What Happens in happn: The Warranting Powers of Location History in Online Dating

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ABSTRACT
Many location-based dating applications allow users to search for potential matches who are physically proximate. A recent mobile dating application, *happn*, adds a temporal dimension to location-based dating, showing users the number of times that they crossed path with each other, as well as the location of the most recent overlap. We conducted qualitative interviews with 15 happn users to understand how people make sense of crossed paths, as well as the meanings they assign to these location overlaps. We discuss the findings in the context of Uncertainty Reduction Theory, and show the various outcomes of the crossed paths and how they play a role in uncertainty reduction. The warranting power of the device-driven location data was accepted as valuable and generated little concern about misrepresentation. Moreover, people assigned meaning to the minimal cues available from the overlap data. In addition, the location overlap data was useful in allowing users to estimate convenience in meeting and establish common ground. On the other hand, concerns of security and recognition by known others persisted in the happn app. Our findings suggest the potential for utilizing location data outside of the domain of online dating.

Author Keywords
location history; warranting; online dating; mobile applications

ACM Classification Keywords
H.5.3. Group and Organization Interfaces

INTRODUCTION
happn (all lowercase) is a location-based mobile dating application that uses the overlap in two individuals' location histories to connect people and motivate them to meet. happn uses location history automatically captured by the mobile device to show users how many times their location overlapped with potentially matching individuals, and exposes the most recent such overlapping venue for each (Figure 1). In that, happn's location sharing model extends the recently popular location-based, real-time dating applications (LBRTD) [6,19] like Tinder and Grindr which are based on matching individuals who are *currently* in the same location, supporting "local and immediate" matching [6]. Using this convention, happn can be labeled *LBPHD*: a location-based, post-hoc dating application.[1]

The use of location history and location overlap information in happn is interesting because it provides built-in warranting. The principle of warranting [39] suggests that individuals prioritize identity claims in computer-mediated communication (e.g. online services) that are less likely to be manipulated by the poster. Usually, warranting of information posted in social media is done through the presence of friends or others that can validate identity claims [29, 40]. For example, on Facebook, deceptive self-presentation information can be pointed out or exposed by friends [40]. In dating applications, the profile may serve as a "promise" for future interaction [14], but often provides little warranting [15, 29] that leads to deception [36].

System-driven warranting like the one provided by happn is likely to be increasingly prevalent with personal devices, sensors and applications increasingly integrated into our lives. Under such a scheme, information is 1) collected and provided by an automated service, 2) reflects the identity of the individual, and 3) is not likely to be manipulated by any person. More specifically, in happn, personal location traces are collected by a mobile application and made available (in the form of overlaps with others) in a manner that is not easy to manipulate, hence providing at once potentially-meaningful information about the individual [33], and warranting for this information.

Using the post-hoc location overlap information, the experience of individuals using happn is likely to be very different than the "proximity-based co-situation" experience of LBRTD systems like Grindr [6]. In this work, we perform a series of semi-structured interviews with happn users to provide a better understanding of the experience of users of LBPHD services. In particular, we are interested in the value of the warranted location overlap information, and aim to address the following research questions:

[1] Yes the acronym has PHD in it. We are tickled.

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RQ 1. *How do people make sense and use information about location overlap when evaluating potential romantic partners?*

RQ 2. *What new benefits and drawbacks does location overlap information offer for dating applications?*

We discuss our results in the context of Uncertainty Reduction Theory (URT) that suggests that strangers looking to communicate will seek to reduce uncertainty in various ways [2]. URT had been applied to web-based dating sites [15] and LBRTD services [10]). The dynamics of these new LBPHDs, and more generally, of system-warranted information, are likely to produce new uncertainty reduction dynamics and practices. Our findings have implications for designing systems that seek to enhance the social awareness in physical spaces using location overlap information. Such applications for "hybrid placemaking" are not limited to online dating, and can extend to, for example, co-working places [4].

BACKGROUND AND RELATED WORK

Self-presentation plays a large role in dating services [14,18], where a user's profile is expected to be a *promise* that a person would not be fundamentally different from the way that they were representing themselves online [14]. However, given that dating profiles can be easily manipulated and subject to selective self-presentation [18,36], individuals on dating sites engage in uncertainty reduction [2] and uncertainty management [7] to support their needs and goals [10, 15]. Uncertainty Reduction Theory posits that when people first meet, they strive to make the interaction more predictable [2]. In online dating, in particular, people who have greater security concerns and higher self-efficacy about one's ability to be successful engage in increased levels of uncertainty reduction behavior [15]. However, as Corriero and Tong have shown, experience of uncertainty on Grindr, a dating LBRTD application, is complex [10], with individuals often showing a desire for uncertainty. We add to the findings of [10] to show the implications of location history and overlap for uncertainty reduction in LBPHDs such as happn.

Warranting plays a major role in constraining the degree of manipulation in self-presentation [39, 40]. As Walther et al. put it, "Warranting refers to the capacity to draw a reliable connection between a presented persona online and a corporeally-anchored person in the physical world" [40]. As a result, when someone is making a claim on their profile (an otherwise unreliable conventional signal according to Donath's signaling theory [13]), the presence of social connections acts as a warrant and can constrain the degree of deception, implying that "they have vetted this description as true" [13]. Researchers had proposed a system using warrants for verification of dating information, validating posted information against Facebook [29], a mechanism similar to what several popular dating apps (Tinder, Bumble, Hinge, and happn) use nowadays. These applications require Facebook accounts to log in and sync name, age, occupation and sometimes photos from Facebook rather than allowing the user to edit directly in the app. In addition to the warrants from the presence of social ties, users of dating sites could also engage in other strategies, such as searching for a particular user on Google [15] and check the consistency of the claims being made. Given the importance of warranting to online self-presentation, in particular in the context of dating where misrepresentation is possible [18, 36], we consider location history as a new warranting mechanism in the experience of happn users.

In addition to warranting, similarity is another key mechanism for both uncertainty reduction [2,17] and enabling social connections through homophily [24]. Homophily, colloquially referred to as "birds of a feather" [24], suggests that individuals are likely to have affinity towards others who are like them. Previous research shows that location similarity can help make connections between individuals [23] in some settings. At the same time, we do not fully understand the mechanisms through which this similarity is perceived and evaluated. For example, whether the frequency of overlap alone would be enough to establish a sense of similarity, and how individuals derive and estimate similarity from this information in the context of dating. Such understanding can provide key insights for system designers to rethink what information they could present to users to minimize privacy concerns [6] while still providing value.

Beyond its role in establishing similarity, location information often reflects personality, and is in turn interpreted by others as a signal of personality and social cues [25]. Researchers have shown that location information "portrays similar characteristics to other instances of online self-representation" [33]. Individuals use various types of location cues to communicate information to others (mostly in their social network) [20], and receivers are adept at making sense of these location-based cues. Most of this research focused on systems where users explicitly share their location "check-ins" [12,20,30], showing that people use Foursquare check-in for performative reasons [12, 30, 31], and have "concerns for presenting themselves in certain ways" when sharing location over time with friends [1].

In dating, location information has most commonly been limited to real-time location-based matching in the style of Tinder or Grindr [5, 6, 19]. Blackwell et al., in this context, have shown that Grindr "aggregates individuals across geographic spaces in ways that conflate and combine socially defined places." [6] – for example, not distinguishing between two adjacent venues that are very different in nature (e.g. a pub and a gym). The proximity data in happn similarly focuses on distance, and does not consider the exact venues frequented by individuals. However, since location data used in LBPHDs such as happn are both retroactive and longitudinal, it is possible that such confusion is less consequential. More generally, this work considers how LBRTD and the new LBPHD applications differ in the benefits they provide and the dynamics they produce.

In non-dating settings, research has long considered helping people who share physical environments to initiate connections. Previous research on location-based social networking applications has shown that simply displaying who is nearby does not necessarily turn strangers into acquaintances [35].

The "networked familiar stranger" [32], a concept built on Milgram's original "familiar stranger" [27] that describes how location-based services such as Foursquare facilitate local interactions with strangers, remains largely unrealized. Indeed, over 100 years ago Simmel had already pointed out the norm of sociability in the city and the blasé attitude that the modern metropolis possesses [34], making it difficult to initiate social interactions in urban settings. Several projects offered various paths for initiating social interactions, from allowing people to chat on their phone with passengers on the same train in Trainroulette [8], to sending a tweet to encourage strangers who checked into the same airport to meet up while waiting for their flights [16]. A better understanding of happn interactions could suggest new ways to use location data to help strangers connect and interact in various physical environments.

To summarize, the happn application presents a unique opportunity for a case study to understand how location overlap information can support uncertainty reduction in a dating context. Such understanding, informed by the theories of URT and warranting, can offer implications for the theory and design of services that connect strangers in dating contexts and beyond.

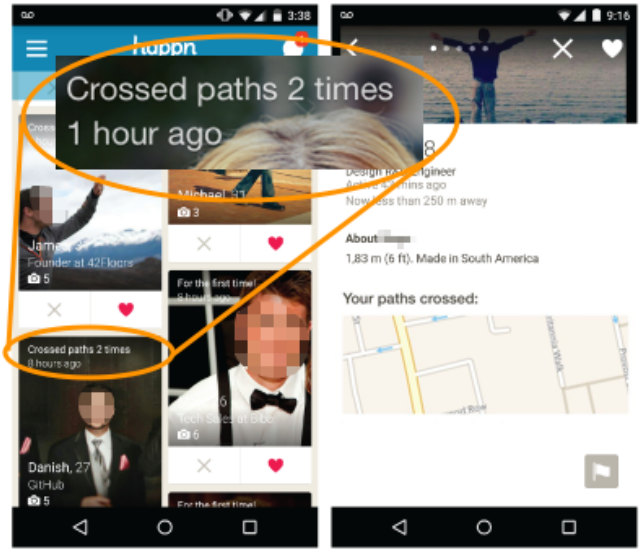

Figure 1. Landing page for the happn app, where users can see how many times they crossed paths with someone (left) and profile page with map displayed showing where a potential match crossed paths (right)

THE HAPPN APPLICATION

In this work, we examine happn, a location-based post-hoc dating application (LBPHD). happn is different than location-based *real-time* dating applications such as Tinder, Bumble, and Grindr: these applications mostly use geolocation to match to people that are nearby at the same moment. The happn app, on the other hand, adds a temporal dimension to location, and uses the location history to present users with how many times their location overlapped with potential matches *after* the occasion in which they overlapped. Launched in early 2014, happn is a France-based start up. As of Jan 2016, happn reported having 10 million users.[2]

There are two types of location overlap information that happn makes available to users, both shown in Figure 1. First, happn shows the number of *crossed paths*: how many times the individual using happn has overlapped in locations with others using the app. In happn, location overlap is defined as when two individuals are within 250 meters at the same time[3]. The app tracks users' geolocation through their mobile devices to find other individuals with whom the user has "crossed path", and displays their profiles in the user's feed. The number of crossed paths is displayed on top of the other individuals' profile pictures in the feed, which is the main page of the app as shown in Figure 1. Second, happn shows a *recent place*: a mini-map showing the time and location of the most recent overlap is available once the user taps on a profile, also visible in Figure 1. These two features of location overlap information are the novel design features of happn. While building on detailed location tracking, individuals do not surrender their complete location history to others; only the most recent overlap, and an aggregate count of all the other overlap occasions are shown.

The interaction flow of the happn app is quite simple, and mimics other popular dating applications. A user logs in to the happn app and creates a profile by uploading pictures and writing a short bio. Then the user can see the profiles of other users and filter by gender and age in a "feed". A user can see the detailed profile information noted above by tapping on another user's profile picture. To interact with users that appear in the feed, a user could click on a heart-shaped button to indicate that they like the other user. If two users like each other, the app sends both an alert for a match, after which they could start messaging through the app. A user can also send "charms" to others. In this case, the "charmed" user will receive a notification regardless of whether they liked the other user or not.

METHOD

We designed a semi-structured interview protocol and used social media and snowball sampling to recruit participants who have used the happn application for more than a month. Broadly, the interview protocol had 24 questions that asked participants about the basics of the application to elicit their understanding of how the app works, the information they pay attention to when using the app, their interpretation of the number of crossed paths and the recent place mini-map, the difference between crossing with people once versus twenty times, and whether they had ever seen someone offline that they had met on happn. Finally, the participants were asked about whether they use other dating apps, and the key differences between happn and those apps.

We recruited participants by posting on social media, such as Facebook and Twitter, and on Craigslist. We also used snowball sampling: at the end of each interview, we asked

[2] http://techcrunch.com/2016/01/19/dating-app-happn-reaches-10-million-users-adds-voice/

[3] according to the application's official website description, https://www.happn.com/en/faq

the participant to put us in touch with other users of the app who would like to be interviewed if the participant knew any. The interviews were conducted by two of the authors through Skype or Google Hangout with voice recording between August 2015 and February 2016. The recordings were transcribed by a commercial transcription company. The interview protocol was approved by an Institutional Review Board (Protocol #1508005747 on August 7, 2015). Each participant was compensated $10 for the interview that lasted approximately 30 minutes.

Two of the authors reviewed and coded the transcriptions independently, before the same two authors compared codes. Similar codes were merged and themes were extracted. Themes were further refined by all authors during the sense-making writing process. The unit of coding was discourse segments that pertained to the same topic (could be a single sentence, several adjacent sentences, or a paragraph). The coding was done in a serial fashion, with each coder coding all responses from one participant before moving on to the next. The disagreements between coders were resolved through face-to-face discussions, with each coder explaining the reasons for his or her own codes and everyone agreeing on one.

A total of 15 people participated in the study, with reported ages between 22 and 42; eight were male and seven were female, residing in four different countries (most of the participants lived in the U.S., two Brazil, one France and one UK). Only two participants were recruited through snowball sampling. One participant reported meeting her current significant other through the application. We summarize the demographic information of participants in Table 1. The reported duration for using the application varied from two months to a year, and reported frequency of usage varied from checking the app every hour to once every other day. Most participants heard about and downloaded the application through word of mouth.

ID	Gender	Age	Location	Occupation
F21	Female	early-20s	San Francisco, CA, US	College student
M22	Male	22	California, US	Software engineer
F23	Female	23	Lansdowne, Mass, US	–
M24	Male	24	Brazil	Student
F25	Female	25	New York City, US	Account manager
M25	Male	25	San Francisco, CA, US	Tech
M26	Male	26	Paris, France	Entrepreneur
M28	Male	28	Berkeley, CA, US	MBA student
F30	Female	30	California, US	Local health system
F33	Female	mid-30s	London, UK	Tech entrepreneur
F34	Female	34	New York City, US	Designer
M34	Male	34	Southern Brazil	University teacher
M38a	Male	38	New York City, US	Research scientist
M38b	Male	38	New York City, US	Security consultant
F42	Female	42	New York City, US	Founder of dating app

Table 1. Demographic Information of Participants

FINDINGS

The main themes from our interview analysis can be organized into three main areas, following the interview themes and research questions. First, we look at how users interpret the location overlap information, the number of crossed paths and the most recent place, available from happn. We then show how this information is appropriated by users for various uses. Finally, we show the relationship between online and offline interactions and encounters that are enabled through the app.

Interpretation of Location Overlap Information

Recall that happn shows users the number of "crossed paths" they have with another individual, and a map of the most recent place where they crossed path with that individual (see Figure 1). Overall, as we show in this section, our participants used this data in various ways to extrapolate information about the other user. The location overlap information, even when represented as a broad map and simple count, provided perceived similarity between users. At the same time, the recent place map could imply either positive or negative potential for matching, depending on the location.

Inferring Similarity

Participants reported noticing a wide range in the number of crossed paths with others on the app, from one to several hundred. For some, the number of crossed paths was a proxy for similarity. M24 described, *"I'm much more likely to talk to a person that I crossed paths 20 times, because we are in the same place. We have similar habits and it's more likely for me to feel safe and for her, too...By the places that I go, by the place where I work at, by the place where I study at, the people who are in those places they are more likely to be alike."*

F25 indicated a *"golden zone"* of having crossed paths five to ten times. *"Less than that, I think it's just chance. They could have for two or three days gone to their friend's apartment in the East Village. More than that, it's because we probably worked in and around the same place."* M26 explained, *"I saw her maybe five times via the app. So, maybe she's working around? Or maybe she's living around my place."* As a result of inferred similarity from crossing paths, people used happn to *"find people that are actually in the same places, or about the same places that you are. That go through the same streets, hanging around the same places that you do, and this feeling is nice. (M24)"*

Meanings of Different Locations

Beyond the number of crossed paths, participants reported extracting meaning from the happn feature showing the place where the most recent overlap occurred. M28 suggested that this location information on happn might be more truthful than other profile information; In contrast to the fact that *"everyone clicks foodie as a tag on their Hinge,"* M28 argued, *"the happn version of it actually would be better, to see that they actually go to that place."* For example, crossing at a touristy area could indicate that a person does not have long-term potential. F21 said, *"In a touristy area, they are probably a tourist, so I probably would never see them again. Or they work at the tourist spot. If it's a cafe, I'm pretty sure they are a regular so I would be more likely to see them again."*

These crowded areas also carry less meaning than unique venues that indicate interests. M34 explained that since he lived downtown close to a bus stop, *"People are passing around all the time... Everyone crosses paths around here."*

The meaningful locations tend to be the ones that indicate a person's hobbies and lifestyle. F34 described how an infrequently visited area could reveal a specific interest. *"Because the climbing gym I go to is in Long Island City and, especially at night, there's not really a lot happening in that area, so if that's where our paths had crossed I'd be like, 'Oh, maybe this guy climbs'..."* Another participant indicated that the specific venue itself was not as important as the category of the venue. *"I'm seeing it as the activity of Tahoe is go skiing, the activity of Napa is go wine tasting as long as [you] know that they went to a winery and you went to winery, you don't actually need to know that you were at the exact same winery. (M28)"*

The uniqueness of a situation could also be meaningful. F25 recounted, *"I was in deep Brooklyn. I went a warehouse party and I randomly opened happn on the subway...I saw that there was a person not far from me who I had [matched with], because I had walked to the venue and gotten dinner. I figured that they must have been in the area. I chatted with him a little bit and then at least I knew then that we had this weird, shared experience of taking the subway thirty minutes into Brooklyn."*

The time of crossing, such as in the morning or during the night, could reveal a diurnal pattern that was often meaningful. For example, as F34 described, *"If it was 11 o'clock and they were active, then I guess I was like, there's a chance that they were at home or they were walking to their apartment at the same time I was walking to my apartment. But you don't necessarily know that they could have just been going to a bar that's nearby."*

When Overlaps are Negative

However, not all crossings were perceived of as positive or at least neutral. Four participants indicated a hesitancy to match with people in certain locations, such as around where they live. F30 described it as a desire to not *"wade in that territory,"* a sentiment echoed by M24 who said, *"If someone matches me when I'm at home, it would feel weird."* Several participants were particularly wary of matching with people that live in their vicinity because of their perceptions of their neighbors. *"The area that I live in is very residential and family versus downtown where I use it, there's a lot more my type of crowd. The folks that I would want to hang out with or go out with. (M25)"*

Friends in Common versus Places in Common

A topic that arose during conversations with six of the participants was the comparison between location overlaps and overlaps in social networks (e.g. Facebook friends, a feature of Hinge, a competing dating app). While both applications provide a level of warranting and verification to users, they did so in different ways. F25 said, *"it felt safer with the checks with your Facebook, so [the app] verifies person and had to be friends through Facebook which I thought was pretty secure."*

Comparing Hinge and happn, M25 said that having a friend in common is *"a closer connection"* compared to having a location in common. He explained, *"Your friend can give you input or can be like, yeah, I think that'd be a good person to go out with or have a drink with...Hinge is the most qualified, then happn just because you're in the same area, and then tinder, where you have no idea who the person is."* M28 also thought that friends of friends was a greater signal for similarity than location overlaps when he said, *"I find that I have more in common with the people that I'm matched with [on Hinge]. I feel like with happn, it's really anyone that's come across your path. For example, in a town like Berkeley, yes there are more students, but there's also just people from all walks of life doing all sorts of different things, and you don't necessarily see as much information about them."* However, relying on pre-existing network connections can present its own challenges, the limited coverage for example, or like F42 who lives in New York City said, *"the problem with that one [Hinge] is that some [of] the friends of my friends live in Australia and I'm like, 'Okay, that's not gonna be fun'."*

Appropriation of Location Overlap

Location overlap data allowed users to learn a variety of information about a person of interest and assess similarity, but it was also useful to enable smooth interactions later, including allowing people to assess the convenience of a potential meeting, and providing a source of common ground.

Convenience

In part because of similarity, location overlaps also indicated if someone might be convenient to date. A higher number of crossed paths was necessary to infer convenience; otherwise, people had more difficulty interpreting whether a potential match worked or lived near them. F42 explained, *"When you see somebody 90 times on happn, they clearly live near you. So, that could be a good thing if you want a convenient person to date. You don't have to spend money taking a cab to go see them."* M26 expressed a similar logic, *"It's easier for us to have lunch because I know where you're going to have lunch, and I know that you're working maybe around my place."*

Common Ground

Location overlaps could be a source of common ground to be used as a point of discussion when messaging someone of interest. Six participants mentioned using the map in messaging conversations. M25 explained, *"most of the conversations have been based on the pretense of the app itself. It's like 'oh, I was just at this place. It's really interesting that we didn't bump into each other, but hey, we're on happn.' That's usually a good conversation starter because we have something in common."*

M26 found that location overlaps provided a broad range of topics that could be used to facilitate conversation. *"You can have a different approach about talking to her, and you have more common point about the fact that you can talk about your city, or the area, the neighborhood, or maybe we have friends in common, or maybe we are going out at the same place around the neighborhood, or where you work...so it puts some more points, some more key points and common points than somebody you don't see and that is living far away."*

F34 provided another example of how a particular location overlap could lead to conversation. *"Let's say we went to the same concert. I'd be like, 'Hey did you like that show? What other music do you listen to?"* Even ambiguity in location overlap prompted a conversation for M38b. He recounted, *"She works for another company that is adjacent from our building so in conversation we were asking each other where we could have possibly crossed paths like if it could have been in the doughnuts over there or if it's at the diner."*

None of the participants mentioned using the location overlap information when meeting a date in person, potentially suggesting that its utility was primarily for initiating conversations through the app, although it is possible that the topic did not arise as our interview's main focus was on app-based interactions.

Online Meets Offline

The temporal and geographic overlaps presented by happn allowed for the possibility that users would see one another "offline", without planning to do so. Such encounters served as verification that the person matched his or her profile, but also lead to privacy concerns and awkward social situations.

Seven out of the 15 participants indicated that they recognized someone (ranging from one to five people) from the app in real life. The app surfaced people that otherwise may never have been noticed. As M25 explained, *"it's just interesting that you could cross paths with someone like eight or nine times and never really even see them or realize that that's them."* This can be viewed as a type of "familiar stranger" interaction [26].

Because the signal that happn provides is a combination of offline and online, M26 felt a sense of "trust" that *"you can find out if it's real or not"*, which is difficult to establish when the interaction initiates online. M26 explained, *"it was the fact that you can recognize people on the street and maybe before chatting, you already see them and it's better than the other app because it puts some more human thing in the application... But happn gives you the sensation that it can be real... because maybe you can walk on the street, you see somebody and you open the app. You can also see her on the app."*

At the same time, this very mechanism could also compromise the safety and privacy of users, a topic discussed by six of the participants. M34 said, *"From where I live there's a bunch of people that work nearby, that study nearby, and if I wanted to I could easily follow them."* M38b also echoed the possibility of being followed, *"say you encounter a stalker or something and the next thing you know he knows where you're eating, he knows where you shop and everything."*

The privacy concerns of two participants were rooted in their real experiences. F33 recounted seeing someone in the app and then passing them on the street, leading her to describe the app as *"a little bit stalker-ish"*. M24 explained how he had "liked" a girl in the app when he heard her react near his vicinity. *"I looked around and there was the girl inside my classroom. It was freaking scary."*

F30 summarized this dichotomy by referring to the application as a *"cool stalker app,"* explaining that *"If you think about it, like I know who lives across the street even though I've never met him and I know what his hobbies and his likes and dislikes are all from this app. So, I mean, that part of it is kind of weird, but it's also kind of cool because you could see who has the same interests as you in terms of where you like to go or where you like to eat."*

Another privacy complication of the happn location-based interaction was the high likelihood of context collapse: encountering a profile of someone you know in work settings, or other professional or social settings that is often perceived as incongruous with dating. Unlike Tinder or similar apps that are only used on demand (and still demonstrate context collapse issues [6]), happn by default shows overlapping paths that are highly likely to include work or home locations. As a result, five participants described "in-app recognition" of people they already knew from other settings. Such encounters were usually described as "weird" or "awkward," contrary from the experience that the app has attempted to create. Many of the recognized users were co-workers or classmates with participants, and it is considered an embarrassing situation when users see people that they know in other contexts.

M34 described how he matched with a future co-worker. *"We actually matched on the app and got to meet on [the] first week of school. It was very weird."* He went on to explain, *"We talked a bit on the app but it didn't work out. We did not talk that long. And on first week of school, all teachers together, I looked to the side and, 'Oh I know that girl.' And she looks at me and kinda looks like, 'Okay I know that, but no I'm not gonna talk to him.' And I was not really in the mood to talk to her as well."*

M22 explained how the norm is to *not* openly acknowledge this recognition when matched with someone you know. *"There's sort of an unspoken rule that if you see someone on a dating app, you don't mention it to them in person"*, perhaps to maintain privacy through contextual integrity [28]. F21 verified this with her experience when matched with other students. *"Sometimes I'll see that I passed someone I know on the app and then we happen to be in the same class. He's never said anything and I've never said anything, so it's that mutual not talking part."*

DISCUSSION

We relate our findings to multiple facets of Uncertainty Reduction Theory (URT). Central to URT is that "when strangers meet, their primary concern is... increasing predictability about the behavior of both themselves and others in the interaction" [2].[4] As we mentioned above, URT has been used in the past to discuss and reason about online dating [15], including location-based real-time dating service Grindr [10]. Our findings suggest that happn, with the dyadic location overlap exposed by it, creates somewhat different URT dynamics than other dating systems.

[4] A more recent theory of uncertainty *management* expands on URT with introducing the idea that individuals may *desire* uncertainty at certain contexts.

The warranting power of the location overlap data in happn plays a major role in reducing uncertainty. Previous research cited "concerns over misrepresentation and deception" [15] as a major factor in the need for uncertainty reduction in dating sites. This concern was also the one most cited by Grindr users [10]. In our interviews, though, such concerns were very limited, an outcome we believe is due to the high warranting value of the location data. Warranting refers to the ability to evaluate or validate the information presented in an online profile [40]. Traditionally, and especially in dating sites, reliance on self-presentation is prone to profile misrepresentations, and profiles are perceived as such [15, 18]. However, individuals "privilege messages that cannot be manipulated" [39], or, in other words, high in warranting value. This issue was directly addressed by M28 when he compared the truthfulness of the location overlap information in happn to tags people use on Hinge. Our participants perceived the happn location overlap as an honest signal, and as a truthful representation of identity. Concerns about misrepresentations were not raised. In Donath's terms [13], the location overlap allows individuals to rely less on conventional, easy-to-fake signals, and was treated as an assessment signal that people take on its merit.

An interesting finding relates to how the hyperpersonal model of communication [37] seemed to play a role in how individuals on happn, as message receivers, interpret the location overlap information. The hyperpersonal model predicts that message receivers will tend to exaggerate perceptions of the message senders, make over-attributions from minimal cues, and fill in missing information [37]. In particular, the model predicts that contextual cues will be used to find similarities to sender, for example, group identification and personality match — a prediction that aligns very closely with what participants reported in the interviews (e.g., F34's climbing gym experience quoted previously). It helps, of course, that location information such as neighborhood and venues are known to reflect (and be interpreted as reflecting) personality and social cues [25]. It is clear that certain location cues provided by happn will have much higher signaling value than other such cues, based on the qualities of the location and dyadic information (uniqueness, number of crossings, context, etc.). Note that the receiver interpretation is happening even when senders are not able to craft their message as is normal in CMC settings and predicted by the hyperpersonal model [37, 38].

Not unrelated, similarity is another concept that plays a significant role in uncertainty reduction, and was suggested as one of URT's "axioms" [2]. Individuals on happn have various rules and mechanisms for deriving similarity from happn data. Those mechanisms often exhibit explicit homopholous tendencies (see M24's quote above about people "more likely to be alike") [24]. In some cases, individuals estimated similarity from the recent place map. In other cases, individuals were estimating similarity by the number of crossed paths.

Reciprocity is another "axiom" of URT [2], and holds that high levels of uncertainty produce symmetric levels of disclosure where individuals "ask for and give the same kinds of information at the same rate of exchange". Unlike other dating apps where users "consider the risks of sharing such information with strangers absent confirmation that others are being honest in their disclosures" [15], happn builds symmetric disclosure right into the user profiles: the location overlap. On the other hand, such built-in disclosure mechanism might break the chain of self-disclosure begetting more self-disclosure, as described in previous research [15].

Security concerns are known to play "the greatest role in influencing uncertainty reduction behavior" as was found in a general dating survey [15], though more recently security was not tied to desire to reduce uncertainty in Grindr [10]. It is likely that happn may reduce such concerns by the nature of information available, though our participants certainly still voiced security considerations. A related risk of recognition, being identified by someone who knows you, is perhaps even heightened in happn compared to other dating applications. In dating systems, individuals are concerned about having profiles recognized by known others, such as friends, family, or work colleagues [5, 6, 10, 11, 15]. Such risk is greater in location-based dating applications [10] where the chance of encountering known people around you is higher than in online browsing of profiles, and was even higher with happn as we show above.

Our findings indicate that location overlap cannot fully replace the common mechanism for warranting via shared social network. Network-based warranting posits that information posted on an individual's Facebook page, for example, cannot be easily faked [13, 40]: the presence of other friends makes it unlikely for an individual to post deceptive content. However, in dating sites, because of privacy concerns, the opportunity to verify or warrant information using a social network is limited. Our findings show that the warranting value of location does not quite achieve a level of uncertainty reduction that could be achieved via common friends. On the other hand, the *potential connections* made through location overlap are much more widely available (as the likelihood of friend overlap with other individuals is not as high), and does provide non-trivial value.

A major assumption of URT is that strangers engage in exchange that is geared to removing friction of future communication [2]. In the case of happn, our findings show a number of ways in which friction is reduced: participants talked about drawing conclusions about convenience of meetings, and discussed using the "common ground" from the location overlap information as a discussion topic and conversation starter when they first converse. Thus, the information available from happn is richer and allows for more uncertainty reduction than dating apps like Tinder that do not provide overlap, and require real-time interactions around the location without much context.

This work has implications for "hybrid placemaking" – designing for places "where its digital and physical space equally contribute to its perceived values" [3]. While we investigated crossed paths in the specific context of dating, such location overlap information has the potential to be used in other settings. Location overlap information, as a link from

the physical to the digital world, can be used to increase the awareness of others who are in the same physical space, as well as facilitate collaboration and social encounters. The popularity of Pokemon Go, an augmented reality game that tracks location, is a platform that further social applications could piggyback on (e.g. match players based on the the number of same PokeStops they have been to.) In other scenarios, residential or office buildings could install ambient displays as a lightweight way to increase the awareness of residents or tenants in the building, who frequently cross paths with each other but do not interact.

Finally, our findings may offer insight towards building tools to enable trust in social networking sites and services. We have shown that implicit signals such as tracked location history are perceived to be more honest and less prone to manipulation. As more and more social systems facilitate offline social exchanges, often forming a marketplace, such as Airbnb and Uber, it is important to consider strategies to ensure the accurate representation of identity as well as the perceived trustworthiness of other users. Warranting, implicit signals, and system verification are strategies that we observed in happn that can contribute to higher trust, and could prove meaningful in other settings as well.

LIMITATIONS

This research is not without its limitations: by choosing to interview participants, we prioritized depth of information over generalizability of our findings. While we attempted to recruit a diverse set of interview participants, many of our participants were from the coastal United States, potentially leading to cultural bias in our results. Previous research on cultural differences in use of social network sites suggests that such differences may also exist in online dating app usage [22]. In addition, the self-selection bias in our sample of users may distort our findings, for example as those that agreed to be interviewed could also have more open personalities. Similarly, relying on snowball sampling could have limited the type of users that we spoke to. Our method of interviewing relied on self-report, and as dating can be a private subject matter to discuss, participants may not have disclosed all of their relevant past experiences.

Our qualitative, self-reported approach may have missed behaviors that could be more easily gleaned from data. For example, it is possible that people turn on and off location services, or temporarily disable location tracking in order to hide their location or control what is visible to others. Understanding whether such behavior exists, or the magnitude of such behavior requires access to log data, and is left for future work. Other open questions include how much such agency may impact the perceived value of the logs by other users, or more generally, how to balance the need for agency and control on one hand, with the usefulness and warranting effect of the data on the other.

CONCLUSION

Building on interviews with users of the mobile app happn, we investigated how individuals interpreted and made sense of crossed paths signals: the location overlap between two individuals using the application. We show that this type of information allows people to reduce uncertainty in various ways that expand on other dating apps. The warranting aspect of location information – the fact that it was viewed as something that cannot be easily manipulated – helped make it into a more potent signal. Based on our findings, we offer the potential for utilizing location overlap information to develop platforms for facilitating social connections in other environments. As a greater number of applications leverage location data, the ethics of how this information is disclosed is a growing concern [9,21]. Ensuring user's privacy and personal safety, potentially through aggregation and anonymization, will be an important component in future work in this field.

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