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Fabrizio Nevola, Tim Coles & Cristina Mosconi

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Hidden Florence revealed? Critical insights from the operation of an augmented reality app in a World Heritage City

Fabrizio Nevola ^a, Tim Coles ^b and Cristina Mosconi^c

^aCollege of Humanities, University of Exeter, Exeter, UK; ^bDepartment of Management, University of Exeter Business School, Exeter, UK; ^cDepartment of Science, Innovation, Technology and Entrepreneurship, University of Exeter Business School, Exeter, UK

ABSTRACT

Prior to the COVID-19 pandemic, overtourism was a major topic in global tourism management discourse. The continued growth of international tourism placed pressure on many high-profile urban destinations containing some of the world's most important intrinsic cultural heritage. This paper critically examines the operation of Hidden Florence, a heritage tourism augmented reality (AR) application (app) for the UNESCO World Heritage Site of Florence in Italy. Since 2016, the city management plan has actively promoted digital and smart solutions to address the issues induced by mass heritage tourism. Through user engagement data from 2013 to 2018, this paper investigates the nature and extent of app use, both in and away from the city. The paper makes two main contributions. First, from a managerial perspective, the empirical analysis points to several major practical and methodological challenges if AR apps, and the data they generate, are to be employed effectively as part of the management of established heritage destinations. Second, the use of AR apps in, and smart approaches to, tourism management have been recently theorised and advocated. Evidence from Hidden Florence demonstrates that translating conceptual possibilities into longer-term management practices and beneficial change is more challenging than existing discourse concedes.

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Introduction

Prior to the COVID-19 pandemic, overtourism was a major topic in global tourism discourse (Dodds & Butler, 2019; Peeters et al., 2018; UNWTO, 2018). Visitors were overwhelming many urban destinations containing some of the world's most precious, yet precarious cultural heritage. Venice, Barcelona and Dubrovnik (Panayiotopolous & Pisano, 2019) were frequently invoked as archetypes of a phenomenon that also blighted very many other towns and cities around the world (Namberger et al., 2019; Smith et al., 2019). Known for their delicate fabric and intricate urban forms, they were not designed for the high volumes of visitors they attracted. Some of the practical strategies for managing the problem included limiting access to 'honey pot' sites, dispersing visitors in time and space (Peeters et al., 2018; UNWTO, 2018; WTTC & McKinsey 2017), and the use of digital technologies to develop agile, even 'real time' smart tourism approaches to destination management (Buhalis & Amaranggana, 2014; Cavalheiro et al., 2020; Jovicic, 2019).

CONTACT Tim Coles  t.e.coles@exeter.ac.uk

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The potential of Augmented Reality (AR) applications (apps) for the production, consumption and management of visitor experiences is acknowledged (Liang & Eliot, 2021; Yung & Khoo-Lattimore, 2019), especially in urban heritage tourism (Han et al., 2018; tom Dieck & Jung, 2018; Tsai, 2020). Indeed, the possibilities derived from AR apps as practical tools for managing a range of different spaces in heritage tourism continue to generate discussion (Han et al., 2018; tom Dieck & Jung, 2018), in particular for bounded spaces including museums and galleries (Trunfio et al., 2020, 2021). Yet several important gaps still exist in research on heritage tourism AR apps. To date, although the composition and perception of trails and routes have been explored (cf. Garau & Ilardi, 2014; Han et al., 2018; Tsai, 2020), there have been few, if any spatio-temporal analyses of heritage tourism AR app use across urban environments, for instance, to navigate around towns and cities as heritage destinations, or between particular venues and attractions. Cross-sectional studies dealing with discrete time-slices have been the norm rather than longitudinal studies tracking use patterns or trends differentiated over time. Indeed, in tourism studies involving AR apps more generally, it is surprising that extensive data held on smart devices about app use and users, and the multiple communication channels used to disseminate them, have not been utilised more (cf. Graziano & Privitera, 2020; Liang & Eliot, 2021). Finally, little is known about how heritage tourism AR apps have been incorporated into destination management planning and practices, their ability to deliver on strategic goals, and specifically their potential to contribute to smart approaches to tourism management.

This paper addresses these research gaps by critically examining the operation of Hidden Florence, a heritage tourism augmented reality app for Florence in Italy (<https://hiddenflorence.org/>). As the first study of its type, it employs user-generated data from smart devices to investigate app use in and across a city, as well as remotely, over time. Florence represents an ideal destination for addressing these gaps. Designed to showcase more of the city's cultural heritage and enhance visitor experiences, Hidden Florence invites users to experience the city at the time of the Medici. As a major international destination with UNESCO World Heritage Status, Florence has struggled with crowding (Popp, 2012) and overtourism (Henley, 2020; Persio, 2017), especially in the city centre around the Duomo, Uffizi Gallery and the Ponte Vecchio. As an early and distinctive example of its genre, a continuous record of the use of Hidden Florence exists from 2013 to present. Moreover, the app epitomises and embodies many of the strategic ambitions in the city's subsequent 2016 management plan (FPM, 2016), as the municipality has since acknowledged (FPM, 2021). Thus, it is one of the very few instances where there is a clear and direct link between the development of AR solutions and smart destination management which, more generally, is an evolving discourse in tourism studies (Boes et al., 2016; Buhalis & Amaranggana, 2014; Cavalheiro et al., 2020; Ivars-Baidal et al., 2019; Jovicic, 2019).

In the next section, we examine the current body of knowledge dealing with heritage tourism AR apps highlighting their potential use in, and management of, smart destinations. This is followed by an account of the research design, including the contexts surrounding the development and implementation of Hidden Florence. With the next phase of Hidden Florence starting in 2019 (Nevola et al., 2022), the subsequent analysis focuses on user engagement data from the original app and its various media channels from 2013 to 2018 (see also Nevola, 2016; Nevola & Rosenthal, 2016). This informs a critical discussion of the practical application of AR apps for managing urban heritage destinations, as well as the possible implications for current conceptualisations in which AR apps are viewed as part of tourism 'ecosystems'.

Literature review

At their most basic, AR apps in heritage tourism use devices – typically a smart phone or tablet (Garau & Ilardi, 2014) – to deliver content that enhances a user's experience of a real-world environment (Yung & Khoo-Lattimore, 2019). Such episodes can take place in real space and real time during in-person, corporeal visits; alternatively, they may comprise virtual visits as

forms of ‘arm chair tourism’, as substitutes for physical travel (Liang & Eliot, 2021) and/or as means for recollecting trips (Bec et al., 2021). Within heritage tourism, experiences are enhanced by the delivery of carefully selected and curated content about particular historical periods, personalities and/or places including sound, video, still images, text and so on. While a range of hardware and software solutions may be deployed to augment reality (Trunfio et al., 2021; Tsai, 2020), AR reproduces in digital form elements from, and some of the broad roles of, the guidebook, the self-directed walking tour, and – to a degree – the tour guide, in particular in narrating space and place. AR apps exist for a range of urban heritage settings from individual sites or attractions to routes through towns and cities connecting locations, for instance in particular streets, districts or suburbs (cf. Garau & Ilardi, 2014; Graziano & Privitera, 2020; Han et al., 2018; tom Dieck & Jung, 2018; Trunfio et al., 2021).

More generally, research on AR and VR (virtual reality) in tourism studies has been the subject of two recent reviews. Yung and Khoo-Lattimore (2019) identified three main critical issues characterising the growing body of knowledge. These were: issues with terminology; a lack of theory-based research; and the emergence of several key knowledge gaps around four themes. Not surprisingly for a nascent topic area, they argued that important challenges still lay ahead in terms of: developing greater understandings of awareness of the technology; the requirements (mainly time) on those using the technology to produce new experiences; the extent to which there is willingness to replace in-person, corporeal experiences with virtual ones; and the usability of such apps. Liang and Eliot (2021, p. 15) reinforced the salience of usability in their later review. In fact, they observed five distinctive clusters of AR research in tourism, noting a major focus ‘on user acceptance of augmented reality, commonly applying the technology acceptance model’ (cf. tom Dieck & Jung, 2018). Among the other foci were: the design and implementation of AR; measuring user experiences, especially as related to visitor satisfaction and intention to revisit; the implementation and management of AR systems; and finally, the possibilities of connecting gamification and AR.

There is not the space here to discuss these reviews nor their detailed contents extensively. Each review is understandably driven by its idiosyncratic processes of compilation and each intends to draw inferences about the body of knowledge developed in tourism studies on AR more generally. Nevertheless, it is noteworthy that, in both reviews, studies of heritage tourism AR apps are invoked as both driving some of the main conclusions (for instance about technology acceptance cf. tom Dieck & Jung, 2018) as well as evidencing some of the wider trends. For example, emblematic of issues on design and implementation (Liang & Eliot, 2021), heritage tourism apps and their inherent attributes have received considerable attention. There has also been significant interest in the measurement of user experiences, including satisfaction (Han et al., 2018; Trunfio et al., 2020). Again consistent with the wider body of work (Liang & Eliot, 2021), the success of such AR apps has been related to the quality of the user experience (Han et al., 2018). This refers not only to the negotiation of the app itself (i.e. usability), including technical issues such as how it runs on particular platforms (i.e. Android, Apple) and/or networks (i.e. Wifi or 3G/4G/5G). It also concerns content, production values, and the perceived authenticity of experiences. For Dueholm and Smed (2014, p. 285), the term ‘authenticity’ has multiple connotations among stakeholders connected to heritage tourism attractions making ‘understanding levels and patterns of authenticity among various groups of actors’ imperative. Similarly, Bec et al. (2021, p. 117) note a major appeal of presenting heritage through AR is ‘not only [to] preserve and manage heritage but to enrich the visitor experience and subsequent engagement with history’. As their four-stage conceptual model of heritage preservation explicates, representation, selectivity and contestation are significant considerations. Yet, by virtue of their budgets and practical scope (Yung & Khoo-Lattimore, 2019), almost inevitably heritage tourism AR apps have to be selective in focus.

Thus, by invoking these two systematic reviews as contextual ‘benchmarks’, important gaps in our understanding of heritage tourism AR apps, begin to emerge. For instance, as hinted above, much of the work on heritage tourism AR apps has taken place in cross-sectional studies (i.e. using data aggregated from time-slices). Rather than exploring issues longitudinally (or

continuously over a period of time), knowledge is built through composite ‘snapshots’. By focusing far more on their intrinsic features and operation, much discussion of heritage tourism AR apps significantly underplays the wider (extrinsic) contexts in which they function as well as the critical issues they generate. For instance, reminiscent of the question ‘Whose Heritage?’ (Hall, 1999), selective narratives and the delivery of contestable content (Bec et al. 2021) raise significant but as-yet unanswered questions about social inclusion (and exclusion) in the creation of heritage tourism AR apps, and hence the extent to which they may be more or less utilised by end users (because of their appeal). Put another way, thus far there has been little consideration of which narratives, spaces or places local communities would privilege for (or prefer omitted from) AR apps. Instead, some differences in stakeholder valorisations of the opportunities afforded by AR apps have been noted in terms of their possible role(s) in future tourism (development). Finally, as tom Dieck and Jung’s (2018) work reveals, AR experiences provide opportunities for small museums to enhance their resilience and competitiveness, for example by providing a focal point for investment. For Graziano and Privitera (2020), positive images of heritage destinations derived from the presence of AR may be attractive for entrepreneurs. However, to be most effective in an integrated approach to destination management, AR should feature in shared, long-term visions that integrate ‘actual capacities in terms of infra-structural systems, funding and human capital’ (Graziano & Privitera, 2020, p. 676). Framed alternatively, the development of heritage tourism AR apps should be examined in the public policy and infrastructural frameworks that configure the local visitor economy (Boes et al., 2016) as well as in terms of their implications for local businesses and attractions. However, few if any prior studies have recognised or investigated this challenge.

Thus, heritage tourism AR apps clearly have the potential to contribute to active multi-stakeholder destination management, in particular where this relates to in-person, corporeal experiences or even substituting them for virtual ones (Mohanty et al., 2020; Sarkady et al., 2021; Yung & Khoo-Lattimore, 2019). Within heritage tourism destinations, just as many others employing integrated ‘smart tourism approaches’ (Ivars-Baidal et al., 2019), AR apps can act as dissemination mechanisms for live messages (e.g. offers, ticketing, information on transport, parking, etc.) as well as nudging visitors to adjust their behaviours. By providing content for less popular (i.e. touristed) sites, attractions or routes, like other apps they offer the prospect of reducing pressure on congested ‘honeypot’ sites. In so doing they may spread the benefits of tourism more widely through urban environments to unfashionable and/or unvisited locales (Boes et al., 2016).

Within the smart tourism canon then, AR apps more generally and those dedicated to heritage tourism specifically, are best understood and conceptualised as elements in ‘ecosystems’, not as individual, isolated entities (Boes et al., 2016; Buhalis & Amaranggana, 2014; Buhalis & Leung, 2018; Gretzel et al., 2015; Ness 2020). The metaphor is intended to capture the diversity and mutually-implicated nature of components involved in contemporary destination management, especially in complex urban environments. Within digital space, apps of all types, not just AR or heritage tourism-related, function with other forms of advanced technology (including other apps) configured to local contexts and conditions to enable communities and destination managers to co-create value from tourism (Boes et al., 2016; Gretzel et al., 2015). Visitor experiences for app users in-destination rely on multiple technologies and platforms, all of which have to be ‘joined up’ to ensure continuity, optimality and quality of experience leading ultimately to (greater) visitor satisfaction (Hausmann & Schuhbauer, 2020). Integration extends though beyond the digital: several commentators have noted that urban tourism experiences – and by implication ecosystems – rely simultaneously on affordances in both the real and the virtual worlds (Graziano & Privitera, 2020; Gretzel et al., 2016; Romero-García et al., 2019). Almost in symbiosis, alongside other services and facilities (i.e. accommodation, hospitality, transport, attractions, WiFi, etc.), apps are conceptualised as contributing to the totality of in-destination experience for visitors (Buhalis & Leung, 2018).

Thinking of this nature emphasises the utility of AR (and other) apps in managing the visitor experience and destination. Yet, very little practical research appears to have been undertaken on the extent to which heritage tourism AR apps have been embedded in the practices and ecosystems

of destination management, and what their effects have been. There has been little apparent effort to understand the spatial and temporal nature of the use of heritage tourism AR apps at the level of the urban, in particular the varying level of use (especially across urban environments or between sites and venues, and representations of them), and how this may vary over time. Little is known about the nature and extent to which AR apps in heritage tourism are being used within the boundaries of a destination compared to away from it. This is despite the wealth of analytics data such apps can (theoretically) generate, and the undoubted value of such data, if it may be obtained, to understanding how urban heritage tourism is consumed and may be managed. Indeed, more generally AR app-generated analytics data appear not to have been widely utilised in tourism studies, as Liang and Eliot observe (2021, pp. 18–20). Finally, a key assumption about urban tourism ‘ecosystems’, especially those involving smart tourism, is that local infrastructure and facilities (including hardware) will support, and hence benefit from, the effects that new digital approaches may encourage (Gretzel et al., 2016; Romero-García et al., 2019). Put another way, there has been little consideration of whether specific conditions in historic townscapes impact on the use of apps around the heritage city and whether there are *de facto* limits to new, alternative ways of consuming space.

These issues are explored in the remainder of the paper. In the next section, we explain the design of the research, in particular the local contexts that establish Florence as an ideal destination through which to investigate these issues empirically.

Research design

Background: Hidden Florence

The history and development of Hidden Florence provides important background to the analysis of the user data. Formally launched in 2014, Hidden Florence was designed as an augmented reality app for smartphones, primarily for visitors in Florence (Figure 1). Intended to make users aware of far more of the city’s cultural heritage, the original content of the app was curated by public history scholars (Nevola, 2016; Nevola & Rosenthal, 2016). Day-to-day management was (and remains) the responsibility of an independent service provider.

Hidden Florence invites users to experience Renaissance Florence through the eyes of contemporary characters, and the quality of the academic research underpinning the content is its primary

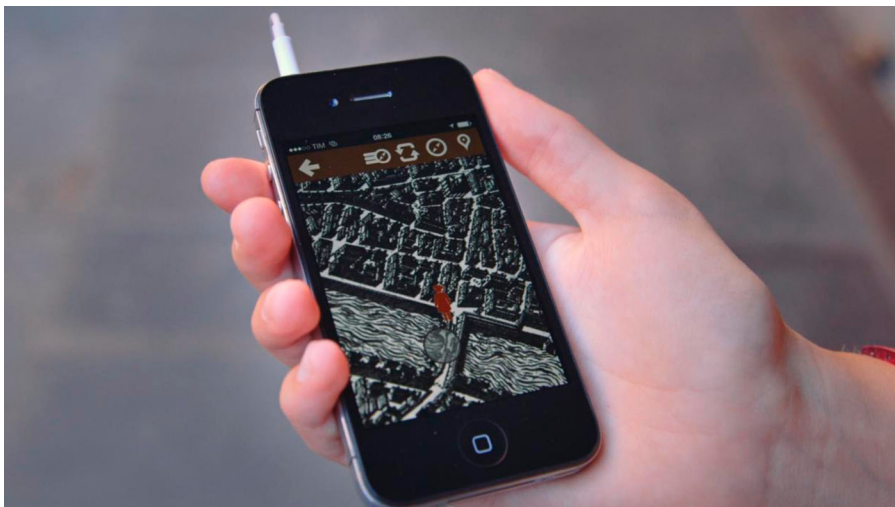


Figure 1. Film still from promotional film created for the Hidden Florence app showing the historic map interface on the iPhone display, 2014 [© Freshground films and University of Exeter (Fabrizio Nevola)].



Figure 2. Screenshot of the current Hidden Florence app showing the 'Neighbourhood' itinerary on the historic map screen, 2019 [© University of Exeter (Fabrizio Nevola)]

selling proposition. The two original guides took users on walking tours through the city's past linking the sites visited to the characters' lives and times (Figure 2). Using a sixteenth Century map created by a Benedictine monk as its basis, the app was designed to deliver immersive experiences that, while they are grounded in rigorous academic research, utilise fictionalised historical accounts narrated by a central character, Giovanni, in Italian or English (Nevola, 2016; Nevola & Rosenthal, 2016).

A team from the University of Exeter (United Kingdom) led the development and curation of the app from 2012 to 2014, which initially cost £30k (Nevola, 2016; Nevola & Rosenthal, 2016). In 2019, a major update was published (Nevola et al., 2022; Figure 2) following its inclusion in the Hidden Cities initiative (see <https://hiddencities.eu/>). The design of the original app benefitted from dialogue with the municipality and the local UNESCO World Heritage Management Team, and it later featured in the *Firenze Card* user guide, published by the municipality and available to all visitors. While the launch of Hidden Florence pre-dated the city's 2016 Management Plan, the app was already closely aligned with the emergent strategic priorities for the management of tourism in the city discussed below (FPM, 2016), specifically its potential for decentring visitors and diversifying audiences through its design. Indeed the compatibility of the app with this ambition and the 2016 management plan was subsequently acknowledged by the municipality (FPM, 2021).

Life in medieval Florence was the subject of the Central Walk (Table 1). Comprising nine stopping points, this was the longer of the two. Located in the historic centre as set out by the World Heritage designation (FPM, 2016), it mostly avoided the problematic Duomo-Uffizi axis (FPM, 2016; Korey, 2017; Popp, 2012) and guided users towards the less-visited western part of the old town. Comprising six stops, the San Ambrogio walk covered the residential neighbourhood of the guide character, a working-class area in the late medieval city, still today above all residential in character. As a shorter tour, it was anchored in the Santa Croce district to the east of the city centre but still in the 'buffer zone' (see below; FPM, 2016). As both walks avoided locales routinely frequented by mass 'excursionist tourists' (FPM, 2016; Popp, 2012), mobile phone coverage, signal strength and possible GPS 'blackspots' were considerations in the design (and use) of the app.

To build interest prior to the formal launch, three communication channels were established in 2013: a dedicated web site, a (Word Press) blog site, and a YouTube channel. The WordPress site included content in development (i.e. 'teasers') from the tours, disaggregated from the app in (web) page format, and additional features on the project, the team and the city. Three features were initially added to the YouTube channel: a documentary on the app project; a promotional film for Hidden Florence; and a shorter 30-second edit. Although not part of the communications strategy *per se*, the app received an unexpected boost when it featured in a prime-time, free-to-air TV

Table 1. Stops on the original Hidden Florence walking tours.

Stop	Location	Theme/added content
Central Walk		
1	Ponte Vecchio	Bridging the Arno
2	Piazza Signoria	Politics and piazza
3	Canto del Bargello	Crime and punishment
4	San Martino	Performance and patronage
5	Orsanmichele	Merchants and workers
6	Viccolo del Giglio	Sex and the city
7	The Opera Workshop	Craft work
8	Piazza della Repubblica	Women in the streets
9	Palazzo Strozzi	Palaces and pavements
San Ambrogio Walk		
1	San Ambrogio Church	King for a day/relics on parade
2	Via dei Macci	The worker's home
3	Via dei Pilastrì	Street ecologies
4	Canto al Monteloro	Neighbourhood Madonna
5	Piazza San Piero Maggiore/Volta di San Piero	A slice of piazza/Tavern tales
6	Canto alle Rondini	The apothecary's shop

programme in the United Kingdom, on 26 December 2016. Syndicated to several countries, in each hour-long episode of Channel 4's *Travel Man: 48 h in ...* the host (a comedian, Richard Ayoade) visits a popular city with a celebrity guest (in this case, the actress, Rebel Wilson) offering useful hints and tips to those viewers thinking of or planning a short (weekend) break. Hidden Florence subsequently featured (and still does) on the programme's page (<https://www.travelman48hrs.com/series4.html>).

Context: recent tourism development in Florence

Inscribed in 1982, the Historic Centre of Florence (Firenze) is a UNESCO World Heritage Site and in 2018 the city attracted 10.7 million visitors (Henley, 2020), with 5.3 million guests staying overnight (CMF, 2021). Of these, the United States, China, Germany, the UK, France and Spain comprised the six largest markets, all in excess of 200,000 staying guests (CMF, 2021).

Like so many world-famous heritage tourism destinations, Florence has continued to face intense challenges from overtourism (Henley, 2020). Many 'excursion tourists' are bussed into the city daily, staying only for a few hours at a time (FPM, 2016, p. 43) and making limited contributions to the visitor economy. Despite the wealth of cultural heritage on offer across the city, most of the marquee and hence most popular attractions, including the Uffizi Gallery and the Duomo (cathedral), are in the city centre within 0.5 km of the Ponte Vecchio, the world-famous bridge over the River Arno. The central area has become very congested, especially in peak season (Popp, 2012) and there have been frequent complaints about anti-social behaviour, including littering, abuse and petty crime (Kirchgaessner, 2015; Korey, 2017; Persio, 2017; Squires, 2018).

All UNESCO World Heritage Sites are subject to management plans. These are agreed by a number of stakeholders, above all the local UNESCO team and the local authority of the hosting municipality. As Mankuvaza (2018: xix) notes, the 'purpose of a management plan is to ensure the effective protection of the nominated property for present and future generations' and, while tourism is not the sole focus, in many locations – including Florence – it is a key consideration. In the 2016 Management Plan (FPM, 2016), six main threats to the World Heritage area were identified – including the 'impact of mass tourism' and the 'collapse of monumental heritage' (FPM, 2016, p. 48) – and five 'macro-areas' of 'project initiatives' were specified to tackle them (FPM, 2016, p. 86). Of the latter, three were more overtly connected to tourism: better management of the tourism system; improvement to the transport system; and enhancing the liveability, commerce and residence in the historic city (FPM, 2016, p. 86). Elaborating a little further, the latter related to the rise of Airbnb, property market shifts, and the pricing-out of local residents from the central area, which remains a persistent problem (Buckley, 2021). Improvements to the transport system were intended to reduce pollution and congestion as well as to encourage greater connectivity around the city, in the process enabling greater access to off-centre attractions and other tourist infrastructure (FPM, 2016).

Of the three, the management of the tourism system [*sic*] – in its entirety or as an 'ecosystem' as some now depict it (Boes et al., 2016; Gretzel et al., 2015; Ness, 2020) – was intended as a means of overcoming an awkward dilemma. UNESCO ascription prevents limiting access to and around Florence (Korey, 2017). This means that, although overtourism had become (and continues to be) a major issue, restrictions on the number of visitors entering the city each day were (and are) prohibited. Instead, the city had to develop alternative strategies for managing visitors. 'Load capacity' was identified as a priority for the tourist system, in particular how to mediate or facilitate 'tourist flows'. Specifically, the solution lay in 'the development of innovative tools for information and tourism programming (smart city), the application of timely solutions for the management of flows and of the queues at the major museum attractions ...' with the onus on '... .tour guides, tour operators and promoter entities ...' to ensure '... .the decentralisation of tourist flows [is] founded on quality' (FPM, 2016, p. 81). The emphasis was to reduce congestion in the historic centre and to disperse visitors to less famous locations. These included the 'Buffer Zone', an area encircling the historic, fourteenth Century city walls which contains several so-called

'secondary museums' (Korey, 2017) and other attractions. However, of greatest significance in the context of this study is that the potential of smart approaches (i.e. 'smart city') is directly referenced, indicating the direction of thinking and favoured trajectory for future development. Moreover, beyond some of the euphemistic language, a closer reading reveals a preference for solutions that make use of new technologies, and that integrate the physical and digital environments (FPM, 2016), much as the literature on smart destination management has come to imagine (Boes et al., 2016; Buhalis & Leung, 2018; Gretzel et al., 2016).

Data sources

To investigate the first phase of the implementation of Hidden Florence (to 2018) and its role in visitor management in the city, use data from the three channels were investigated. From the WordPress blog and YouTube sites, data were collected from 2013 when they were first established for publicising the initiative as part of its 'soft launch'. Data generated from a third channel – the use of the Hidden Florence app – were collected from two sources – its two distribution platforms, iTunes and Google Play – on a quarterly basis from the formal launch of the app in 2014.

In principle, data from web sites and apps can be rich potential sources about users (e.g. their demographics) and their uses (e.g. the behaviours they induce). In practice though, there are important conditions constraining the nature and extent of post hoc analyses. Paramount among them are cost, access, time and the extent to which third-party hosting sites, web developers and service providers act as data controllers. The General Data Protection Regulation (GDPR) regulation implemented by the European Union in May 2018 requires measures to be in place to ensure privacy and that consent is obtained for the processing of data. Too extensive to discuss here in detail (see instead Mourby et al., 2019), GDPR formalised and consolidated preceding regulations in many jurisdictions before 2018 including Italy, and in so doing impacts on research practices.

Here, each user of the three main channels generated large volumes of basic data about use (e.g. number of downloads, openings, time of use) as well as the location of usage, either in-situ in Florence or away, elsewhere outside the city. In the case of the Hidden Florence app, this included navigation of the app pages, the locations (i.e. sites) they depicted and where they were consumed (i.e. in both virtual and real space). As we noted above, the data from the Hidden Florence app were hosted on third-party sites. This meant that there was no automatic (i.e. contractual) right of access to the highly granulated (e.g. geospatial) data, and the costs of obtaining (post hoc) permissions and/or finer processing of the data were prohibitive. Instead, the data on which this paper now reports were secondary data. Although generated by and for the Hidden Florence project, they were supplied by third parties in a pre-processed manner with aggregated, categorical values (n.b. a privacy safeguard).

Data quality and analytical choices

Hence, the choice of analytical approach was driven by the nature and characteristics of the data set. On the one hand, while the metrics reported later may be regarded as relatively coarse, on the other hand – and to the best of our knowledge – they represent the only continuous, differentiated longitudinal data set on the use of a heritage tourism app (cf. Graziano & Privitera, 2020). Hence, this paper represents a novel and valuable empirical contribution set against the prevailing trend for composite, cross-sectional analysis on AR apps in tourism (Liang & Eliot, 2021). Its major advantages are that it presents a census of users of the channels to 2018, no sampling was necessary, and no discussion of issues such as bias, skew or representativeness are necessary (as they would be of a sample). While descriptive statistics are mostly employed, these are entirely appropriate to the exploratory nature of the research. The application of more sophisticated techniques may have been desirable; however, the data mediated against adopting this approach. Indeed, a major methodological finding from this project is just how limited and limiting secondary data derived from

heritage tourism AR apps can be without significant additional investment in data design, governance and management.

Data analysis

The WordPress site attracted 38,052 views between its first appearance in May 2013 and March 2018, from 14,426 visitors at an average of 2.6 views per visitor. Although monthly and quarterly data exhibited some variability and suggested some cyclical effects (i.e. associated with seasons), the general trend over the period was modest growth in total users. Geographical distribution of the users was dominated by the English-speaking world which accounted for four of the top-five countries or 64% of the total (UK 28%, USA 26%, Canada 7%, Australia 3%). The exception was Italy where nearly a fifth of users resided (19%).

Over the same period, the YouTube channel was viewed for a total of 6288 min, with a total of 2916 views averaging 2 min 9 s per view. The mean varied little over the five years in which data were collected (range 2.0 in 2018–2.3 min in 2017). None of the content was watched in its entirety across the audience accessing the channel (Table 2). Even the short 30-second edit was, on average, only three-quarters viewed by the audience; the longer items were watched for around half their total length. Greatest monthly viewing was in August and October 2014 (600 and 350 views, respectively) after which, although some fluctuation was present, there was a general decline in viewing the channel as the content was not updated. In March 2018 there were still around 80 views, though. As per the WordPress site, users came from the same main five countries (UK 30%, USA 15%, Canada 5%, Australia 5% and Italy 15%), although the relative total shares point to a wider overall distribution beyond them. There were no significant differences in view times among the audiences from these main countries (range 2.24 for UK to 2.39 min USA).

The app was installed 3492 times in total (Table 3); Google Play (2897) was a more popular platform than iTunes (595). Monthly Installs from both platforms initially peaked in December 2016 (Figure 3), suggesting immediate and beneficial effects of coverage on *Travel Man* as a popular programme on prime-time, free-to-air TV in the UK (see above). Whereas iTunes downloads reverted to their more gradually-increasing trends afterwards, Google Play installs followed a more complex pattern. Decreasing through the winter, these started to increase to a peak in April 2017 which was largely sustained to August (i.e. during high season) after which it started to decline. Visitors from five main user countries installed the app (Table 4), with most from the UK and Italy but significant numbers were recorded from USA, Germany and France. While users in the UK, Italy and USA were also among the top visitors to the WordPress blog site and YouTube channel, those in France and Germany were not.

Variations in engagement were also evident across the platforms. iTunes users started the app on average 4.1 times each, while Google Play participated in just 2.6 sessions (Table 3). Average session length for Google Play users in 2017 was 7 min 5 s but there was a split in usage patterns. Session length was three minutes or under for 68.5% of users who mainly just quickly browsed the app. Just over a third (31.5%) used it more than this, of which only 5.6% of sessions were longer than 30 min. Sessions lasting 3–30 min involved listening to many if not all tracks of the guide and the more extended sessions of over half an hour suggest users accessing the external content available through the web site.

Table 2. Audience participation in the Hidden Florence YouTube channel.

	Video length (minutes)	Watch time (minutes)	Views	Average view duration (minutes)	Average percentage of item viewed
Project	5.27	4761	1901	2.5	47.6
Documentary					
Promotional Film	3.12	1462	845	1.7	55.5
30-second edit	0.52	66	170	0.4	75.0

Table 3. Installation of Hidden Florence app by platform.

	iTunes	Google Play
Installs	595	2897
Total sessions	2436	7408
Average sessions per install	4.1	2.6
Number of unique users	665	1569
% of those who triggered app	29.8	70.2

More detailed profiling from Google Analytics on Google Play/Android users as the most populous group (Table 5), explored differences between those using the app in Florence (i.e. *in situ*) and elsewhere (i.e. remotely) in 2017. Among the latter may be those at home or travelling elsewhere, outside the city: the data did not allow for a finer granulation. Over double the number of the Hidden Florence users accessed the app outside the city than inside it, although there was no significant difference in the average number of events for each user. Events are user interactions with content that are tracked independently from a web page or a screen load (e.g. downloads, mobile ad clicks, gadgets, Flash elements, video plays, etc.). Within Florence, 499 users started to download the app; again this was just under a half the number outside the city. The proportions who attempted to download the app were broadly similar (range 70.5–73.7%), as were those that successfully achieved this (range 37.8–38.2%) and those that made it from the web page to downloading the app at a little over a quarter (27.0–27.8%). Marginally more users in Florence who had managed to download the app, shared content from it via social media but at 5.3% of all users, this was still a small minority.

Tables 6 and 7 record the number of users engaging with core content for the Points of Interest (POI) on the tours (cf. Table 1) and extra content related to the curated narratives. Total interest in,

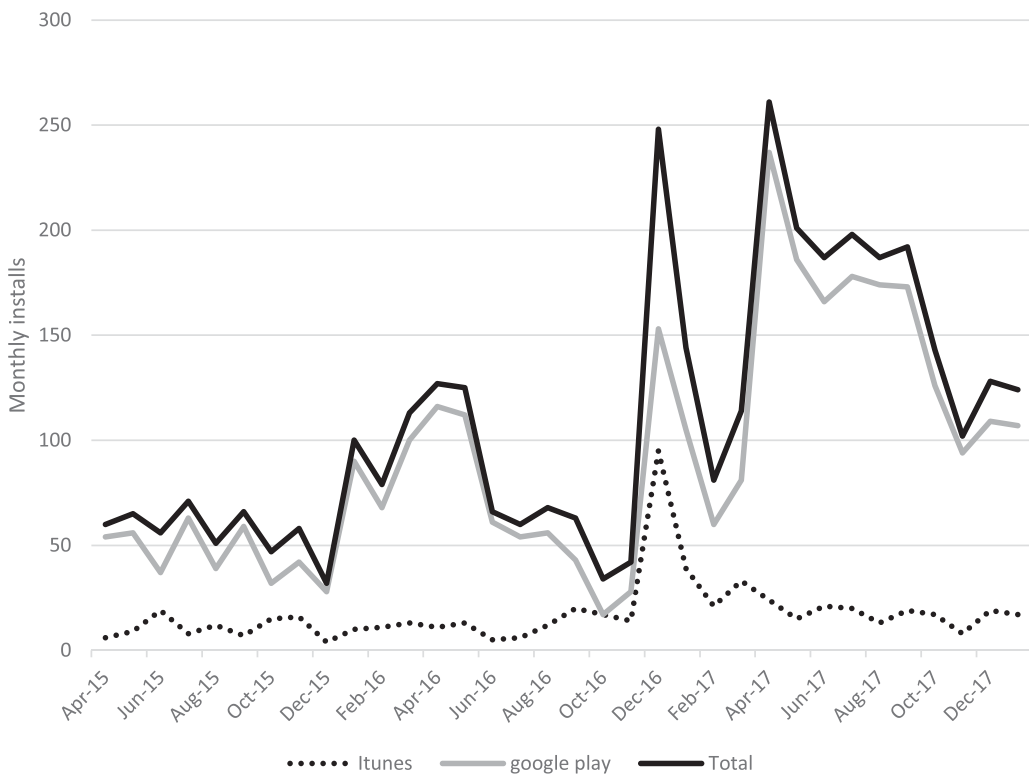


Figure 3. Monthly downloads on iTunes and Google Play.

Table 4. Geography of audiences and installations (2015–17).

Country	Google Play		iTunes	
	Installs	% installs	Installs	% installs
United Kingdom	698	24.1	255	42.8
Italy	524	18.1	191	32.1
United States	423	14.6	37	1.0
Germany	183	6.5	22	3.7
France	166	5.7	13	2.2
Others ^a	900	31.1	77	12.9
Total	2894	100	595	100

Source: iTunes and Google Play.

^aAll other countries which were individually responsible for less than 6% and 2% share of Google Play and iTunes installs, respectively.

Table 5. App usage data in 2017 for Google Play users.

User type. In:	Florence	Elsewhere
Users	681	1598
% of users	29.9	70.1
Number of events	2177	5001
Events per user	3.2	3.1
Number of users attempting downloads	499	1127
% of users	73.7	70.5
Number who completed downloads	189	431
% of all users attempting downloads who succeeded	37.9	38.2
% of all users who completed downloads	27.8	27.0
Number who shared app contents via social media	36	74
% of users who shared via social media	5.3	4.6

and engagement with, the Central Walk was higher than the San Ambrogio walk. The most plausible reason appears to be because the former was in closer proximity to, and more conceptually connected with, the city's marquee attractions than its latter, more peripheral counterpart. The Central Walk created around six times the number of events in total more than the San Ambrogio Walk for POIs and seven times for Extra Content Events. For both walks, users outside Florence generated more events than in-situ users; for both tours and types of events, this was around double the number in total. This was consistent with the higher number of app users outside the city than inside it, as noted earlier. For only one case in the Central Walk was the level of interest in a POI higher for in-situ users than outside users (Stop 6: Vicolo del Giglio); in all cases of extra content, use outside Florence was heavier than inside it. For the San Ambrogio Walk, the same pattern emerged with one exception: in addition to greater in-city demand for POI events at one stop (3, Via dei Pilastrini), there was no demand for extra content from either type of user.

Table 6. Engagement with the Central Walk, Hidden Florence.

		POI Events			Extra Content Events		
		Florence	Outside	Total	Florence	Outside	Total
1	Ponte Vecchio	204	463	667	123	286	409
2	Piazza Signoria	146	366	512	85	225	310
3	Canto del Bargello	99	221	320	65	159	224
4	San Martino	79	170	249	57	123	180
5	Orsanmichele	86	198	284	56	122	178
6	Viccolo del Giglio	69	67	136	42	105	147
7	The Opera Workshop	63	138	201	43	94	137
8	Piazza della Repubblica	67	145	212	43	61	104
9	Palazzo Strozzi	62	139	201	46	91	137
	Total	875	1907	2782	560	1266	1826

n.b. reference numbers refer to [Figure 4](#) and [Table 1](#).

Table 7. Engagement with the San Ambrogio Walk, Hidden Florence.

		POI Events			Extra Content Events		
		Florence	Outside	Total	Florence	Outside	Total
1	San Ambrogio Church	59	130	189	24	60	84
2	Via dei Macci	21	17	38	14	27	41
3	Via dei Pilastri	15	19	34	0	0	0
4	Canto al Monteloro	16	43	59	12	28	40
5	Piazza San Piero	33	60	93	14	40	54
6	Canto alle Rondini	13	45	58	9	29	38
	Total	157	314	471	73	184	257

n.b. reference numbers refer to Figure 5 and Table 1.

Tables 6 and 7 suggest ‘distance-decay’ effects in engagement with content, which Figures 4 and 5 reinforce. Care must be taken because these are abstract representations of the tours and there is no depiction (on the *x*-axis) of distance in ‘real space’: that is to say, the distance between data points (i.e. stops) is not constant in time nor space. Moreover, the material in the guides does not have to be consumed in strict ascending numerical order.

Notwithstanding, there was higher engagement with content and locations at the ‘start’ of a tour compared to its end. For the Central Walk, there was around three times the level of interest in POI events and extra content for the first stop (Ponte Vecchio) compared to the last (Palazzo Strozzi). A similar trend characterised POI events in the San Ambrogio Walk: demand for extra content was around two times as high for the first stop (San Ambrogio Church) compared to the last (Canto alle Rondini). Although flexibility was built-in to the app, users still appear to have engaged with material in sequence. Later stops tested their capacity to engage with the tour, especially the time they had available in-situ.

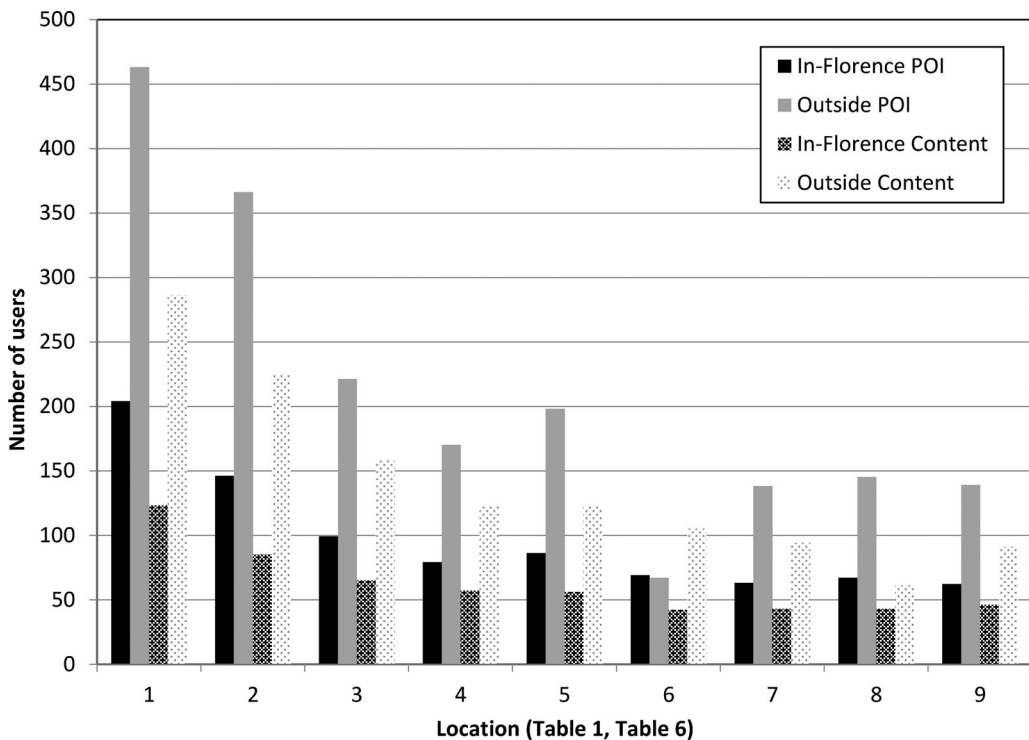


Figure 4. User engagement, Central Walk.

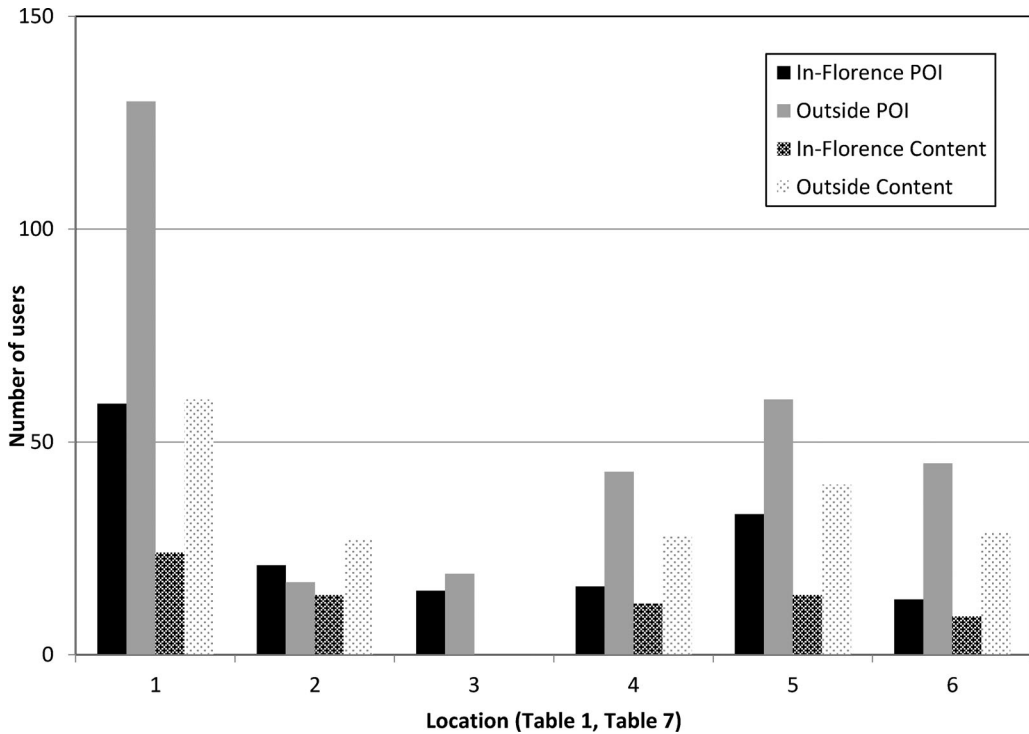


Figure 5. User engagement, San Ambrigio Walk.

Unlike archetypal distance-decay functions, there was instead some fluctuation in interest among the later stops. Engagement with POI events for Stops 5 and 8 (Orsanmichaele and Piazza della Repubblica) in the Central Walk was greater than the adjacent stops for both in-city and remote users. As with the final stop, there was greater engagement with extra content for Palazzo Strozzi than the previous stop, among both user groups. Within the San Ambrigio Walk, the distance-decay effect appeared weaker, and the final three stops, especially Piazza San Piero, showed comparable if not greater interest to the second and third stops (Via dei Macci and Via dei Pilastri). Finally, the relationship between marquee attractions and engagement was unclear. Admittedly, the highest engagement in the Central Walk was for Ponte Vecchio, the world-famous bridge, but, as a significant landmark, this was used as an anchor to start the walk. Stops 6 and 7 skirt close by the Duomo but did not attract significantly greater engagement with material than Stops 8 and 9. If the proximity to the cathedral was perceived (by either user group) as adding to the experience of this site, higher engagement may have been expected.

Discussion

Although only an analysis of relatively basic data, the results offer significant insights with respect to the strategic aims of the Management Plan (FMP, 2016), specifically its ambitions to disperse visitation, enhance connectivity to off-centre attractions, and to manage visitors flows, especially away from the most congested sites (FPM, 2016).

Prima facie, the contribution of Hidden Florence, over time, to realising the plan appears somewhat modest. There were more external (i.e. remote) users than in-city users of the app, and the number of in-city users represented a fraction of the number of visitors in the city each day. English-speaking audiences dominated the usership although the city attracts a much more diverse,

international visitor profile (CMF, 2021). Some limitations in the capability of the app to disperse in-city visitors into and around the 'buffer zone' (FPM, 2016) from the historic centre, were evident among the distance-decay effects. Furthermore, engagement with the digital content was relatively short, with some polarisation between those fully immersing themselves in the content and other users with comparatively limited attention. Recalling the question of 'whose heritage?' (Hall, 1999), the latter raises the question of whether the particular representation of heritage – specifically the periods covered or the curation – were ones which resonated with visitor audiences, although they are clearly compatible with the city's positioning (FPM, 2016, 2021).

Data of this nature present only a partial, arguably misleading view, though, of the value of AR. Strong use by remote users reflects the ability of digital media to enable places to be experienced when not physically present (Mohanty et al., 2020; Sarkady et al., 2021; Yung & Khoo-Lattimore, 2019). Experience in this manner and coverage on *Travel Man* has increased awareness of the issues that Florence faces, to much larger, international audiences. For instance, while the programme continues to be available on-demand (i.e. to download from TV hosting services) anywhere in the world, according to the British Audience Research Bureau (2021), 1.7 million viewers watched the initial 2016 airing in the UK alone.

We would contend that the contribution to destination management depends on the framing of the assessment and the expected level of beneficial change. High hopes for the potential of new technologies as future management solutions stem from narratives of the possibility, capability, and capacity of smart approaches (Buhalis & Amaranggana, 2014; Gretzel et al., 2016; Ivars-Baidal et al., 2019). As Hidden Florence testifies, AR apps can be relatively straightforward, comparatively cheap to develop, and are (in principle) able to deliver powerful insights into visitor behaviour through user-generated data. Even with a modest initial investment of £30k and highly selective coverage, significant, cost-effective outcomes were generated for the funders, municipality, residents, visitors and even the local UNESCO office.

The data presented here suggest it is also unrealistic to suppose that apps of this nature or scope will, of themselves and in isolation, result in wholesale and/or radical behaviour changes or visitor redistributions, especially in the short term. Alone, such apps will not provide the solutions to the grand challenges of mass and overtourism. With adoption of such technology still in its early stages, the main contribution of an app like Hidden Florence is limited – just as it has been in other locations (Graziano & Privitera, 2020) – focused as it is on awareness raising and encouraging shifts to begin by widening visitors' 'choice architecture'. In fact, this study challenges several assumptions about the way in which AR apps function alongside other affordances and services in urban tourism 'ecosystems' (cf. Buhalis & Leung, 2018; Gretzel et al., 2016; Ness, 2020). All are seen as integral and mutually reinforcing in the delivery of coherent, higher quality visitor experiences. Yet, there is very little discussion of the effective operating time-scales, future resilience and obsolescence, or the possible need to replace or upgrade individual components to maintain or improve the operation of the (destination management) system. Some commentators have argued that apps, like products, have particular life-cycles that are revealed through key performance indicators like downloads and user numbers (Vagrani et al., 2017). It is unclear whether the decrease in downloads from August 2017 is indicative of this effect. However, Figure 3 suggests that a distinctive component in a tourism ecosystem like an AR app needs more regular and frequent update to maintain its individual contribution to the collective management effort.

Thus, apps and other affordances and services are assumed to work in mutually-reinforcing ways. Within such systems of inter-dependencies, while apps complement existing infrastructure, products, offers and experiences, the latter have a reciprocal role to play in supporting, promoting or marketing the use of AR apps. Yet, this latter direction of reinforcement (from existing tourism infrastructure to new tech) seems to be overlooked. For instance, as a facility often perceived as important to the future of tourism (Moy, 2018), public WiFi is still not universal; certainly not in Florence and especially not in Santa Croce which may offer some basis for effects reported in Tables 6 and 7. Current studies of AR in tourism focus most extensively on the technology and

its intrinsic characteristics (Liang & Eliot, 2021; Yung & Khoo-Lattimore, 2019). In so doing, they divert attention away from the extrinsic conditions shaping the deployment, diffusion and utilisation of apps in destination management. Put another way and to adapt the metaphor further, many studies describe the features of urban tourism ecosystems and their components, including AR apps, but they overlook the ecology; that is, the relations and interactions of the ecosystem with the surrounding environment. An app like Hidden Florence exists alongside highly embedded forms of existing behaviours and destination structures. The majority of visitors are in the city for a limited time (FPM, 2016), and the centrally-located highlights are an understandable draw. Urban form is also a major influence on use. Mobile signal strength and GPS blackspots determine app use and stopping points for app-based tours. Visitors also require ancillary services such as cafes, restaurants, bars, toilets and shops. The San Ambrogio tour takes visitors to a less-visited part of the city in the buffer zone. Visitor infrastructure in the Santa Croce district is still relatively limited. Finally, at the time of writing, a search for apps containing travel advice and guidance on Florence in Google Play and the App Store revealed well over 20 possibilities, in English alone. Competition in the digital ecosystem for users interested in Florence is clearly intense, with very many apps concentrating on the principal attractions; in other words, directly counter to the logic of Hidden Florence and the city's management plan.

Conclusion

This paper has presented an examination of the critical issues raised by the operation of a heritage tourism AR app for the World Heritage City of Florence. Initially, Hidden Florence delivered two self-directed tours accessible both in-city and remotely via smart phones and other devices. This study makes two main contributions to our understanding of AR apps in urban heritage tourism and destination management. First, from a managerial perspective, several major practical challenges emerged if AR apps are to be employed as part of the management of established heritage destinations. These included generating greater in-destination usage, spreading visitation away from less popular spaces in Florence through completing the tours, and the practicalities of data protection with respect to accessing more detailed user-related data. In principle, the development of AR apps for urban heritage tourism offers a means of adding value to visitor experiences, with obvious potential benefits for destination management. Second and connected then, the paper acts as a counterpoint to some of the recent theorisations of, and advocacy for, the use of AR apps in, and smart approaches to, tourism management. While Hidden Florence has been embedded in the ecosystem of urban heritage tourism management in the city, its effects in altering visitor behaviours have been somewhat limited. In fact, this longitudinal perspective demonstrates that translating the conceptual possibilities of AR apps into longer-term management practices and beneficial change is a more challenging and potentially time-consuming project than permissive discourses around smart tourism concede (Boes et al., 2016; Buhalis & Amaranggana, 2014; Ivars-Baidal et al., 2019). Viewing AR apps as part of an urban tourism ecosystem in this study demonstrates the challenges of relying on underpinning technology and digital infrastructure in heritage tourism destinations.

This paper reports on one, albeit instructive case. There is potential for future research to take extended views of other similar apps with a view to corroborating these findings in other urban heritage tourism destinations. Hidden Florence has inspired the emergence of several other similar AR apps, for example in the Hidden Cities initiative (Nevola et al., 2022). Similar curated guides have appeared since 2019 for Exeter, Valencia, Deventer, Trento and Hamburg. Although still relatively early in their operation, in time these Hidden Cities will provide opportunity for comparative analysis. Accompanying them, a major update to Hidden Florence was published in 2019 (Figure 2), with new content. Not only will this have the potential to extend the longitudinal view, but it also offers an insight into the extent to which the 'product life-cycle' may be extended by addition to, and/or rejuvenation of, the offer. Finally, the coronavirus pandemic

happened after these developments. Comparison of user data from early 2020 to the end of the pandemic with the effective baseline presented in this paper will, in due course, add to our understanding of the extent to which digital (or ‘arm chair’) tourism formed a ‘travel substitution tool’ (Sarkady et al., 2021) for corporeal, in-person visits, or possibly even as a means of relaunching tourism (Mohanty et al., 2020).

As exciting as this clearly is, it is worth striking a note of caution. Future research on Florence and other cities is contingent on the availability and granulation of use data. The main limitation of this study, which is instructive to app developers, destination managers, policy-makers and even cultural organisations and institutions commissioning such apps, concerned user-related data which were not as readily available nor as insightful as they could have been when delivered as pre-prepared secondary data. More granulated and hence more useful data generate further costs in terms of obtaining permissions, managing them, and processing and retrieving information by or from third-party service providers (i.e. web developers or hosting services). Thus, in future research design involving AR app development and delivery, further careful consideration of data ‘processing’ is required. With this in place, there is demonstrably greater analytical and practical management potential, for instance through time series analysis or through a range of (multi-variate) statistical techniques for segmentation by socio-demographic, app usage and/or behavioural patterns of individual users.

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Notes on contributors

Fabrizio Nevola is Professor of Art History and Visual Culture at the University of Exeter (UK). His research focuses on urban and architectural history of early modern cities, with a particular attention for public spaces in Italy on which he has written and published extensively. His most recent book, *Street Life in Renaissance Italy* (Yale UP, 2020) accompanies several edited collections involving comparative work on urban space and his first book, *Siena: Constructing the Renaissance City* (Yale UP, 2007), was awarded the Royal Institute of British Architects, Sir Nikolaus Pevsner International Book Award for Architecture. Through several grant-funded research projects, including Hidden Florence, he has developed digital humanities spatial approaches using geospatial, 3D modelling and GPS technologies. He is currently project lead for the *Hidden Cities* (www.hiddencities.eu) initiative, funded by the Humanities in the European Research Area (HERA), and co-editor of a collection that explores this work, *Hidden Cities: Urban Space, Locative Apps and Public History in Early Modern Europe* (Routledge: London, 2022).

Tim Coles is Professor of Management in the University of Exeter Business School (UK), specialising in the sustainable development and management of travel and tourism. Much of his research examines the interface between policy and practice, including the critical issues associated with the adoption of new technologies to manage contemporary challenges in tourism development. He has a long-standing interest in visitor flows in heritage environments, previously publishing work on the City of Bath as a World Heritage Centre. He was a member of the original editorial board of the *Journal of Heritage Tourism*.

Cristina Mosconi is a Research Fellow in the University of Exeter Business School (UK) responsible for the EU INTERREG-funded VISTA-AR project developing AR and VR solutions for tourist attractions. She is completing her PhD in Art History and Visual Culture (University of Exeter) under the guidance of Professor Fabrizio Nevola. Structured as a collaboration with Calvium Ltd, a company specialising in geo-located audio tours, this examines the implications of the locative media interpretative solutions for urban history.

Data availability statement

The data on which this paper is based are available in aggregate form in an unpublished report compiled by Cristina Mosconi entitled Hidden Florence Analytics Report, 2017–18 which is deposited at <https://ore.exeter.ac.uk/repository/handle/10871/125232n>.

ORCID

Fabrizio Nevola  <http://orcid.org/0000-0003-1965-1383>

Tim Coles  <http://orcid.org/0000-0002-3142-3183>

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