User Experience with Intelligent Proactive Technology in Automotive: A Longitudinal Study in Context

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Abstract— In the next few years, cars will tend to be smarter and provide more intelligent services, better connected and better adapted to user's habits than ever. Information system will be able to learn about behavior and then display personalized content in a proactive way. In order to develop user oriented car systems, the goal of our research is to study user experience related to the use of a learning and proactive application in automotive sector. We collected quantitative and qualitative data by observing evolution of driving style and by interviewing 13 end-users. Our results show that the learning and proactive application (a) negatively impacted driving safety; (b) did not really help users to anticipate dangerous events; (c) did not really help users to plan a new route; but (d) was considered as interesting to personalize their driving experience, with parameters related to real-time, privacy, transparency, unobtrusiveness and personalization. Based on our findings, we discuss essential aspects to consider learning and proactive informational systems as a gamified user experience.

Keywords-User Experience; intelligent car; proactive information system; gamification.

I. INTRODUCTION

In the last decades, the automotive sector has emerged as a key player in the development of innovating services through connected and autonomous car. Embedded technology is improving day after day, in order to provide more enjoyable and satisfying experience to their user by being more attractive, adaptive and intelligent. All of these new technologies present a same objective: improving safety and global driving experience. Most of the existing vehicles are already integrating smart and connected services, such as advanced driving assistance systems that help drivers to detect dangerous events, anticipate situations and help in overall decision making process. Some of them present more intelligent behavior by even taking decision and directly acting for the drivers. In one word, technology tends to be more proactive. Proactivity is defined [1][2] as the ability of device to act on its own initiative, on behalf of user needs and intentions, in order to help him/her to realize his/her tasks. The particularity of proactive technologies is working in an autonomous way, and proposing personalized information at the appropriate moment, regarding to user's activity [3][4]. In the next few years, these smart technologies will be able to send more and more relevant information and personalized suggestion to the driver by integrating learning abilities.

But what would be the effects on the driver and on his/her experience of driving? In a context where the industrial operates to offer better service by deploying technology, user needs and requirements need to be intently studied and took into account in a design process. In this research, we then specifically study user experience with a learning and proactive application. User experience refers to users' perception of one product qualities and to his responses towards this product such as emotional or physical reactions [5]. The aim of this article is then to study effects of a learning and proactive application on users' perceptions and reactions by focusing on their real driving activities and lived experience.

In this study, research questions are:

- What are the effects of a learning and proactive information system on driving activity and user experience?
- What features of a learning and proactive information system could influence the user experience?
- What recommendations of interaction design can be addressed?

In Section 2, we will describe the context and methodology of our study. Section 3 will present our main findings that we will then discuss in section 4.

II. ERGONOMIC EVALUATION OF PROACTIVE TECHNOLOGY: METHODOLOGICAL IMPLICATIONS

This section describes context and methodology. We first present the assessed application and then describe method that we have set to answer our research questions.

A. Context

Renault research teams have recently developed a first version of a learning and proactive driving information application, named as "Driving coach" (Fig. 1 and 2). It aims at assisting drivers in their daily trips by helping them to plan their route and to anticipate dangerous events on their usual routes. In a contextually and autonomous way, the application is proactive: it displays personalized content to the user

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without any request of him. The application presents two main proactive functionalities for the driver:

- Predictions of Destination: It aims at helping the user to plan his route before a trip by displaying address of usual destination. This functionality allows the user to be directly guided to that destination with optimized routes, with few physical operations.
- Predictions of Dangerous Spots (PDS): PDS are defined by specific places where the user needs to make (1) hard braking, (2) hard acceleration or (3) hard cornering in bends on his usual routes. More the driver is making trips, more the application is able to recognize places that might be dangerous for him. The aim of the functionality is to predict PDS and then warn the user 500 meters before PDS, in order to help him to anticipate these spots and to control them by not making hard breakings, hard accelerations or hard bends.

Two modes are also proposed to the user for interacting with Driving Coach application: Challenge Mode and Companion Mode. Both present the same functionalities, except that Challenge Mode is offering more gamified means and procedures such as rewards to collect and challenges to take up. These game design elements aims at providing more enjoyable interactions and inducing user's behaviors [6].

Considering both these gamified aspects and abilities to display personalized content in a proactive manner, we can then wonder what are the overall effects of such an intelligent and personalized application on the user experience?

Figure 1. Screenshot of the proactive functionality "Predictions of Destination" in Driving Coach application

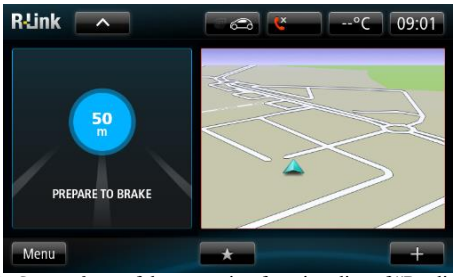

Figure 2. Screenshots of the proactive functionality of "Predictions of Dangerous Spots" in Driving Coach application

B. General orientation

This research follows a first work that had inspected the ergonomics of the system with ergonomic criteria based on accessibility, usability, emotionality and persuasiveness [7]. But this heuristic inspection does not assess the effects of proactivity over a long period of use. To do that, a longitudinal study is needed. Indeed, according to the literature, more the system is able to learn about user's habits and preferences, more it will be able to send personalized and relevant content to the user. Nevertheless, before being able to send relevant content can also depend of time and frequency of using the system. For these reasons, users may wait for several days before receiving information, which can affect user experience. To answer our research questions, we have conducted a study over a period of 6 weeks to assess how user interact with a proactive information system.

C. Recruiting

15 persons employed in Renault society have been recruited to participate to this study (12 males and 3 females). Participants were recruited according to the following conditions:

- Being familiar to the R-Link environment (Renault multimedia device embedded in cars),
- Having connectivity in car for being able to install and use the application "Driving coach",
- Not sharing the car with another driver,
- Realizing every journey with the same car on which Driving coach" would be installed.

Users were also asked to inform the examiners of their driving habits in order to constitute heterogeneous sample of participants having different types of journey, short, medium and long distance.

In order to collect heterogeneous and complementary data about how the persons were using the Driving Coach application and how they were feeling during this using period, observations had been conducted within two different manners. Indeed, our sample was divided in two groups:

- Group 1 was constituted of 6 participants. They were asked to use the application and to make a daily report on both troubling and pleasant aspects they observed and how they felt in these situations. They were interviewed every two weeks in order to collect their verbalization towards the main functionalities over time. At the end of the six weeks period, they were interviewed about their global satisfaction while using the application.
- Group 2 was constituted of 9 participants. They were asked to freely use the application, with no obligation to make a daily report or even to use the application. They were only interviewed at the end of the test to collect their feedback and reactions about the application.

D. Material and Equipement

Experiment material is composed of:

- "Driving Coach" application, installed in every car for each user of Group 1 & Group 2;
- Smartphone with a "recording" application for each user of Group 1. They were asked to make vocal comments for each troubling or pleasant situation they encountered during the six weeks test;
- Smartphone car charger with lighter socket for users of Group 1.

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E. Longitudinal using test

As seen, it might take a long time for the user to get personalized information and suggestions, according to his habits and journeys frequency. For this reason of time delay, using tests had been conducted over a period of 6 weeks (Fig. 3). We considered this period as sufficient for the user to both familiarize with the learning and proactive driving information application, and to get personalized content throughout the proactive functionalities.

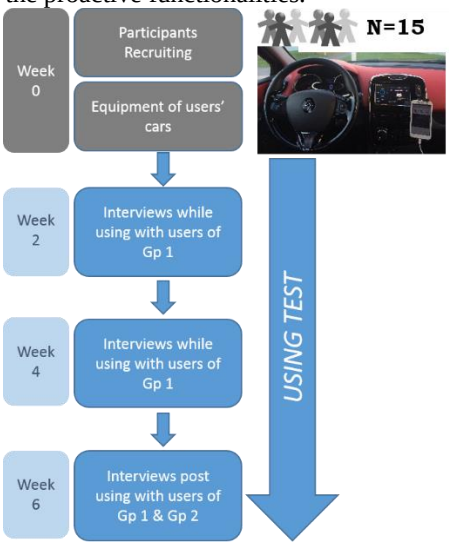

Figure 3. Scheme of the experiment proceeding

F. Quantitative data collection

Monitoring of driving activity was about observing what would be the impact of the application on the way of driving of the users. As we said previously, the objective of the application was to help users to adapt their driving style to proactive functionalities aiming at help them to anticipate dangerous events and to plan their journey: In other words, studying the impact of the application on driving activity correspond to study efficacy. Efficacy can be defined as the capacity of a system to reach a specific objective [8]. Efficacy refers to the expected effect and deals with the performance of a user to successfully reach a goal thanks to a system's features. In our case, measuring efficacy of the application "Driving Coach" aims at assessing pragmatic aspects of the application. That is to say, does the application really help users to plan their route and to anticipate dangers? We then focused on three data:

- Data to describe overall driving style evolution, by observing vehicle data of the participants to assess if the Driving Coach application would be useful and helpful to improve user driving style.
- Data to describe the success of PDS predictions; by observing if the users were adapting their driving style when they received personal suggestions to be careful on dangerous spots. To measure success of PDS predictions,
- Data to identify the success of destination prediction; by observing selection rate of the predicted destination.

G. Qualitative data collection

Lived experience with the Driving Coach application was studied by conducting explicitation interviews with users during and after the longitudinal test. This method aims at helping the users to remember specific situation, be aware of their actions and describe their lived experience [9][10][11]. Through specific techniques such as non-directive questioning and revivals, the interviewers establish a state of evocation for making the participant describe actions through verbalizations [12]. Explicitation interviews helped us to get the participants remember the most precisely the situation in which they were while using the application and how they were feeling at these moments. The 13 users that participated to the full period of test were asked to express their feelings and interest towards the application and if the application helped them to change their driving style. The aim was to identify, through user verbalizations, critical aspects in the application that can impact overall experience with such intelligent product. To analyze our results about the lived experience, we classified positive and negative comments in a smartsheet according to the overall application and its proactive functionalities. With this classification, we could then identified comments related to perceived utility, satisfaction/dissatisfaction and sources of satisfaction that we consider as crucial aspects of the learning and proactive application impacting the lived experience. In our study, we define satisfaction as the level of comfort that the user is feeling when he uses a product [8]. Satisfaction results from a subjective evaluation of the user, considering further aspects than just efficacy, such as aesthetics, need of the product or pleasure towards the product.

III. ANALYSIS OF RESULTS

During the first week, 2 users had stopped the test because of robustness and compatibility problems with their driving habits. We then focused on the results collected about the 13 other users.

A. Record analysis during driving activity

The main objective of the application was to help drivers to realize their daily trips by first helping them to anticipate dangerous driving events on their usual routes, and also help them to choose a route for going to their daily destinations. To assess the efficacy, we first decided to focus on the evolution of user's driving style along the 6 weeks period of test. We then observe how the users succeeded to master dangerous spots which were predicted on their usual routes and to finish how they could be helped to choose a route to go to their daily destination.

1) Impact on driving style evolution

For measuring driving style evolution of the participants, we have first calculated an index for each participant based on dangerous events that could happen during their test (sharp braking, sharp acceleration, sharp cornering) and based on the distance they travelled. This index is named as "Unsafety index", which is a ratio calculated as following:

$$\frac{\text{Sum of dangerous events per one user (sharp braking, sharp accelerating, sharp cornering)}}{\text{Distance travelled}}$$

The higher the Unsafety Index is, the riskier the driving style of one user is. Unsafety index was calculated for each of the 13 users, at 3 steps during the 6 weeks period: after 1 week, 3 weeks and 6 weeks of using.

In our data analysis of the overall driving style evolution, we first observe an overall constant worsening during the using test period Indeed, results are showing an average deterioration of the Driving style along the test period (Table 1 and Fig. 4). According to these data, as long as the participants are using the application, they are realizing more dangerous events such as braking, acceleration, bends while they are supposed to realize less dangerous actions.

TABLE I. DANGEROUS INDEX FOR EACH USER AFTER 1 WEEK, 3 WEEKS AND 6 WEEKS OF TEST

User	After 1 week of test	After 3 weeks of test	After 6 weeks of test
1	0.21	0.52	0.58
2	0,55	1,51	1,59
3	0,81	0,7	0,94
4	0,32	0,56	0,60
5	0,57	0,69	0,67
6	0,55	0,61	0,58
7	0,91	1,24	1,46
8	0,44	0,95	0,76
9	1,40	1,37	1,79
10	1,13	1,69	1,80
11	0,63	0,49	0,68
12	0,87	0,74	0,76
13	1,88	1,84	1,99
Average	**0,79**	**0,99**	**1,09**

However, analysis of results for each participant also show 4 main types of variations in their driving style evolution along the test period (Fig. 4):

- Five users got a constant worsening during the 6 weeks period.
- Five users got improved in the middle of the test before getting worse at the end of the test than in the beginning.
- Three users got worse in the middle of the test.
- Only one user got improved at the end of the test period, compared to the beginning.

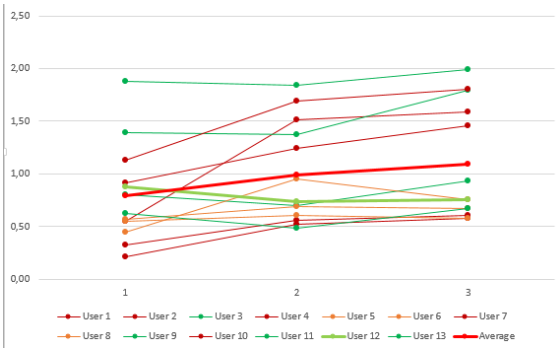

Figure 4. Graphic of driving style evolution for each participant according to their Unsafety index at the three periods of using

Ten users had deterioration in their driving style while using the application. This can be explained by the fact they were tempted to test the limits of the application and observe how it behaved by adjusting their driving style in an intentional way. What we finally observe in results analysis is that that no one of the participants got a constant improvement during the test period while the application was supposed to help the drivers to adopt a better way of driving.

2) Impact on ability to master predictions of Dangerous Spots

The first functionality of the Driving Coach application was about predictions of personal dangerous spots on usual routes of the users. Among the displayed information, only 61 percent of the predicted dangerous spots were passed by users. This means that in 39 percent of cases in which users were alerted of a personal dangerous spot on their route, the functionality was not efficient because users were not adapting their driving style and though did not succeed to master the predicted dangerous spots (Table 2).

TABLE II. OVERALL NUMBER AND PERCENTAGE OF PASSED PDS BY USERS FOR EACH PDS PREDICTION RECEIVED

Number of PDS predictions for all users	Number of passed PDS for all users	Overall Percentage rate of passed PDS
988	725	**61,84 %**

According to us, two assumptions can explain these results:

- Users could not pay attention to the information they received because it appeared too late on the screen, after they received information. According to a previous study that we have conducted with inspection methods [7], we indeed observed problems of robustness which negatively impacted real-time information display.
- Users did not even tried to master the predicted dangerous spots because they did not care about information they received and did not perceived any utility of these information in the context they were driving.

Impact on ability to plan routes with destination prediction

Among the 13 users, 10 have received at least one prediction of destination at the beginning of trips they made during the test period. In 41 percent of the cases in which the users received these predictions, we observe they did not accept to display the predicted route for going to their destination. We consider this percentage too low to say that the application was efficient and able to assist the user in their route planning.

B. Analysis of the interviews focused on lived experience

Results about overall lived experience with the learning and proactive application "Driving Coach" were analyzed by classifying positive and negative comments obtained during explicitation interviews with the 13 users in a smartsheet.

From verbalizations, we first identify comments related to perceived utility, satisfaction/dissatisfaction and then highlighted main sources of satisfaction/dissatisfaction.

1) Perceived utility

During explicitation interviews, each participant was wondered to express about their feeling of improvement on their driving style. Among the 13 participants, 11 consider they did not improve their driving style: *"I don't think that I changed my way of driving"; "I already had a soft driving"; "To be honest, I did not radically change my driving habits"*.

The application is even perceived as useless: "it doesn't present a lot of interest"; "I don't need it, it doesn't provide

me anything"; "on a regular trip, it is less relevant because we know it" ; « I've made a trip into Paris last week-end, it didn't tell me anything whereas I don't know Paris. I would have appreciated to get information for helping me to anticipate things ».

2) Satisfaction/Dissatisfaction comments

- In spite of the lack of perceived utility, all participants agreed about 2 main positive aspects of the proactive behavior of the "Driving Coach" application: The application is seen as a way of being aware of the way of driving, provided that the information is displayed in a real-time manner: *« I've been sensitized to my way of driving but it did not make me change »; "it is more an application which helps you to stay watchful, than teaching you to drive differently and helping you to anticipate"; "it confirms for me that I have a manner to drive too sharply and too fast, that's it".*
- The proactive functionality of destination prediction has been appreciated because of minimization of offered tactile commands: *« it avoids to handle the app »*; *"it is simple because we don't need to look for the information into the device"; "I found that it was clever to recognize my trips, it is something convenient. It is reassuring"*.

All participants are nevertheless expressing negative feelings about the learning and proactive behavior of the intelligent informational system. We then distinguish many feelings of frustration and discomfort related to the application: *"it didn't get any interest" ; "I didn't feel secure at all" ; "it made me nervous" ; "some messages for being cautious are unfair, you just want to slap it!" ; "Once, the app told me to prepare to brake in 500 meters whereas I was stopping. We feel embarrassed because the app is telling something wrong"*.

3) Sources of Satisfaction/Dissatisfaction comments

Among the negative comments that we collected through the explicitation interviews, we could identify 5 main sources of dissatisfaction of the application that need to be improved:

- Robustness of the application: *"When you go out of an alert zone, it says there is less than 50 meters after 3 km, this is painful"; "it can be interesting but it has to start immediately, it needs to be quick, instant"; "the problem is that it is very long to be launched but when we start the car, we usually want to launch the navigation immediately, and in that situation, this can be already too late for some users".*
- Temporal compatibility with the driving task, which means delivering proactive messages at the good time : *"If I receive information about being careful to the next bends whereas I'm already into it, I won't pay attention anymore to the messages because things already happened"; "if the information is given into the 10 seconds before the area, this might be interesting". ; "there is some places where we cannot brake like we would like to do it".*
- Level of comprehensibility of the messages, which means that the user needs to know and understand why he gets a proactive message in a situation. This might be with explanations if the information is not displayed in a logical way during his activity : *"Why in the morning it considers I'm going to work?"; "I got the messages twice and then I've never seen it anymore, I've never understood why?" ; "I got the message only once, I didn't understand why it didn't warn me each time" ; "sometimes, with exactly the same way of driving, the application didn't tell me anything and sometimes it got woke up and kept saying be careful; I didn't understand why?".*
- Mental workload, legibility and unobtrusiveness regarding to the driving activity : *"When you get a suggestion, you might pay less attention to your driving situation, it can be risky" ; "It is good because he directly proposes to go at my place with only two steps"; "it is an easy way to display GPS, it avoids to look for a destination"; "I saw at a certain point that he suggested me to go at that place and it helped me , it is good, it spares me to handle the device and look for the information"*.
- Privacy, which means respecting data which can be estimated as confidential according to the user: *"It's ok because I'm alone in my car. If something else is with me, and I don't want him to know where I'm used to go, this might be embarrassing"; "it was surprising about that and was wondering how it knows that?*
- Personalization, which means offering means to the user to personalize the way he can receives proactive information: *"Maybe it can display something that you can personalize, it would be more user-friendly"*

IV. DISCUSSION - CONCLUSION

This research is about a longitudinal evaluation of users experiences with a learning and proactive information system in car. The information system that we assessed aims at display personalized information in a proactive way, without any request of the user.

Our objective was twofold: to assess the impact of a learning and proactive system on driving style; and to study the lived experience by conducting explicitation interviews with the drivers sample.

The main functionalities were to help users to anticipate personal dangerous driving events and also to help them planning their routes to their usual destinations. Longitudinal tests have been conducted with 15 participants during 6 weeks in order to study the effects of a driving proactive information system on the user's behavior and feelings. In our methodology, qualitative data obtained by explicitation interviews helped us to understand how the users behave with the application and to explain what aspects negatively impacted driving activity and overall lived experience with the application.

The results of this study emphasize the fact that the learning and proactive information system assessed leads to low efficiency, reduced satisfaction and sometimes frustration and misunderstanding.

- Success percentages that we obtained were considered too low to talk about efficacy of the application to help users

to anticipate dangerous driving events and to plan their route for going to their usual destinations.

- Plus, results have showed that using the application during 6 weeks negatively impacted the driving activity over the test period. We observed an overall deterioration of the driving style, while the application was supposed to help the driver to anticipate dangerous events and to plan their route.
- According to explication interviews results, we could identified six crucial aspects of the learning and proactive behavior of the application that could explained its negative impact on the overall activity and experience. In the verbalizations of the users, we had identified problems of robustness, temporal compatibility (relevance regarding to the driving task and real-time feedback), comprehensibility of information (lack of explanation and transparency), mental workload (lack of legibility and obtrusiveness), privacy (lack of respect with confidential and personal data), and personalization (means offered by the application to personalize the way that information are displayed). Some of these aspects, such as relevance, transparency, obtrusiveness were also mentioned in previous research work as key factors in human-interface interaction in the way it can impact acceptance of proactive information system [3]. For the future steps of the ergonomic design process of information proactive system, we must conduct further research work to formulate appropriate guidelines that take into account these human factors considerations.

In spite of the overall lack of interest and perceived utility according to our sample of users, proactive behavior of an automotive information system can be interesting added value to the user in the way it provides personalized content without requesting, handling or searching anything in the multimedia device. In our study, results show that users were mostly disturbed by robustness aspects of the application which also negatively impacted relevance of the information, due to technical incompatibility that is currently being improved. The six crucial aspects that have been mentioned as critical points in user interface interactions need to be confirmed by conducting further experiment on bigger samples, with experimented and also novice users. Plus, these results have been obtained with R-Link environment. Additional experiment on another kind of automotive environment would also be useful to confirm our results. Finally, further studies need to be conducted, such as participatory design to involve users in the design process and decide how to improve the current interfaces and interactions. Brainstorming, design studio, personas or focus group could help to answer these central questions in a design process of a learning and proactive information system: When, why and what information should be presented during activity to enhance and enlarge the foreseen part of driving experience?

With this point of view, evaluation is not enough! Collect future expectations and future requirements of users are needed. Indeed, the anticipation of human needs and activities is based on the analysis of numerous factors and data, and on scenario planning as it is done in prospective. Prospective ergonomics [13][14][15] emphasizes the investigation of the use of artifacts to discover their strengths and flaws, and sources of satisfaction and dissatisfaction that could lead to the design of innovative artifacts. Prospective ergonomics, and not only corrective or preventive, will be the next step of this research.

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