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Horse, Butler or Elevator? Metaphors and enactment as a catalyst for exploring interaction with autonomous technology

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As technology becomes increasingly intelligent and progressively gains agency, the relationship between system and human is redefined. Conventional interaction design methodologies cannot fully encompass the emerging new types of relationships, and new methods are necessary to address interaction at early stages in the design process. Both design metaphors and enactment techniques have been suggested as a way forward, and this paper explores whether a combination of the two can support the design of interaction with future autonomous systems. In three workshops, 27 participants in total utilised this combination of methods to design the interaction with an autonomous vehicle. The analysis of the workshops shows that the combination of the methods manages to support the imagining and design, where the metaphors aided the creation of a joint conceptual vision of the relationship, and the enactment created tangible experiences and contextualisation of the design concepts. Nine guidelines for the use of the methods when designing intelligent systems are defined, based on the insights from the workshops.

design methods; metaphors; enactment; autonomous vehicles

1 Introduction

Machine learning and artificial intelligence are enabling systems that act with a greater degree of autonomy than ever before, drastically changing the relationships between systems and the humans who interact with them. This intelligent technology creates a challenge for designers, who must proactively suggest ways for people to understand and engage with these new systems. The interaction with highly intelligent future systems may be difficult to imagine at an early stage in the development process and places novel demands on the processes and methods used (Höök, 2000;

Taylor, 2009). For example, how can design handle potential conflicts between system and user, and how can disciplinarily diverse design teams agree on the character of the human-system relationship?

These questions are currently a pressing issue in the automotive industry, where the introduction of increasingly advanced automation in vehicles requires a rethink of the relationship and interaction between driver and vehicle (Kun, Boll, & Schmidt, 2016). In the development stages toward full automation, the vehicle becomes an independent actor that the user still must interact and share control with. Issues of mode confusion (Endsley, 2017), mistrust (Parasuraman et al., 2004; Verberne, Midden, & Ham, 2012), loss of situation awareness (Kaber & Endsely, 2004) and even misuse (Parasuraman & Riley, 1997) are possible consequences. To ensure safe use, the system must communicate appropriate use (Beller, Heesen, & Vollrath, 2013; Inagaki, 2008) as well as sense the user's state and capabilities (Sibi et al., 2016), creating a much more mutual and dynamic relationship than before. Conventional interaction design methodologies and guidelines may not encompass this increased agency of the system and need for mutual understanding (Pettersson & Ju, 2017; Schmidt & Herrman, 2017). New methods, as well as application of old methods in new ways, may be needed to address interaction with autonomous technology at early design stages. Considering the complex technology, and the potential effects on users' everyday life, it is also important to find methodologies that serve as communication tools in early design efforts for finding common ground between developers from different disciplines, as well as when involving users.

In the automotive case, suggestions have been made to use metaphors as a way into imagining the interaction (Davidsson & Alm, 2009; Flemisch et al., 2003; Ju, 2015), and to evaluate designs at a very early ideation stage through enactment methods (Pettersson & Ju, 2017). We see that these methods perform complementary roles in the design process and can be combined to address the design of the relationship between human and vehicle. The aim of this paper is thus to explore if, and how, design metaphors and early enactment together can support the design of interaction with future autonomous systems. More specifically, the focus is on investigating how these techniques help the designing team to imagine and conceptualise designs of autonomous systems.

2 Combining metaphors and enactments

In a design process, both conceptual association to frame the problem and concretisation of the solutions are necessary (Burns, Dishman, Verplank, & Lassiter, 1994). We propose employing metaphors and enactment as a hybrid design tool for autonomous systems, as they together should theoretically provide those two necessary parts when applied to a use scenario. Design metaphors should be able to provide the conceptual groundwork and create the vision necessary to guide the design process, while enactment should create the tangible experiences necessary to move forward. This section provides overview of the separate methods and their relation to autonomous vehicles.

2.1 Design metaphors

Metaphors have been used in design to frame design problems, to create meaningful product experiences and, perhaps most famously, to guide user's interaction through e.g. the desktop metaphor of personal computers (Cila, 2003; Hey, Linsey, Agogino, & Wood, 2008). The suggestion to use metaphors in the design of automated vehicles was made by Flemisch and colleagues (2003), as a way to handle the interaction consequences of the vehicle's increased agency. They argued that a design metaphor has two strengths; it can serve a way to create a uniting vision for the design team, and it can help the user create an initial mental model of the system if properly communicated in the design. In the context of autonomous vehicles, the metaphors have to be applied to a new level of the relationship between vehicle and human, compared to previous use of metaphors in design. That is, instead of relating how to use the vehicle, it should help clarify the division of control and responsibility, communicate intentions and goals, and set the tone of relationship (Bruemmer, Gertman, & Nielsen, 2007).

The power of the metaphor is that it can, via conceptual association, link disruptive ideas to well understood objects and processes (Bruemmer et al., 2007). It creates the link between source and target by mapping properties from the source to a blended target (Cila, 2013). By doing so, abstract ideas (like the character of a relationship) can be given concrete properties and made more accessible (Bruemmer et al., 2007). Specific suggestions for metaphors have been made, notably comparing the new human – vehicle relationship to that between rider and horse (Flemisch et al., 2003), husband and wife (Ju, 2015), or players on the same team (Davidsson & Alm, 2009). However, neither of them has gained traction, and the translation of metaphors into the design of a vehicle – human relationship is not well explored. Research on design metaphors suggests significant challenges including how to choose an appropriate metaphor and how, and through which features, to transfer the conceptual association to concrete design (Cila, 2003).

2.2 Enactment

A metaphor alone is not enough for design decisions, the characteristics of the relationship need to be represented in concrete interactions, filling in the gap between metaphor and interface in the design process. There are a number of ways of which design ideas can become tangible, e.g. by sketches, lo-fi prototypes and storyboards. However, capturing the dynamics and the tacit aspects of the interaction design may be difficult in static or inflexible representations (Arvola & Artman, 2006). Enactment/body storming (Burns et al, 1994; Buchenau & Suri, 2000) serves as a very flexible and swift way of exploring future designs. By gesturing and expressing the interactions taking place between user and system, enactment can give "…the possibility to be flexible and contingent to user and system actions and reactions" (Pettersson & Ju, 2017). Furthermore, it provides a space for a group of designers/researchers to improvise and together "create a common focus" (Buchenau & Suri, 2000) of a future design.

Enactment has for example previously been used for example in improvising autonomous vehicle value (Jorlöv, Bohman, & Larsson, 2017), postures and activities in autonomous vehicles (Ive, Sirkin, Miller, Li, & Ju, 2015), expectations on interactions with autonomous vehicles (Pettersson, 2017) and evaluation for non-autonomous in-car interfaces (Davidoff, 2007). However, as enactment is in its nature explorative, using the technique as stand-alone base for generating interaction designs may lack the goal and stringency needed.

3 Methodology

The hybrid design tool of metaphors and enactments was explored in three workshops, where participants worked in groups to develop an interaction design concept for an autonomous vehicle[1]. There were small differences between the workshops as the setup had to be adapted to the preconditions but the structure comprised the same three steps for all workshops, as described in Figure 1. To support the process the following material was provided (more details in Figure 1):

- **Metaphor cards:** a set of ideation cards, each describing a metaphor for a potential vehicle-human relationship (see Figure 2), plus blank cards to encourage new metaphor creation.
- **Enactment techniques:** in all three workshops, a simple mock-up of a car was placed in the room as the scene for enactment; the "setting the stage" method (Pettersson & Karlsson, 2015). The mock-up consisted of four chairs and the outline of the car drawn on paper covering the floor. In the third workshop, two further enactments were available: a small-scale road scene constructed using a play-mat with a map and toys representing cars and pedestrians (Figure 4), and a lo-fi driving simulator, constructed of a projected film of driving scenarios, and a simple foam board mock-up of a cockpit (Figure 6).
- **Prototyping material:** paper, cardboard, pens to make simple mock-ups for interface elements.

[1] Vehicle was SAE level 4: The driving mode-specific performance by an Automated Driving System of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene (SAE, 2016)

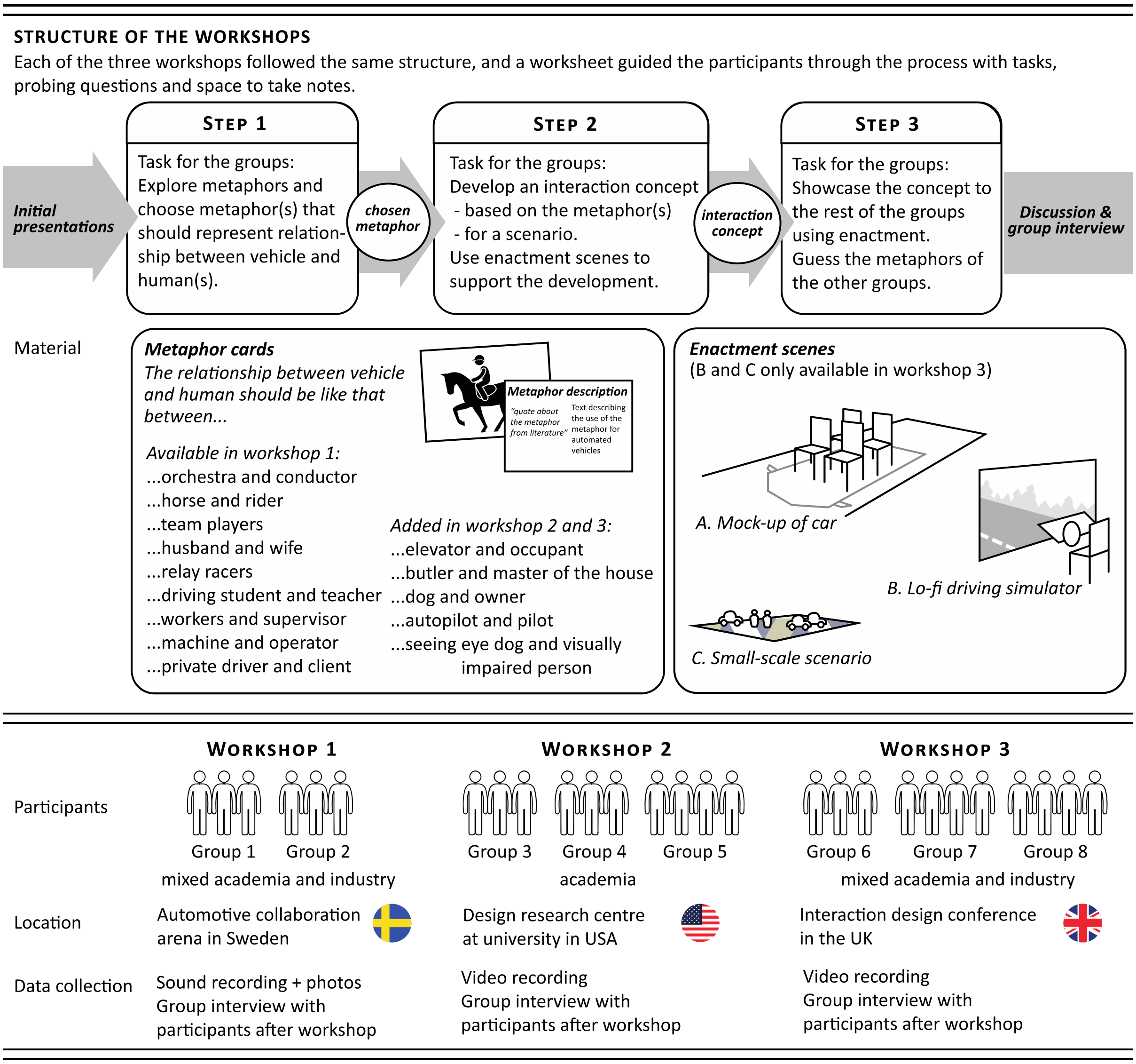

Figure 1 All three workshops had a common structure and similar material, but the number of participants and location varied for each workshop occasion.

Since the study focused on understanding whether the methods help the design team to imagine and conceptualise designs of autonomous systems, participants with some experience of working on the interaction between humans and automated vehicles were sought. Some participants came from industry and others from academia (from master students to assistant professor). The workshops were organized between late 2016 and mid-2017.

For the analysis, notes from the workshops and video recordings where gathered in a spreadsheet, where information from the individual groups and general discussions where structured according to metaphor choices, evoked discussions, created interaction designs etc. A thematic analysis was performed, utilising affinity diagrams (Martin & Hanington, 2012), to map out and group the general outcomes and insights from the use of metaphors and enactment. Next, these findings based on the analysis of videos, notes and worksheets are presented.

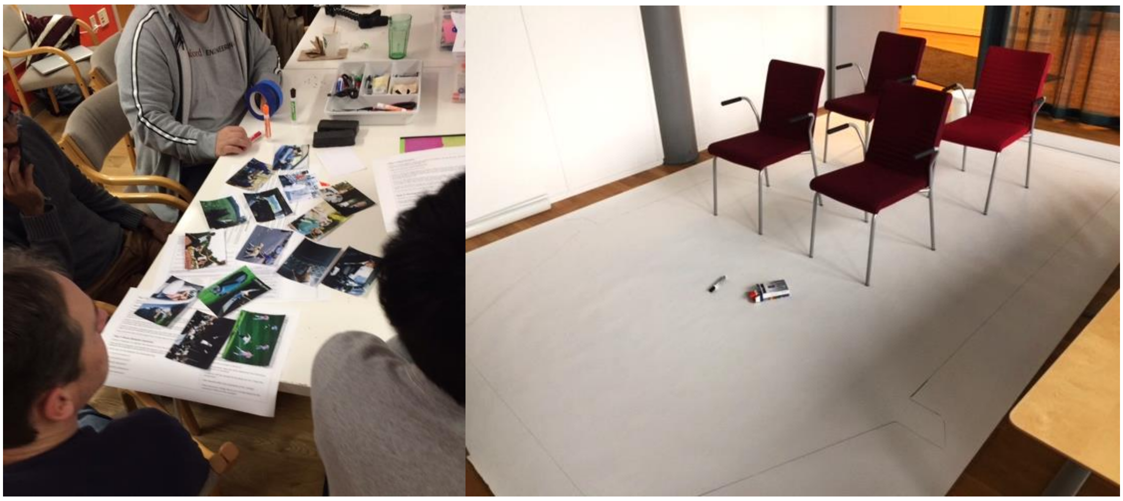

Figure 2 Metaphor cards during discussions in Workshop 2 and enactment "stage" in Workshop 1.

4 Findings

During the workshops, participants produced a diverse set of interaction concepts, making different prioritisations regarding which aspects to include and which events to design for. Figure 3 gives an overview of the concepts created.

4.1 Imagining a relationship together

The first hurdle for the groups was agreeing on which metaphor to choose and which relationship they would like to see between vehicle and human. The discussion leading up to a choice was approached differently in the groups and took different amount of time.

4.1.1 Design experience and diversity

Some groups quickly identified a few of the metaphors to analyse further and get to designing. For example, within a few minutes, group 6 had picked Husband, Guide Dog and Kit (vehicle in the TV series Knightrider) based on interest, and begun analysing the characteristics of these metaphoric relationships, saying e.g. about the Guide Dog that *"there is a lot of trust in that, [...] you put your faith in the dog".* Group 1 instead strategically chose metaphors representing different levels of involvement in driving; Butler (low), Horse (high), and Relay racers (switching between none or full). Both groups had a high degree of design experience, a good preconception of what they were applying the metaphor to, and quickly settled on a final choice.

Other groups seemed to struggle more with the choice, and spent more time discussing what they were going to apply a metaphor to. This was especially noticeable in group 7, where the different disciplinary backgrounds of the participants affected which approach they took to the metaphors. The system designer wanted to apply it to the intelligence of the system, the interaction designer to the relationship and the anthropologist wanted to string metaphors together into a narrative. While either approach could lead to interesting results, the group needed to agree to move forward in their joint design process. The discussion appears to have been useful for both highlighting how many dimensions there were to the human-vehicle relationship as well as merging the group's different perspectives. Group 7 and other groups with similar patterns indicate that groups with more disciplinary diversity will have to discuss more to come to an agreement, but that this discussion gives better insight to the dimensions of the problem.

The metaphors themselves were perceived as useful in this discussion as they opened up the design space and pushed participants to new discoveries; *"to be forced to think about this was actually nice because the metaphors open up for these extremes […] for us it was helpful as you realize the different dimensions* [of the system/user relationship and communication]*"*. The metaphors and the discussion together helped participants question their assumptions. For half of the groups, this

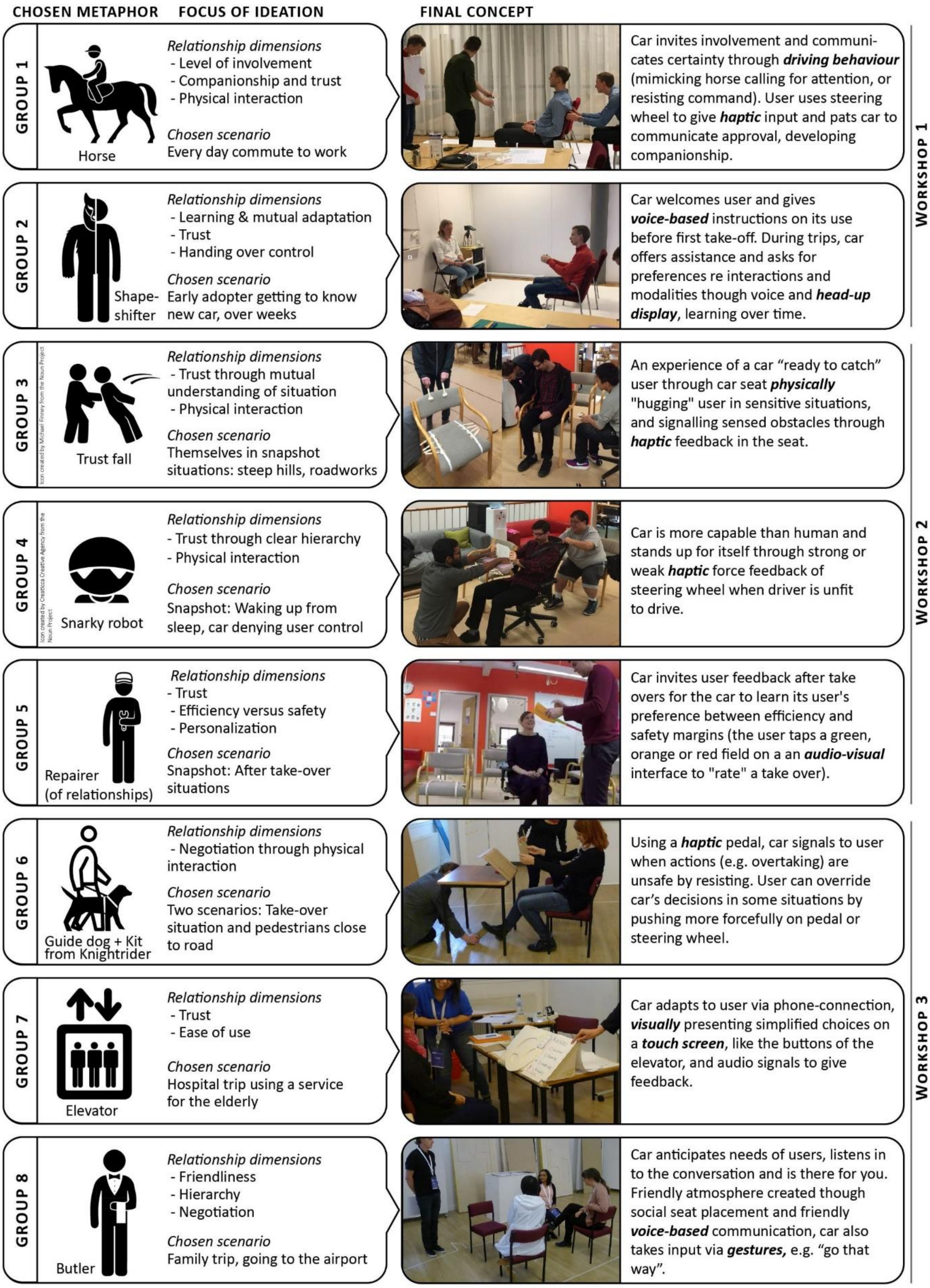

Figure 3 Overview of outcomes from all 8 groups, including which metaphor they chose, the focus of their discussion (relationship dimensions and scenario), and the final concept.

combination of design space and relationship dimensions resulted in the decision to go with a self-defined metaphor that described their specific idea, while the rest of the groups chose from the cards provided (groups 1,6,7,8).

4.1.2 Relationship dimensions and system expressions

The metaphor choice discussions revealed insights into the identification and prioritizing of relationship dimensions, including trust, adaptation, and level of involvement, as well as expressions of the system, for example assertive as in group 4's Snarky Car or submissive and subtle as in group 1's Horse. It is worth noting that all groups chose a different metaphor (see Figure 3) and the prioritisation of relationship dimensions played a major role in that choice.

Trust was mentioned by almost every group and was generally conceived as a fundamental issue to address, both in order to support the formation of trust (e.g. groups 3, 4, 5,7) and also avoiding over-trust (e.g. groups 1 and 2). Another frequent dimension was the *level of engagement* in the relationship; when, how and how much the system should engage with the user. This dimension is easily conflated with automation level but relates to the expression of the system rather than which tasks are automated. Thus, it includes both the level of involvement with the user and the communication style of the vehicle. Group 1 explored a relationship based on the Horse where the need for involvement was gently hinted at by the vehicle but using unobtrusiveness as a guideline: "*it's always there and you can control it super easily by just doing a small thing, otherwise it goes back to a baseline where it does its own thing".* Other groups (2, 6, 8) explored a much more active role for the vehicle; asking the user continuously for input and feedback. Group 8 expressed their concept as "*the butler [metaphor] has a very clear hierarchy, but the car is also your friend. So, we made a talkative machine, this whole idea of a friendly machine, a friend in the car* ". In contrast to the vehicle inviting involvement and "small talk", group 4 proposed a different approach, where the "Snarky Car" instead denied involvement through very decisive interactions, like the steering wheel spinning away from the user "*it would kind of be like snatching your hand, like - don't touch me!".* The concept demonstrates another dimension discussed by the groups: *hierarchy* and who has control over the interaction.

The *negotiation* of the system's and user's understandings of the situations was also explored, e.g. group 1's Horse signalling that there might be a better route to take by changing its driving behaviour, and group 5's Guide Dog providing haptic feedback to correct the user wanting to perform potentially unsafe operations. Other concepts created a shared understanding of the situation instead, including group 3’s Trust Fall concept that physically communicates to the user that the car has sensed road obstruction. Also, the relationship’s *evolvement* over time was explored (e.g. groups 2 and 5), where the car (and the user) adapts to each other.

4.1.3 Own or others' relationships?

The prioritisation of dimensions was partly based on interest, but also on who the groups imagined as user. Some groups prioritised dimensions based on their own experiences or desires, e.g. the recent experience of driving a very steep hill that led to the Trust Fall metaphor in group 3 or experiencing a passive-aggressive self-service check out that lead to the Snarky Car of Group 4. Others imagined what would be important to future users, e.g. the owners of the first, ground-breaking autonomous vehicles in group 2's Shapeshifter and the elderly person using a ride service in group 7's Elevator concept. Figure 4 shows group 7’s concept under development in the small-scale scenario, and group 3's Trust Fall concept is tried out in enactment. Groups that based their choices on an imagined other user tended to cover a wider range of events in their designs, including both mundane events like telling the car where you want to go, and situations where there was a conflict of interest between the car and the user. Self-experienced designs instead focused more on the specific situation.

Figure 4 Different starting points of the concepts: group 7 is working on an elderly person's trip to the hospital in the small-scale scenario, and group 3's Trust Fall metaphor is being translated into a tactile design inspired by one of the participants' own recent driving experiences.

4.2 Moving from the conceptual to the concrete

Two major types of outcomes can be distinguished from the groups' work; the overarching conceptual ideas about the relationships, and the concrete design of the interactions. As mentioned above, the range of metaphors forced participants to question their assumptions and explore the full design space and relationship dimensions, leading to the former type of outcome.

The latter type of outcome was instead more a result of the combination of metaphors and enactment, which directed participants *"to make it concrete and make it into something*" according to a participant in workshop 3. Applying the metaphor to the interaction meant taking the conceptual leap from the broad to the details and practical solutions. In doing this, three different levels of abstraction where employed. Some applied only the inherent meaning of the metaphor to the design (e.g. creating trust by physically "being there" as in the Trust Fall concept), some chose a combination (e.g. the tacit information from a guide dog combined with the assertiveness and smartness of Kit), whereas other let the metaphor guide interactions throughout the whole concept on a more overarching level (e.g. the elevator concepts selection of simplified choices and characteristic audio notifications).

Based on the groups discussions, certain types of metaphors seemed easier to interpret directly into a design solution than others. The clarity of the metaphor seems important here, as fuzzier concepts, such as the Shapeshifter, tended to result in less actionable design ideas. Group 2 reflected on the fuzziness of their metaphor in the design, saying *"but now we have a really hard time to say anything* [about the design]*, since we say that it is super fluent and can do whatever more or less".* Metaphors that instead were concrete, well-known to the participants and "complete" in themselves, resulted in more actionable interaction concepts. Furthermore, metaphors that involved movement, as in going for a ride in an elevator, taking a horseback ride or a blind person walking with a guide dog appeared easier to transfer into interactions, than for example butlers and shapeshifters, where interactions are fuzzier. Another aspect that appeared to help the concretization was the provocativeness of the metaphor – a strong metaphor with potential "drama" offered a more accessible "problem" for the interaction design to address. An example was the "Snarky Car's" authoritative behaviour hindering the user from driving when unfit to do so (Figure 5).

Figure 5 Becoming concrete: Enacting Group 4's "snarky" car's defensive haptics of the steering wheel and developing Group 2's "Shapeshifter " interactions during the enactment session.

Despite the guidance that the metaphors provided, after a while many groups started to feel restricted by the metaphor and took a more pragmatic stance in their design. One participant in group 8 commented *"the metaphors are a good start to get you thinking, but you get to a point where thinking about the metaphor is holding you back*, *maybe it's not the elevator but more of a plane*". At this point, the combination with enactment led the designs to evolved, as new design ideas emerged and new discussions took place:

> *"It was good to have the metaphor and also all these [enactment scenes] because it helps you to discuss the different levels, you go from the details to the more abstract...and the metaphors helps you to take on the scenario in different levels. It expands the design space. […] it was great to be able to show stuff here* [in the car mock-up]*. It was like the diamond model, you go back and forth..."* (participant, group 8).

However, in workshop 3, the different enactments gave rise to different experiences. The majority of the participants preferred the freer enactment scene of a simple car mock-up, e.g. "*I liked that it had no restrictions what so ever, it's more imaginative and less restricted by technology"* (participant, group 6). No one preferred the small-scale scene and a minority the lo-fi driving simulator (Figure 6), e.g. "*it's good that it puts* [the design activity] *into an everyday context, that's how we came up with the idea of the car stopping...*". Our observations confirmed the insights of the participants; the open car mock-up contributed by being an open space for innovation, but still offering the basic notion of a car contextualizing the interactions.

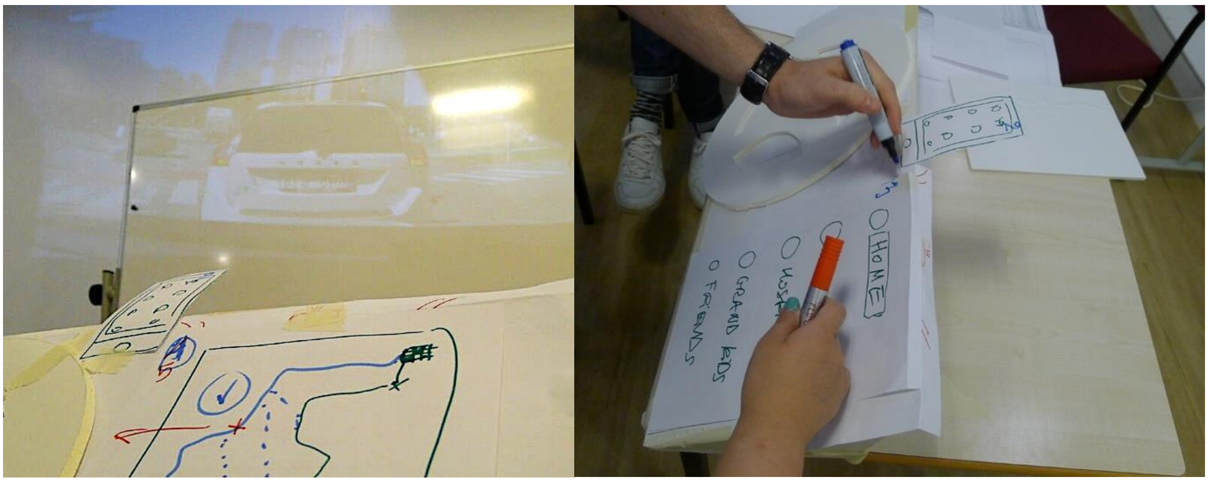

Figure 6 Developing the visual interface: the "Elevator" interface under development in the lo-fi driving simulator.

4.3 Methods trigger modalities

The vehicle context is unique in the range of interaction modalities available to communicate between vehicle and user. The vehicle envelopes the user, creating a range of channels for communication; senses pick up on speed and lateral control, sounds, visual and tactile information. New technology also enables advanced visuals, gestures, haptic and speech communication. In the workshops, the groups' propensity to take advantage of this range of available modalities was noticeably affected by the enactment techniques used and the metaphors chosen. The groups that chose a human-human relationship metaphor, like the Butler, and the Shapeshifter (which started out as "the new kid in town") tended to rely on solely voice-based communication. The human-human metaphors pushed the imagination towards a separate “agent” controlling the car, that should be embodied as a character, and use voice as primary means of interaction. In contrast, metaphors of human-animal/object relationships triggered more haptics. Group 6 reasoned:

> *"Dogs don't talk...it's that notion of you know, you're walking your dog and the dog pulls you away and you react to something you don't know what it is yet. But you trust the dog and you say, OK, that's fine I'll go with you..."*

The enactment techniques also helped develop the modalities used, in some cases challenging the chosen modalities and exploring other means of interacting. Group 7 for example, evolved their elevator-based design to incorporate more audio features in the move from small-scale scenario to very simple simulator. "Setting the stage" appeared to trigger the "body-based"/physical interactions, especially when combined with props (such as cardboard steering wheels, a block of wood acting as gas pedal, conveying haptic feedback, see Figure 7). Enactment allowed participants to express ideas that were difficult to verbalize - by acting them out. Imagining and trying out the physical use and actions in a concrete space thus provided a means to generate and evaluate the practical and embodied aspects of use. The timing of the utilization of the technique may have influenced, comparing group 6 who employed enactment early, and group 8 who used enactment later in the process (and through it added gesture interaction).

The physical interactions were positively evaluated by participants, as they were perceived as both natural and non-annoying compared to voice-based interaction. One participant said of the Guide Dog: *"this felt like the friendliest...because our interaction* (the Elevator) *felt so machine like, and unlike nature. This was much more natural and friendly*". The haptic modality could not only be used to convey information but was also seen to evoke feelings of safety and trust, two of the important relationship dimensions. Group 3 explored this emotional communication based on the Trust Fall metaphor (Figure 7) and by enacting the haptic interactions of car seats, belts and steering wheel, the experience was effectively communicated.

Figure 7 Physical interaction: Props conveying the haptic "hug" of the Trust Fall metaphor and the enactment of the "Guide Dog" where force feedback is given through the pedal.

4.4 A note on the impact of the scenario

The impact of the scenario on the design process was made evident across the workshops. The scenarios used by the participants to design and enact the interactions were of different character which impacted the character of their designs. Two different temporal dimensions of the scenario had an impact; *how far in the future* they were placed and the *timespan of the scenario* itself. Scenarios placed too far into the future offered challenges as they contained too many unknowns, in similarity to the fuzzy metaphors, and made it difficult to evaluate ideas. However, staying too close to the present limited the innovativeness of the designs and kept the discussion on the interface design rather than the relationship.

The timespan ranged from individual snapshots, to one leg of a trip containing multiple events, to over a longer time period (see Figure 3). Group 2 for example struggled with the evolving relationship over a considerable timespan, indicating that for first design steps this is not a fruitful scenario. However, choosing too simple scenarios risks leading to shallow design ideas too focused on one isolated interface aspect, rather than the essence of a relationship. It was also noticeable, that to really get involved with the relationship dimensions, the scenario also needed to contain situations where there was a difference in understanding or interest between vehicle and human. All in all, the granularity of investigation is important to consider, and the more concrete scenarios, the better the techniques appear to be applicable.

5 Discussion

The focus of the workshops was to explore how metaphors and enactments may work together to help design teams imagine future relationships and interaction designs with autonomous technology. Based on the findings, we believe that the combination of the two techniques did manage to push participants into imagining new types of relationships <u>and</u> concretizing them into designs that could be communicated to others. In comparison to creativity methods in interaction designs which may lack the necessary connection to the use context (cf. Biskjaer et al, 2010), the enactment helped to bring context to the design activity. This means that the method combination supported the challenging "conceptual leap" from discussions to concept (cf. Odom et al., 2012). In this process, the metaphors served as a way to formulate and challenge undirected approaches to the relationship, capturing the essence, and enactment served to bridge the metaphor into concrete interactions and offer a structured space for comparing the concepts.

5.1 The value and limitations of the methods

The design of an autonomous system encompasses both fail-safe, intuitive functionality and crafting the expression of the interaction. In an automotive context, different brands may follow similar guidelines to create a system that is easy to use and employ similar hardware and software, but the style of communication and tone of voice may be very different across brands. The metaphor and enactment combination offered a tool to address this differentiating quality in terms of both aesthetics and the nature of the communication, which was an additional value of the methods highlighted during the workshops. The combination also resulted in that participants explored the full design space of interaction modalities that the car has to offer.

In relation to the issue of designing communication with future intelligent technology, the metaphors managed to become the joint visions suggested by Flemisch and colleagues (2003) to constructively guide the design. The way in which metaphors were utilised by the participants could be likened to Hey and colleagues' (2008) description of prescriptive metaphors leading to innovative solutions by removing mental constraints, but the participants' discussion shows that the metaphors manage to both narrow down and open up the design space simultaneously, which compares better to Flemisch and colleagues (2003). In that, the metaphors managed to make the abstract concept of a mutual and dynamic relationship between vehicle and human more accessible to the participants, as suggested by Bruemmer and colleagues (2007). The way enactment was employed demonstrated previously concluded strengths with such methods (cf. Davidoff et al., 2007; Odom et al., 2012;

Pettersson & Karlsson, 2015), such as the ability to accentuate the flow of interaction between user and system, and to introduce and reflect on contextual factors affecting the use of the system (cf. Davidoff, 2007). Based on these findings, we see the combination of metaphors and enactment as able to contribute with a holistic outlook on interactions rather than islands of information exchange.

In the workshops, some limitations of the methods could be observed. Metaphors were for example limited by the participants knowledge of them. The power of a metaphor is connected to linking the unknown to something well-understood (Bruemmer et al., 2007), so metaphors that the participants did not fully understand themselves were harder to work with. It is easier to predict how an elevator would react than a mythological creature as a shapeshifter. However, metaphors that involved provocation could make up for an incomplete understanding of the metaphor by bringing out the nature of the agency of the interface, addressing the core of the interaction with the autonomous system. All metaphors did at some point limit thinking as well, as the translation into design could only be partially guided by the metaphor itself, and was highly impacted by the scenario, the dimensions that participants focused on, and the enactments.

As made visible in the enactments, the concreteness of the scenario impacted. It was clear that some concepts worked less well with enactment than others, especially those concepts encompassing learnability and long-term aspects. This does not inherently mean that they were worse ideas, just more difficult to map out with the techniques used.

The enactments used also affected the nature of the interaction designs in different directions, which has also been seen previously (Arvola & Artman, 2006; Tholander et al., 2012). The free form of enactment in a simple car mock-up, in combination with simple props, helped the participants to surface and exemplify the aspects of interaction designs that are difficult to bring into words, while the two other enactments appeared to tune associations in other directions (e.g. to a helicopter perspective of an entire drive in the small-scale scene and to audio/visual interaction in the lo-fi simulator). These perspectives are valuable in their own right, but not as useful when focusing on the essence of the relationship and flow of communication.

We recommend keeping scenarios focused and concrete when employing the techniques, given their nature and limitations. Being concrete in terms of context and scenario, by including contextual situations (e.g. road works and steep hills) and relationship events (e.g. different understanding of a situation) appear to make the techniques more applicable, in comparison to a free range of scenarios and problems.

5.2 Translation of workshops into real projects

It is difficult to get the full picture of how the method combination would work in the real-world context of a design project, based on three one-day workshops. However, there are some indications in the workshops. Designing interactions with autonomous technology is challenging and requires collaboration between multiple disciplines. With complex systems, multiple disciplines need to communicate and share ideas in the development, each bringing in own knowledge but also own assumptions. To work effectively, the joint vision of what the team is bringing into being mentioned above becomes even more important (cf. Buchenau & Suri, 2000; Heide & Henning, 2006). The metaphors offered an initial probe for developing this vision, but we also found that the more multidisciplinary teams generally took longer time to agree on the vision and start creating interactions. For the even more diverse teams which will be necessary in the development of autonomous systems, this stage will expectedly take even longer time, but will likely be very valuable to highlight disparities in assumptions and work towards a shared understanding. Enactment here served as a useful tool for these teams to push forward in the discussions, moving from the visionary and abstract to the more concrete. Experiencing tangible situations together in the team is an important part of creating a shared understanding (cf. Buchenau & Suri, 2000).

The enactments thus worked to create tangible experiences for the design team, but they also serve as a first step into prototyping of physical interactions. This is an important step for beginning to involve users in the design process, and truly evaluate the concepts. In a real development project, metaphors and enactment will need to be blended with other types of design activities, such as subsequent prototyping and user studies, where it is possible explore users' reactions including trust, mode confusion and misuse. In that process, it will also be possible to evaluate whether the metaphor-based designs manage to translate into users' mental models as argued (Bruemmer et al. 2007; Flemisch et al. 2003).

5.3 Future work

The design concepts that emerged from the workshops were in many cases very interesting, especially given the limited time for ideation. Most concepts contained seeds worthwhile further explorations, addressing identified issues of automation, such as misuse (such as the Snarky Car's and the Guide Dog's haptic feedback hindering the user to interact when unsuitable) and trust (e.g. the Trust Fall concept's intuitive communication for creating a shared understanding of the road scene). The discussions leading up to the concepts also captured important dimensions that are important for both for development of, and further research into, autonomous vehicles.

Our plan is to continue the explorations of metaphors as a vehicle for interaction design, analysing the application and translation of metaphors in these workshops further, as well as how they translated to the users. Exploring how the metaphors translate (or not) to users will also be further investigated through user tests with more finished interaction concepts.

6 Conclusion and recommendations

In conclusion, we found that overlapping the two techniques, creating a metaphor-enactment hybrid, can help multi-disciplinary teams design the interaction with autonomous systems: from the creation of a joint conceptual vision of the relationship they want to bring into being, to seeds of innovative concrete interaction design concepts utilising the full range of modalities the vehicle as a design space has to offer. However, the method also has limitations in the range of scenarios and dimensions that can be covered and requires a certain range of contextual knowledge from the participants. Based on our experiences from the workshops, we formulated 9 guidelines for the use of metaphors and enactment together in the design for intelligent systems:

1. Set a reasonable scope for the scenario in terms of time scope of the interactions explored, futurism, and evolving relationships.
2. Explore a number of metaphors before selecting one to help find your assumptions and draw the design space.
3. Chose a metaphor that you can relate to.
4. Include potential for drama in the metaphor and/or scenario, as this is when the new agency-related relationship dimensions truly surface.
5. Use enactments early to become concrete when designing the interactions.
6. Consider the dialogue/flow between the user and system. Designing for autonomous technology requires focus on the communication, i.e. not singular patches of information transfer.
7. Use "props" in the enactment to elicit physical interactions; i.e., introduce objects that may be part of the interaction itself and/or in the environment.
8. Keep it tangible and consider the full palette of modalities.
9. Invite others try out your ideas in the evaluation enactment – not only enacting for yourselves means even more pressure to become clear and challenge ideas.

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