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EVALUATING THE INTUITIVENESS OF AUTOMOTIVE INFOTAINMENT SYSTEMS WITH TOUCH INTERFACE AND THAT WITH TRADITIONAL PHYSICAL BUTTONS AND KNOBS

ABSTRACT:

As the new technologies force the carmakers to incorporate them into their launching vehicles, they may succeed in developing a better version than their competitors in the market but conversely, they are making it increasingly difficult for the potential users i.e. their customers, the ones who buy the car just to commute as a daily drivable vehicle. Over the years, several accident reports proved that the driver interfacing with the controls and displays has always been a potential reason for distraction of driver. For instance, an accident on a Highway in Texas occurred where a freightliner rammed into cars stopped at the red signal causing the death of a 6 years old girl and several causalities. During the investigation, it was stated by the driver that He was trying to change the Media (song) which deliberately costed the life of a young girl. We need to understand it's not just the negligence of driver that caused the accident also the complexity of Infotainment system has to be accounted. In this paper, I'll evaluate the intuitiveness of Automotive Infotainment system with different modes of input/interface.

INTRODUCTION:

The underlined fact of the Vehicle Ergonomics involves the statement "People don't use anything if they don't understand", having this why do we still find it difficult to pair a mobile phone to the car, why do we still find it complex to adjust display settings. The possible reason is that the Interaction and Ergonomics engineers assume that the driver is smart enough to quickly master the new interface, this cannot be true in all cases as humans vary from person to person in IQ, attitude, and several aspects. So, designing a new HMI should brainstorm the design ideas in perception of being a normal driver than being an engineer/designer.

In the recent years, we observe every car's infotainment system is being ungraded in a faster pace compared to other interfacing systems. In this project, I'll evaluate how far these Infotainment systems are intuitive and user-friendly basing upon the type of Interface i.e. a Touchscreen Infotainment system and a Traditional Infotainment with display, buttons, and knobs. So, I've selected two Different car models 2016 Buick Envision and 2016 Ford Focus Sedan.

The 2016 Buick Envision comes with a Capacitive Touch screen with an LED screen of 8.0-inch touchscreen and high resolution along with advanced features of Buick's Intellilink which makes the user to control the whole infotainment using voice commands, this infotainment looks so aesthetic and the layout with the color theme looks classy and appealing. On the other hand, 2016 Ford Focus Sedan comes with a traditional style display (non-touch), physical buttons and knobs.

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Figure 1-2016 Buick Envision and its Infotainment System

Figure 2-2016 Ford Focus Sedan and its Infotainment System

In order to evaluate these systems task analysis is conducted by choosing the subjects who were new to both the car's infotainment system. The subjects were asked to pair their mobile phone to the car's infotainment system, the time taken and the number of errors committed by each of the subject with respective cars is recorded. The duration in executing the task is considered as the criteria for making the evaluation by comparing with the time taken by an expert user to perform the same task.

TASK ANALYSIS:

Task analysis is the analysis of how a task is accomplished, including a detailed description of both manual and mental activities, task and element durations, task frequency, task allocation, task complexity, environmental conditions, necessary clothing and equipment, and any other unique factors involved in or required for one or more people to perform a given task. [1]

The term "task" is often used interchangeably with activity or process. Task analysis often results in a hierarchical representation of what steps it takes to perform a task for which there is a goal and for which there is some lowest-level "action" or interaction among humans and/or machines: this is known as hierarchical task analysis. Tasks may be identified and defined at multiple levels of abstraction as required to support the purpose of the analysis. A critical task analysis, for example, is an analysis of human performance requirements which, if not accomplished in accordance with system requirements, will likely have adverse effects on cost, system reliability, efficiency, effectiveness, or safety. [2] human factors and ergonomics professionals often perform Task analysis.

The following steps should be followed when conducting a HTA [3]:

1. Define the task under investigation and identify the purpose of the task analysis.
2. Data collection -This could be collected via observation of the task in question or from a detailed specification of the device under analysis. Alternatively, interviews or questionnaires with people that have first-hand experience of performing that task could be conducted to gather the necessary detail.
3. Define the overall task goal, which will be presented as the top level in the HTA [4]
4. Determine the next level of sub-goals by breaking down the overall goal.
5. Continue breaking down the sub-goals until all operations are identified.
6. Define plans to describe how to perform the operations in each sub-goal level of the hierarchy. Numbers should be assigned to the different levels in the hierarchy.

EVALUATION PRACTICE-*TASK ANALYSIS OF PAIRING MOBILE PHONE TO INFOTAINMENT SYSTEM:*

0- Connect Phone to Car's Infotainment System.
1- Switch ON the Bluetooth on phone.
    1.1-Open settings on phone.
    1.2-Open Bluetooth settings.
    1.3-Switch ON Bluetooth and make device discoverable.
2- Press Home Button.
3- Navigate to Phone Option on Main screen.
4- Press on "Add Device", Screen shows "searching for nearby devices" and displays PIN.
5- Enter PIN on the phone.
    5.1-Open Bluetooth settings on phone.
    5.2-Search for SYNC/INTELLILINK for respective cars.
    5.3-Enter PIN shown on screen.
    5.4-Select Pair option.
6- Bluetooth Pair complete message shown on the screen.
7- Phone Connected to Infotainment System Successful.

The task analysis is carried on 6 subjects, who were completely new to each of the car's infotainment system and for comparison, the owner of car who is considered as Expert is also made to perform the same task. The whole operation is recorded using a camera and the recording are used to obtain the data which is represented in the tables.

OBSERVATIONS:

Table 1: Time taken and Number of errors by Subjects for 2016 Buick Envision

Subject Name	Time taken to Perform the Task, Seconds	Number of Errors committed	Type of Error	Expertise Level
Nadeem Saco	24	0		**Expert**
Pranove Bandi	34	0		Novice
Abhishek	36	1	Omission Error	Novice
Venu Vardhan	38	2	Substitution Error	Novice
Karthik	35	2	Substitution, Omission Errors	Novice
Rohit	35	0		Novice
Samip Joshi	40	2	Substitution and Sequential Error	Novice

<u>Substitution error:</u> It can be considered as Slip, Subject pressed the Audio icon instead of Phone icon on the screen to connect phone.
<u>Omission Error:</u> Subject skipped an operation, like search of devices in his mobile phone for pairing.

<u>Sequential Error:</u> Subject directly jumped into paired devices without pairing his device to the system.

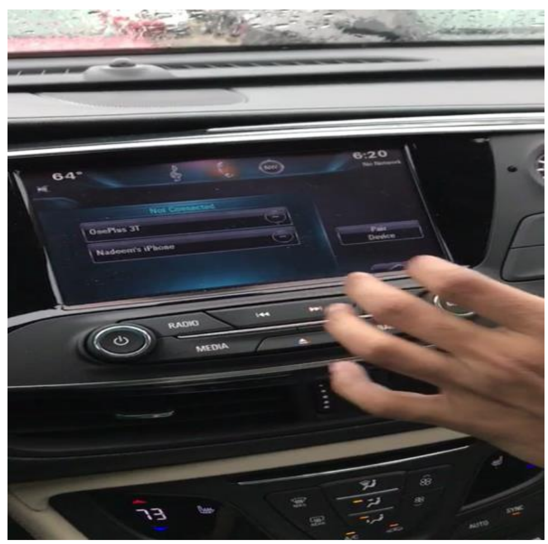

Figure 3- Left shows Substituition error ; Right image shows Omission error made by subjects

Table 2: Time taken and Number of errors by Subjects for 2016 Ford Focus Sedan

Subject Name	Time taken to Perform the Task, Seconds	Number of Errors committed	Type of Error	Expertise Level
Abhishek	38	0		**Expert**
Pranove Bandi	46	1	Substitution Error-2	Novice
Nadeem Saco	44	1	Substitution Error-1&2	Novice
Venu Vardhan	42	0		Novice
Karthik	46	1	Interpretation Error	Novice
Rohit	40	0		Novice
Samip Joshi	48	1	Legibility Error	Novice

Substitution error-1: It can be considered as Slip, Subject pressed the Power ON/OFF Button instead of OK Button on the Center stack to connect phone.

Substitution error-2: It can be considered as Slip, Subject considered the Volume knob as selector to scroll and select the device.

Interpretation error: subject failed to understand the information shown on the screen.

Legibility Error: subject failed to track the mapping of options from screen to the buttons on the console.

Figure 4- Left shows Substituition error-1 ; Right image shows Substituition error-2 made by subjects

RESULTS:

1. In the test using Touch screen infotainment system of Buick envision, subjects on an average performed the task at 10 seconds later than the expert.
2. Certain Subjects even committed errors in performing the task.
3. For the conventional interface i.e. Display with Physical buttons and knobs of Ford Focus Sedan though it appears to be lucid, subjects had trouble in mapping the display with buttons on console.

4. Surprisingly subjects took more time to perform the task using Traditional Interface than using the Touch screen Interface, which subjects visualized as complicated to operate.
5. Overall, subjects found touch screen interface to be more intuitive to operate and easy to understand than the interface with knobs and buttons.

CONCLUSION:

From the Task analysis on Both the cars, results show that subjects who are using the interface for the first time found it difficult and some felt too complex just to pair their device to the infotainment system.

Though it was assumed by subjects that touch screen is complex to understand, but it was more Intuitive to the subjects than the traditional interface of physical buttons and knobs.

From the test performed to investigate intuitiveness of Automotive infotainment systems, by the subjective task analysis, it can be concluded that Touchscreen interface with capitative feedback makes it utmost user-friendly in terms of ease of operation and reducing the mental workload on the driver.

REFERENCES:

1. Kirwan, B. and Ainsworth, L. (Eds.) (1992). A guide to task analysis. Taylor and Francis.
2. DOD Data Item Description (DID) DI-HFAC-81399B: Critical Task Analysis Report. 2013.
3. Ergonomics in Automotive Design by Dr. Vivek Bhise
4. Course notes and lecture slides of User Interface Design course

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VERIFYING THE TIME TAKEN BY THE EXPERT USERS OF AUTOMOTIVE INFOTAINMENT SYSTEMS WITH GOMS-KEYSTROKE MODEL

ABSTRACT:

Every user finds it difficult to operate the Audio interface in the very first time, but on prolonged usage over the time, every feature and technique of operating gets stored in his/her long-term memory. Every time the expert user tries to operate he don’t to think and operate, he can just operate with very less duration of eyes-off the road or without even looking at the system. The expert user’s gulf of execution and gulf of evaluation are always met.

Though the time taken by expert users to perform an operation is less when compared with new users, their time of execution always differ from the time suggested by the GOMS model. GOMS model considers the expert is performing the operation, so that it helps in better interaction with system in problem solving thereby decomposing problems to lower levels so as to identify timing values of each operation. So, in this project, I’m going to verify the time taken by an expert user to perform a task and verify with Time of execution suggested by the GOMS model.

INTRODUCTION:

Transferring task from short-term to long-term memory requires lot of mental effort, it may need rehearsal or repetition of certain task for numerous times so that it gets transferred into his long-term memory. However even a task is transferred to long-term memory, time of execution in many cases is always greater than the time that is suggested by the GOMS model.

In this project, I'll verify the time of execution in performing a task by an expert user (owner) of automotive infotainment system by comparing with GOMS model. So, I have chosen two different subjects who are daily drivers of their cars. Subject 1 has 2016 Buick Envision which comes with Capacitive Touch Infotainment System and Subject 2 has 2016 Ford Focus Sedan which has a display with buttons and knobs.

Figure 5-Infotainment Systems of 2016 Buick Envision(left) and Ford Focus Sedan(Right)

GOMS-KEYSTROKE MODEL:

In human–computer interaction, the keystroke-level model (KLM) predicts how long it will take an expert user to accomplish a routine task without errors using an interactive computer system. [1]

STRUCTURE OF THE KEYSTROKE-LEVEL MODEL:

The keystroke-level model consists of six operators: the first four are physical motor operators followed by one mental operator and one system response operator [1]:

- **K** (keystroke or button press): The time for this operator depends on the motor skills of the user and is determined by one-minute typing tests, where the total number of non-error keystrokes divides the total test time.
- **P** (pointing to a target on a display with a mouse): This time depends upon distance to the target and the size of the target, but is held constant. A mouse click is not contained and counts as a separate K operation. [2]
- **H** (homing the hand(s) on the keyboard or other device): This includes movement between any two devices as well as the fine positioning of the hand. For example, It can be moving hand from keyboard to mouse.
- **D** (drawing (manually) N_D straight-line segments with a total length of D (n_D, l_D) cm): where N_D is the number of the line segments drawn and l_D is the total length of the line segments. This operator is very specialized because it is restricted to the mouse and the drawing system has to constrain the cursor to a .56 cm grid.

- **M** (mentally preparing for executing physical actions): denotes the time a user needs for thinking or decision making. The number of M's in a method depends on the knowledge and skill of the user. Heuristics are given to help decide where an M should be placed in a method.

ASSUMPTIONS/LIMITATIONS:

The keystroke-level model has several restrictions:

- It measures only one aspect of performance: time, which means execution time and not the time to acquire or learn a task [1].
- "Expert is performing UI operations [4].
- It considers only routine unit tasks [3].
- Interacting with the system is problem-solving [4].
- The method is specified step by step, involves decomposition of problem into subproblems [4].
- Determine goals to attack problems [4].
- The mental operator aggregates different mental operations and therefore cannot model a deeper representation of the user's mental operations. If this is crucial, a GOMS model has to be used [3].

ANALYSIS:

To validate the time of execution by the expert users, I've asked the subjects to pair their mobile phone to the Infotainment System and recorded the whole scene in a camera. Having the task done by the experts at a faster pace than the novice users, even the experts sometimes lag in performing a task unconsciously. So, by calculating the time of execution using GOMS-keystroke model, we can validate the expertise level of the user.

Expert using 2016 Buick Envision:

Table 1: Time recorded for performing task by expert using 2016 Buick Envision

Expert Name	Time taken to perform the task, Seconds
Nadeem Saco	24

GOMS-Keystroke Calculated Time:

Considering all the operators involved in performing the task of pairing device to Infotainment System
Rf- Time taken to move the hand from steering wheel to center stack

M-Mental preparation to press the Phone icon on the screen

P-Pointing the finger over the Phone icon

B-Button press of phone icon

M-Mental preparation to decide the option to select

P-Pointing finger over Pair Device button

B-Button press of pair device on screen

W-Waiting for the system to respond

B-Button press on screen for Set PIN (here the finger is not moved)

B-Button press on YES option to confirm the device that we are trying to connect

B-Button press on OK after pairing is completed

As we have predefined values for each of these operators as

M=1.35 sec, P= 1.10 sec, B= 0.20 sec and W is calculated from the video recorded while the subject is performing the task.

Rf= 0.45 sec, is considered from the SAE standards from the journal SAEJ2385

Total Time as per GOMS-keystroke Model= Rf+M+P+B+M+P+B+W+B+B+B

= (1.35+1.10+0.20+1.35+1.10+0.20+12+0.20+0.20+0.20) seconds
= 18.35 Seconds

Experts using 2016 Ford Focus Sedan:

Table 2: Time recorded for performing task by expert using 2016 Ford Focus Sedan

Expert Name	Time Taken to perform the Task, Seconds
Abhishek	38

GOMS-Keystroke Calculated Time:

Considering all the operators involved in performing the task of pairing device to Infotainment System
Rf- Time taken to move the hand from steering wheel to center stack

M-Mental preparation to press the Media Button on the center stack

P-Pointing the finger over the Media button

B-Button press of Media option

W-Waiting for system to respond

P-Pointing the finger over Mapped button with respect to screen for option Device

B-Button press of Mapped button on center stack for device

B-Button press of Mapped Button on Add option on center stack

W-Waiting for the system to respond

P-Pointing the finger over mapped button to confirm the device trying to connect

B-Button press on YES option to confirm the device that we are trying to connect

W-Waiting for system to respond, shows Pairing Successful

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As we have predefined values for each of these operators as

M=1.35 sec, P= 1.10 sec, B= 0.20 sec and W is calculated from the video recorded while the subject is performing the task.

Rf= 0.45 sec, is considered from the SAE standards from the journal SAEJ2385

Total Time as per GOMS-keystroke Model= Rf+M+P+B+W+P+B+B+W+P+B+W

= (0.45+1.35+2+1.10+0.20+0.20+14+1.10+0.20+11) seconds
= 32.70 Seconds

RESULTS:

Table 3: Comparison of Time taken to perform the task

Subjects(Expert)	Time to perform task	GOMS-Keystroke Model Time	Delta, Δ
Nadeem Saco	24 Seconds	18.35 Seconds	5.65
Abhishek	38 Seconds	32.70 Seconds	5.30

It can be observed from the results that Time taken by both the subjects, who own the cars are longer than the time suggested by the GOMS-keystroke model.

Though the Owners are considered experts, they lack in perform the task within the time prescribed by the GOMS model.

CONCLUSION:

The reason for the time difference in performing the task can be explained by the assumptions made by the GOMS-keystroke concept. The reason can be reaction time by the subject to perform the muscle movement or the subject still takes more time to make the decision than time allotted by the GOMS theory.

REFERENCES:

1. Card, Stuart K; Moran, Thomas P; Allen, Newell (1980). "The keystroke-level model for user performance time with interactive systems".
2. Fitts, Paul M (1992). "The information capacity of the human motor system in controlling the amplitude of movement". Journal of Experimental Psychology: General.
3. 23- Card, Stuart K; Moran, Thomas P; Newell, Allen (1980). "The keystroke-level model for user performance time with interactive systems". Communications of the ACM.
4. Course notes and lecture slides of User Interface Design course.
5. SAEJ2385 Journal