Comparing Distributed Cognition and Course of Action: An application to car driving

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ABSTRACT

Distributed Cognition and Course of Action theories offer frameworks for micro-analysis of activity. The former leads to an abstract level of description of the propagation of information in a socio-technical system. The latter embeds conclusions from the Situated Action approach in the enaction theory to observe and analyze the Course of Experience.

A compared analysis of the same moment of driving illustrates the discussion about similarities and differences between these approaches on topics such as the unit of analysis, the degree of stability assumed in the system, the contribution to design and the articulation of individuals, group and artifacts.

Keywords

Situated cognition, Course of Action, Distributed cognition, Driving, Design

INTRODUCTION

Taking the context of use into account is a crucial issue in such domains as mobile systems, collaborative tools and, more generally, in all artifacts design. Studying users' activity is necessary to design tools that fulfill theirs needs, insure their safety and are both acceptable and usable for them.

The approaches based on a computational view of cognition capture something of the interaction between a human and a computer. However they fail to take into account the influence of the context but also the cultural, situated and embodied dimensions of activity (Dreyfus, 1972). Several approaches of cognition have been developed and have interacted to challenge the information processing paradigm, including Situated Action (Suchman, 1987), Cognitive Ergonomics, Distributed Cognition (Hutchins, 1995) or Activity Theory (Nardi, 1996). Comparisons of these approaches have been performed. Nardi (1995) offers a general theoretical comparison. Decortis, Noirfalise et Saudelli (2000) show the differences appearing in the analysis of a cooperative work situation. Marmaras et Nathanael (2005) posit these theoretical perspectives according to the degree of invariance that is assumed in the situation (stable goal structure *vs* opportunistic action). All these others show differences in issues such as unit of analysis, relations between objects, individual and group, etc.

The Distributed Cognition approach keeps the notion of symbolic representation but challenges the computational approach in two ways: 1) manipulation of symbolic representations is not considered to be limited to the processes internal to a single individual but occurs across people and external tools, and 2) cognitive processes are studied in "the wild" and are not limited to controlled experimental laboratories.

The Situated Action approach is very poorly present in these comparisons. Nardi underlines its historical benefit in correcting the role of rationalization and planning in cognition. However she emphasizes the weakness of using the situation as a unit of observation: 1) difficulty of generalizing moment to moment analysis across context and 2) "behavioristic undercurrent" by focusing on the reaction to the situation and not considering consciousness, intentionality plans or prior knowledge.

The Course of Action framework (Theureau, 2003) aims at studying how experience influences activity over short and long term. It includes findings from different theories and methodologies, Situated Action included, but embeds them in the enaction theory (Varela, Thomson et Rosch, 1991). The positive definition of the on-going cognitive processes brings a new light on Situated Action issues.

This paper proposes a comparison between the Distributed Cognition and the Course of Action framework, which are both interested in fine grain analysis of activity. After a brief theoretical comparison, the analysis of a moment of driving in both frameworks is presented, from a study conducted at the HCI-DCog lab, UCSD (McCall, Achler, Trivedi, Haué, Fastrez, Forster, Hollan et Boer, 2004). Finally a discussion is proposed to revisit the issues of emergence, individual-group perspective and contribution to design.

TWO ALTERNATIVE FRAMEWORKS

The Course of Action (CoA) and Distributed Cognition approaches (DCog) share common perspectives and interests in cognition[1]. They both:

- Study cognition, where 1) cognitive processes are grounded on the interaction between human actors and their environment, both social and cultural 2) learning creates new forms of interactions.
- Stress the necessity of studying activity in natural settings (in the "wild").
- Have a strong interest in design and modeling (even if the focus is different)[2].

However they present differences, which will be presented according to the following themes:

- Definition of cognition and more precisely the nature and locus of the cognitive processes,
- How individual perspective, the group and the technical artifact are articulated,
- Their contribution to design (presented later).

DCog specificities

The main hypothesis of the DCog theory is that the cognitive processes are constituted by the "propagation of representational states across representational media"(Hutchins, 1995).

Propagation of representational states

In the DCog framework, representation media may be any material thing, including external tools, people's brain and body. The notion of representational state is inspired from Bateson's definition of information, a "difference that makes a difference". It is defined as a "configuration of the elements of a medium that can be interpreted as a representation of something". The actual interpretation of a representational state can therefore be considered only in the physical, cultural and social context of human practices. An example provided by Hutchins et Klausen (1990) is how a plane cockpit remembers the speed of reference, according to the procedure of a specific maneuver.

In this framework, studying cognitive processes during a given activity is done by performing a micro analysis of the trajectory of representational states through the coordination of representational media. This abstract level of analysis can be applied at different levels. One may find different cognitive properties if he focuses on the processes 1) internal to a single individual, 2) between an individual and a set of tools or 3) between a group of people and a set of tools. DCog emphasizes the danger of attributing to one's internal processes cognitive properties that actually belongs to the larger system. In other word, a "technologically advanced" human without internet, plane and cell phone would loose all his cognitive abilities.

Studying learning is done by identifying how organization of representational media is propagated within a system. Moments of practice and socio-technical guidance leads people to acquire and share internal organization that permits their coordination. In an even wider horizon, culture and technology are seen as the crystallization over time of partial solutions to frequently encountered problems.

Definition of the system

In order to perform an analysis of cognition understood as propagation of representational states it is necessary to identify what the representational media are. As all the human activities and artifacts are ultimately related, studying cognition would require including the entire known world in the cognitive system. Studying a given activity therefore requires identifying the adequate system.

Reviewers consider that the DCog theory implicitly assumes that a socio-technical system preexists and has a stable goal structure (Nardi 1995) at least during a short time frame (Maramaras et Nathanael, 2005). However, DCog theory does not require assuming such a socio technical system. On the contrary it assumes an existing culture, as a long term process of crystallization of coordination possibilities in mind and tools.

The studied system can be defined as the cognitive system enacted in a given moment of activity. It supposes drawing the boundaries of the system around all the elements that are needed to explain the outcome of this activity. The internal states necessary to explain the activity are deduced only once the propagation of information across the system is established from the observable events.

It is therefore researchers' responsibility to carefully define the system actually enacted and not to rely on the configurations inscribed in the material and cultural context, which are more easily accessible.

Finally two consequences follow from this definition:

- At the theoretical level, human and artifact are not considered as different in nature. Both are representational media.
- At the epistemological level, verbalizations are not considered as valid data about activity but rather as a socially acceptable construct.

Course of Action specificity

The main hypothesis is that cognition is a structural coupling between a human and its environment, in which an experience is continuously enacted and manifests an autonomous perspective on the situation.

Asymmetrical interaction and experience

The CoA framework is based on the enaction theory (Varela, Thomson et Rosch, 1991) that defines the

[1] The activity theory, not presented here, has also very similar interests.

[2] DCog is more interested as computational modelling as a validation method and CoA bases its analysis on a descriptive modelling of the experienced activity.

functioning of a living system as a structural coupling with its environment. The only stable unit is the *biological* system itself, which has his own internal processes. The *cognitive* system is defined as the emergent interaction between the biological processes and the perturbation/stimulation from the environment. Unlike traditional Situated Action approaches, the interaction is explicitly considered as asymmetrical and historical. The biological system adapts its structure to his environment: in doing so, it restitutes configurations of perception and action that were learned during its history of interaction. This creates its own autonomous perspective on the situation.

For the enaction theory, the correct level to describe the cognitive processes is not the biological one but the configurations that associate the biological adaptation and the environmental elements. A description of the functioning of how the biological processes learn to restitute a configuration would not only be too detailed to be achieve about real situations but would also miss the part of the cognitive processes that is located in the interaction with the environment.

To apply this theory, which has been developed in the biological field to the study of cognition, the CoA framework sets an additional hypothesis borrowed from the phenomenological tradition: human activity comes with an experience provided to the actor, i.e. what is potentially accountable for him at any moment. This experience is considered as the surface effect of the structural coupling. Getting data about the course of experience - that is the temporal development of this experience - provide an insight on what is relevant for him and, by deduction, what configurations of interaction are currently enacting the cognitive system.

Finally studying cognitive processes comes to study, through data on the course of experience, what are in the course of action: 1) the actor's involvement maintaining at any moment attention, expectations, goals, etc., referred thereafter as the anticipation state and 2) the reaction of this anticipation state to the perturbations resulting both in its adaptation and in actions, including reflexive practices.

Studying learning comes to study how an actor can appropriate a new configuration of interaction. When integrated in its proper world (Merleau Ponty, 1945), the adequate perception and possibilities of action related to the configuration are anticipated by the preparation state and structure the cognitive system without need for any explicit effort. For instance, drivers appropriate their daily route. Moments and actions required to turn, adapt the speed or pay attention are given to them and barely require a thought.

Individual and articulated Course of Action

Stable moments of experience that are identified in an actor's CoA are described by semiotic structures nested at different temporal levels. The hexadic sign presents six categories used to describe how activity emerges:

- The anticipation state is described by:
    - **E:** The engagement in the situation is defined by the current openings, which are the themes of activity as opening of expectations or anticipations (e.g. involvement in a lane changing).
    - **A:** The anticipation structure, organizes the anticipated events or future courses of action, within the openings (e.g. absence of car in a lane).
    - **S:** The referential gathers the schemes of attention, action, perception or communication that are maintained ready to use in relation with the anticipations (checking blind spot).
- Actual actions and perceptions are described by:
    - **R**: the representamen is what is actually perceived, the perturbation of the environment framed by the anticipation.
    - **U**: The unit of experience, the response emerging from the interaction of the perception (R) and the prepared schemes (S).
- **I**: The "interprétant" concerns what is learned in the situation: creation of new schemes and extension of the scope or improvement of old schemes.

In a collective activity, actors' CoAs are articulated. Any actor reacts to others' communications and actions according to his preparation state, more or less efficiently coordinated with others'. Studying the articulation of individual CoAs therefore allows identifying the cognitive processes regulating the collective activity.

The CoA theory explicitly constrains researchers to look at the enaction of the course of experience in the current context. The occurrences of regularities inherited from the individual history, material and cultural context are only discriminated in a second step, while comparing moments of activity.

COMPARED ANALYSIS OF A LANE CHANGING

Presentation of the study

The study has been done at the DCog-HCI lab, UCSD, in a project about Intelligent Driver Supporting System design funded by Nissan and involving 7 universities and 10 laboratories.

The goal of the study was to conduct an ethnographic analysis of driving in order to 1) identify driver's information needs and to 2) provide tools and method to enhance behavior analysis by taking driver's meaning into account. A process has been performed on the topic of Lane Changing (LC) to generalize models and interaction patterns from detailed analysis, including the one presented below.

Moment of driving

This moment of driving, lasting 40 sec, takes place in one of the highways of the run set around the university. This subject is located on the far left lane when a sign announces her exit. Data collected for the analysis includes not only quantitative measures but also ethnographical observation of behavior and context. Figure 1 presents a selection of the quantitative measures. It firstly presents data automatically extracted from videos recorded during the drive. The lateral position within the lane is presented on the top, clearly showing the two lane changings. The audio activity is presented next with the transcription of speech. It is followed by the lateral position of the head, giving cues about perception needs, and by the foot activity. Secondly is presented data from the canbus, which records at any moment the parameters of the car: the pedals pressure and the steering wheel angle.

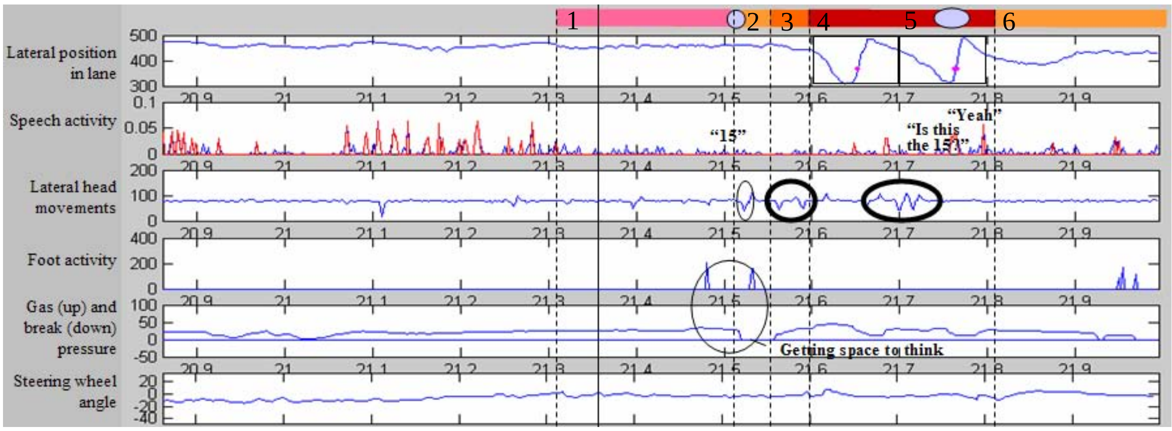

Figure 1: Selection of measures about the moment of driving when the LCs occur

Figure 2: additional ethnographic data about the moment of driving: behaviour (left) and context (right)

Before doing quantitative analysis of this data, it was necessary to identify how to interpret it in term of interaction with the environment. Figure 2 shows additional ethnographic data used for the detailed analysis. It presents the behavioral data on the left. The orange period starts when the driver whispers "15", acknowledging the perception of the sign announcing the exit (barely seen in the context snippet). Driver's hands were represented in this situation because their movement going back and forth between a relax position and a "control" position seems significant. The different looks are finally presented. The context is restituted by selected snippets and the position on the highway, approaching the exit.

Distributed cognition analysis

The analysis was initially done through the lenses of the DCog framework. According to the available data, the analysis focused more specifically at the level of the processes between the driver, his car and his surrounding. However some situations presented interesting coordination between drivers: a driver changes lane because another one is merging, other drivers leave some space to facilitate a lane changing, a driver infers another driver's behavior according to the context, etc.

Figure 3 shows the collaboration between the representational media at the different stages of the situation. A first result of analysis was to empirically identify interaction loops that are recurrent paths of propagation of representational state. These loops can be seen as the functioning of typical subsystems, which respect classical decompositions found in the literature (e.g. lateral and longitudinal management). Four loops are mainly involved in this situation. The two first loops concern the trajectory and speed/distance regulation. They involve the elements used to maintain the adequate position or speed between cars and the position of cars within lanes. They typically involve the lane lines and the wheel position for the former and the pedals, speedometer (or other noise/vibration feedback about the speed) and the shield (in order to monitor ahead) for the latter. About speed/distance regulation, it is interesting to note that we have collected data about drivers that not only use the regulation loops classically described (according to car speed or to the distance with the car ahead) but also regulate their speed according to the rate they are passing cars on their right or the rate they are passed from their left (to have time to react if such a car switches to their lane). The third loop, maintaining traffic coordination, involves mainly the different monitoring areas (shield, mirrors, etc.) and signaling devices (light, gesture, gaze) that allow each driver to maintain an evaluation of the traffic around and to communicate with others. The last loop, maintaining route, could involve the direction signs, the landscape, the GPS network, and drivers' individual resources (map, copilot, familiarity with the route).

The state of each interaction loop at each period is described in figure 3, which presents only the observable elements participating in this situation. The rear mirror is not used, for instance, but the shield is an element of two subsystems.

Loops	Rep. media / Periods	1	2	3	4	5	6
1 Maintaining trajectories	Lane line	Staying in lane	Staying in lane	Staying in lane	Changing lane	Changing lane	Stabilizing trajectory
	Wheel position						
2 Maintaining speed / distance	ACC	Maintaining speed	Stopping ACC				
	Pedals			Speeding up / car ahead	Giving gas / car ahead	Giving gas	Stabilizing speed
	Shield						
3 Maintaining traffic coordination	Over the shoulder				Blind spot checking	Blind spot checking	
	Shield	Monitoring ahead	Checking around	Checking around			Monitoring ahead
	Side mirror						
4 Maintaining route	Signs		**Sign of exit**			Correct lane between signs	
	Copilot						

Figure 3: DCOG collaboration between representational media within and across sub system during the LC

An analysis of a LC event, as the physical crossing of lane lines would focus on the subsystem "1 Maintaining trajectory" during the step 4 and 5.

During these steps, the trajectory of the car crosses a line. However the steering wheel is not used in the same way as the second LC is made in the continuation of the first one. The subsystems 2 and 3 are also mobilized in order to support this change in subsystem 1: each time, the gas pedal is pushed when the crossing of the lane is initiated and a check of the blind spot is done over the shoulder. This check has been observed for most of the LCs with this driver and for an important amount of LCs across drivers. In order to explain the step 4 and 5 it is also necessary to extend the domain of analysis to include the step 2-3 and 6. During the step 6 the trajectory perturbed during the step 4 and 5 is stabilized. Checks on the traffic are also done during the step 2 and 3. It is necessary to infer that they provide the driver with the knowledge that the spot to do her LC is safe in order to explain that only a blind spot checking is performed during step 4 and 5.

But even if it is extended to subsystem 1 to 3 during the period 2 to 6, this analysis does not explain what triggers the first LC and its continuation in the second one. When enlarging the scope of the analysis, it appears that the subsystems 1 to 3 are coordinating in subordination to the subsystem "4 Maintaining the route". From the uneventful driving occurring in period 1, the perturbation actually starts with the sign announcing the exit, which perception is attested by a comment whispered by the driver. This sign immediately triggers events in other subsystems: ACC is turned off to switch to manual control and the right side mirror is added to the shield to provide the driver with a perception of the traffic around (behind on the right). If the subsystem 4 triggers the LC sequence it also indicates its ending, as shown in period 5. Because signs indicate two different exits (cf. sky view in figure 2), the driver asks a confirmation to the copilot to discriminate the good one. Once in the correct lane, the LCs have no more reasons to be executed.

The levels of grey restitute the configuration of higher level that organized the cooperation between the subsystems. The light grey is about the apparition of a configuration requiring a change of lane in the system, in this case triggered by the subsystem 4 (planned route and announced exit). The medium grey is about assuring the spot (space, speed and traffic control) and the dark grey is about the physical crossing of the lanes. This kind of analysis has been used to identify such configurations of interaction in the system and to end up with a state model of LC (not published yet).

Course of action analysis

The analysis of driver's Course of Action was done for the same moment of driving. In order to interpret the dynamic of driver's experience inferences were checked against the behavioral and contextual data but also information from driver's comments during other moments of drive or during the interviews.

Sign	1 Following the road	2 Getting ready to cross road	3 Preparing LC	4 LC to go to the right	5 LC to go to the right	5.2 Checking right lane	6 Arriving to exit
E	Driving, relaxed (**Exit ahead**)	**Getting exit**	Assuring spot for LC	Entering lane	Entering lane	Checking lane	Adapting to new lane
A							
S	Trajectory (**Exit schemes**)	**Exit/LC Schemes**	Exit scheme **LC: Spot**	Exit scheme LC: Blind spot	Exit scheme LC: Blind spot	**Exit scheme**	
R	Ego lane empty Signs	**Exit sign** Light traffic	**Just one car ahead**	Car ahead Lane lines	Lane lines	**Signs for 2 lanes** **Copilot's answer**	Exit ahead
U	Follow lane Exit not yet	Whisper "15" Need to cross road Hand up	Check behind Hand up Speed up / car **Ready for LC**	Check behind Change trajectory	Check behind Maintain trajectory	**Uncertainty** **Ask for lane** **Lane ok** Restore trajectory	Hand down Adjust driving
I							

Figure 4: Description of driver's CoA during the LC.
Sign categories are described in the previous section.

The moments of experience follow almost exactly the steps identified in DCog analysis. However, informing the categories of the sign for each moment of experience helps inferring what is going on for the driver. It becomes possible to specify for instance the differences between LCs in step 4 and in step 5 or the role of driver's familiarity and preparation.

In figure 4, the description of the preparation state (EAS) shows how driver's adaptation to the situation prepares his actions. The first line presents a summary of the course of experience (the levels of grey correspond to the high level configurations, described previously, in which the drivers is involved). It shows how the engagement in the situation creates and closes openings. Nested openings are created while the interaction focuses toward the LC. The depth of driver's engagement coming with this focus is shown by a body of indications: 1) the general quantity of activity especially head and hand movements, 2) the position of the right hand taking a higher position in anticipation of the wheel move and 3) the body posture that gets straighter up toward the scene.

Sign 1. During the first sign, the driver is engaged in driving in an empty lane (1.E) supposing no more anticipation than staying in the lane (1.A) and trajectory regulation scheme (1.S). But data from the interview tells that the driver is a little bit familiar with this portion of the route. From this fact and the quick but smooth reaction of the exit sign, occurring later in sign two, we can assume that during sign 1 she is also expecting the exit to come, without knowing exactly where. This background engagement (1.E) and the corresponding anticipation (1.A) has two consequences: 1) the driver perceives as significant the direction signs when they occur[3] and can conclude that the exit is not yet (1.U); 2) the set of schemes necessary to get an exit is maintained active[4].

Sign 2. The perception of the expected exit sign (2.R), which is manifested by the whisper "15" in (2.U), provokes an adjustment of the preparation state[5]. The theme of interest about the exit, which was in the background, becomes preeminent (2.E), which prompts both the anticipation (2.A) and the interpretation about the need of crossing the road (2.U). The exit schemes are reactivated too, including LC ones (S), which leads to the hand moving up in anticipation to the trajectory change (2.U). The first look on the right, before any acceleration and before the more systematic visual monitoring occurring in sign 3, seems to be an assessment of the traffic to select the adequate schemes. The very light traffic in this situation only requires a very simple strategy.

Sign 3. During the third sign the driver actively prepares the LC. She increases her speed, while taking the position of the car ahead into account. Several looks are done to check if any car is coming from behind, which not the case is. The preparation state during this period, prior to the actual LC, is focused on assuring the spot needed (3.S) to perform the anticipated LC (3.A) until the LC is considered ready (3.U). Note that the theme of interest and anticipation in this sign (LC and spot) are not completely new but included in the previous one (getting the exit).

Sign 4 and 5. During the sign 4 and 5, the driver adapts her trajectory to physically cross the lane line. The last second checking over the shoulder, observed in most of this driver's LC, is one of the LC scheme (4&5.S) related to the anticipation of having a car coming in the blind spot (4&5.A).

[3] It is not possible to identify what a driver is looking at beyond observable head moves without an eye tracking, which is hard to use in naturalistic situations.

[4] Getting such an exit requires knowing that it is located on the right of the road, the typical distance from the sign, the difficulty according to the traffic, etc.

[5] Please note that the different categories of the sign are not sequential steps. They describe the dimensions from which driver's experience locally emerge.

Sign 5.2. The sign 5.2 shows a wavering in the driver's anticipation state, leading to the question to the copilot (5.2.U). The perception of different exit lanes (5.2.R) explains this trouble. The current structuring of the engagement was entering a lane, while checking the traffic around, in order to get the exit on the right side of the road (built from 2.E to 5.2.E). In this context, the discrimination of the correct lane (5.2.U) could not be achieved with too announced exits. Known exit patterns actually allow that the far right lane is only for the first exit or that it stays a lane of the road (5.2.S). The anticipation of being brought into the wrong exit (5.2.A) leads to the question about the adequacy of the current lane (5.2.U). The copilot's confirmation fixes the uncertainty and provokes the restoration of the trajectory.

In the last sign, the driver is arrived in the adequate lane. Her expectation related to getting the exit, crossing the road, doing one more LC can close and the anticipation state can get back to the more relaxed position of driving in her the new lane.

Nothing precise from the data could be said about formation of new scheme or habits (I). Being on this route later could therefore benefit from this moment and the driver could recognize landscape of road configuration related to this exit.

DISCUSSION AND CONCLUSION

Stable or emergent definition of the situation

The DCog and CoA analyses show comparable patterns occurring during this moment of driving. The global configurations of the interaction loops (fortunately) correspond with the structuring of driver's experience. However, the two frameworks stress different theoretical points of view on the interaction. According to the degree of assumption of persistent constraints in the situation, they can be positioned in different locations in the A-B continuum (Marmaras et Nathanael, 2005).

The interest of each perspective depends on the given activity domain. Driving is a good example because it is neither a very structured domain, such as plane driving, nor a very loose one such as informal work meetings.

On the one hand, micro analyses in the DCog framework stress out the persistence of *structure and relation* between elements of the system (pole A). Even if the representational media can be defined according to the activity in a specific situation, it is tempting and interesting to rely on the typical interactions supported by cultural and material settings. For instance, the prior identification of interaction loops makes it possible to create very concise descriptions that restitute the coordination between subsystems.

Road infrastructures and social conventions definitively bring stable constraints on driving. The lane lines and the driving rules have shared symbolic meaning. Their conventions restrain the minimal information needed. Staying in a lane normally protects from car not only from behind but also from both sides. Entering a new lane requires more information, in order to secure the spot necessary for safely changing trajectory: from behind, from one side and from ahead. Finally the spot formation, for instance, is not only the result of the driver's activity. Other drivers can detect or predict the LC project and change their own driving to respect it.

On the other hand, CoA framework requires focusing on the emergent process of interaction without relying on existing situation invariants (pole B). The distinction between engagement (E), anticipation (A) and schemes ready to use (S) offers a finer and more flexible description than the classical notion of goal. Historically constructed socio-technical constraints are however not ignored, as in classical situated action approach. They are just subordinated to their integration in actor's engagement. Moreover the situation is not isolated but integrated in the history of interaction. The structuring of actor's engagement captures the just past history. Configurations learned during actor's history provide him with anticipations and schemes, according to his engagement.

Each driver has a different history, different habits and styles. The familiarity with the route played an important role in our LC, as well as the light traffic, the presence of the copilot, etc. Each context is different and can enact an important number of intra and interpersonal variations in driving that could lead, for instance, to multiple sources of failure in LC.

A physical object is not in or out of a given system. It could be active in the system, ready to be activated, available but not active, present but not appropriated, etc. Individual learning, cultural learning and technical evolution change the relations between people and objects at different time scale. Different perspectives about stability or emergence of situation constraints seem necessary to cover these multiple dimensions.

System behavior VS individual experience

Both frameworks describe the processes going on during the human(s)-environment interaction at an abstract level.

The CoA framework uses data from actor's experience, which is assumed to be the surface effect of his structural coupling with his environment, to get a relevant summary of the asymmetrical interaction.

The DCog framework does not consider experience but a symmetrical interaction between human and tools, defined as a manipulation of representation. It describes the observable part of the interaction in order to identify their coordination and internal states.

Relying on human experience to get data brings many issues that are avoided when using only observable behavior:

- Testimonies about experience are socially and historically constructed. The CoA framework had to develop methods to collect data as well as methodological and epistemological criteria evaluating its validity.

- The collected data is rarely rich enough to inform all the categories of the hexadic sign and must be completed by deduction from comparison with prior or post moments of action.
- Getting a satisfying description of experience by filling the sign categories requires an important work. The result should be concise enough and should explain the different observed phenomena.
- The influence of others, environment and artifacts is disseminated in the categories of the different signs. Identifying recurrent configurations requires comparing the temporal structures of different CoAs.

Facing the issues about human experience allow a deeper understanding of activity, integrating for instance its opportunistic or emotional aspects. Moreover, the CoA framework takes the autonomous perspective of actors into account, while the DCog offer a description that is more concise but only at the system level. Understanding some situations may indeed require unravelling the individual courses of experience.

According to the situation, a DCog analysis could be enough to capture the configurations that explain activity. A CoA analysis would require more data and efforts but could dig up more elements potentially important.

Contribution to design

Because of its cybernetic roots, the DCog framework selects the abstract level of description where both the activity analyst and the designer could gather. The interaction loops categories provide configurations that can be used to integrate automation tools and driver's information need. Scenarios and alternatives could be elicited to provide a common ground for design. What if an Intelligent Driving Support System was inserted in the "vigilance on traffic" loop in order to help finding the LC spot or checking the blind spot?

However this high level of abstraction and the validation by creating computational models keep away all the contextual elements of the situation. Their consideration is nevertheless important to identify the possibilities and conditions of improvement of the interaction.

The CoA framework explicitly adopts the perspective of transforming the situation to improve users' experience. Introducing the hypothesis of appropriation (Merleau-Ponty, 1945) in a cognitive engineering approach (Haué 2004) presents many interests. It leads not only to search where and how a tool could be introduced to help a driver while respecting its preparation state but also to anticipate and support the appropriation process itself. The hexadic categories produce a litteralisation of users' experience that articulate the local emergence (within the sign) and its temporal integration (trough engagement structure). This description can be manipulated to explore design alternatives. Supporting spot finding of spot checking would decrease driver's involvement. But a system, either within the car or by direction signs, which would elicit the correct exit lane during the moment between sign 2 and 5.2 would also have avoided the trouble experienced by the driver.

The CoA framework can inform design choices with material about users' experience. The cost is that the application is not straight forward. It requires a generalization to go from a particular situation to generic needs and an extraction/formalization to get technical specifications.

This research was supported by Nissan Motor Co. LTD, Japan.

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