Making Sense of Screen Mobility: Dynamic Maps and Cartographic Literacy in a Highly Mobile Activity

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ABSTRACT
Dynamic, digital maps are increasingly used in many settings. It is an emerging domain of technology extending on previous maps studies and positioning technology. We draw upon ethnographic field studies of collaborative hunting, where hunting dogs are tracked and their location made visible on digital maps. We discuss mobility of two different kinds. First, we refer to mobility as the practice of physical movements of hunters, dogs and prey. Second, we refer to the movement of symbolic objects on a digital map screen, i.e. screen mobility, and the interpretational work that the hunters do to make sense of it. Representations of motion on a screens, are of ongoing practical concern for the hunters. We show how they interpret such mobility in terms of accelerations, distance, trajectories and temporal alignments. The findings are used to revisit mobility theories and populate them with new notions to inspire design in broad domains.

Author Keywords
Screen mobility; GPS; dynamic maps; mobile technology; hunting; dogs; ethnography.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
In recent years we have seen a proliferation of real-time geo-systems, often called *dynamic maps*, which rely upon representations of objects' movements on maps [26]. The weather chart is perhaps the most classic example of a dynamic map, where the continuant fluctuation of the meteorological conditions is represented on a map. Recently, dynamic cartography has found its way into such varied practices such as the tracking locations of friends, peers or prisoners [25, 34], as well as the representation of air traffic [30]. Despite the proliferation and popularity of these technologies, we still know relatively little about how the users of such dynamic map technologies bring the information on the screen into play in their everyday activities.

In this paper, we discuss a case where representations of mobility on a digital screen are a practical concern for the participants. We describe the details of the social and interactional work that goes into making sense of the screen information, as part of the situated achievement of mobility work. In doing this, we re-examine two previously published field studies of hunting. In the first study [20], the hunters relied upon broadcast radio talk to coordinate the hunt. In the second study [36], two of the hunters were using a dog tracking system with a dynamic map. In this paper, we revisit our material, focusing on the hunters' orientation to mobility. In hunting, mobility is a practical concern for the participants as an integral part of the activity. They are engaged in tracking to localize moving objects such as dogs, prey and sometimes other hunters. In this work they orient to different forms of mobility, in that they need to understand how all these actors move through the terrain. This enables the ethnographers to get an understanding both of what we refer to as "screen mobility", i.e. the representation of physical movement on the dynamic map, as well as the participants' ways of accounting for these movements.

The empirical findings have implications for both mobility research and for technological development of mobile geographical information systems relying upon or involving location, tracking and navigation. First, the mobility concept has not only received extensive attention within the social sciences [e.g. 11, 35], but has also been widely adopted into various strands of research within human computer interaction [14, 29]. The latter is not least boosted by the commercial success of mobile technologies, and as a means to identify differences between mobile and desktop centered human computer interaction. At the same time, the conceptualization of users' everyday mobility practices seem to be underrepresented, and the analytical frameworks describing how people are doing mobility are still few. This might lead to missed opportunities for design of future mobile applications, as well as missed influences in the generation of next generation technology. Fortunately, the emergence of new technology reveals ways in which mobility is a concern for the participants, which then makes it possible to develop and extend our concepts. The research presented

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here adds to previous work by discussing how users make sense of physical movement as part of a practical activity.

Second, studies of mobile geographical information systems within HCI has focused primarily on the issue of location [4, 23], that is the localization or tracking of moving objects, rather than focusing on the physical movements per se, and the ways that these systems are relied upon to carry out different activities. Thus, the present study is also of relevance for research on both navigation systems and tracking systems. Other studies concern navigation systems, which continuously display where a user is located relative to a passing landscape. This type of tracking systems keeps a record of the location of a user in an environment. The studies of navigation have focused on how wayfinding instructions fit with driving practices [19], as well as how such systems fit embodied practices of finding a way through an environment [7, 23]. The studies of tracking have examined accountability in use of tracking systems and their consequences for e.g. family relations, parolees and parole officers [26, 34]. In contrast to much of this previous work, our study is not about wayfinding but rather about the participants' work to locate moving objects. In doing so, they reveal and make available for analysis their own ways of accounting for physical movements.

Third, our empirical findings provide new insight into the use of dynamic maps, being a new form of map technology. New map technologies require a new type of cartography literacy "in which calculations switch between the flat representational plane of the map and the anticipation of embodied movement through a landscape. (…) "These successive shifts from abstraction to experience require fuller consideration." [24]." One such example is *alignment*, i.e. how the map is matched to the surrounding environment. When the map is dynamically updated, we encounter challenges in these alignments procedures. In addition, while some researchers have suggested that dynamic maps allow for a de-skilling in navigational tasks and a disengagement with the environment [1], we show how the integration of this new type of geographical information takes work, and relies upon the hunters' underlying knowledge and experience of hunting and the terrain they move through.

In the following, we present a number of examples of the multiplicity of ways in which the hunters we have studies are interpreting and articulating the information that the tracking system provides them with. The hunters use dynamic maps with its moving digital symbols to make sense of the dogs' movements through the terrain and in doing so they use a number of different terms to talk about motions, and nuances of movements. First, we discuss how the hunter interprets the screen information in terms of shape of lines, or *trajectories*, of the dog's whereabouts in the terrain. Second, we show how *momentum, distance, acceleration* and *direction* are central characteristics of the ways in which hunters talk about movement, and where the tracking system has provided them with more fine-grained information to do so. Third, we introduce the notion of *temporal alignment*, a new form of alignment work involving the matching of identified objects, audio feedback and feedback on the digital screen.

RELATED WORK

This research draws on three strands of work of relevance for the mobile computer human interaction community: conceptualizations of mobility, mobile geographical information systems and studies of map use.

The mobility concept

The role of mobility in HCI has been a long time concern either as a focus on the characteristics of mobile technology per se or on the role of the users' physical movement in interaction. First, there is research on the specifics of mobile technology e.g. designing user interfaces for small devices or designing for network variation. The problems of handling traditional heavy desktop computing, in comparison to the light weight so called micro-mobility [3, 3232] of paper, have also been discussed as critical technical characteristics with consequences for social interaction and group work.

Second, the need to account for users' motion in computer interaction has been discussed for various reasons. This includes questions related to enabling computer interaction when the user is physically on the move [28, 29]. Another concern has been the way in which mobility influences access to information, either travelling away from useful resources [25], or accessing new places of which the users are unfamiliar and in need of information [13]. A large body of research focuses on physical movement from one place to another, which makes it relevant to link information and data to specific positions or locations [13, 23]. The use of human computer interaction to affect the total amount of physical motion has also been addressed, both on its role in environmental pollution [16], and as its potential to increase users' health through physical exercises [3]. The "nature of mobility" [14] has been another topic, such as in the early attempts to categorize types of mobility in office work [12] in categories such as "visiting, wandering and travelling," or in Dix et al.'s [14] categorization in mobile use contexts as either fixed, mobile (carried by another object) or autonomously moving around. There has also been an interest in the experience of mobility, for example concerning how a user's mobile gaze affects the experience of a passing landscape [8] or the experience of movements of the body [18].

As shown above, the mobility concept has been widely adopted into various strands of research within human computer interaction, not least boosted by the commercial success of mobile technologies and as a means to identify differences between mobile human computer interaction and desktop human computer interaction. At the same time, the conceptualization of users' mobility practices still seems to lack in descriptions of how people are doing mobility.

Navigation and tracking

Recently, the understanding of users' mobility has come to the fore both in studies of commercially available navigation and tracking systems, as well as in experimental design of games with tracking features, since both of these types of systems provide representations of physical movements. The studies of navigation have focused on how the systems instructions work and how it fits with what the drivers are doing. Brown and Laurier [7] identified a set of "ordinary troubles" where the driver struggled with making sense of the navigation instructions made by the systems. Such problems occurred due to e.g. the timing of the instructions with the driving or when the driver's intention was not accounted for by the system.

Other studies of GPS navigation systems [23] show that their use lead to a deskilling of the drivers' previous navigation and orientation abilities, which then generate disengagement with the surroundings. Studies of systems that track the whereabouts of people have also revealed aspects of how such systems are brought to use in ordinary situations. The analysis of such systems mainly considers how people come to account for where their locations are represented on the maps [14, 4]. A study of an experimental tracking system for families [6] focused on the ethical aspects of such systems, and how it influenced and complicated social relations, which depend very much on balancing when members should be allowed to be on their own and when they justifiably should be monitored.

Another more experimental study of a tracking system, being a part of a pervasive game, focused on how uncertainties in the positioning and communication technology influenced the game play, and how such ordinary ways of handling problems could be used in games design [4]. A study of a tracking system, directed to controlling paroled sex offenders, focuses on the ways in which locations are accounted for in social use [34]. For example, the way the offenders followed the rule of not being within a defined distance to e.g. children's schools and parks, included interpretation of temporality and how the map systems estimated such distance. The authors argue that the use of location–based systems, and the availability of defined rules, still depend on many forms of interpretative work to account for the ways the rules are followed.

The use of dynamic maps in pervasive games was investigated by [4] in a game called Can You See Me Now?. It consisted of a chasing task where online players' activities were visualized to players running around physically in a city environment and vice versa. The study investigated how players handled distractions in the form of loss of networking or loss of GPS positioning. They argued that "human-computer interaction observably relies on the collaborative production of a common stock of knowledge and on monitoring other participants to diagnose interruptions." In a later version [5], which included laymen as street runners and a more "mysterious" game play structure, the evaluation pointed to the various ways in which positions were reported. Although both applications depend on dynamic maps, the interest is not on the physical movement of objects and people, but in their location and how that should be displayed and handled.

Although increasing our understanding of both the technical characteristics of these systems, as well as the social and institutional arrangements in which they come to be used, previous studies fail to reveal how the physical movement per se is done. In the tracking studies, users' activities are understood as a series of visits at various locations, and in the navigation studies the focus is on how instructions for mobility are done. Our study is intended to add to this research by taking a step back and unpacking members' ways of accounting for mobility including both the interpretational work and its supporting technology.

In addition, we hope that our findings can feed into the longstanding discussion on place and space within HCI, taking inspiration from Spinney's argumentation on cultures of mobility: "the focus on the `doing and acting' the practice of movement and the movement of practice opens up a space by which to understand how meanings are constructed through and within mobile practice. […] Such an approach seeks to understand the production of space in everyday mobility at the level of the body, but in conjunction with technologies [33, p. 715]. Here, digital maps are an example of one such technology.

Using maps

"Like most humans artifacts—like cars, tables, belt buckles, spoons—maps are more readily exemplified than defined. You point to one. "This is a map," you say. What a map most is becomes apparent in use." [37, p. 18]

The map is a very important technology for various forms of mobility. It can be used support physical movement, to make sense of a place, and as an aid in wayfinding. We take on an approach to this topic, where the focus is on the 'working out' that occurs in use of these objects i.e. the collaborative combination of maps, the world and the matter at hand [21].

A similar approach is taken in a study of Scottish hill walkers [24], where wayfinding is considered an embodied achievement. Navigational technologies, including maps, GPS and compasses, provide information that requires skills to be interpreted and lived out: "following the bearing requires our walker to take the abstraction and act it out through an orderly performance" [22, p.140]. Novice hill walkers have to learn how to make sense of the data presented by these technologies. Skilled mountain walkers were able to do what Lorimer and Lund [24] call a cartographic visualization, where they could examine the route and visualize the landscape and the different terrains that they would walk through: "A simple formula on paper, in practice it requires a form of 'cartographic literacy' in which calculations switch between the flat representational

plane of the map and the anticipation of embodied movement through a landscape. These successive shifts from abstraction to experience require fuller consideration." [24, p. 136]. This type of map literacy involved an anticipation of what it would mean to move through this terrain in terms of moving the body. This relates back to the discussion above, on embodied mobility [33].

In contrast to many other studies on the use of maps, our study is not about wayfinding. Our hunters are (most of the time) not involved in trying to figure out where they are in relation to where they are going. Rather, they are trying to work out where the dogs and the prey are and what they are up to. This means that, again in contrast to many previous studies on route finding map use, they are looking for a moving object. Cafés, museums and other tourist attractions are locations which generally do not move around. Another difference is that when tourists or other wayfinders are using maps, they are in unfamiliar places where they need the map to find where they are and/or where they are going. The hunters we have studied, in this and our previous project, are very familiar with the terrains that they are moving through. As we will see, these different characteristics make the map into a different form of resource.

Method and setting

This paper relies upon two rounds of ethnographic field studies of hunting. In total, we have participated during five full days of hunting; including about eleven so-called drives. The roles in the hunting team, including the dog handlers, the rifles on stand and the leaders of the hunt are discussed in the previous studies [18; 35]. In the current study, we return to our previously collected material, focusing specifically on the dog handlers' role since they are equipped with dynamic map visualizations. The GPS-enabled dog tracking system used by the dog handler is a Garmin Astro. Every five seconds the dog's unit sends its position to the handheld unit (figure 1). The hunter can then see the dog's current position, represented by a small dog symbol. A trace showing how it has moved is drawn on a map. If the interface is shifting to another mode, it displays a compass indicating the direction in which the dog is located, as well as the distance to it. The hunter we followed, here called Ansgar, functions as a dog handler in this hunt. He has hunted together with his dog, here called Sam, for about ten years, and used a tracking system for the last two years. It is important to mention that only Ansgar and another dog handler used the system; all other participants in the hunt did not use this technology.

There are many different forms of hunting. In our two field studies we have focused on group hunting within designated geographical areas, so called drives. These hunting groups are normally divided into three different roles: the leader, the rifles posted at stands, and the dog handlers. The rifles are stationary shooters who are placed in different positions, stands, waiting for the prey. These stands are numbered, and are marked on printed maps that all hunters have access to. Besides having a number, the stands have names within the hunting teams alluding to stories of previous memorable experiences or to landmarks that are known to the team members. This information is not available on the maps, but is something that is shared knowledge within the team. The dog handlers then pass by these stands as they move through the terrain with their dogs. In the ideal case, they scare the animals and drive them towards the rifles. The rifles generally do not move from their stands during the beat. The hunting team consists of about a dozen hunters, where all hunters have access to radio, but not (in this case) GPS.

In both field studies we have used ethnographic methods to capture the hunt, including video recordings and photography, as well as audio recordings of the radio communication. We have matched the audio recordings of the radio communication with the video, allowing us to get close to the participants' perspective, as the hunters had simultaneous access to both the local environment (as captured on video) and the remote sound environment (the radio talk as captured on audio recordings). Some of the data has been shown to the dog handler, enabling the discussion of analytic issues as well as clarifying misunderstandings.

While in the field, the ethnographer would sometimes ask the dog handler to clarify his use of the tracking system. It could be argued that this disturbs the natural use of it. However, of relevance here is how the positioning information, no matter on whose initiative it is accessed, is taken up and used as a resource in the interaction between hunters and dogs. The video and audio material have been transcribed and analyzed according to conventions in conversation analysis [31], see the appendix for transcription standard). The translations to English were made by the authors. Body movements, dogs barking, whistling and other non-verbal and verbal behavior difficult to render in writing are described within double parenthesis, and relevant events are illustrated with pictures from the video. Broadcasted radio talk is italicized. The transcription notations are adapted from [2].

Figure 1: The GPS used by the dog handler studied in this paper.

ANALYSIS

Mobility, as an integral part of the actual activity, is a practical concern for the participants in hunting. The hunters are dealing with tracking, i.e. localizing moving objects (dogs, prey, and other hunters sometimes). The main concern is to find the location of the prey. That location is identified by analyzing the actions and

movements of the dogs, being indicators of the prey. Thus, figuring out what the dog is up to is one of the most important tasks of the hunter. Hunters rely upon many different resources to keep track of the dog i.e. what they can see and hear in the vicinity as well as sounds from a far and the radio communication. There is a complex web of sounds and visual impressions that the hunters map together to get a sense of the ongoing hunt. In fact, as was shown in a previous study, doing the work of puzzling these pieces together is a big part of the enjoyment of the hunting experience [20].

The GPS provides a new form of information. This new visual information is interpreted and combined with traditional resources and knowledge. In the following, we present a number of examples of the multiplicity of ways in which the hunters are interpreting and articulating mobility: *momentum*, *direction*, *trajectories* and *temporal alignment*.

Momentum and direction

The first example from the field is used to give a general sense of how group hunting is coordinated using maps and to introduce a recurring theme in the hunters' use of the dynamic maps, i.e. how they interpret the map as displaying the dog's movement and direction. We will take part of a very dramatic moment of the hunt where the dog goes hunting after a wild boar, which eventually attacks the dogs. This attack stirs up excitement among the hunters who fear for the dog's life. Featuring in this excerpt from our fieldwork is, Ansgar (A), our dog handler, the researcher (R) doing the fieldwork, the leader of the hunt Wolfgang (W) who is in charge of coordinating the overall activities and movements, and finally we have an unidentified rifle at stand, calling in over radio.

Example 1: The dog is still moving

Lots of dog barking heard. Ansgar takes off his glove, takes the tracking system from out of his pocket and watches it. Dog barking and voices from someone nearby is heard in the background.

```
106 A:  Yes Sam is hunting something up towards
107     stand 28 stand 27 (.) probably pig (cause)
108     she just went into the dense spruce area
109     (10.9) two beeps from the horn nearby
110 A:  okay stop the beat then Sam is hunting
111     (30.0) continuous dog barking
112 A:  the beat now goes down towards stand 10
113 R:  °what do you see that from this Garmin°

114 A:  °there and there is stand
115     10 there is the dog° ((points on the
116     screen))
117 R:  °yes°
```

The example starts when the dog handler reacts on the dog's increased barking. He shares his information over the radio, but the sound of his colleagues' horns tells him that the other nearby dog handlers did not stop moving to point their guns towards the potentially upcoming game. He tells them to stop walking forward (line 110) and gives them more information on the activity of his dog, which is now moving in a direction "towards" where rifle number 10 is standing (lines 114-5). The tension increases and the dog handler interpret the dog's altered barking as a sign that he is now very close to the boar. Ansgar is watching the tracking system the whole time, ready with the radio at hand:

```
122 A:  yes pretty close one can hear from that
123     one=
124 R:  =°what°=
125 A:  =the coarser barking that it's close
126 R:  °aha°
127     (6.0)
128 W:  Ansgar is that pig)
129 A:  °Yes I'm almost totally certain of that°
130 W:  (maybe you should walk downward then)
131 A:  Yes I'll do that
```

Ansgar puts away the tracking system, takes the gun off from his shoulder and starts walking towards the dog into a very difficult terrain. Dog barking is heard continuously. One final shriller barking is heard, then there is silence. Because of the boar's action, the hunt is changing, from a situation where hunters are in fixed positions waiting to shoot the boar, to a situation where they themselves, or at least the dog handler, move into an encounter to save the dog. Ottar increases his speed and then stops and says:

```
139 A:  (I have to see him)
```

Ansgar takes the tracking system out of his pocket, it gets stuck and he tears it out. He looks at it quickly, and then walks again, only to stops again shortly. He looks at the GPS again and sees that the dog is moving. Now we see how a relative change of location, the fact that the dog maintains momentum (line 145), is taken as a sign that it is alive. Direction, speed, location etc. is no longer relevant; it is the simple fact that the dog is moving at all that is important.

```
145 A:  (He's) moving at least (1.0) hhhhh
```

Ansgar stops watching the tracking system, continues to walk. He calls out for the dog, when another hunter contacts him over the radio to let him know he has heard the dog:

```
148 A:  >Sam Sam<
149 X:  (x) to Ansgar
150 A:  yeah Ansgar here over hhh:::
151     (3.9)
152 A:  Ansgar here over
153     (1.0)
154 X:  I heard how the dog cried out then it was
155     silent (xxx)
156 A:  yes I know I am a bit worried about that
157     also he: but he is at least MOVING
```

When the dog goes silent after a last shrill barking, the handler moves in towards the dog. We see how a relative change of location, the fact that the dog maintains momentum (line 145), is taken as a sign that it is alive. Direction, speed, location etc. is no longer relevant; it is the simple fact that the dog is moving at all that is important.

This example of a very tense situation for the hunters illustrates how the dog handlers share the information they have from the screen, along with the interpretation of what it means for specific hunters. We see how the dog handler uses the dynamic map as a resource to make statements on the dog's mobility in terms of momentum (lines 145 and 157) and direction (lines 106-7 and line 112), including what stands it will pass by. Since the dog handlers are the only participants in the hunt who have access to hunting radios, talking about what they see on the radio does the work of creating awareness for the rifles at these stands [20]. For this awareness to occur, the tracking system is used alongside other resources, and the hunters rely upon their knowledge of the different terrains of the hunt.

Trajectories

In this example we discuss how the dog handler interprets the screen mobility, in this case the speed of the icon on the screen and its recent positions on the dynamic map, in terms of trajectories reflecting the specific shape of the dog's running pattern. This example illustrates how the tracking system has transformed the practice of hunting, but also how the hunters rely upon previous knowledge of animal behavior and the terrain.

The dog handler is standing still and the dog has not been seen for a while. Ansgar holds the device with his right hand, explaining how he interprets the screen.

Example 2: Gesturing circles

```
201 R:  what    do    you    mean    good    beat
202 A:  yes you see like that ((points towards the
203     screen with his thumb)) he follows/keeps
204     up pre- pretty sure it's deer
206 R:  what keeps up what do you mean then
207 A:  yes but ((he moves the device to his left
208     hand and points toward the screen with the
209     index finger on his right hand)) like that
210     he bends ((makes a half circle with his
211     finger)) you see he's keeping up in the
212     bends ((makes several curves after each
213     other on top of the screen)) you see
214     throughout the entire beat [area] so it
215     comes like (.) ((points toward the left
216     side of the screen)) and then it goes up
217     along the fence ((points upwards on the
218     screen))
```

The hunter makes use of the representation of the dog symbol's mobility on the screen i.e. both the iconic dog symbol and the line that represents the log of its previous GPS coordinates. He interprets what he can see on the screen in picture 1 as the running pattern of a deer; the graphic features he refers to are highlighted in picture 1. First he points towards the screen and shows one bend, and then he indicates that there are several bends. The ability to interpret the figures as curves on the screen makes him draw the conclusion that the dog is chasing a deer, since they are supposedly running in half circles to get away from a chasing animal [cf. 17]. This was later discussed in an interview after the field study:

"An animal naturally falls off in a circle, which implies that they bend around. This means that they do not run straight forward. They so to say try to get away. Often towards the wind to sense what they are running against, because they already know what´s behind. And then they travel in a circle to get away."

The dog handler added that the GPS gives him an opportunity to see the kind of animal the dog is chasing:

"You can see that somewhat on the dog´s running pattern... you learn by seeing those patterns and then the animal that was shot. Then you already know some of the animals' running behavior. You could presume that it is a hare, a deer, or an elk."

The interactional work that is occurring in this situation depends on two different resources. First, the representation of mobility on the screen which makes him "see" things he has not seen before, that is game running in bends. Second, it depends on previous knowledge about animal behavior, which he learnt long before the occurrence of dynamic maps. Both are utilized to make sense of the representations of mobility on the screen. As the hunt continues he is continuously immobile while looking at the screen and the moving symbols on it:

Figure 2: The trajectory of the dog's movement, highlighted in red, is understood by the dog handler as the running pattern of a deer.

Example 3: Interpreting direction

```
301 A:  so probably (they) will go to the side
302     path by north ((Lifts his hand and points
303     towards north))
304 R:  what the fence is it the road
305 A:  yes towards the road there is an animal
306     fence ((points on the right side of the
307     screen))
308 R:  yes
309 A:  the animals usually go along that but
310     there is a side path up by north ((lifts
311     his hand and points towards north)) where
312     there is a rifle at stand where they'll
313     probably go I think (.) or there is a
314     walking path
315 A:  also that (.) I'll zoom out a bit because
316     now he's pulled away ((the small dog icon
317     is no longer visible on the screen, see
318     picture 2))
319 X:  Ohlander Ohlander
320 A:  I'll just ((shift hands again and grabs
321     the head set cable to talk in the radio))
322 R:  yeah
```

```
323 A: yes e:::: now Sam is soon out on the
324    clear-cut area along the two ninenty then
325    (.) that is what we previously used to
326    call the tongue (.) he is like one hundred
327    meters from there I would think
```

Here he refers to the movement of the map symbols as the compass direction "north" (line 302) and "pulled away" (line 316). Being pulled away might imply that the dot on the screen has either increased its speed or just disappeared. In this case he probably refers to the latter, but it could also refer to the acceleration of the dog symbol.

Picture 2: "now he's pulled away"

In this example, the hunter references the dog's whereabouts without any recent audio indications, as we have not heard it bark for a while. He is leaning forward towards the screen when he states that the dog is close to the 290 (the number of a road passing by), "one hundred meters" away from "the tongue" (line 326). In all, it seems like his interpretation of the dog's activities draws solely on his interpretation of the information presented on the screen of the GPS. Hence, the spatial reference in meters is then interpreted from the screen mobility. Again, this way of talking about the hunt differs from the forms of hunting where dynamic maps where not applied [15]. As in our previous study, where the hunters did not use tracking systems, there were several references to idiosyncratically named geographical references, e.g. "side path" (lines 302; 310); "walking path" (lines 314) and "tongue" (line 326). What differs when the dog handler has access to the dynamic map is that these descriptions are more precise, for instance by approximating distances in terms of meters or specifying location in a more exact way.

Temporal alignment

In the interpretation of the dynamic map, several forms of alignment [21] are at play, both a type of alignment that has been described in previous work, and a kind of alignment that is not covered in earlier research. First, in some situations it is necessary with a form of alignment in conversations, where there is an asymmetry in between those hunters having a tracking system and those without [36]. There are also examples where the map users need to figure out how the representation matches the real world and therefore align it in space [21]. Second, we see a new form of alignment that appears with dynamic maps, where the map object being identified is moving. This is a form of *temporal alignment*, which is a result of the presence of a dog sign on the screen at the same time as the physical dog being a 'sign' for game i.e. hunting dogs' presence as understood as an indication of where the prey is to be found. The hunters rely much on sounds in the environment, e.g. the character of dogs barking and shots. These sounds are immediately accessible to all hunters within hearing distance, but do necessarily result in any immediate interpretable action on the screen. The sounds have to be temporally aligned with the movements on the screen. That means that the hunter has to wait to follow the dog's trajectory in order to be able to be able to align the motion with the sound. It is not because of a technical lag, but rather a delay in the visibility of the dog's actions.

As an illustration of this, we return to a case previously reported on [36] where the dog handler is trying to figure out if the shot just heard killed the animal that the dog is following. In this case, there is a sound of a shot, but it is initially unclear whether the animal has been killed or just wounded, or if it was even another animal, than the one his dog was chasing, that was shot. The dog handler relies upon the tracking system to make this interpretation; he waits to see whether the small dog on the screen, representing his dog, will stop moving:

Example 4: Waiting for the dog to catch up

```
401 A: I check like if it was (.) if it was shots
402    e Sam's e: drive animal that was shot
403 R: How do you see that then=
404 A: =Eh I should see that then he like
405    stops/stays there
406 R: =Yes
407 A: By the animal (.) but he's usually a bit
408    behind so ((laughs))
409 R: Right it takes some time
410 A: So it takes some time
```

If the gunshot was aimed for the prey that his dog was following, the physical movement of the dog on his screen should stop as the dog halts at the fallen animal. But such an interpretation calls for a temporally alignment of the sound and the movements. Later on, during an interview, we asked the dog handler to clarify this event:

"That's always difficult. It depends on how quick a dog you have. Dachshunds are always very far behind, so it can be everything between five and fifteen minutes behind sometimes before they get the animal. Therefore it is difficult to judge. But you can see a little bit in relation to where the shot fell and then when you see how the dog moves if you can see that the dog moves towards the shot, then you can assume that it was the drive animal but you don't know for sure until you see that it is up by the animal."

Thus, the non-movement of the dot on the screen, occurring somewhat close in time, makes him connect his dog to the sound of the shot and the prey. When he during the interview claims that he can "see" that his dog is "up by the animal" what he refers to is looking at the screen and seeing

a representation of the animal, rather than seeing the physical dog. Thus, this temporal alignment is in this case very much dependent on the resource of the dynamic map.

DISCUSSION

In this paper, we point to dynamic map systems as an emerging domain of mobile technology, which draws upon and adds to previous research in mobile HCI. Hunters' orientation to physical movements is both frequent and varied. It is constantly addressed in the radio traffic and they use the new representations of the mobility in the tracking system throughout the hunt. What is obvious in their use of these system is the strong orientation to details in physical movement as an aspect of their organizational work. In the following, we discuss the relevance of our findings to mobility research the domain of map studies, and the development of mobile geographical systems.

The concept of screen mobility

We introduce the concept of screen mobility to make visible the details of the mediated content that the hunters account for in their activities. We have provided a set of examples of how representations of physical movement on the dynamic map were used by the hunters. For example, the dog handler aligned the dots moving on the screen with the gun shots to decide which dog was following a specific animal; he interpreted the patterns and forms of lines drawn on the screen to decide whether a dog was chasing a particular type of animal and made estimations on distance in meters based on the reading of the dynamic maps.

It is a somewhat new feature in hunting practice made possible by screen mobility since we did not see any of these ways of accounting for mobility in our previous study, where the hunters had no tracking systems. It is also possible to see how tight the reference to the way mobility is represented in the dynamic map, e.g. the scale of the map, and how they also use these to account for mobility. It indicates that we are looking at a reformulated hunting practice, with a more extended way of accounting for mobility, which seems to evoke their interest without spoiling the experience of the hunt per se [36].

However, there is not a strict distinction between before and after the tracking system, for two reasons. First, not all hunters are using the tracking system; in the study we made only two hunters in a big team, used a tracking system. Second, and most importantly when looking at how the practice has changed with the introduction of new technology, we cannot say that it has transformed into something completely new, rather the tracking system provides the hunters with an additional resource to do the work they are doing. The information that the tracking system provides adds to, rather than replaces, the use of other resources – such as the hunters' vision and hearing, reports over radio, etc.

In all, dynamic maps introduce new dimensions into map technologies. The ways in which it transforms hunting and the hunters' view on mobility depend on a close reading of what happens on the screen, i.e. the screen mobility.

Accounting for mobility in studies of GPS and tracking

The use of dog tracking systems differs from the use of navigation systems, since the former type of systems do not provide instructions on how to move. The use of the latter type of systems is very much about giving such instructions and the "ordinary problems"[7] is about how to align them to the environment. The hunters on the other hand, do give instructions. But those are made over broadcast radio, which is not an integrated system feature.

More importantly, our study reveals the users' orientation to accounting for and interpreting what type of physical movement that is occurring, e.g. the type of trajectory or in what speed something is moving. This seems to be an orientation which the accounts of navigation use is missing, perhaps due to the way such systems hide these issues behind "instructions". Again, what we see in the field is the complexity and situatedness of accounting for movements.

This finding takes us to the next point and the relation between accounting for motion and accounting for position or location. In HCI research, it has been recognized that position data, such as the one we get from GPS, is related to mobility. However, there has been a huge concern to discuss how to answer the question "where are you", rather than questions such as "how does it move?" Similarly, previous studies of tracking systems [26, 34] have an orientation to focus on accounting for locations visited by the participants, leaving out the ways in which participants account for physical movements. Obviously, that is likely a valid description of these people's social practices. In this study we see how this technology (GPS) can be used both to discuss where something is, as well as the characteristics of movement. Here we agree with Spinney [33, p. 713] who argued that:

"[T]he focus on the `doing and acting' the practice of movement and the movement of practice opens up a space by which to understand how meanings are constructed through and within mobile practice. I contend that the experiences of movement and mobility can be seen as constitutive of the meaning and character of a place because of an ongoing dialectic between body and place."

In sum, the present study makes visible how mobility is handled among such groups, which can influence research to other domains where it is of importance, already in the use of tracking systems or in need of such technology.

Dynamic maps and cartographic literacy

The introduction of dynamic maps in situations where static representation of space was provided previously calls for new types of interpretational work to situate the information provided by the GPS. With these maps the cartographic literacy required to move from representation to experience becomes more complex, as the map is constantly updating [24].We have shown how dynamic maps call for new forms

of alignment practices. This is a form of temporal alignment, which is a result of the presence of a dog icon on the screen at the same time as the physical dog works as a 'sign' for game i.e. hunting dogs' presence as understood as an indication of where the prey is to be found. The icon then represents not only the dog itself, but the knowledge that it might be following an animal. This temporal alignment involves matching the actions going on in the world (including visual and aural impressions) with the information on the screen. The concern for the hunters is not, as in many other uses of maps, "where are we and where are we going?" They do not need the map to find a location but rather to find a moving target. The question of "where" something is located is no longer the main concern, rather "what happens next". That makes the map into a different form of resource, one which requires a new type of cartographic literacy.

It has also been argued that the GPS leads to a deskilling of navigational techniques [1] However, we wish to emphasize, based on our fieldwork, the skilled work that goes into reading a dynamic map. The dynamic map has not replaced the underlying knowledge and experience of hunting. In order to interpret the information presented on the Garmin Astro GPS, the hunters rely upon previous knowledge e.g. about the geographical area and the terrain, animal behavior and the dogs running pattern. In resonance with Lorimer and Lunds findings, we have seen how the "GPS certainly disrupts established modes of interactivity and relational conduct, but clearly does not disallow them [24, p 142]."

Relevance for design and mobile HCI

The technology use studied in this article makes visible mobility in two ways. First, the dogs' physical movements to the hunters, and how they account for it in between themselves. Second, and more important from our perspective, the study makes visible the importance of orientations to mobility when designing for people. It is not the attempt of this study to influence next generation of hunting systems, but to develop our understanding of what people attend to as part of their mobile life. In this sense, the hunters' orientation to physical movement might be a source of inspiration to design for motion in other areas, for example by developing alternative ways to represent it in social media or in pervasive games.

The way to utilize the findings presented here and to support such a step in design is to revisit the mobility theories and populate them with notions describing screen mobility and accounts of physical movement (acceleration, momentum, direction, distance, speed and trajectories). It seems like the mobility concept as a way to describe user practices, has lost some of its appeal to inspire design and open new areas of research. In social theory, the concept has mostly been used to account for social change on a macro-level [35], which gives limited clues to developing new forms of systems. This could be compared with our account of members' orientation to physical movements which are more strongly linked to what people are doing as part of their everyday activities on the go. Furthermore, the concept of screen mobility ensures that the movements of digital objects on a screen are not conflated into, and taken as the same as, the physical motion of non-digital objects. The concept is intended to act as an analytical tool to unpack the details of both the interpretation of this sort of mobility, as well as what is going on in the screen. It allows us to unveil some of the richness of the interaction.

CONCLUSION

Dynamic maps are an emerging technology, which depend on GPS tracking. Our study of a hunt revealed how the use of such systems sparked a fine-grained collaboration, which makes mobility and physical movement, visible for themselves and the ethnographer. Their interpretational work involves participants' detailed analysis of representations of movements on the maps, i.e. screen mobility, which is made sense of as articulation of accelerations, distances, trajectories and temporal alignments. This strong orientation to motion in everyday life is previously underrepresented in theory and related fields of research. We hope that this detailed empirical investigation of screen mobility, although appearing in somewhat esoteric areas of use, will increase the interest for this aspect of mobile life.

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