

# ‘Eyes Free’ In-Car Assistance: Parent And Child Passenger Collaboration During Phone Calls

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## ABSTRACT

This paper examines routine family car journeys, looking specifically at how passengers assist during a mobile telephone call while the drivers address the competing demands of handling the vehicle, interacting with various artefacts and controls in the cabin, and engage in co-located and remote conversations while navigating through busy city roads. Based on an analysis of video fragments, we see how drivers and child passengers form their conversations and requests around the call so as to be meaningful and paced to the demands, knowledge and abilities of their co-occupants, and how the conditions of the road and emergent traffic are oriented to and negotiated in the context of the social interaction that they exist alongside. The study provides implications for the design of car-based collaborative media and considers how hands- and eyes-free natural interfaces could be tailored to the complexity of activities in the car and on the road.

## Author Keywords

In-car assistance, collaboration, family, qualitative, ethnography.

## ACM Classification Keywords

H.1.2 User/Machine Systems

## INTRODUCTION

Car travel often involves managing the nuance of family conversations and activities across front and back seats in addition to the dominant task of driving. Families spend an increasing amount of time travelling in their cars, and the routines of parenting and caring increasingly involve the family car [2]. In this paper, we investigate some of these routines in the family car, examining the intricacies of social interactions and travelling practices, with a particular focus on an investigation of the nature of initiating and receiving mobile phone calls, showing how child passengers can impact on the ways that these are carried

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*MobileHCI '13*, August 27 - 30 2013, Munich, Germany  
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out. This work sits alongside an increasing interest within the HCI community to develop technology to support interaction in the car [e.g. 6, 10-12, 24, 28, 34].

On average in 2011, more trips were made by people living in households containing 2 adults with children than any other household type [9]. In addition, the car is the most frequent mode of transport for children aged 5-10 [9], yet with the exception of game-based studies, young children (defined as between 6-12 years old) in particular have been overlooked in the design of in-car technology. Within our own study, participants transported young children not only on daily trips to school or after school activities, but also included them on trips when they could not leave the children alone at home. Given this context, we were motivated to study the role of child passengers in assisting parent-drivers during family journeys. Collaboration with adult passengers has been studied in detail through ethnographic explorations of the car space [12,14, 28]. The findings from detailed ethnographic work brought us to extend the focus on the collaborative use of technology by children while assisting adults. As we will show, families reference prior knowledge and monitor comprehension during in-vehicle interactions by drivers and passengers. In doing so, both driver and passenger often draw upon speech and gesture in communicating and making sense of their interactions with one another.

This investigation of children assisting parents while mobile sits alongside the advent of commercially available natural language interface ‘assistants’. Smartphone applications, such as Apple’s ‘Siri’ and Google’s ‘Voice Actions’ offer interaction with mobile devices that no longer require “hands-on” operation. The idea of such interactive systems becoming part of in-car technology poses a unique situation that promises to transform what other activities can be undertaken safely while driving, and adds a new dimension to the experience of car travel. Indeed, Apple already appears to have designs on the car: *Through the voice command button on your steering wheel, you’ll be able to ask Siri questions without taking your eyes off the road [...] With the Eyes Free feature, ask Siri to call people, select and play music, hear and compose text messages, use Maps and get directions, read your notifications, find calendar information, add reminders, and more. It’s just another way Siri helps you get things done, even when you’re behind the wheel” [1]*

Of course, other organisations have similar interests in this arena, and there appears to be a common recognition that the cognitive demands of driving mean that speech interface systems need to be attuned to minimal visual and physical involvement from the driver (hence hands and eyes-free), focusing on a system that is highly sensitive to recognising and making sense of verbal instructions. This set of complex and interdependent activities that take place in vehicles makes the design of natural language interfaces such as Siri and Google Voice particularly challenging, as they will need to cater to a number of features in the types of concerns that arise during conversations in the car, as well as the highly variable particularities of membership, relations and configuration of the family unit within the vehicle. Indeed, family car travel, as with other forms of car travel may already involve collaboration with, around or through media, such as map reading [5], operating the radio, or providing entertainment [22], and this is also likely to be the case around computer-based car technologies.

### BACKGROUND

In the context of HCI, car-based mobile interactive technologies form a distinct subset of technology with people using navigational devices, a range of mobile telecommunications, handheld computing, and entertainment systems in this setting. However, the development of new technologies often skirts around issues relating to social interaction within and outside the vehicle. More recently however, several studies have begun to shift emphasis away from their operation by individuals towards looking at social interaction involving driver and passenger/s around these devices. The adoption of these approaches to the context of the car has lent valuable insight into drivers, passengers and the paraphernalia of material and digital media used. Regarding collaboration in cars, there is a notable body of literature in HCI on driver and front passenger engagement with navigational devices [6,12,18,23]. Brown and Laurier [6] have looked at users' behaviour using GPS to inform design that considers users' wayfinding practices as an integral part of navigation systems. Similarly, with respect to the ways travellers interact more broadly on and off navigation devices, Leshed et al [23] examine the ways GPS users engage and disengage with the environment outside their moving vehicle. Further work on collaboration explores how familiarity, driving conditions and other factors impact driver and front passenger's interaction [14]. Forlizzi et al [12] looked at how navigational devices are used in practice through collaboration between adult drivers and front seat passengers. They found that people often rely on shared knowledge and experience between speaker and listener, and that navigational judgments based on shared knowledge have an advantage over individually based information. Similarly, Perterer et al. [28] in their study of driver-passenger pairs describe the social and collaborative mechanisms of assistance provided by front-seat passengers. They found that prior acquaintance and

familiarity with routes, difficult weather (rain/poor visibility) were key determinants of assistance provided. While we would already expect an uneven distribution of knowledge between adults, we would expect more dramatic asymmetries in the knowledge and competence between young child passengers and adult drivers, leading to the need for different collaborative strategies in these settings.

Extending beyond assistance, the car is also seen as a convenient place to handle phone conversations [11,15], despite the legal restrictions on their use. Laurier [21] found making phone calls was for a way for mobile workers to recuperate time otherwise lost while travelling. Esbjörnsson & Juhlin [11] in an early study of mobile phone use in cars extensively describe how drivers initiated and managed calls while driving. Ethnographic studies around mobile phone use in other contexts also provides rich background and useful insight into the use and design of mobile communication devices [33].

With regard to developing in-car technology for families, many studies have focused on augmenting the 'experience' of car travel across front and rear seats. As one solution to this, entertainment media serve the main purpose of keeping child passengers occupied and engaged during long journeys. These vary in their purpose and nature from immersive gaming to interactive applications on portable devices. A number of entertainment technologies developed for cars in the past have been woven through, the activities of driving the car. Systems such as these include "Soundpryer" [27] which allows music being played to be communicated between close vehicles, and Backseat Games [20], an interactive, location-based system that both relates the game to the car journey, but also brings the passengers together in play, rather than withdrawing them from their road environment. Apart from this, explorative work on the rear seat of family cars [34] using cultural probes showed valuable insights into how families engage with each other as well as provided insights into the future design of technology for the rear seat.

Outside of the car, there has been a growing HCI interest in studies of the conduct of ordinary family life [7] [31] and the practices around how computer technology is used and shared in domestic environments. Yet extending families' spaces for "doing family" in the car is neither quite in the home nor fully apart from it. Personal devices like iPods or individual entertainment systems seem to embed easily into the car. By contrast, desktop computers or home appliances like televisions, which support use by multiple members of the family, seem harder to transfer to the car. It seems the car carries characteristics of home, but differs sufficiently to warrant additional research to explore its 'fit' with technology and its practices of use.

This overview of literature around in car media, technology use, collaboration and family practices sets the background for our study by emphasizing the vital place of the car in everyday life, and the value it holds to the way families

organize themselves over time. Building upon this here, we look specifically at the assistive capabilities provided by children as front seat passengers. Given these conditions, we explore how technology, in this case a mobile phone, is placed in the context of multiple users with their own particular skills and competencies. We think of how the collaborative use of technology by adults may differ from that of children assisting adults with technology. Within this context, we were motivated to study the role of child passengers in assisting parent-drivers during family journeys. This brought up to shift focus to the collaborative use of technology by children while assisting adults. We draw inspiration from this literature in our analysis of the vignettes chosen for this paper, showing how the participants' knowledge and use of technologies is shaped by their familiarity with the device, their knowledge and capabilities, the prevailing circumstances, and other available resources at hand.

## METHODOLOGY

The data presented here were collected using a 'follow-and-film' approach [22] where the project ethnographer spent a week travelling with each car, learning about its occupants' routes and gaining familiarity with groups of families. After the follow fieldwork, two camcorders were handed over to the participants and they were asked to film half a dozen of their typical journeys over the next week. Informed consent was obtained from the participants for their video data to be used in further research. The two vignettes chosen for analysis are taken from a large video corpus of approximately 60 hours of video clips from family trips in the car drawn from 6 families. While examples shown here involving interaction and assistance in the car (e.g. writing notes, looking for something, taking a message) with old style phones are from 2006 data, interactions during phone calls has not changed over this period even though recent developments in smartphone technologies themselves have changed [see 33].

The approach for analysis draws on previous analytical work in talk and interaction in cars [13, 22, **Error! Reference source not found.**]. We apply conversation analysis to understand the turns and placement of requests in the mediated interaction between parents and children. We also draw heavily on Heath et al [16] video studies of people and technology reflexively producing their social context. Examining single instances allow us to describe practices in a level of detail [16] that would otherwise be lost in a more extensive analysis [see 15 & 17]. While we do not aim to generalize from a small number of cases, these vignettes nevertheless stand as perspicuous examples [29] that focus attention on features around important aspects of in-car collaboration between parents and young children.

## DESCRIPTION AND ANALYSIS

When using the phone, there are two clear modes of use, one of making a call, and the other of receiving one. Each

places different demands on the driver and passengers, and we have selected typical instances from our dataset that illustrate these modes. With the knowledge and capacities of adults and young children in mind, we will see how driving and media use come together and apart. For ease of reading, the following abbreviations have been used: M-Mother, D-Daughter and DF-daughter's friend. All names are anonymised. In the interests of brevity and clarity, we have not transcribed all of the events in the vehicle. In what follows in both cases is a series of excerpts broken down into short sequences; these excerpts are thematic rather than being formed from discrete events, and allow us to pull out key features from events as they occur.

### Making a call

In this first vignette, the mother has initiated a phone call to her son's nursery on her hands-free headset while driving. Holding a mobile telephone is not legally permitted when driving in the UK, although this kind of hands-free interaction is allowed. Her young daughter (aged 7 years) is sitting beside her, and two younger children are in the back seat. The mother has left the house without the address of the family with whom her son (in the backseat of the car) has a play date. However, while asking for the address, she realizes that she needs to record the address provided over the phone.

### Engaging the passenger

The mother takes the opportunity of a traffic light change and her stopping to search around in the car for something to write on. She finds paper in the glove compartment, and reaches across the legs of her daughter, who appears oblivious to her activities (fig. 1a). During this phone exchange, the daughter has been looking at a trading card (see fig. 1a) and discussing this with the children in the back seat. On finding a large sheet of paper, the mother places it on her daughter's lap (line 5 and fig. 1b) and asks her to help (line 4-5):

1. M: I'm just in the ca:r, ((reaches to glove
2. compartment)) if I have [(a pen) to write it
3. down] ((searches in glove compartment again))
4. M: Em[ma, could you write this number down,
5. luv? ((gives paper to child passenger)) ]ermm



Figure 1a

Figure 1b

From this we can surmise that the daughter either does not immediately consider it her responsibility to support the obvious needs of her mother, or does not understand how she might assist. She cannot be unaware of this activity, because her mother physically needs to reach over her to

access the glove compartment and noisily clicks it open, but it is only with an explicit request for assistance by the mother that the daughter is co-opted into the activity. This begins to mark out how younger children are distinct from adult passengers, in which assistance is frequently and freely offered by them [22, **Error! Reference source not found.**]. We could understand this otherwise unhelpful behavior as a considerate action if we see this as the daughter allowing her mother to engage uninterrupted in ‘mother’s work’ [31], and remaining involved with her younger siblings in the back. Also, and given that she cannot hear the other side of the conversation, her knowledge of what is being discussed is limited. From the transcript (lines 4-5), we see the mother then presents a request to the daughter who has the responsibility as both a front passenger and a related child to comply with her request [3]. While the mother’s statement suggests that it is a request, the accompanying and simultaneous action of placing the paper on the child’s lap (lines 4-5) slightly before the daughter’s response indicates that the daughter has now been firmly assigned the responsibility of assisting with the call.

#### *Solving problems together in the car*

The mother’s engagement of her daughter in the front seat is carried out simultaneously with the request from the back seat to hand back a trading card (see below). The daughter’s turn and return of the card is timed perfectly with the mother’s request to help her, and to free her hands for writing the address down [see 19 & 25]. This move opens up the opportunity for the next sequence of actions to take place which is to write the address down. While the daughter remains waiting, the mother carries on her phone conversation and continues driving, until her daughter vocally reminds her about the absence of the pen for writing (in line 10).

6. DF: [°y’have to give it back please° Give it  
7. back please!] ((D turns, passes the trading  
8. card to SF in the back seat; car moves off))  
9. M: I’m not coming in  
10.D: Pe:n?  
11.M: Uhm, I might have to ring you back  
(daughter opens and looks into glove compartment))  
12. when I’m not driving.

Now that the car is moving again, finding an item in the car is harder to do. After a cursory attempt to look for a pen while dividing her attention with the road and she begins a closing sequence (lines 11-12). Her response is indicative that making a record of the address has now reached a level where it is distracting, where she is unable to give her attention to driving and recording the information [see 15]. This is also observed in her slowing down of the car intermittently during the conversation, which is one of the indicators of cognitive overload arising from increased auditory instructions to drivers [32]. Almost immediately on the mother closing the compartment, her daughter re-opens it, and quickly finds a pen:

13. M: we got we got one,  
14. < Hang on, go on, you can-  
15. she can write it down. .hh What is it?  
16. It’s oh two oh, (0.9)  
17. D: Oh two oh.

Here, we see how the situation changes from the mother’s closing sequence, to when her daughter manages to find a pen. In lines 13 and 14 while accounting for her readiness to now continue the phone call, her ‘we’ marks that she is doing this with someone will be able to record the address. Her conversation on the phone is doing ‘double duty’ for both remote and local participants [25]. Having announced that she has a pen, the mother immediately follows this with a successful attempt to keep the caller on the phone before ringing off (*‘hang on, go on’*), and explains that they can continue. The mother repeats a phone number from the phone call, and the daughter also repeats it showing that she correctly understands its importance and relevance to her assigned task.

#### *Instructing and recording*

The driver and child front passenger then work together to write down the address, as the mother provides instructions to her daughter *how* to write down the details from the phone call (see fig. 2b). The mother points to the drawing pad to indicate where the daughter must start the address line, after recording the phone number. Then, she goes on to explicitly instructing her on *what* to write in the following extract:



Figure 2a

Figure 2b

18. M: Oh two oh eight. Eight, Emma.  
19. (.) ((child screams in the back))  
20. D: so I write oh two-  
21. M:°Just an eight°. ((gesture + turns at a  
22. junction))

The front passenger is now actively engaged in the task, although this situation is challenged because the daughter’s knowledge and capabilities are not well matched to the requirements of the situation. As the phone number is being read out, it is evident that the daughter is confused whether to write the area code of ‘020’, which for a similar adult passenger would be obvious. The mother therefore has to adapt her instructions, while also attending to the demands of both driving and the number being spoken over the telephone. At this stage of the call, she is intently looking at the road and maneuvering, which means that she cannot closely monitor what her daughter writes. She uses her hands to draw an ‘8’ shape (line 21) while turning, allowing her to both listen to the details of the call as well as visually emphasize her brief verbal instruction.

The data presented in this vignette illustrates a number of key features in child passenger assistance, from how the child passenger enrolment in driver assistance takes place, to how the driver instructs and monitors the progress of the child's assistance.

### Receiving a call

The second vignette presents another example of a mother driving and a young child in the passenger seat, but in this instance, the driver is being phoned while driving and the child front passenger (aged 11) has to field the call.

#### Orientation to the device

The sequence of conversation begins with the mother bringing to her daughter's attention that the phone is ringing; this might seem rather self-evident given that they can all hear it ringing:

1. M: oh Lucy, ((1.3 seconds into ringing)) phone
2. is ringing, it's in that orange thing there
3. ((points to passenger footwell)), can you-
4. D: (I'll) answer it ((bends into footwell))
5. M: yes. a little green phone sign, °you put it
6. to your ear °and press the little green-°°
7. D: Hallo?



Figure 3a

Figure 3b

While it is an indirect way of initiating assistance from her daughter, this response by the mother marks the call out as being of interest to her, and framed as a question, it seems to invite a paired response. The explanation of where the phone is (line 2) reinforces that this is a request for her daughter to answer it; she doesn't need to complete this as her daughter anticipates the request (line 4). Subsequently, the mother goes through the steps of acquainting or perhaps re-acquainting her daughter with the layout of the phone (see figure 4a), by describing 'a little green phone sign' and that she needs to place it near her ear (lines 5-6). The daughter reaches down to retrieve the phone in fig. 4b and the mother's request trails off into quieter and quieter speech as she sees it answered.

#### Handling the call

At first, we observe that the daughter fulfills what she is directed to do by her mother in answering the call. In the exchange that follows, we see that her role moves from simply answering the call to handling the call with the assistance of her mother. However, as can be seen in the transcript below, the daughter initially attempts to pass the call on to her mother, who appears unwilling and unable to do so, giving rise to some conflict:



Figure 4a

Figure 4b

8. D: [mum],
9. [(°I don't know who it is°)],
10. M: [who- who is it darling].
11. [cause I'm driving,]
12. D: [(°I don't know.° )]
13. M: I ca:n't,
14. >I haven't got my< hand[s-free].

We see a typical child-parent exchange here, where the daughter, now realizing her role may extend to engaging with the caller, turns towards her mother and in apparently increasingly desperate attempts, tries to disengage with the call by passing the responsibility for dealing with this to her mother. She first calls to her mother (line 8) so that it can be heard by the caller. As well as calling for her mothers' attention, this also allows the caller to know that she is temporarily disengaged with the call. She then says in a quiet, but highly emphatic voice, 'I don't know who it is' while simultaneously staring intently at and moving the handset towards her mother (see fig 4a). We can recognize in this set of actions and utterances the daughter's unwillingness to take the call accounted for by the fact that the caller is unknown to her.

The mother responds rather impassively to the daughters' apparent attempts to hand over the call with a question that directly follows the daughters' statement, asking who the caller is, which is responded to by the daughter, again emphatically repeating 'I don't know'. The mother then puts an end to the exchange by stating the restrictions on her ability to take the call: in saying, 'I haven't got my handsfree' she informs her daughter that she would not be able to directly handle the call (see fig 4b). We might reasonably expect that an passenger adult in this situation would probably continue the phone conversation, going on to enquire who the caller was and the reason for the call. However, this does not naturally occur here.

While the mother's physical lack of interest in fielding the telephone call seems to point to her expectation that the daughter should deal with it, her glances in her daughter's direction reveals that she is monitoring the daughter's responses [Error! Reference source not found.]. She follows her daughter's lead in supporting the conversation, as the pair move to a speak-and-repeat form of interaction with the caller. However, even this form of proxy conversation itself is not maintained for long. From the conversation excerpt below, it is also evident that the daughter is not repeating her mother's responses verbatim:

15. D: [Ehm], she doesn't have her hands-free.
16. (3.2)
17. M: Could they ring me at home?
18. whoever it is [Linda?

19. D: [Could] uh (.)  
 20. you ring at home?  
 21. (2.0)  
 22. M: In about fifteen minutes.  
 23. (1.6)  
 24. D: okay. ((turns off the phone)) (.)

The front passenger almost repeats her mother's earlier statement "*She doesn't have her hands free*", reporting the most salient pertinent feature of the situation to the caller, carrying with it an inherent assumption: that the mother is driving and that this is an awkward moment to take the call. The mother then asks her daughter who the caller is and when she receives no response, she gives indirect instruction by asking "*Could they ring me at home?*" This request has the obvious purpose of asking the daughter to assess the urgency of the call and possibly delay it. It references their 'not-at-home' location so that the daughter can add more explicit context to the caller that this is not a good time to take the call, and offers an alternative location to call her at. This simple request also serves the purpose of identifying whether she would need to take any further action, such as stopping the vehicle to answer the call.

Three lengthy pauses occur in this excerpt, during which we can infer that the caller is conveying the responses to the front seat passenger. Notably we do not see the mother attempting to speak over these pauses: thus in line 21 we see the mother leave a brief pause after her daughter's question (perhaps allowing completion of any responses to her request to the caller) before responding further, even though she is unable to hear the outcome of this on-going conversation, again leaving a pause in which the caller's response can be heard uninterrupted by the daughter. At the end of these lengthy pauses, the daughter provides a final utterance (we assume this to be a paired closing turn to the caller), and presses a button to turn the phone off. The conversation between mother and daughter that follows this explains the content of this final part of the conversation on the call:

25. D: .hh Sue has an appointment  
 26. >at the parlour at half past three<.  
 27. (1.3)  
 28. M: Right.  
 29. (1.0)  
 30. M: three forty-five actually, but,  
 31. (1.3)  
 32. D: they said half past three, about when we  
 33. leave school.  
 34. M: Yeah, I know.  
 35. D: Heard it. Oh, that's not so good. (.)  
 36. So, we'll have to take her out school early,

Following the termination of the phone call by the daughter, we see her immediately reporting what was conveyed by the caller to the mother (see figure 4b). The conversation sequence in this final excerpt opens with the daughter's announcement (lines 25-26) stating that Sue had an appointment (at the 'parlour'/hairstylist, where the call came from). The daughter has analyzed the most pertinent part of the conversation to convey to her mother. In the lines that follow, we see why this is of especial relevance, because the daughter has linked this information with the

school day timings. Her commentary (lines 32-33 and 35-36) is clearly interpretive, as she does not just repeat information from the caller, but identifies and highlights a key problematic aspect from the call: drawing from her own knowledge about the school day to predict the likely consequences of this event, in this case, that Sue's appointment will result in a timing clash and that they may have to take her out of school early.

## DISCUSSION AND FINDINGS

The forms of talk within cars—and specifically the talk between adults and young children when handling mobile phone calls—reveals much about managing instructions and negotiating (inter)actions (as well as the dynamics of family life). The implications of talking, driving and distraction have been well documented in the literature [11, 15]. What we see is how children's ability to cope with the situation depends on their level of competency in dealing with the complexity of the situation. While adults are able to adapt to challenging environments, children's interaction around driving, distraction and technology may be more dependent on their developmental abilities and prior interaction with the artifacts [8]. In the first example, the child who has to record the address has only basic skills with writing, whereas in the second vignette, the mother has to orient her daughter to the mobile phone's features. We also see that the mobile phone, although not a sophisticated technology in its functional operation, demands particular types of engagement; that it too exerts a presence by how it must be addressed and orientated to.

### *Children as Front Passengers*

In the examples used in this paper, the parent drivers are seen to adapt their speech and interaction to match the assumed capabilities of the child passengers assisting them in their mobile telephone calls. In the front seat, these children are in close proximity to drivers and are in quite a different position to children travelling in the back seat, who may be immersed in other activities. The child front passengers have a clearer view of the road conditions and the actions of the parent driving. This insight brings a shift from the previous work of in-car technology for backseat entertainment media for children [20, 34]. While providing some means of engaging child passengers in the car, these technologies treat them as passive travellers. However, in our data, even although they are relatively young, the children in the front seat were able to actively and successfully participate with the parent to engage in the work of the journey. This presents a very different perspective to the trope of the bored and disengaged child that needs to be entertained in the car; while this may frequently be the case, but need not always be so.

### *Levels of Involvement*

Between the vignettes, the level of involvement of the driver in the assistive task is seen to vary. In the first, the mother is more engaged in the moment-by-moment activities of her young daughter (whose gaze is directed to

the mother at all times), while in the second, the slightly older child is able to relatively competently convey, capture and interpret relevant information during her handling of the call more independently of her mother. In neither case are the young children entirely independent in assisting their mothers who attempt to structure, or ‘scaffold’ the children’s interactions with a sequence of instructions. Both instances also differ in the expectations that the drivers appear to have of their children, in the first vignette, with the mother providing detailed instructions and careful monitoring of the child’s actions, while in the second, the mother displays an expectation for the child to do this independently and (who somewhat unwillingly) manages the role of acting as an assistant in organizing the driver’s childcare activities. In neither case do the children simply follow their mothers’ instructions, and we see both act independently in assisting on the calls being taken.

#### *Manipulating Objects*

While travelling in cars, passengers and drivers access and manipulate a range of newer artifacts like mobile phones, or older devices like the pen and paper and trading cards seen in vignette 1. In the car, there is often a sense of time-pressure in accessing these devices given the car’s mobility and the prevailing road conditions. Where and how devices are placed and moved around in the car by passengers and drivers, and gaining timely access to them are important issues based on our data. For example, if in vignette 1 the daughter had not found a pen, then the conversation would have ended with the mother’s unsuccessful attempts in this search. Both vignettes show participants making use of resources that passengers can access in the car. In our data, as with many cases from our corpus, they involved resources that were inaccessible to drivers given their seat location or driving conditions.

#### *Placing and Managing Requests*

When an activity is initiated between two people of varying skills and capabilities, a number of factors come into play. This is particularly true when the front seat passenger is a child. In the body of our data, as in the vignettes presented here, we frequently saw the driving parents make direct requests to their children as there was little opportunity to wait for a response or provide an explanation for the request while driving or interrupting the call itself. However, as with other social interactions, some kind of response monitoring usually takes place following the presentation of requests. In both vignettes, this can be seen after direct instructions are issued by the mother, despite their visible engagement in driving or talking on the phone. In making a call in vignette 1, the request to record information is followed by careful monitoring of how the numbers and address are recorded. In receiving the call in vignette 2, the mother pre-formats the verbal information being provided to the caller as well as checking what is being conveyed back to the assisting front passenger. This issue of monitoring—at varying levels of intensity and through direct observation or overhearing—is a crucial one, somewhat

comparable with the role of feedback in computer-based interactions: they allow the mother to determine that what has been requested is being carried out, precisely how the instructions are being followed, what stage the instructions being followed have reached, and so on. The way that monitoring is carried out is necessarily dependent on the driving conditions, but as can be seen in the data, pauses in the traffic are used by the mothers to pace the conversations and to shape the interactions with their children, so opportunities for monitoring are not just a result of what happens on the road, but are also designed for the on-going and predicted driving conditions.

#### **IMPLICATIONS FOR DESIGN**

So far, we have explored interactions between agents (be these between family members or computer agents) in the car. As can be observed from the analysis, the situated nature of these interactions sits at the forefront of the interactions that we have observed, and of course, it is critically important that any systems developed attend to these features. However, we should not discount the different set of skills, knowledge and competencies of the agents involved, and how these may also offer opportunities for design. As we have seen in the HCI literature, there has been a growing emphasis on the importance of human assistance to support drivers and supplement driver assistive systems [e.g. 14]. Looking at the ways that children support the management of managing incoming calls (in our case), it does not directly follow that systems simply need to offer a restricted and simplified set of functions. Rather, we suggest that it may be more fruitful to draw from a consideration of *how* calls are co-ordinated, supporting the negotiation of skills and activities between driver and child passengers. In this respect, the fine-grained analysis that we present offers design insights that we explore below.

#### **Children as agents of assistance**

An important theme seen in the data is the direct request for assistance by parents to children in the front seat. There are many reasons why this may happen; the most prominent (at least as shown by drivers in our broader data set) being that the driver is engaged with the demands of driving as illustrated in the two vignettes here. Despite variation in their levels of technical ability, both of the children seen in this paper act independently (to a degree) in predicting the needs of the driver, adapting to the resources available and the events developing around them. They do not simply follow the driver’s requests to perform functions that the driver themselves cannot. What we see is that they are able to take on tasks semi-autonomously, react appropriately to the driver’s demands (though not necessarily as directed), provide largely appropriate verbal accounts of their action so that their behaviour can be made sense of by the driver, and form their responsive actions in such a way that they are visible to the driver. While both children in the vignettes here are young, they are already able to deal with the technology of the mobile phone, if not directly, as in the

case of vignette 1, then by attending to its use practices and the constraints that it places on her mother's action and communication. We *do not* suggest here that children can use the technology unproblematically—indeed our data suggests that the reverse would seem to be the case—but that children need not be designed out of in-car technology solutions. It would appear that they may be able to offer assistance to a driver, albeit in a way that is different to another adult or an intelligent computer-based agent, and actively take part in what would otherwise be the work of the adult driving.

Where an in-car system may have multiple users, providing system responses and feedback that is understandable and relevant to them would be useful. In this respect, if the system is able to sense who is speaking or dealing with a particular problem (driver or passengers) then information can be delivered in a suitable form. For example, in navigation planning (a task often delegated to passengers, but involving the driver who may know shortcuts, and be more cognizant of the traffic conditions) when using a digital map, determining and following abstract geospatial routes may be difficult for a child passenger. Here, the presentation of images of buildings at key junctions on the map would probably be easier for the child assistant to plan, locate, recognise, describe, or even show the route to the driver. However, what we see in the data is that there may be a degree of flexibility around over-complex system demands on younger users: the driver is at hand to help make sense of these, although their interaction may be delayed or intermittent. This opens up the space for systems design that does not pander to simplified interaction, as the adult driver (as we have seen) may be able to instruct and moderate its use. In this case, allowing the technology to make its internal state 'visible' to the driver (e.g. through audio or a quick sideways glance), or easily describable by the passenger, would allow for richer driver-passenger negotiation around the system.

While they may have less capability in complex interactions with technology, our analysis suggests that children can usefully offer the driver assistance in device-based interactions, and we have a number of observations to offer here. First, as we have seen, drivers are not always able to immediately attend to information requests (in our data, from the remote caller), and even young child assistants can provide a means of delaying this content until the driver can deal with this, both through attending to the conditions on the road and their assessment of driver's availability to engage, but also thorough their verbal and non-verbal interaction with the driver. This allows them to relay information between the device and remote caller to the driver, in a sense acting as an informational 'buffer' until the driver is available to deal with it. Such delays evidently apply to phone calls, but this also may apply to system-based demands from devices that require driver input. In this case, the child assistant need not act on behalf of the adult, but simply smooth the timings between the driver's

availability and non-availability. A second observation is that child passengers offer the possibility for reminding the driver about events arising as a result of device interactions, or to offer redundancy checks on this (for e.g. as seen in lines 25-36 of vignette 2). In many cases, given that the parental activities of the driver are often based on, or arranged around, the activities of the children, the children are likely to be aware of issues that concern them, such as constraints on their own availability and that of their friends, or, as we see here, potential diary conflicts. Third, and following the previous point, we see that even relatively young children are (to a degree) able to pick up on salient information that is necessary to perform summarization when reporting this to the driver. In vignette 2 we see a clear example of how the child reports only brief details of her much longer phone conversation regarding the potential appointment clash back to the mother. All three of these forms of assistance would seem to be at odds with developments in in-car technologies that 'cocoon' the driver from the passengers, allowing them to directly interact with the technology (typically through audio/voice), either without assistance from the passenger (who need not be enrolled into the activity), or actively excluding passengers from this interaction through the use of a headset. Enrolling the passenger into the management of device interaction is nevertheless not unproblematic even though we see this operate effectively in vignette 2, the passenger is unwilling at first to do this. As many parents would attest, this is a situation where the passenger *may* act as a resource for the driver, but clearly cannot not be relied upon just because they are present, and this also may need to be considered in designing such technology.

#### Front-seat media

Another finding that adds to previous work on collaboration is the scope for developing media in the front passenger space. Our study brings out this feature of travelling as a family as it was common in our data to find children travelling in the front with parents. However, compared to adult front passengers, children may not be as proficient at reading or writing, particularly when this involves timely access to materials in a moving car. They may benefit better from technology that is voice-based or interfaces that allow them to draw characters, as opposed to a keyboard to input characters. We see this in vignette 1 where the daughter records the address on a large piece of paper, and that this form of media provides a tangible resource that is suitable for a younger child to use. Were these details to be directly entered onto a tablet keypad they would likely be difficult for the parent to instruct, harder for the child to achieve, and harder for the parent to check, given their primary visual focus on the road. Similarly, interfaces that support bigger screens and large fonts may allow children to engage more effectively with such systems as seen in the 'Family Pad' concepts in the market. Yet as we have already intimated, to focus on simplified forms of interaction is not the only solution for these settings, and it may be



worthwhile to consider supporting children's ability to reason or engage in extended collaborative discussions [see 8, 30]. In the second vignette, the daughter is already engaging in a discussion of how the call impacts the day's activities based on the information she receives from the caller. Research on designing age-appropriate digital environments suggests that children benefit from scaffolding on previous knowledge (here, it is the knowledge of school timings) and engaging collaboratively in completing tasks [8]. As might be expected, the data shows engagement between the child assistant and driver is heavily influenced by the driving conditions, but in particular, when the vehicle is stopped. These are the brief occasions that allow the parent to prioritise in-car interactions over the event unfolding on the road. Computer technology is well placed to take advantage of this, deploying accelerometer and GPS data to determine device movement in adapting its presentation format and information content to suit the driver's availability to observe or interact with it.

The SatNav is a device that holds a special value in the car, and presents similar problems to the telephone call interactions we have observed. While adults interacting and assisting them has been looked at in detail [6,12,18], how such systems could be adapted to suit use by child front passengers is worth considering, given that we found many instances of children travelling in the front seat in our family data. Although children may potentially be able to interact with devices, their problem solving and spatial reasoning skills may depend on their stage of development [8]. The locations of 'home' or 'here', and the relative distances between locations (for example) may be less well understood, and children may find this hard to use or draw inferences from. Looking more closely at our analysis above, it would appear that children are also likely to encounter some trouble in entering data from direct verbal instruction or to infer meaning from conversation with an adult where the relevant interactional or navigational concerns are implicit. While trying to carry out a search, children often need to clarify and reformulate queries with an adult [8], which may not always be possible in the car, where there is an urgency to complete a task quickly and often without extensive help from an adult (who is driving). Systems that present concepts in explicit or more tangible ways, or that give visual representations of distances and directions in a manner that children can relate to would appear to be valuable—these are likely to be hard to demonstrate in a primarily speech-based interface (i.e. "eyes free"), and mixed media solutions may be more suitable for this purpose.

#### **Adapting 'Natural' user interfaces**

Physical activity between the front, and between front and rear seats, lends itself to consider the role of gesture, movement and multi-person interaction, as well as speech, and it is worth considering how this important feature of car-based, family interaction might be supported. If we are

going to consider how multi-user/speaker issues are handled in the car as tasks are delegated to the passenger, or divisions of labour are negotiated between the travellers, user location may help in determining who is speaking, and this may subsequently help identify the topic that they are speaking about. At a more fine level of detail, pointing gestures or even passing tangible (i.e. trackable) objects between travellers may allow a computer-based system to draw meaningful inferences about the current state of an interaction with that system, for example, of who currently holds 'ownership' of dealing with media content (e.g. music controls) or of some problem solving activity (such as locating a destination address). As we have seen, pointing gestures prove useful in identifying and highlighting relevant content to passenger, and these gestures are possible for the driver to do under surprisingly demanding conditions while they are speaking, and add another modality to interaction. Image processing and computer vision technologies (such as Microsoft's Kinect) are already capable of identifying gestures, although in the light of the data presented here, it may not so much be recognition of stereotyped gestures acting to control aspects of a computerized assistant that is useful, but rather the use of gestures to highlight and identify topics of relevance.

#### **CONCLUSION**

This paper provides a close analysis of the initiation and reception of mobile phone calls in the family car, showing how calls can be managed through the collaborative efforts of driver and child passengers. It outlines the challenges of managing mobile phone conversations that occur while navigating through busy city roads and shows how drivers orient to mobile phones while driving and draw assistance from their family members in the car. Our focus of discussion was the family car and the implication that family travel has on the interactions within the car space. The findings point to the social and technological organization of activity in the car, and are oriented to inform design that considers the multi-faceted nature of family car travel.

In relation to our interest in adapting interfaces to cars, drawing from our family car data we pick out some specific design considerations. The design of these systems are particularly challenging, as they need to cater to a number of unique features of in-car interactions; these systems may need to attend to more than one user interacting with it and possibly including child passengers of a young age who may be asked to act as a proxy for the driver and to interact with these media. If such systems are not just used by the driver but with other family members taking some responsibility for the on-going interaction, for example, in receiving calls or engaging with content, they may need to recognize whether their user is a driver or passenger, but also what their role in the task is and what their competencies are, possibly with different users acting through different interaction modalities (e.g. voice and touch). Perhaps it may be useful to look at families, cars,

interactive systems and so on as an assemblage of agents involved in constituting and accomplishing emergent tasks, and our design challenge is to imagine possible configurations between these agents, and how they might operate in concert, over time.

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