The study on space structuring by information type of car navigation

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Abstract: The main purpose of the car navigation spatial display is offering a user to grasp one's location, movement, direction. At this time, the 3-dimensional spatial concept is projected to the 2-dimensional interface area. The user comprehends and thinks the distance, the present and the future through the reconstructed 2-dimensional interface. As a result, to represent the space to the flat interface appropriately, the study for the arrangement of relative location according to the information types.

This study took four steps to conclude the adequate spatial structure with which the user can rapidly recognizes object in the map interface of the car navigation. Firstly, we summarized the mental model of the user's experience and the theory about the visual points. Secondly, we analyzed the spatial structure of the widely-used navigation based on the theory and made a diagnosis of the problems. Thirdly, we executed a expert evaluation with the theory and the analysis of the present state of the navigation. Fourthly, we concluded the spatial structure of the car navigation through the expert evaluation.

For the visual distraction during the driving has a direct connection with the driver's life, more detailed care and the concentration are needed. This study expects that considering the information characteristic of the map interface of the car navigation would prevent the visual distraction that can be occurred during the driving and help the user to drive safely.

Key words: Car Navigation, Space structuring, Information Type, Cognitive space structure

1. Introduction

A car helps us to move conveniently, on the other hand, it threatens our safety and life. A car is moving fast and there are plenty of dangerous factors out there. Furthermore, if the road is the one that a driver has never been before, the dangerous factors get increased.

When one drives, one executes double tasks which are driving and finding a route. McGranaghan, Mark and Gould(1987) defined that the process the drivers are following the given route is like as follows. The driver

views the presented information from the current display and takes the appropriate actions. If the 'view-action' pair is completed, the next turning point information is presented and the driver shows the appropriate reaction to that situation. This whole cycle is repeated. At this time, if the driver spends too much time on recognizing navigation, the driver's safety is threatened for the distraction of one's visual concentration. So it is the crucial role of the navigation to reduce the spent time.

The market for navigation has been growing fast from the dawn of 21th century. The description level of navigation graphic images has been improving for the growth of memory capacity and the technical development. But, the market selling navigations show that there are no standard for the consistent spatial structure in the space arrangement of visual factors of navigation map. This implies, in making a map, there is no spatial structure standard considering user's recognition.

The main purpose of the car navigation spatial display is offering a user to grasp one's location, movement, direction. At this time, the 3-dimensional spatial concept is projected to the 2-dimensional interface area. The user comprehends and thinks the distance, the present and the future through the reconstructed 2-dimensional interface. As a result, to represent the space to the flat interface appropriately, the study for the arrangement of relative location according to the information types.

It seems that the reconstruction of interface display, this paper is going to research, according to the car navigation information types would act as assistance for the safe driving.

2. The mechanism of space recognition of the user (The Background Theory)

The demand for the navigation started at 2000 and became popular after 2005. The discussion for the navigation has also been increasing gradually after early 2000. But the number is not quite large.
Before developing the discussion, this study examines the user's spatial experience and the point of view from the cognitive aspect.

2.1 'The spirit model' of the experience in recognition

When a human recognizes the space, the space and the time is given. The time in this context indicates 'the present' time. In recollecting the route, the past experience interacts with the present recognition when one recognizes the space. In other words, The memory formulated from the past experience of the space influences the memorization process of the present space and the present experience of the space also influences the memory of the past space experience. As a result this interactive process modifies the past memory.

The aviation psychologists made a display which is based on the theory of space experience. The frequently collected displays are laid on the center and the display pairs, which show the conceptual similarity, are laid close each other [1]. As a result, the people tend to collect the channel where the event happens frequently than the one where the event happens less.

According to Wickens(1994), in every day reading, the staring time increased when the difficult passage or words are given. This implies that low familiarity, low frequency, the contents out of the context are converted to high level information and it forces user to make more effort to understand the meaning than familiar context. In other words, the staring time is related to the information contents on the display.

Wickens (1994) defines that the familiarity mentioned above comes from the formation of "spiritual model" about the statistical properties of the idea around the environment. The spiritual model represents the visual collecting and guides the user's point of view. Because, the strategy for collecting enables us to infer the inner model of the manipulator under the supervised system, the pattern of the gaze helps the system designer to display the location information more appropriately [1].

When we are examining Clark and Brownell(1975)'s interpretation of the arrow, it is influenced by the relative location in the display. When representing top and bottom and right and left in organizing the display map, the user can recognize the upward sign more rapidly when it is located on the top than when it is located on the bottom. Similarly, the user can recognize the downward sign more rapidly when it is located on the bottom than when it is located on the top. The right and left concept behaves similarly to the top and bottom.
We recognizes the object being distant when it is located relatively on the top of the horizontal line of the display [8]. Also, the warm color looks close, the cold color looks distant and the color possessing the high saturation value looks close to the observer in contrast to the color possessing the low saturation value [8].

As a result, this 'spiritual model' should be applied to the design of the visual spatial structure of the car navigation interface.

2.2 The user's point of view _ a pseudo magnetic field and visual collecting

The user's point of view is biologically the point where the center of the eye reaches to the object, i.e. often referring to a visual point. It can be either a relative point of view where the self is a basis or an absolute point of view where everyone is a basis, depending on the selection of the location where the point of view reaches. After all, the most important thing in the point of view is the standpoint from which one look at the object [3]. Factors influencing the movement of the user's point of view are the pseudo magnetic field of the display and the method of visual collecting.

According to Zettl(1998), the edge of the display acts like a magnetic that there is a tendency of pulling the near objects. Both sides of the display also have a strong magnetic field. When the mass of the graphics locates on the center of the display, the space of the circumference and the edge of the display come to equilibrium. If the object is biased, the mass of the graphics increases. In other words, as the object deviates from the center of the display, the magnetic field gets stronger and the mass of the graphics increases. As a result, it is essential to arrange the visual factors in the interface evenly distributed to get the balance of the display.

The visual collection refers to the act of finding the information needed by user and grasping the current user's location and the route. According to Wickens(1994) we do two types of exercises to 'look at' the object. First of

them is the following exercise where the eyes move with a constant velocity following the object and second of them is the jump exercise where the starting point jumps to the other staring point in the visual field. The eyes show the following exercise when it chases the trajectory of the ball or the flying bird. Besides, when the velocity of the flying ball or bird is too fast that the eyes cannot follow it, the eyes use the jump exercise and relocate the object in the center of the eyes to 'catch' the object.

The jump exercise used in the visual collecting has two decisive aspects, the first one is the procedure where the starting point is transferred from one part to another part in the visual field and the second one is the staring itself. The main features of the latter are the location (the center of the starting point), the meaningful time (the diameter of the vicinity of the center where the information is extracted), the dwell time (how long the eyes stares specific location) [8]. As a result, in making the strategies of the information navigation, it is required to minimize the eyes movement (connect the nearest visual factor pairs) relative to the center point.

When utilizing the navigation map, the user recognizes and comprehends the space sequentially according to the power being pulled. So, the standard for the spatial structure is needed. Also, it is required to arrange the visual factors in the interface evenly distributed to get the balance of the display and to minimize the eyes movement by locating the visual factors sharing the similar characteristics close.

3. The analysis of spatial structure of the navigational map interface

The visual factors expand our experience on the space and the shape. Furthermore, it helps us to recognize extended outer environmental information. This chapter analyzes the visual factors constituting a spatial structure of the car navigation map (four types) and deals with the thoughtlessly arranged visual factors not considering cognition factors.

3.1 The analysis target and the method

The 80% of the current domestic car navigation market is occupied by ThinkWare and M&Soft. So, to make this study representative, the two representative models of the two software company are selected for analysis model (ThinkWare K2, G1 and M&Soft JINI, Mappy). Figure 1 shows the map interface of the selected four domestic navigational devices. Starting from the upper left, each figure indicates Mappy (M&Soft), G1(ThinkWare), K2(ThinkWare), JINI(M&Soft) in clockwise direction.

The visual factors appeared in the spatial structure are classified by 9 categories. The criterions for the classification are visual factors for the position and the moving direction and each factor is appeared on the four analysis examples. The visual factors of the navigation map consists of 1) current position, 2)the upcoming route, 3) the change of road direction, 4) background, 5) road(street, pedestrian passage), 6) the traffic lane information, 7) the environment symbol, 8) text, 9) controllable menu. (figure 1) This chapter deals with the spatial structure of the navigation map using nine visual factors.

Figure 1 the map interface of the selected four domestic navigational devices

Figure 2 Visual Factors

3.2 The analysis result

Figure 2 shows the map interface of selected four domestic navigational devices. Starting from the upper left, each figure indicates Mappy (M&Soft), G1(ThinkWare), K2(ThinkWare), JINI(M&Soft) in clockwise direction. As we examine the spatial arrangement of the interface using the visual factors appeared in figure 1 as a basis, the 'controllable menu' lays on the opposite location, although JINI and Mappy are manufactured by the identical company. In the case of the symbol 'the change of road direction', Mappy located on the upper-right, JINI located on the upper-left, G1 and K2 located on the lower-right. In the case of symbol 'traffic lane information', Mappy located on the upper-left, JINI located on the lower-left, G1 and K2 located on the upper-right.

Reflected from the spatial structure analysis of the visual factors appeared on the four devices, there exist no standard for the traffic lane information, the change of road direction, the controllable menu except the current position of the driver and basic factors. Also, it seemed that the discussion for the spatial structure had not been made when making the display.

4. The study of the spatial structure of the car navigation map through expert's evaluation

This chapter carries out expert evaluation based on the spatial structure of the navigation concluded from the previous chapter 3. The expert's evaluation, which is the Delphi method, collects the opinion about the question given and let the others know the entire opinion about the question, and repeat the same procedure multiple times. As a result they can converge to the reliable conclusion. This paper diagnosis the problem of the spatial arrangement of the navigational map using expert evaluation and are going to deduce the improvement for the easily recognizable spatial structure.

4.1 The subject and the method for the evaluation

A. For the evaluation, the GUI experts are asked to reply to the open-ended question without knowing other's opinion. They are offered a device manual and an enough time for the proficient control over the devices.

B. Categorize the non-systematic reply on the open-ended question which is just taken once(common opinion, opposite opinion and the other opinion) and redistribute it to the panels.

At this time, one can reference the other's opinion which is obtained by redistribution and use that information to reinforce or retract one's opinion.

C. Collect the replies which were taken twice from the panel and summarize the opinions that comes to the consensus. We define the spatial structure considering the user's recognition and draw the right spatial structure of the car navigation based on the above result.

The participants for the evaluation consist of four GUI expert and the subjects for the evaluation are restricted to the four types of navigation (iNavi G1, K2, JINI, Mappy).

4.2 The evaluation result

The open question given on the 1st evaluation phase was 'analyze the spatial structure of the car navigation and propose the problems and improvements'. Four GUI experts freely replied.

The evaluation criterion was based on 'spirit model' of the experience in the user's point of view and recognition. The 1st evaluation was taken by the one expert and one tester (1:1) and was progressed with approximately 1~2 hours. The contact between experts was prohibited during the evaluation. The 1st answers for the evaluation were summarized considering redundant and opposite opinions. And the results were put together into one answer sheet.

When looking into the 1st answers for the evaluation, the opinions about the relative location of the visual factors, the route and the center of the eyes were dominant. The following are opinions. 'is it adequate to locate the visual factors of the route using the user's current location as a basis', 'was the route(moving path) used appropriately to grasp the user's moving direction', 'is the main route located on the point where the user's center of the eyes resides', 'doesn't the background distract the user's sight (the route navigation, the symbol).

The summarized 1st opinions were redistributed to the four experts using e-mail excluding the opinions not relating to the spatial structure. At this time, the evaluators were given the chance to modify or retract one's previous opinion and were given the chance to agree or disagree to the proposed problems and improvements by the others.

The opinions being collected twice were classified as the one where more than 3 experts come to a consensus and the one where 2 or less experts come to a consensus. Opposite opinions and failed-to-consensus opinions were excluded from the result. The common main opinions were 'consider the user's spatial comprehension in the spatial structure of the navigation map', 'need for the location classification based on the importance of information and the frequency', 'Too many visual factors should not concentrated on one spot'.
The other opinions were 'there should not be too many visual factors on the environmental symbol', 'redundant information needs to be avoided', 'excessive presentation of information should be avoided', 'very complicated symbols should be avoided'.

Table 1 The evaluation result

Main Opinion	• **Consider the user's spatial comprehension (The spirit model)** • The need for the location classification based on the importance of information and the frequency • Too many visual factors should not be concentrated on one spot
Sub Opinion	• There should not be too many visual factors on the environmental symbol • The redundant information needs to be avoided • Excessive presentation of information should be avoided • Very complicated symbols should be avoided • Should not use the color possessing high saturation value on the unimportant parts

Wickens said that the user has a 'spirit model' according to a familiarity. If the user has familiar location, direction and shape, then the user can recognize rapidly and easily. For examples, when representing top and bottom and right and left in organizing the display map, the user can recognize the upward sign more rapidly when it is located on the top than when it is located on the bottom. Similarly, the user can recognize the downward sign more rapidly when it is located on the bottom than when it is located on the top. When representing the feeling of the distance, the user recognizes the object being distant when it is located relatively on the top of the horizontal line of the display and recognizes the object being close when it is located on the bottom. As a result, one should distribute the time-space information to the vertical region of the display (the present, the future, far and near) with consideration of the user's spatial comprehension.

Also, the user recognizes and understands the space sequentially according to the power being pulled. As a consequence, there should be a location classification based on the importance of the information and the frequency. At this time, it is needed to maintain the visual balance through evenly distributing the visual factors on the display and to minimize the eyes movement by locating the similar visual factors close together.
Based on the result from the expert's evaluation, we divided the row and the column into 3 regions, respectively as the figure 3.

The row division categorizes the information types by the importance of the information and the needs for the user control. The column division categorizes the types of information by considering the user's time-space distance. The categorized types of information are as the following table 2.

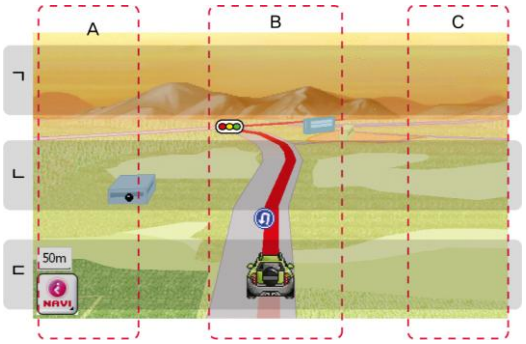

Figure 3 The spatial division of the map

Table 2. The proposal for the right spatial structure of the car navigation

The horizontal division_ the degree of the importance, the frequency, the need for the user control	**The vertical division** the present and the future, the far and the near
A. the controllable menu, unimportant information B. The information about the self, important information C. The auxiliary information for grasping my moving direction	a. The information representing the upcoming route b. The information not being affected by the time and the space c. The information about the current location

Even if facing the 2 dimensional image, the one understands and thinks through the spatial reconstruction of the far, the near, the present and the future. So, the classification of the location based on the characteristics of the information is needed. By analyzing the evaluation result, we could see that the importance of the information, the frequency and the need for the user control became the criterion of the information types on the horizontal structure. When examining into the horizontal arrangement, the left side of the display was occupied by the unimportant information needing the user control with taking into consideration of the difficulties of receiving the direct visual concentration of the user, the center of the display where the center gaze resides was occupied by the important information including the self information and the right side of the display was occupied by the auxiliary information for grasping my moving direction.

By analyzing the evaluation result, we could also see that the time space information like the present, the future, the near and the far became the criterion of the vertical structure. Based on the center of the display, the top region was occupied by the information representing the upcoming route, the center region was occupied by the information not being affected by the time and the space and the bottom region was occupied by the information about the current user's location.

After finishing the arrangement of the space, we could see that the display division was largely influenced by the user's gaze and the gaze moved from the center, right and left order. Also, we could see that the user recognized the 3 dimensional time space concept (the far and the near, the present and the future) as the top and bottom of the 2 dimensional interface.

5. Conclusion

The people have a tendency that they react fast to the expectable object, but they do not to the unexpected object. This expectation role is important to the driver's recognition [6], as a result the design should be utilizing the properties of the expectation effect [5]. In using the navigation, if the arrangement of the visual factors is standardized, the drivers can easily expect where to look at to get the information or to take an appropriate traffic action at some event [5, 6].

This study took four steps to conclude the adequate spatial structure with which the user can rapidly recognizes object in the map interface of the car navigation. Firstly, we summarized the mental model of the user's experience and the theory about the visual points. Secondly, we analyzed the spatial structure of the widely-used navigation based on the theory and made a diagnosis of the problems. Thirdly, we executed a expert evaluation with the theory and the analysis of the present state of the navigation. Fourthly, we concluded the spatial structure of the car navigation through the expert evaluation.

The proposed space arrangement divides rows and columns into 3 parts respectively. The categorization for the columns follows the information characteristics. Top column shows the information to be presented from the current position for the moving path, the bottom column shows the information related to current position and the middle column shows the information not relating to the space and the time.

This arrangement is based on the fact that when the user look at the time-space, the user cognize far and near as top and bottom of the plane, respectively. The categorization for the rows also follows the information characteristics. The center shows the user's current location and moving direction, the right side show the auxiliary information for grasping the user's moving path, the left side shows the controllable menu or the information having less importance.

The criterion for the arrangement follows the movement of one's central gaze and if we take an assumption that the navigation is located on the right of the driver, central gaze is connected from the center to the right and to the left. For this reason, the arrangement is made according to the importance of the information. Also, because the manipulation of the navigation is a dangerous action when one is driving and it is prohibited from the law, we located the controllable menu where one's central gaze stays less and improved the visual concentration on the important information.

For the visual distraction during the driving has a direct connection with the driver's life, more detailed care and the concentration are needed. This study expects that considering the information characteristic of the map interface of the car navigation would prevent the visual distraction that can be occurred during the driving and help the user to drive safely.

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