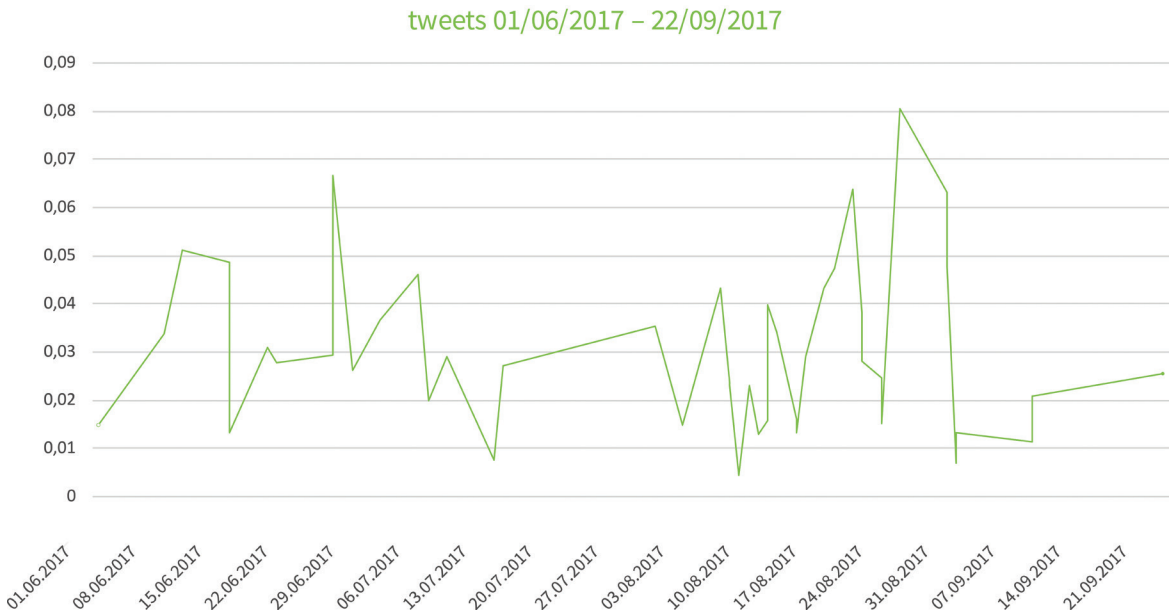

Figure 3. Engagement rate of the tweets (n=46) from 2017-06-01 to 2017-09-22 (Dominik Hagmann 2017. Data received from Twitter Analytics).

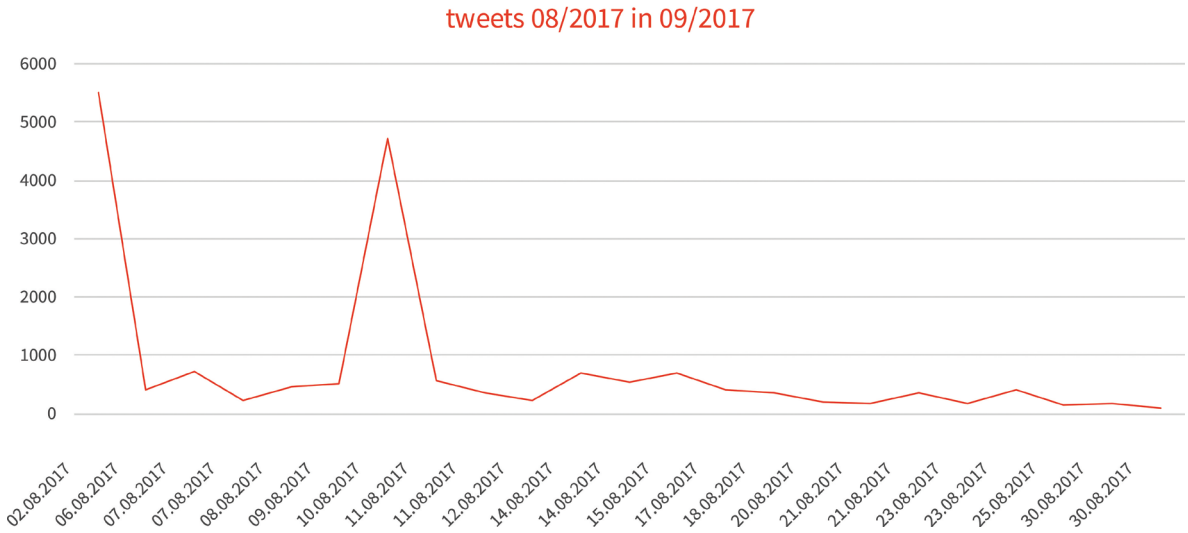

Figure 4. Impressions of the tweets (n=23) from 2017-08, downloaded on 2017-09-04 (Dominik Hagmann 2017. Data received from Twitter Analytics).

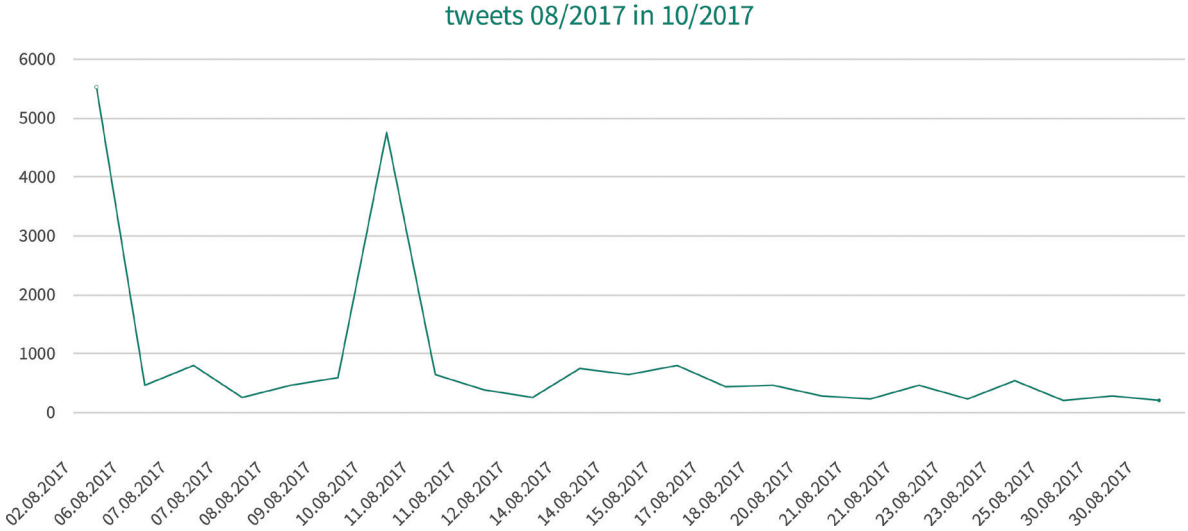

Figure 5. Impressions of the tweets (n=23) from 2017-08, downloaded on 2017-10-12 (Dominik Hagmann 2017. Data received from Twitter Analytics).

mainly from Austria, followed by users from Germany and the United Kingdom.

6. Discussion

A high variance in metrics can be clearly observed. Some tweets were shown 75 times on Twitter, others over 5000 times (Figure 1). While most of the impressions have a stable and uniform level of *c.* 600, there are a few massive peaks of *c.* 5000, the lowest values being *c.* 100. The data peak was generated through an informal status update including a photo, while the lowest value is represented by a tweet with an embedded 3D model, meant for digital research data dissemination like the example shown above. So, the more data-related tweet has been far less successful regarding the number of times the tweet was shared. Compared to all tweets (n= 23) from August 2017 (retrieved on September 9th), tweet no. 892754365618028544 was extraordinarily successful with 5497 impressions and 82 engagements. However, the engagement rate of 0.015 (1.5%) can be considered far below the average mean of 0.03 (3%). Although tweet no. 902917404883394560 has a lower number of impressions (105) and engagements (5), all in all it has a significantly higher engagement rate of 0.05 (5%) (Figures 2 and 3). The average engagement rate (*c.* 3%) seems to be comparable to other science communication accounts on Twitter: A recently published study in medical sciences mentions an average engagement rate of 4.75 (median: 3.4%) *(Wadhwa et al. 2017)*. Aside from the contents of the tweets it seems to be of high importance which followers are retweeting: Tweet no. 892754365618028544 has been retweeted by the official Twitter account of the University of Vienna, for example, which resulted in many more impressions from its currently *c.* 10,800 Twitter followers (@univienna).

These two examples show that the use of integrated SNS for scientific research data dissemination has a lower absolute reach than tweets focusing on communicating actual fieldwork activities. Tweets focusing on pure research data dissemination may have much higher rates of interaction, due to the people actively engaging with the tweet. However, it is problematic that various engagements (likes, retweets, replies) may be performed by a single Twitter follower, so a seemingly high number of engagements may be based on an interaction with a relatively small number of users.

The metrics of the Twitter data presented are generated quite quickly. Looking at the same dataset from August 2017, again in September 2017, and again in October 2017, reveals that there is only moderate activity 30 days later (Figures 4, 5). In September 2017, *c.* 780 impressions per tweet could be recorded on average, while in October 2017, this value was *c.* 850. This is an average growth rate of *c.* 9%. Therefore, there is some interest in older tweets, but most of the impressions refer to current tweets with no additional data peaks generated after one month. Accordingly, the engagements and the average engagement rate do not alter significantly.

All things considered, it is difficult to explain precisely why there are such high discrepancies in the Twitter metrics. Moreover, it is hard to decide which factors influence the perception and distribution of the tweets. One additional problem is that the algorithms which generate the Twitter timelines are not freely available. Finally, it must also be noted that the results presented here are primarily valid for the RRL Twitter account; therefore, it may be problematic to draw general conclusions using this dataset.

7. Conclusion

This study showed that scientific communication using integrated SNS is definitively possible and useful. Twitter is capable of data-driven science communication and, at least, it can be assumed that there is some stable perception of tweets on a certain level. It is also obvious that the sole use of integrated SNS as a dissemination tool for archaeological research is just one aspect among many possibilities. On the one hand, through integrating SNS like Twitter, Sketchfab, and ResearchGate into one dissemination tool, above-average engagement rates were observed with relatively low values of impressions. On the other hand, through using Twitter as a pure microblogging platform as intended, relatively high numbers of impressions could be achieved, occasionally with below-average engagement rates.

It can be assumed that the more retweets that are made, the more impressions may be recorded per tweet (see Richardson 2012). If accounts with numerous Twitter followers make these retweets, then the original tweets seem to be further promoted. As Richardson (2012) stated, it appears that on Twitter most of the interactions concerning research data dissemination are restricted to a core audience. Unsurprisingly, but worth mentioning, it looks like that the use of Twitter as a dissemination tool for specific archaeological data in the form of 3D models focuses more on communication within a small group of specialists (often knowing each other personally), rather than being a tool for broad science-to-public communication. Similarly, it may be true that this group of specialists is one that could use the data for scientific purposes. As Pilaar Birch (2013) mentioned, "this is not necessarily to be viewed as negative, as it depends on the intent of the project". Additionally, people who are interested in these datasets, such as researchers from other fields of science or science journalists, may also belong to this core audience. Alternatively, tweets which focus on actual archaeological fieldwork and which give insights into actual research activities do have the potential to gain much attention. That is why Twitter could very well serve as a tool for science-to-public communication.

Now we ask, are there only scientists reading the tweets and hopefully using the data, while "the public" simply just react on random tweets for no reason? Such posts used to be called *cat content* in German-speaking countries and contain messages like *we wish you a pleasant weekend* (*e.g.* Baumann 2014; Firsching 2017; Podhovnik 2016). Is Twitter,

then, just a tool for gaining attention as an application used for marketing only which serves to *entertain* followers? This seems hardly likely. Indeed, one must adapt contents carefully according to the targeted audience and the SNS used, mindful of the economic and administrative effort involved. Focusing on the desired target group, suitable contents must be found. These contents may be status updates which give insights to the role of cultural heritage and archaeology in general, tweets about research and fieldwork activities, and research data dissemination. (Deslis 2012a; 2012b; Gruber 2017; Colley 2013; Kim, Cha 2017).

It seems that there are chances to reach a small but engaged group of Twitter users at the time the tweet is posted. Furthermore, it must be noted that this small core audience also has to be enthusiastic about the tweets as well. This would manifest itself through commenting, liking and retweeting, because Twitter is always about interaction. In the end, however, it seems that SNS can be used as an integrated tool for scientist-to-scientist communication with no issue. Furthermore, depending on the content, these SNS are powerful tools for public archaeology itself (*e.g.* van den Dries 2014; Gould 2017; Grima 2017; Hardy 2015; Jensen 2012; Matsuda 2017; Moshenska 2010; Richardson, Almansa-Sánchez 2015).

There is simply not enough data yet to answer the above-mentioned questions precisely. The observation period must be much longer and a significantly larger dataset must be checked to reveal the full potential of Twitter for archaeological outreach. To do so, further studies are planned: Firstly, a paper about the implementation of digital archaeology during the excavations and surveys at the Roman site of Molino San Vincenzo is going to be published in 2018/2019, incorporating data from Facebook, Twitter and YouTube, and serving as an example of the use of *personal accounts* in digital science communication. Secondly, to make further data available, an additional paper is planned for 2020, offering critical evaluations of the utility of different SNS for science communication and data dissemination within digital archaeology, based on individual *and* institutional user accounts. The study presented here is thus only a first step in a multistage case study on digital public archaeology.

Returning to the question mentioned at the beginning of the article, currently there is no need to start a Twitter war or engage in other active communication strategies to successfully disseminate archaeological information. Indeed, everything seems to depend – quite unsurprisingly – on a clearly defined social media strategy. Moreover, one should adapt the contents to the desired target group, and attracting and using the reach of active followers is of utmost importance. With this as the main consideration, the presented dissemination strategy should be suitable to the unique goals of digital archaeology and may in turn enable fruitful science communication. The above-mentioned additional research will test this assumption.

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