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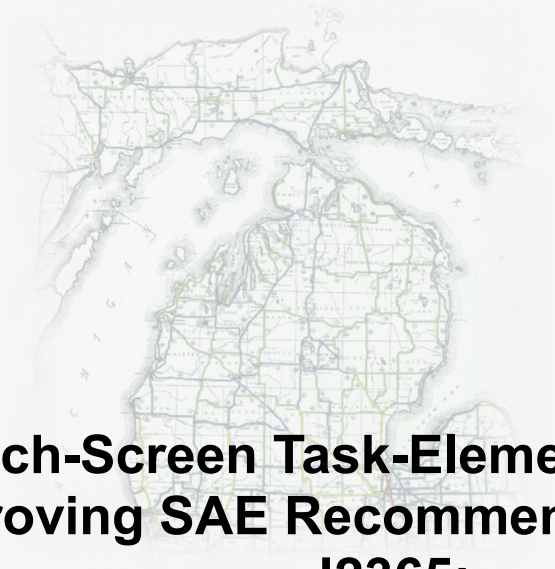

Touch-Screen Task-Element Times for Improving SAE Recommended Practice J2365:

A First Proposal

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Touch-Screen Task-Element Times for Improving SAE Recommended Practice J2365: A First Proposal

Report: ATLAS-2015-07

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16. Abstract

This report describes the identification of task elements and the estimation of their times for in-vehicle tasks such as dialing a phone number or finding a song using a touch screen. These elements were derived from an experiment in which 24 drivers distributed across three age groups completed 40 trials involving various in-vehicle tasks. These data will be used to develop a new version of Society of Automotive Engineers Recommended Practice J2365, which is used to predict task times when the driver interface is at the wireframe stage, well before hardware and software are available to collect driver-performance data. The predicted, static (non-driving) task times are used to predict which tasks are most likely to be unacceptably distracting and unsafe to do while driving.

Based on those data, the following elements were identified along with initial estimates for young drivers (age = 24). Estimates for other ages can be obtained by multiplying the times that follow by age-correction factors described in the report. Elements and their times include cursor other (read page content, 2.4 s), cursor 1 (cursor down an first ordered page, 2.7 s), cursor 2 (cursor down on a subsequent page, 0.8 s), drag (3.5 s), function button 1 (for initial screen, 2.9 s), function button 2 (2.4 s for following screens), press and hold (a button, 1.6 s), letter 1 (entering a letter on a new screen, 1.9 s), letter 2 (entering a subsequent letter, 1.0 s), number 1 (entering a number on a new screen, 1.4 s), number 2 (entering a number on a subsequent screen (0.7 s), slider s (after a new screen, 5.0 s), and slider 2 (after the first, 2.5 s).

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INTRODUCTION

More than 3,000 people were killed and 421,000 were injured in distraction-affected crashes in the United States (US) in 2012 (U.S. Department of Transportation 2013b). The *Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices* (U.S. Department of Transportation 2013a) specify two methods for assessing distraction. Of them, the visual-occlusion method is the least costly and most commonly used. In the occlusion method, subjects perform an in-vehicle task while wearing goggles that alternately open and close, simulating the driver seeing the display (and making progress on a task) and not seeing it (as though the subject were actually driving and looking at the road instead). The National Highway Traffic Safety Administration (NHTSA) guidelines stipulate a maximum total task time of 12 seconds for a series of 1.5-second open/close cycles.

As an innovative alternative to testing, Pettitt (Pettitt, Burnett, and Stevens 2007; Pettitt 2008; Burnett et al. 2011) developed a method to predict total task time in an occlusion experiment. His method involves determining, step by step, how a user performs a task, looking up the associated time elements (for mental operations, pressing button, etc.) in SAE Recommended Practice J2365 (Society of Automotive Engineers 2002), and then totaling them to determine total static (while parked) task time. In this report, the term *elements* is used to refer to the fundamental actions (pressing a letter key, a mental operation, and so forth) instead of the term *operator*, which has been used in the past in J2365. This is because the term *operator* also refers to the subject, usage that is confusing, and the term *element* is more consistent with the language used in industrial-engineering predetermined time systems.

Pettitt's method predicts total task time in the occlusion method by assuming that operations proceed normally when the subject is not occluded, but when occluded, visual-manual operations are delayed (but not purely cognitive operations) until the interface is visible again. This research team implemented Pettitt's method using an Excel macro.

Based on an analysis of occlusion data from a prior project (Kang et al. 2013), a previous ATLAS project found that Pettitt's assumptions are not always true (Elwart, Green, and Lin 2015). That project showed that the probability that a task will proceed depends on when in the occlusion interval the task occurs.

The quality of occlusion-task-time estimates depends not only on how the element times are combined, but also on the accuracy of the time estimates and the comprehensiveness of the set of elements. The element times in SAE J2365 are based on data from the use of the Ali-Scout Navigation System (Steinfeld et al. 1996; Manes, Green, and Hunter 1997), MTM-1 (Matias 2001), and the Keystroke-Level Model (Card, Moran, and Newell 1980). The Ali-Scout driver interface had small physical buttons, not virtual buttons. Furthermore, there are no touch-screen elements such as *drag* in J2365, because touch screens were not in use when SAE J2365 (table 1) was developed.

Table 1. SAE J2365 Element Times (s)

Name		Code	Element Description	Time (s)	
				Young (18-30)	Older (55-60)
Reach	near	Rn	from steering wheel to other parts of the wheel, stalks, or pods	0.31	0.53
	far	Rf	from steering wheel to center console	0.45	0.77
Cursor	once	C1	press a cursor key once	0.80	1.36
	>=2 times	C2	time/keystroke for the second and each successive cursor keystroke	0.40	0.68
Letter	or space 1	L1	press a letter or space key once	1.00	1.70
	or space >=2 times	L2	time/keystroke for the second and each successive cursor keystroke	0.50	0.85
Number	once	N1	press the letter or space key once	0.90	1.53
	>= 2 times	N2	time/keystroke for the second and each successive number key	0.45	0.77 (0.765)
Enter		E	press the enter key	1.20	2.04
Function	or shift	F	press the function keys or shift	1.20	2.04
Mental		M	time/mental operation	1.50	2.55
Search		S	search for something on the display	2.30	3.91
Response Time	scroll	Rs	time to scroll one line	0.00	0.00
	new menu	Rm	time for new menu to be painted	0.50	0.50

Thus, this research attempted to fill in some of the gaps in SAE J2365, in particular, times for touch-screen gestures such as scrolling and dragging. More broadly, the research goal of this project was to develop estimates for those touch-screen actions using available data and to verify times for elements currently in SAE J2365 to the extent feasible within the project resources and schedule.

More specifically, this project examined six questions.

1. What are some of the problems with J2365 and how J2365 is applied?

2. How can the J2365 and measured-time data be adjusted for age?

3. Where do those J2365-estimated total task times not agree with measured performance data?

4. What are some weaknesses of the performance data used for comparison?

5. What are some new elements in J2365, and what are time estimates for them?

6. How can the estimates of the number of occurrences of cursor and slider actions in J2365 analyses be improved?

SUMMARY OF THE PREVIOUS EXPERIMENT BEING REANALYSED

The elemental estimates described in this report have been determined by reanalyzing data from a recent experiment (Lin et al. 2012). In that experiment, 24 subjects from three age groups (young: 18-30, middle: 40-55, and older: =>65) performed 14 tasks (table 2) such as dialing a phone number and finding a song using a Flash simulation of a production touch screen in a vehicle mockup. Tasks were performed two to six times, but each time with different data (e.g., a different phone number). The vehicle (actually a simulated vehicle) was static ("parked') while the in-vehicle tasks were being performed. The Flash simulation recorded the time each virtual button on the screen was contacted and when contact was released, both to beyond the nearest millisecond. Table 3 provides additional details concerning each task. Data entered and the names of buttons pressed are shown in quotes. Figures 1-5 show some example screens.

Subjects were given a minimum of 15 practice trials before the experiment to become familiar with the interface. Additional practice was provided if needed. Test trials were collected in four blocks of 10 trials. Each block was fixed with either cursors keys or a slider for scrolling. This does not mean that a slider or cursor key was used on each trial, only that when scrolling occurred in tasks in that block, that a particular method was used. Appendix A provides a more complete description of the practice trials.

Table 2. Tasks Examined

#	Base Task	# / 40 Trials	Why Selected, Subtask of Interest
1	adjust audio balance	2	drag icons to change value
2	adjust equalizer	2	hold down to change value
3	adjust climate airflow	2	press once to toggle
4	adjust climate temperature	2	drag on a scale to change a value
5	adjust seat heat	2	press same key repeatedly to change value
6	call from phonebook	2	search with 1-key entry
7	call recent #	4	search a randomly-ordered list
8	dial phone #	6	enter long numeric values (9 digits), repeated to provide accuracy
9	find nearest gas station	2	search with a *sorted* function key
10	find song title	4	search alphabetic-ordered long list search using string entry search using slider with initial letter pop-up
11	get phone message	4	search numerically ordered short list
12	select radio channel	4	search numerically ordered long list
13	set clock	2	press button entry repeated
14	tune radio	2	enter short numeric values (4 digits), repeated to provide accuracy
	TOTAL	40	

Table 3. Tasks and Comparisons between Replicates

#	Block 1 (Arrow Keys)	#	Block 4 (Slider)	Similarities
1	"More" In "Travel Link" find the nearest gas station with "Diesel" fuel	10	"More" In "Travel Link" find the nearest gas station with "Regular" fuel	diesel and regular fuel
2	"Phone" In "recent calls" list call "Neil Strickland" (home), and "End" call	9	"Phone" In "recent calls" list call "Jenny Baxter" (home), and "End" call	similar location in the recent call list
3	"More" In "Rear Entertainment" turn "power" on, "browse" for channel, and using the arrow keys select channel "119"	8	"More" In "Rear Entertainment" turn "power" on, "browse" for channel, and using the sliders select channel "33"	searching for items with number ordered
4	"Phone" In "phonebook": Using "ABC" search call "Tammy Graham" (home), and "End" call	7	"Phone" In "phonebook": Using "ABC" search call "James Hardy" (home), and "End" call	same length of the first names
5	"Player" "browse" "Songs", and using "Search" play song "Mississippi Kid"	6	"Player" "browse" "Songs", and using "Search" play song "The Needle and the Spoon"	repeated letters in targets (ss, pp, ee, oo)
6	"Phone" "dial" phone number "248-359-1760", "Call", and "End" call	5	"Phone" "dial" phone number "248-157-3940", "Call", and "End" call	# keys were at opposite side of the keypad
7	"Phone" In "messaging", find "11th" message from "Beatrice Adams", and "Listen" to message	4	"Phone" In "messaging", find "9th" message from "Lin Ford", and "Listen" to message	similar location in the message list
8	"Climate" Change air flow for "Front Seats" to "Face"	3	"Climate" Change air flow for "Front Seats" to "Feet"	similar location in the interfaces
9	"Player" In "audio" settings, drag audio balance icon to the "Front-Left seat" (Driver's)	2	"Player" In "audio" settings drag audio balance icon to the "Right-Rear seat"	opposite direction (upper left, lower-right)
10	"More" In "Settings" adjust "Clock" to 11:59	1	"More" In "Settings" adjust "Clock" to 01:02	needs to adjust the hr and min

#	Block 2 (Arrow Keys)	#	Block 3 (Slider)	Similarities
1	"Player" "browse" artist "Aerotrio" using arrow keys, and play song "Megatrombosisciclica"	10	"Player" "browse" for artist "Barenaked Ladies" using sliders, and play song "If I had 1,000,000 Dollars"	targets were easy to recognize (long word, numbers)
2	"Phone" "dial" phone number "734-928-5501", "Call", and "End" call	9	"Phone" "dial" phone number "734-382-5503", "Call", and "End" call	# keys were at opposite side of the keypad
3	"More" In "Rear Entertainment" turn "power" on, "browse" channels, and using the arrow keys select channel "40"	8	"More" In "Rear Entertainment" turn "power" on, "browse" for channel, and using the sliders select channel "60"	searching for items with number ordered
4	"Phone" In "messaging" find "5th" message from "Bob Fedder", and "View" message	7	"Phone" In "messaging" find "3rd" message from "Don Knotts", and "View" message	similar location in the message list
5	"Player" In "audio" settings adjust the Equalizer: Using +/- buttons set "Bass" to "+3"	6	"Player" In "audio" settings adjust the "Equalizer": Using +/- buttons set "Mid" to "-5"	use of the "+" or "-" buttons
6	"Climate" Adjust the climate for "Driver": Using arrow keys set to 78 F	5	"Climate" Adjust the climate for "Passenger": Using sliders set to 74 F	adjust the temperature
7	"Phone" In "recent calls" list call "Lorna Donlon" (home), and "End" call	4	"Phone" In "recent calls" list, call "Kevin Bishop" (cell), and "End" call	similar location in the recent call list
8	"Phone" "dial" phone number "313-464-9979", "Call", and "End" call	3	"Phone" "dial" phone number "313-646-7797", "Call", and "End" call	# keys were at opposite side of the keypad
9	"Radio" "tune" to AM 1530, and using "browse" save it to Preset #11	2	"Radio" tune to AM 1570, and using "browse" save it to Preset #2	# keys were at opposite side of the keypad
10	"Controls" set the "Passenger" "Heated Seat" to "LO"	1	"Controls" set the "Passenger" "Vented Seat" to "HI"	toggles at opposite side of the interface

Figure 1. Main Screens

Note: The navigation screen, which was not used, is not shown.

Figure 2. Other Radio Screens

Figure 3. Other Player Screens

Figure 4. Other Phone Screens

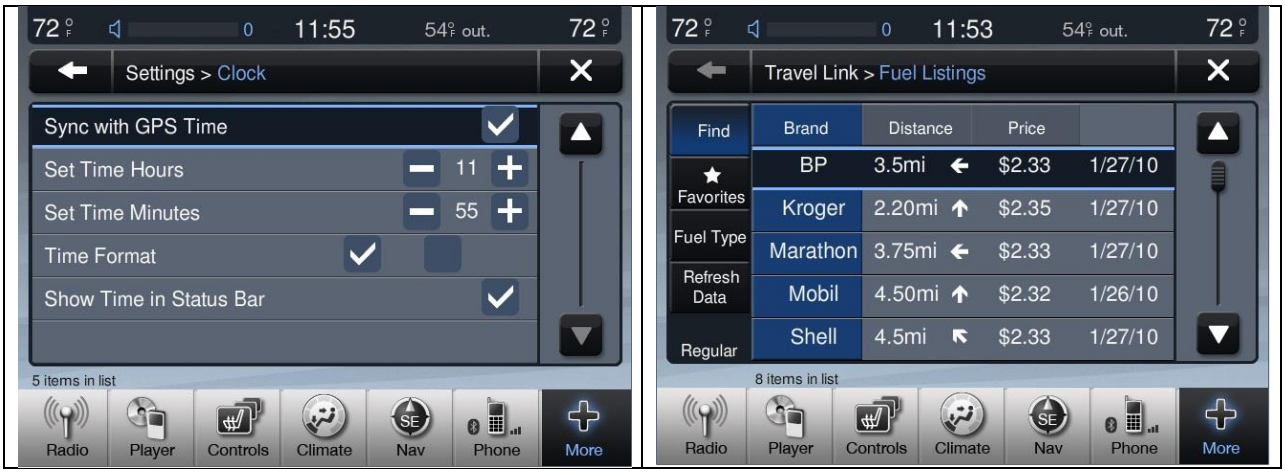

Figure 5. Other More Screens

A series of data files resulted from that experiment. Each record in the file pertains to one event, either a button press or release. The initial file listed the technical name for button operated (e.g., Browse Selection value: *Thorntons*, pageDownBtn), and the subcategory (TravelLink, recent calls) and category (e.g., radio, phone, more) to which it belonged. In addition, there was information about the subject and test condition (subject number, block, and trial), the running clock time, along with other information that was used to determine the time to move between buttons and the time they were held down.

This master data file was used to create a number of derivative files such as one that collapsed the data from both the pressing of each button and its release into a single record. Thus, that

record contained the movement time between that button and the prior one, as well as the hold time for the current button. Furthermore, summaries were developed for each trial by subject and collectively over subjects.

A large fraction of the project time was spent constructing, checking, modifying, rechecking, and rechecking again the data files that were created. For additional questions about the data, see Lin et al. (2012).

ANALYSIS 1 – REEXAMINATION OF THE J2365 EQUATIONS IN LIN ET AL.

Issues with the Lin et al. (2012) analysis and development of corrected J2365 calculations

This reexamination of Lin et al. (2012) involved (1) reconsidering the keystroke-level (button press) equations for tasks in Lin et al., (2) developing new keystroke-level predictions based on the revised equations, and (3) developing new task elements and predictions using the data in Lin et al. For the original predictions, see the appendix of Lin et al. (2012). Many of the predictions have been revised to correct errors that were found after the report was produced. See appendix B.

Review of the previous keystroke-level analyses revealed several problems. First, for several of the tasks that were done repeatedly but with different data, such as dialing, the keystroke elements listed should have been identical. They were not identical. Table 4 provides the original and corrected equations for the dialing task. They should have been identical because only the phone number changed, and this had no effect on the task elements (operators) needed. This inconsistency in determining the keystroke-level equations was due to the inexperience of those who performed the analyses and ambiguities in terms of when certain elements should be used for each subtask, as described in the following paragraphs.

Table 4. Equations for Dialing

Set	Block & Task	Task	Equation
original	B1T6	dial "248-359-1760" and call	3M + 2F + N1 + E + 9N2
	B2T2	dial "734-928-5501" and call	3M + 2F + N1 + 9N2
	B2T8	dial "313-464-9979" and call	3M + 2F + N1 + 9N2
	B3T3	dial "313-646-7797" and call	3M + 2F + N1 + 9N2
	B3T9	dial "734-382-5503" and call	4M + 2F + N1 + 9N2
	B4T5	dial "248-157-3940" and call	3M + F + E + N1 + 9N2
corrected	all 6		3M + 3F + N1 +9N2 + Rt

Second, as always with keystroke-level analyses, there are difficulties in determining where the mental elements occur. A particular challenge is determining where subjects pause to confirm an entry, such as before the final keystroke of a sequence. This is in contrast to command entry, where there is a single string of text, and confirmation that the string is correct may occur before the final enter button is pressed. The automotive tasks examined often consist of several sub-steps, each of which involves a different screen. For the tasks examined in this report, mental elements confirming that a sub-step was completed occurred inconsistently, varying between subjects and tasks.

Third, there was some ambiguity regarding which of several J2365 elements was most appropriate. For example, in many instances, subjects would press a virtual button, and in

response a new screen would appear. This raised several questions. Should that button press be coded as a function key or enter key? What if that button was the final button pressed? Did it matter if the button was labeled "go"? For consistency, the decision was not to use the enter element at all, but to identify those actions as function-key elements. This should reduce uncertainty as to which element to use. As the times for function and end buttons are the same, it does not matter which one is selected.

Fourth, there was no element in J2365 for drag. Because of its similarity to the P (pointing, usually with a mouse) element in the Keystroke-Level Model, that element and its time (1.1 s for young subjects) was used for dragging objects some distance across the screen, such as for changing audio balance. It was not used for moving sliders because the short movements have a much lower index of difficulty than that in a typical Fitts' Law movement that P represents.

Fifth, there was uncertainty about how to estimate times using sliders. Was the element preceding the movement a mental operation or a search, and what element should be used for moving a slider? In the original analyses, there was a mental element to start each slider sequence, followed by a succession of search and reach-near elements. However, search is intended for searching an entire screen for information. Furthermore, for several tasks in the original analysis, the items on screen were listed in alphabetic or numeric order, so the entire screen did not need to be searched. An exception would be a recent call list, where the search was for a particular caller, not a call number, and every entry in the list needed to be examined. Note that calls were ordered, but from most to least recent.

Sixth, there was no push-and-hold element needed for setting radio presets. As it is a persistent action which uses visual feedback, P (pointing with a mouse = 1.1 s) was used to provide the data. The duration required for a preset to engage could be interface specific. However, for the purpose of developing an estimate, using 1.1 s for young subjects should be adequate. To estimate the time for the older group in J2365 (55-60), multiply the element time for young drivers by 1.7.

Seventh, there were inconsistencies in terms of the action associated with a task beginning. To be technically correct, these tasks begin when the hand leaves the steering wheel. In this experiment, the starting screen was always the player screen. Thus, for the purpose of describing the task, each task began with a mental operation followed by a function-key selection that was specific to the task, such as the radio virtual button. However, in terms of measuring when the task began to estimate button-pressing times, timing should start when the first function button was pressed, because that is when the first task can begin.

Note that using that rule leads to problems for functions that involve press and hold, such as for radio presets. For these types of functions, the action does not occur until the button is released. Thus, times for elements were determined as the time from when a button is released until the next button is released as shown in figure 6. Keep in mind that for most other button actions, the hold times should be about the same, so using the hold time for the current button or the prior one should not matter. This assumption should eventually be examined.

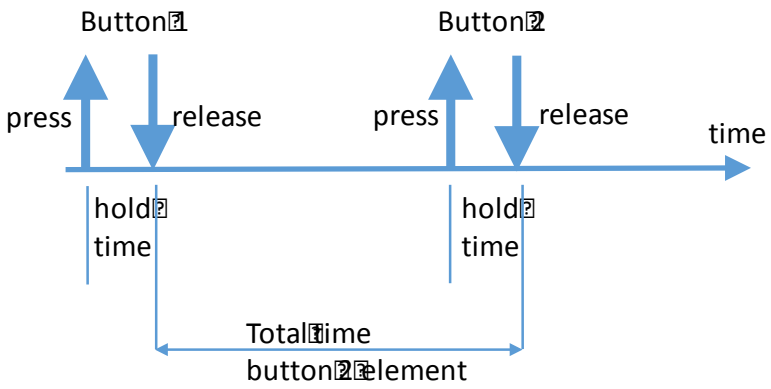

Figure 6. Button Timing

Eighth, the value for L2 in J2365 was 770 ms, which was rounded off from 765 ms (1.7 * 450). Normally, the round-off error is not an issue. However, as some sequences can involve multiple N2 elements in a row, such as dialing a 10-digit phone number, the 0.765 value could be used. The review of the original analysis led to a revised set of predictions, listed in appendix B. In addition, it also led to a new set of elements, described in the next major section of this report.

Ninth, there were inconsistencies in how subjects performed tasks. This was particularly an issue with spelling names, where the intent was to have the subject spell out the entire name. However, after a few keystrokes, the intelligent speller/data base search tool provided the desired entry, but not every subject recognized that at the same point. This led to differences in the button presses entered by each subject, and therefore, the appropriate J2365 parameters.

Tenth, there was no element or time data for repeatedly pressing a function key. This occurs when changing between multiple function states, such as pressing a heated seat button (off, low, high).

All of this may lead readers to be seriously concerned with the Lin et al. (2012) report. Readers need to keep in mind that this research was completed with limited funds and time, and the resources needed to fully address many potential questions of interest were not available. Furthermore, SAE J2365 was developed before touch screens were available, so there were no elements in J2365 to predict the duration required for elements such as using sliders and dragging. Lin et al. (2012) did the best they could with the information available. Furthermore, there were issues in Lin et al. with subjects performing the task as requested, and making errors when they did so, complicating the development of predictions. Thus, for some tasks, what subjects did varied, yet J2365 assumes tasks are repeatedly performed in the same manner.

Nonetheless, useful predictive equations were developed based on the existing version of J2365. This project went to the next level, cleaning up predictions based on the previous analyses and providing the basis for new elements and time values for then.

Given the previous discussion, to eliminate inconsistent use of the E (Enter) element, it was dropped and F was used in its place. Both elements had the same duration, and eliminating decision concerning which to use also sped up analyses. Second, the P element (1.1 s) from the Keystroke-Level Model was used for drag.

How can the J2365 estimates and measured (experimental) data be made comparable?

To examine the quality of the J2365 predictions for the tasks in Lin et al. (2012), the data in the report were reexamined. As was noted previously, there were difficulties in data collection that made it a challenge to identify which data to use for comparison. Again, subjects did not perform the tasks as requested, so the button presses were not consistent with the J2365 analysis. Subjects made mistakes, so tasks needed to be restarted and data eliminated from the analysis. Some of this clean up was done after the Lin et al. (2012) report was completed. Finally, there were a few instances where the recorded times appear to be in error, such as where hold times for buttons were negative, which is not physically possible. Fortunately, these timing errors were small, all less than 0.1 s, the resolution accuracy of the analysis, so they were ignored.

Given this, what measured data (from Lin et al., 2012) should be used for comparison with the J2365 estimated task times? The issue is how to adjust for age differences between the two data sets. SAE J2365 provides time estimates for young drivers (defined as 18-30 yr, mean=24) and older drivers (55-60 yr, mean = 57.5), whose element times were 1.7 times the mean of the younger group. Assuming the effect of age is linear, one can use these two data points (24, 1 and 55.5, 1.7) to determine a multiplier of the young J2365 times (age =24) for any age. Using regression analysis, the equation is:

multiplier = 0.0209Age + 0.4984. (J2365 age adjustment using young subject data)

As a check, the computed multiplier for age 24 is 0.9999. (A perfect prediction would be 1.0.)

When the first version of J2365 was written, the reason for selecting 55-60 as the age for the older group was that colleagues in industry claimed it was too difficult to get subjects whose ages exceeded 60 years for testing in driver interface studies. The authors have found otherwise. Using age 70 as a target for older drivers, the multiplier is approximately 1.96, a value greater than 1.7 in J2365.

A similar approach was used to adjust the measured times in Lin et al. (2012) to develop estimated task times younger subjects (age 24). As shown in figure 7, the change in task time with subject age measured in years in Lin et al. (2012) was very linear. Although a more detailed analysis shows some gender by age interactions and other differences as well, they are overpowered by age effects, and for initial quick analyses, considering only subject age is sufficient.

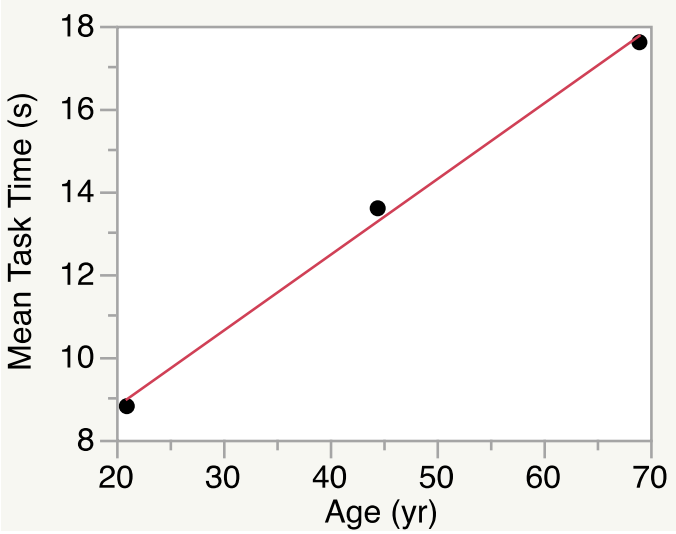

Figure 7. Effect of Mean Age on Task Time (s)

In considering the age effects, keep in mind that subjects were grouped in three ranges. To further simplify further analyses, the effect of age for each age group was assigned to the mean age of each group. Thus, as shown in table 5, the mean ages were 21, 45.5, and 69. Associated with each mean age was a mean task time. The mean task times used were not those in Lin et al. (2012), but were recomputed using the most recently corrected data set (no errors, tasks performed close to but not exactly always as requested). Those more recent data reflected further cleanup of the data set.

Table 5. Mean Ages of the Six Subject Groups

Age	Gender	Age Group		
		Young (18-30)	Middle (40-55)	Older (>65)
	Female	21	44	71
	male	21	45	67
	Mean	21	44.5	69
Task time	female	8.31	12.67	18.59
	male	9.31	14.50	16.61
	Mean	8.81	13.59	17.60
	Ratio to young		1.52	2.00

From a regression analysis of that data,

Task time (s) = 0.1830*Age + 5.1294.

Using 24 as the age for the younger sample, the mean time for younger groups is approximately 9.5214 s. Dividing the task time expression by that value, gives the following expression:

Multiplier based on age 24 = 0.0192*Age + 0.5387 (Measured data age adjustment)

The intercept for the age-adjustment multiplier is about the same as that in J2365, but the slope is less, but less than 9%, a small difference. The differences in their intercepts are tiny, 0.0403. Thus, using J2365 data for young subjects (mean age =24) as the baseline, the measured data from Lin et al. (2012) suggests the multiplier for older subjects in that document (55-60, mean=57.5) should be 1.64, 3.7 % less than the 1.7 value used in J2365, a very small difference. To provide some perspective, these data suggest that to estimate the task times for an 80-year-old driver, one should multiply the times for a 24-year-old by 1.88 and a 21-year-old by 2.00. It should be noted that various cuts at the data, in terms of how major and minor errors are handled, can alter this multiplier. However, the key point made here is that the multiplier in J2365 is reasonable, and to the very limited degree that it has been explored, is very linear.

In addition to estimating task times for an arbitrary age, this analysis was used to develop estimates for the measured data that could be compared with the J2365 estimates. In this experiment, the mean age was 44.8, approximately 45. Substituting Age=45 into the multiplier equation for this data set (0.0192*45 + 0.5387), the result is 1.4027. The inverse is approximately 0.71. Thus, multiplying the measured mean times by 0.71 gives the estimated time for a 24-year-old, the youngest subject group in J2365.

Multiplier = 0.0192*Age + 0.5387

Expanding

TaskTimeAgeX = TaskTimeAge24 * Multiplier

Rearranging terms

TaskTimeAge24 = TaskTimeAgeX / Multiplier

Substituting terms

TaskTimeAge24 = TaskTimeAge45 /(0.0192*45 + 0.5387)

TaskTimeAge24 = TaskTimeAge45 / 1.4027

How well do the corrected measured times from Lin et al. agree with the corrected and revised J2365 estimates?

The regression equations just described were used to develop parallel estimates for comparison (table 6). They include (1) the mean task time for each block and trial for young subjects (age=24), (2) data for older subjects (age = 57.5) for reference purposes, (3) the cleaned-up mean times from the experiment (the measured data) averaging across subjects, (4) that mean multiplied by 0.71 to give an estimate for age 24, (5) the arithmetic difference between the two estimates (measured and J2365), and (6) the relative percentage differences between the two estimates. One of the reasons for the large differences in the data where the measured time was

much larger than the J2365 estimate was due to outliers in the original data that were not removed. For example, for block 3, task 4, all of the responses except for two had durations between 0 and 60 s, with the mean being in the 20 s range. However, there was one trial with a duration of 120+ s and another trial with a duration 190+ s. Removal of these two trials, along with the age adjustment, would have led to an estimate 24-year-old time for 14 or more seconds, quite close to the J2365 estimated of 13.2 s.

Table 6. Comparison of J2365 and Measured Data

Block & Trial	J2365 from Appendix (s)		Measured Means (s)		Difference	
	Young (age = 24) (B)	Old (age = 57.5)	All Ss	* 0.71 (age 24 estimate) (E)	Col. B-E	%
b1t1	18.9	32.1	22.8	16.2	-2.7	-17
b1t2	25.3	42.3	30.5	21.7	-3.6	-17
b1t3	22.2	37.7	26.4	18.7	-3.5	-18
b1t4	17.0	28.2	18.8	13.3	-3.7	-27
b1t5	20.3	34.5	26.5	18.8	-1.5	-8
b1t6	16.1	27.3	16.4	11.6	-4.4	-38
b1t7	8.1	14.5	8.5	6.0	-2.1	-34
b1t8	2.7	4.6	5.8	4.1	1.4	34
b1t9	2.6	4.4	7.7	5.5	2.9	52
b1t10	23.2	39.4	19.1	13.6	-9.6	-71
b2t1	15.4	26.2	29.6	21.0	5.6	27
b2t2	16.1	27.3	17.5	12.4	-3.6	-29
b2t3	15.5	26.4	18.4	13.1	-2.4	-19
b2t4	9.2	15.6	12.5	8.9	-0.3	-4
b2t5	7.7	13.1	16.4	11.6	3.9	34
b2t6	5.8	9.9	12.1	8.6	2.8	32
b2t7	14.9	24.6	21.2	15.1	0.2	1
b2t8	16.1	27.3	15.8	11.2	-4.8	-43
b2t9	19.4	31.9	32.7	23.2	3.8	16
b2t10	5.4	9.2	5.7	4.0	-1.4	-33
b3t1	2.7	4.6	4.4	3.1	0.4	14
b3t2	18.9	31.1	28.1	20.0	1.0	5
b3t3	17.1	28.3	18.5	13.1	-3.9	-30
b3t4	13.2	21.8	35.0	24.9	11.6	47
b3t5	3.3	5.6	13.6	9.7	6.3	66

b3t6	8.1	13.8	18.1	12.9	4.8	37
b3t7	7.2	12.3	19.2	13.6	6.4	47
b3t8	14.5	24.7	26.8	19.0	4.5	24
b3t9	17.1	28.3	15.8	11.2	-5.8	-52
b3t10	13.8	23.5	39.6	28.1	14.3	51
b4t1	22.4	38.1	22.6	16.0	-6.4	-40
b4t2	2.6	4.4	7.8	5.5	2.9	53
b4t3	2.7	4.6	6.9	4.9	2.2	45
b4t4	7.2	12.3	10.3	7.3	0.1	1
b4t5	16.1	27.3	18.5	13.1	-2.9	-22
b4t6	23.3	39.6	34.3	24.4	1.1	4
b4t7	15.9	27.0	23.6	16.8	0.9	5
b4t8	13.0	22.1	25.8	18.3	5.4	29
b4t9	23.5	40.0	36.3	25.8	2.2	9
b4t10	16.2	27.5	25.0	17.8	1.6	9

Further indications of limits of the original data are highlighted by comparisons that involved the same steps but different data. The sequences that should be most consistent are dialing, because the task is well learned and simple. For the dialing tasks, only the phone number was changed, not the J2365 elements, and all elements needed exist in J2365. As shown in table 7, the means for these dialing tasks (24 responses, 1 per subject) varied from 15.8 to 18.5 s, reflecting the natural variability in human performance. Given these data, clearly a prediction of 16-18 s, is about as good as the subject data permits.

Table 7. Dialing Tasks Times

Block and Task	Task Time (s)
b1t6	16.4
b2t2	17.5
b2t8	15.8
b3t3	18.5
b3t9	15.8
b4t5	18.5

Similarly, the predicted times for the two tasks associated with toggles (b1t8 and b4t3) were 5.7 and 7.7 s.

Table 8 provides further insight into why the J2365 predictions and the measured task times are not in complete agreement. Notice that for 24 of the 40 block-trial combinations there is at least one element of the task for which J2365 does not provide predictions. Given this outcome, new elements and times for them are needed.

Table 8. Differences and Descriptions

Block & Trial	Difference		Abbreviated Description	Control or Element
	B-E	%		
b1t1	-2.7	-17	find the nearest gas station with “Diesel	-
b1t2	-3.6	-17	in “recent calls” list call “Neil Strickland” (home),	arrow keys
b1t3	-3.5	-18	in “Rear Entertainment” select channel “119	arrow keys
b1t4	-3.7	-27	in “phonebook”: find and call “Tammy Graham	-
b1t5	-1.5	-8	find and play song “Mississippi Kid”	arrow keys
b1t6	-4.4	-38	dial and call “248-359-1760”	
b1t7	-2.1	-34	find and listen to 11th message	arrow keys
b1t8	1.4	34	change airflow to face	
b1t9	2.9	52	change front left audio balance	drag
b1t10	-9.6	-71	set clock to 11:59	arrow keys
b2t1	5.6	27	for artist Aerotrio” play song “Megatrombosisciclica”	arrow keys
b2t2	-3.6	-29	dial and call “734-928-5501”	
b2t3	-2.4	-19	in “Rear Entertainment” select channel “40”	arrow keys
b2t4	-0.3	-4	find 5th message (from Bob Fedder)	
b2t5	3.9	34	adjust audio bass to “+3”	arrow keys
b2t6	2.8	32	change driver temp to 78 F	arrow keys
b2t7	0.2	1	in “recent calls” list call “Lorna Donlon”	arrow key
b2t8	-4.8	-43	dial and call “313-464-9979”	
b2t9	3.8	16	“tune” to AM 1530, and save to Preset #11	arrow keys
b2t10	-1.4	-33	set the “Passenger” “Heated Seat” to “LO”	
b3t1	0.4	14	set the “Passenger” “Vented Seat” to “HI”	
b3t2	1.0	5	tune to AM 1570, and” save to Preset #2	slider
b3t3	-3.9	-30	“dial” and call “313-646-7797”,	
b3t4	11.6	47	in “recent calls”, find and call “Kevin Bishop” (cell)	
b3t5	6.3	66	adjust “Passenger” temp to 74 F	slider
b3t6	4.8	37	adjust audio equalizer to -5	arrow keys
b3t7	6.4	47	find and view “3rd” message from “Don Knotts”	slider
b3t8	4.5	24	in “Rear Entertainment” select channel “60”	slider
b3t9	-5.8	-52	“dial” and call “734-382-5503”	
b3t10	14.3	51	for artist “Barenaked Ladies” find and play song “If I had 1,000,000 Dollars”	slider
b4t1	-6.4	-40	set clock to 1:02	arrow keys

b4t2	2.9	53	drag audio balance to right rear	drag
b4t3	2.2	45	change air flow to feet	
b4t4	0.1	1	find and listen to “9th” message from “Lin Ford”,	slider
b4t5	-2.9	-22	“dial” and call “248-157-3940”	
b4t6	1.1	4	find and play song “The Needle and the Spoon”	unknown # entries
b4t7	0.9	5	in phonebook find and call “James Hardy” (home)	
b4t8	5.4	29	in “Rear Entertainment” select channel “33”	slider
b4t9	2.2	9	in “recent calls” list find and call “Jenny Baxter” (home)	slider
b4t10	1.6	9	find the nearest gas station with “Regular” fuel	

ANALYSIS 2 – DETERMINATION OF NEW J2365 VALUES

The previous analysis showed that there were a number of shortcomings with the existing J2365 estimates including (1) no elements or times for them for elements having to do with using cursors to change scroll and change pages, (2) questions about the accuracy of elements that could be carried over, such as entering numbers and letters, and (3) questions about when to insert Ms (mental elements), especially if they occurred at the end of a sequence.

Accordingly, a new version of J2365 was developed based on the following principles and observations.

1. Determining where to include the M (mental) and S (search) operators should be included is difficult. They cannot be timed independently as there is no readily observed point as which thinking ends and pressing a button begins. Therefore, if possible, the M element and the element that follows should be combined, simplifying analysis and reducing analysis time.
2. Most control-related actions (e.g., pressing buttons) are of two types listed below.
   a. Seeing a new screen and pressing a button.
   b. Pressing another button on a screen on which a button was just pressed
3. Scrolling actions, using a cursor key or slider are of three types listed below.
   a. Seeing the first screen and then selecting another where the content is in a readily scanned order (numeric, alphabetic) and the subject is looking for a number or letter.
   b. Seeing all screens after the first where the content is ordered as in 3a. The embedded mental time for this element is much less than 3a.
   c. Seeing any screens where much of the screen needs to be read. A good example is a recent call list by order of occurrence, and the subject is looking for a call from a particular person but does not know where it is on the list. Another example is looking for a song in a similar situation.
4. Dragging an object across a screen (to set speaker balance) was quite different from dragging a slider a short distance, in that it has a lower index of difficulty (based on Fitts Law).
5. As most in-vehicle tasks consist of multiple intermediate tasks, distinguishing what constitutes an end key is superfluous, especially as the time for function-key and end-key tasks are the same. The end-key task was therefore dropped.

The database examined consists of 8,211 button presses developed from a much larger set. Each data point contains the associated descriptors, such as the subject number, block, and trial, and the category (e.g., radio, phone, more), subcategory (TravelLink, recent calls), and button (e.g., Browse Selection value: *Thorntons*, pageDownBtn). Also included are dependent measures including the total time for that button press, which is the time since the last button was released until the current button was released.

Of the 8,211 data points, for 204 the total time was missing due to bugs in the interface simulation software provided by the sponsor of the original research. Another 132 times were negative, which is not possible, and eight responses were 0, which seems unlikely. On the other end of the range, there were a number of extremely large element times that also did not make

sense. These times could reflect situations where the subject got lost or forgot to press a terminating button. Fortunately, those extremely large values were uncommon and occurred for elements for which there were a large number of responses, often 200 or more, so the impact of one or two suspect data points was mitigated. Ideally, additional cleanup of the data set was desired, but due to resource limitations and for other reasons, that was not done at the time. For the purposes desired, the data set is considered adequate as is, but it would have been better had there been additional resources available. Figure 8 shows the overall distribution of all responses.

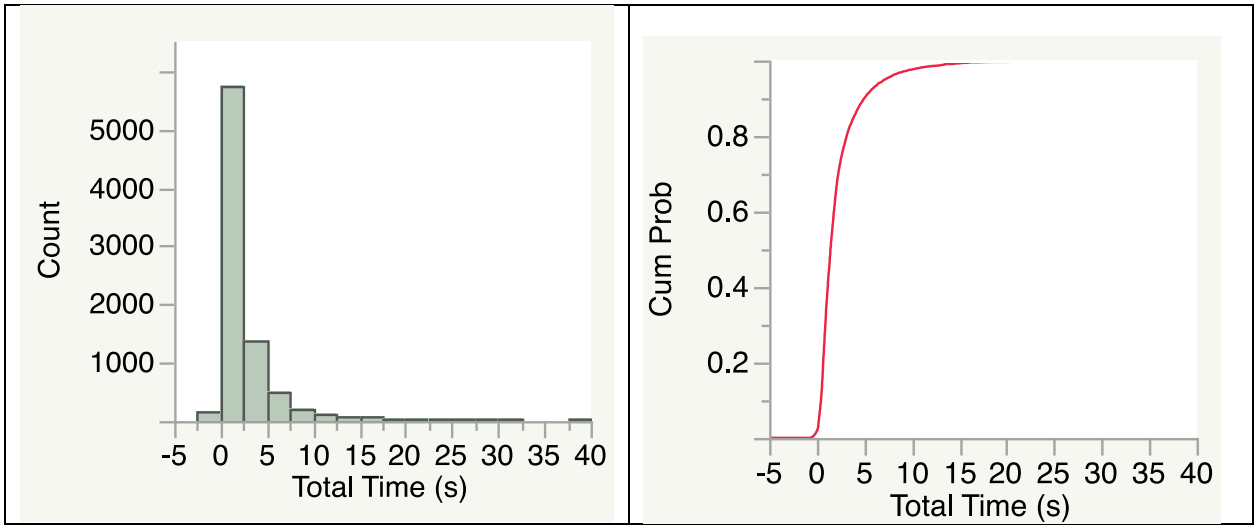

Figure 8. Overall Distribution of All Button Presses

Given issues with the existing J2365 elements, a new coding scheme was developed. Table 9 lists all elements in alphabetical order by element code along with descriptive statistics for each element. The major changes were to merge the mental (M) element with other elements and to add in times for arrow button and slider actions associated with scrolling. The standard deviations are not intended to be part of SAE J2365 in the future and are provided for reference purposes. Likewise, the minimum and maximum values are intended to give the reader a sense of where additional filtering in follow-on analyses should be considered.

In addition to elements shown here, 91 were coded as "Err" (error) in the original data set as there was ambiguity in those cases as to what the appropriate codes were. Note that this is out of 2281 data points, approximately 4% of the button presses. The mean time for Err was 3.7 s with a mean of 4.1. There were too few of them and their values were not sufficiently different from other times to markedly affect the element-time estimates.

The most important column in the table contains the new J2365 estimates, computed by multiplying the mean measured time (from the experiment) by 0.71 to adjust for age using the multiplier described earlier. The J2365 young estimate is for a 24-year-old driver.

Table 9. New J2365 Elements

Code	Element Name	N	Mean (s)	SD (s)	Min (s)	Max (s)	New J2365 Estimates (Young)
C0	Cursor other – read entire screen, message from a person, when the list is in order of occurrence	51	3.38	1.84	1.03	10.63	2.40
C1	1st cursor action on a screen (e.g., scrolling list), list is in alpha or numeric order.	459	3.79	3.08	-0.39	20.25	2.70
C2	>=2 cursor action on a screen, list is in alpha or numeric order.	1639	1.13	1.25	-0.65	13.52	0.80
D	Dragging from 1 place to another on a screen (e.g., audio balance)	60	4.92	3.36	0.49	14.94	3.50
F1	1st cursor action	2618	2.86	2.61	-0.64	26.89	2.00
F2	>= function key action on a screen	459	2.36	2.24	-0.62	16.86	1.70
H	Press and hold key (e.g., preset)	21	2.21	1.05	0.92	3.47	1.55
L1	entering 1st letter after screen change	55	2.66	1.94	0.51	9.57	1.90
L2	Entering all letters after 1st	428	1.48	1.24	-0.56	12.56	1.05
N1	entering 1st number after screen change	191	2.03	2.01	0.28	25.94	1.45
N2	Entering all numbers after 1st	1470	0.98	0.61	-0.34	6.49	0.70
SL1	1st slider action after a new screen	281	7.07	5.66	-0.35	38.75	5.00
SL2	All slider actions after the 1st	388	3.49	4.17	-0.39	30.96	2.50

Additional details for each element follow, provided by element in alphabetical order.

C0 – Cursor other

This element is used when using the arrow buttons to scroll through a list where each entry needs to be read, such as looking for a particular name (song, person to call). Based on 51 button

presses, the mean time was 3.38 s and there was a large cluster of points between 1 s and 3 s. There were no button presses less than or equal to 0, but there was 1 button press in excess of 10 s. Both the Log-normal and two-parameter Weibull distributions fit the data reasonably well (figure 9). Note: To facilitate comparison of all of the elements in this section, the x-axis is the same.

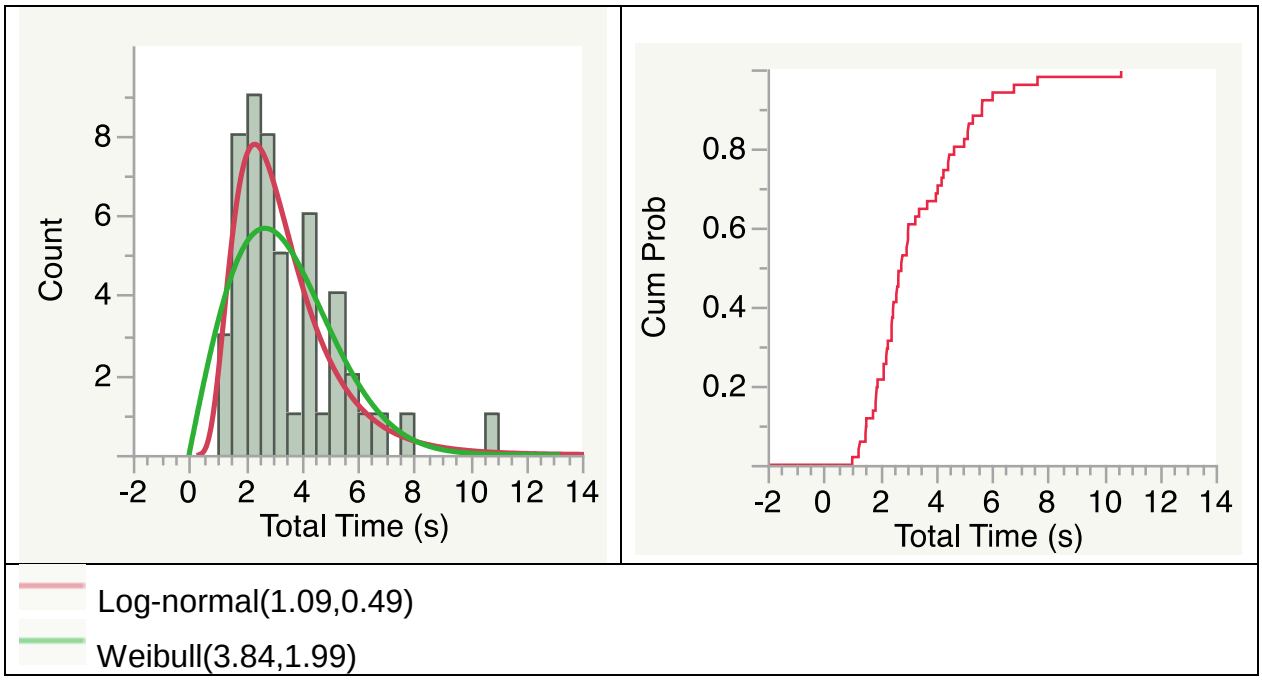

Figure 9. Frequency and Cumulative Distributions for C0

As was noted earlier, the mean age of the measured sample was not equal to the young-age mean of SAE J2365 (24 years old). Using the multiplier (0.71) derived earlier, the estimated mean time for an action that involves scanning a small screen (about five or six brief lines of text) and operating a cursor key is approximately 2.37 s, which rounds off to 2.40 s. That scan is much less extensive than the search element in Keystroke-Level Models, but more akin to a mental element. To provide some perspective, the Keystroke-Level Model time for a mental element is 1.35 s and in J2365 the time is 1.5 s.

C1 – First Cursor

This element is used when a new screen appears and the first action is to press a cursor (arrow) key to scroll the screen. The mean time was 3.79 s for 459 responses. Most of the responses were between 0 s and 7 s, but there were some very long responses, the longest being 20.25 s, although there were few greater than 14 s. As there were a large number of responses overall, the few large values should have a limited effect on the outcome, at least for a first-cut estimate. These data were reasonably well fit by a three-parameter Weibull distribution (figure 10).

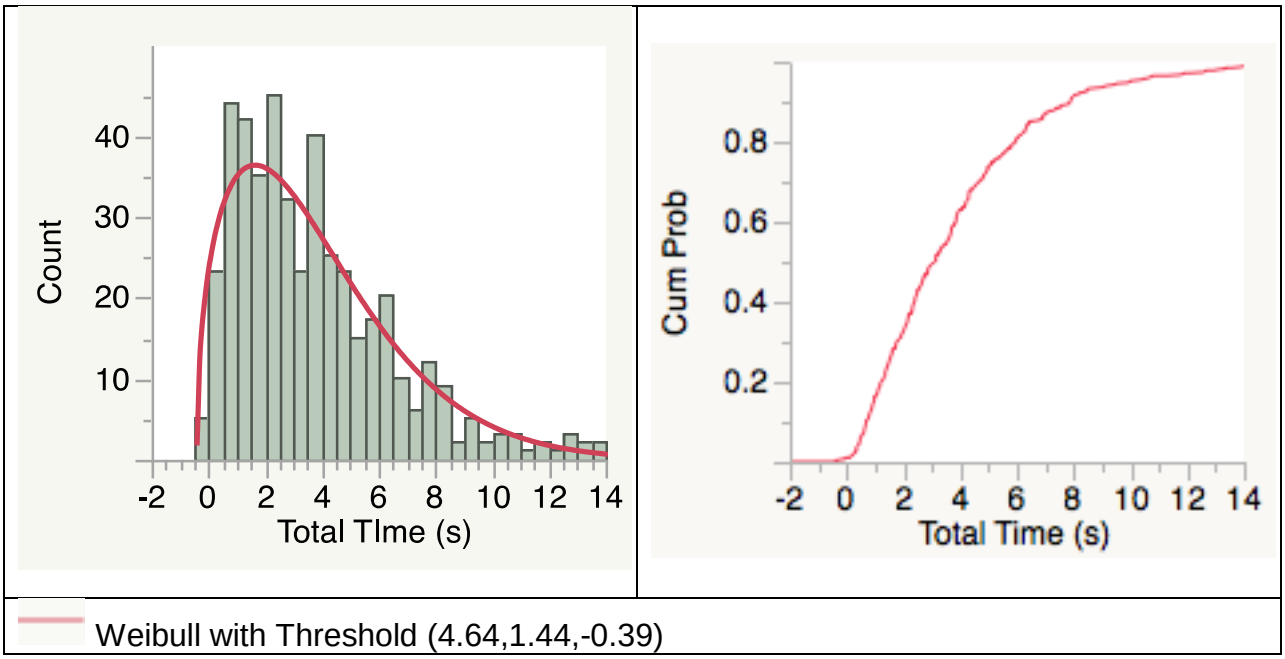

Figure 10. Frequency and Cumulative Distributions for C1

Mutltiplying the mean time of 3.8 by 0.71 leads to a J2365 estimated time for young drivers of 2.69 s (rounded off to 2.70 s), which seems reasonable, given that the element involves a mental element (either 1.35 or 1.5 s) and then a cursor action,. It also seems reasonable that this time should not be very different from C0, which is the case.

C2 – Second Cursor

This element is the second in a sequence of cursor-key operations where the screen has not changed from the previous element and a cursor (arrow key) action scrolls the screen. The mean time was 1.13 s for 1,639 responses. The mean time is much less than C1 because the amount of scanning and thought required to determine what to do was less, and because some of those activities occurred in parallel with the previous action (C1). Most of the responses were between 0 s and 2 s, but there were a few negative responses due to recording errors. These data were reasonably well fit by a three-parameter Weibull distribution as with C1 (figure 11).

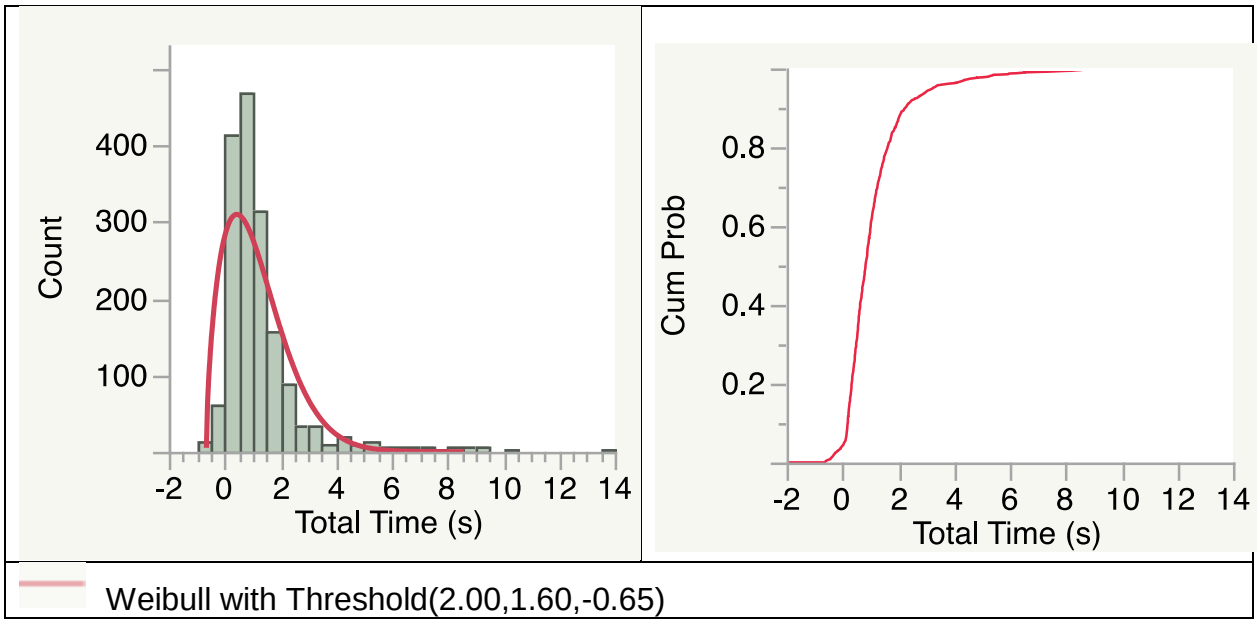

Figure 11. Frequency and Cumulative Distributions for C2

Multiplying the mean measured time by 0.71 leads to a J2365 time for young drivers of 0.80 s for this element. Note that in the Keystroke-Level Model, the time to type a random character is 0.75 s. In the current version of SAE J2365, the estimated time for a first cursor element was 0.80 s and for subsequent operations it was 0.40 s. The 0.40 s time is most appropriate for rapid -fire cursor movement, such as moving a cursor across a line. Thus, the 0.8 s value is consistent with what is reported here.

D – Drag

This drag element is used to move an object across the screen, such as changing audio balance. The mean time was 4.92 s for 60 responses and the number of instances where subjects focused on the task (and total times were much larger) was significant. Obviously, such a visually demanding task is ill advised while driving. Log-normal and two Weibull distributions (two-parameter and three-parameter with a threshold) all fit the data reasonably well (figure 12).

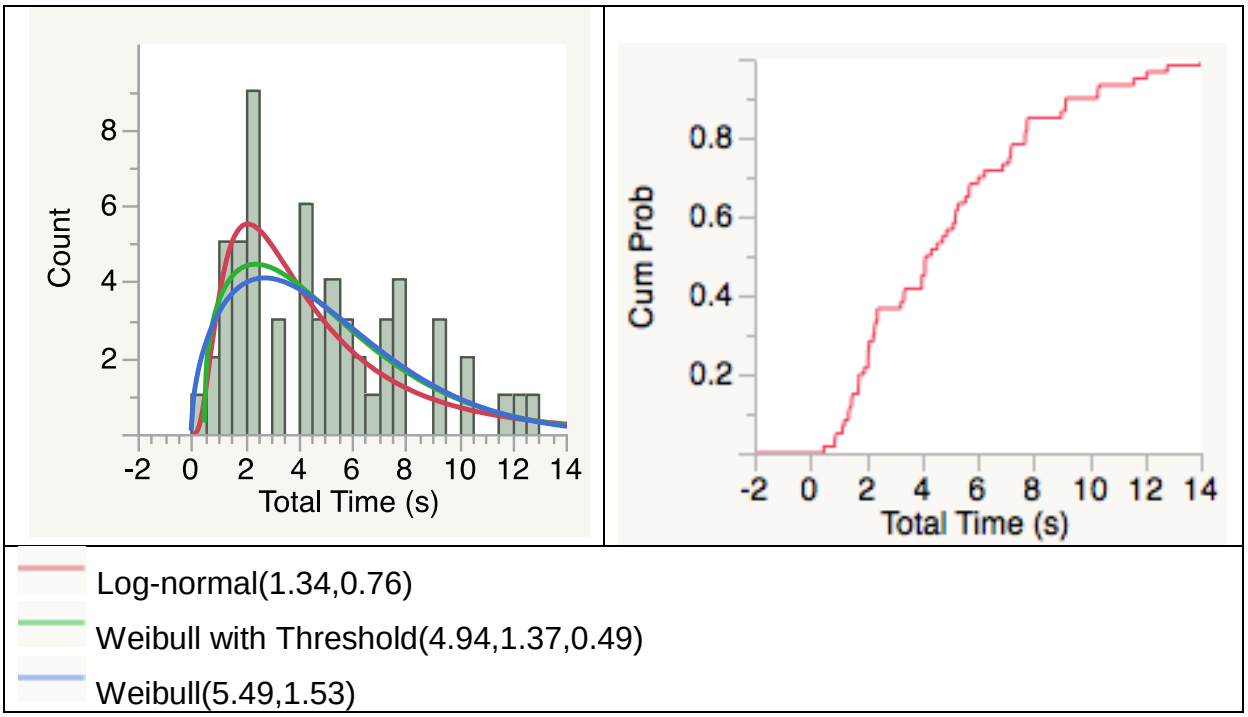

Figure 12. Frequency and Cumulative Distributions for D

Multiplying the measured mean time by 0.71 leads to an estimated time for young drivers in J2365 of 3.49 s (rounded off to 3.5 s). To provide some perspective, the P element in the Keystroke-Level Model has a time of 1.1 s and the M element is 1.5 s for a total of 2.6 s. Because of the movement difficulty, it is almost as if the subject needs to make two movements, or 2 P elements. Assuming that were true, the estimate time would be 1.5 + 1.1 + 1.1 or 1.35 + 1.1 + 1.1, which leads to time estimates of 3.7 s and 3.55 s, quite close to the estimate of 3.7 s offered.

F1 – First Function Key

This function-key-1 element is used for the first function-key action associated with a new screen. The mean time was 2.86 s for 2,618 responses. Their times ranged from 0.61 s to 26.89 s, with a number of responses in excess of 10 s. Both a Weibull distribution (with a threshold) and normal distribution fit the data (figure 13).

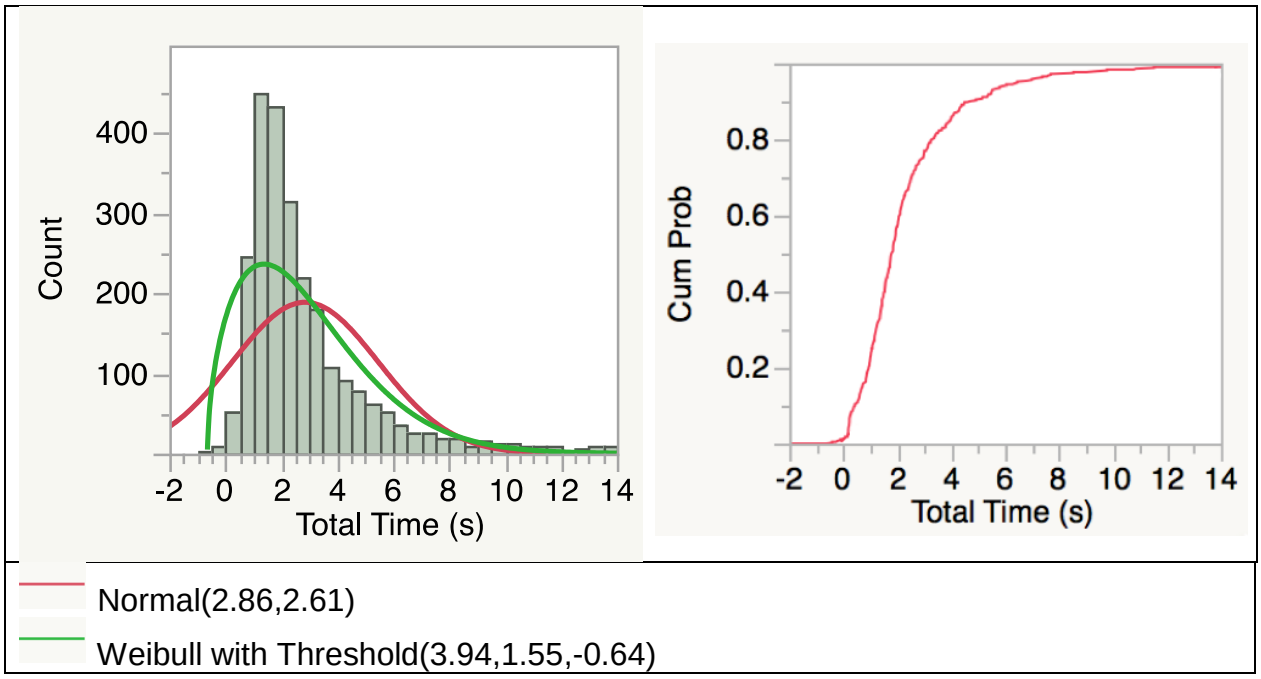

Figure 13. Frequency and cumulative Distributions for F1

The mean estmated time for F1 is 2.03 s (2.86 x 0.71), rounded down to 2.0 s. Given that this element includes a mental time plus button operation, this time makes sense. However, given the large number of different function-key-related activities in this category, further partitioning was worth considering.

Function-button times could depend on a number of factors. Some factors include how often the subject has seen the screen before, whether the decision is a category match (is the item desired in the category identified by the label, such a tuning is a radio function) or an identity match (the desired end item, looking for the tuning button and the label is so named), how far down in the menu tree one needs to go (is it a submenu, a subsubmenu), whether the button appears in multiple interfaces, how big the button is, and so forth. Bearing all of those possibilitites in mind, as part of this first cut analysis, function keys were partitioned into five categories.

As shown in tables 10 and 11, there were some differences in the category mean times of practical importance. However, there also was considerable overlap. Given the variability in the underlying data and the overlap noted, the classification of function buttons needs further investigation.

Table 10. F1 Categories, Examples and Mean Task Time (s)

Category	Description	Example	Mean Time (s)
array	array of buttons in the center of the screen	climate control and settings	4.27
fix	menu of buttons at the subcategory level that is fixed	bottom row of buttons for radio functions	2.67
list	buttons in the listing of a data set	contact list (alphabetical ordered), recent call list (random)	2.25
sub	buttons that are fixed but nested under subcategory menu	search button in the song list page	3.71
other	does not fit into other categories	message button located at the right side of contact list	2.82

Table 11. Mean Times for F1 Buttons

Button	n	Mean Time (s)	SD Time (s)	Category
iconFeet	24	6.90	4.30	array
iconPanel	24	4.67	4.34	array
passVentSeat	33	3.13	1.78	array
passHeatSeat	51	2.36	2.21	array
radioBrowseBtn	50	4.94	4.15	fix
phoneBookBtn	46	3.67	3.49	fix
fmamTuneBtn	14	3.47	2.69	fix
radioSourceAmBtn	38	2.93	2.11	fix
numberPadBtn	133	2.68	2.16	fix
travelLink	45	2.48	1.51	fix
recentCallsBtn	96	2.41	1.83	fix
radioNextBtn	10	2.38	1.93	fix
settings	46	2.30	1.39	fix
messagingBtn	94	2.25	1.67	fix
endCallBtn	141	2.16	1.20	fix
rearEntertainment	95	1.84	1.09	fix
callBtn	150	1.23	0.55	fix
Browse Selection value: *1.00mi*	30	3.56	3.09	list
Browse Selection value: *James Hardy*	30	3.04	1.69	list
Browse Selection value: *Aerotrio*	24	2.69	1.79	list

Browse Selection value: *Tammy Graham*	18	2.59	1.34	list
Browse Selection value: *Neil Strickland*	22	2.53	1.17	list
Browse Selection value: *Thorntons*	17	2.47	1.54	list
Browse Selection value: *33 The Bridge*	21	2.37	1.89	list
Browse Selection value: *Diesel*	28	2.31	2.09	list
Browse Selection value: *Barenaked Ladies*	28	2.27	1.47	list
Browse Selection value: *60 The Highway*	20	2.06	0.82	list
Browse Selection value: *The Needle and the Spoon*	23	2.02	0.94	list
Browse Selection value: *Mississippi Kid*	23	2.01	1.30	list
Browse Selection value: *Regular*	21	1.95	0.89	list
Browse Selection value: *Megatrombosisciclica*	24	1.93	0.78	list
Browse Selection value: *Lorna Donlon*	23	1.92	0.80	list
Browse Selection value: *Jenny Baxter*	21	1.87	0.91	list
Browse Selection value: *40 Hip-Hop Nation*	23	1.84	0.64	list
Browse Selection value: *119 Only Classics*	25	1.82	0.71	list
Browse Selection value: *Kevin Bishop*	19	1.50	0.87	list
songsRB	50	5.08	4.22	sub
fuelType	17	4.92	4.59	sub
equalizer	47	4.89	4.95	sub
listenBtn	20	4.67	2.76	sub
Browse Selection value: *All Songs*	37	4.24	4.68	sub
browseSatBtn	97	4.08	3.06	sub
searchBtn	51	4.02	3.18	sub
Browse Selection value: *Call*	66	3.69	2.49	sub
fuelSearch	39	3.38	2.67	sub
jumptToBtn	52	2.66	2.03	sub
Browse Selection value: *Clock*	49	2.48	1.03	sub
tuneToBtn	38	2.42	1.85	sub
otherBack	70	1.65	1.86	sub
Selection	158	2.85	2.06	other
highlite	65	2.79	2.46	other

F2 – **Second Function Key**

This function-key/button activity is the second in a sequence of function-key operations where the screen has not changed from the previous element, so less mental activity could be required. The mean time was 2.36 s for 459 occurrences. Times ranged fom -0.62 s to 16.86 s, and there were several occurrences in excess of 10 s (figure 14).

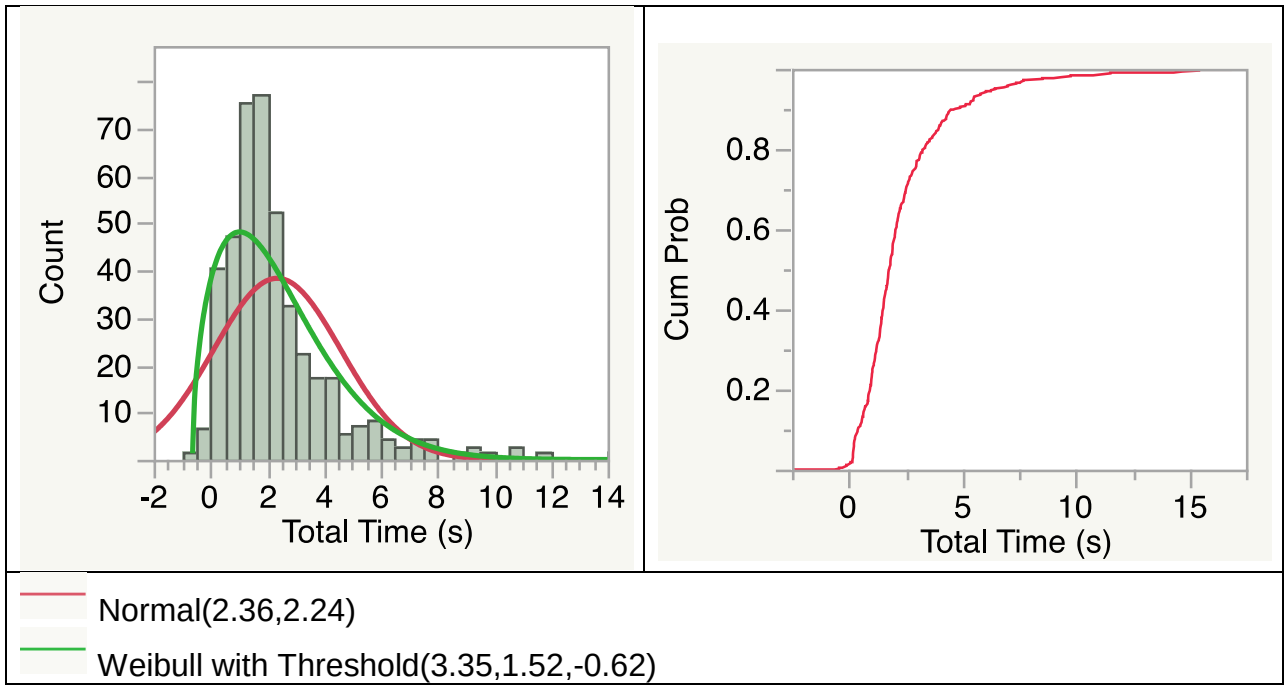

Figure 14. Frequency and Cumulative Distributions for F2

The estimated J2365 time is 1.70 s, rounded off from 1.68 (2.36 X 0.71). F2 should be less than F1, and it is.

H – Hold

The hold element occurrs when a button is held down, such as for the radio preset. Although 21 instances of this element were identified in the data set, only five of them had times associated with them, for a mean of 2.2 s. Given the small sample size, the mean is not very reliable and there is insufficient data to assign a distribution to it (figure 15).

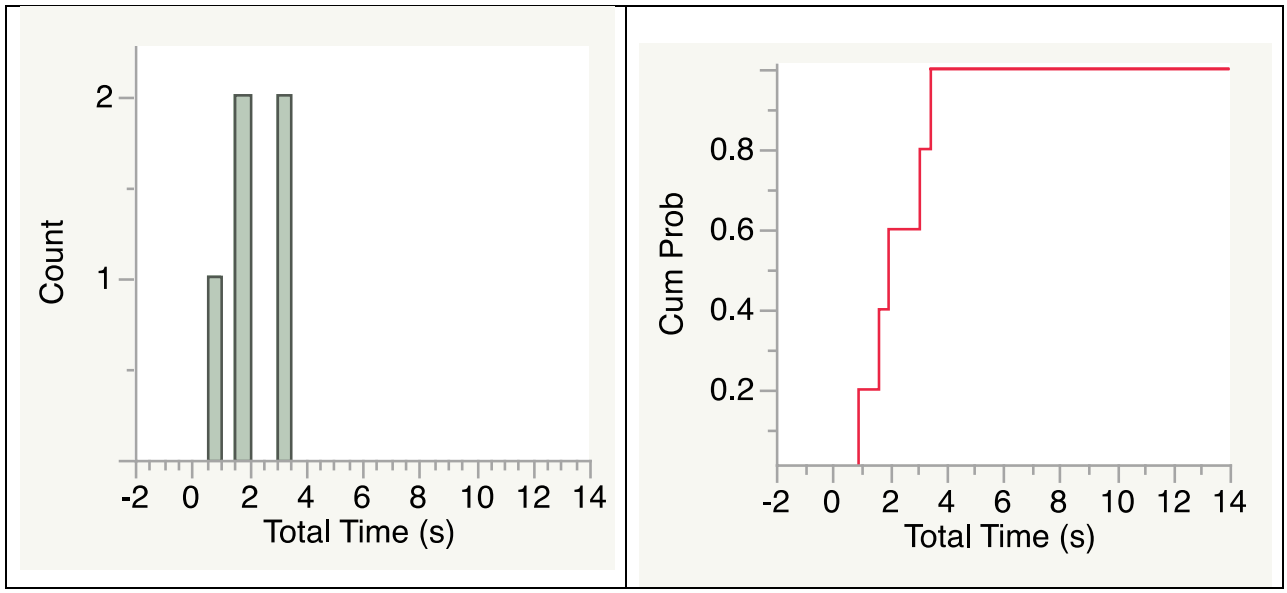

Figure 15. Frequency and Cumulative Distributions for H

The time for this element is very application dependent. The duration needs to be long enough for the system to recognize that the keypress is entended, for the driver to recognize that feedback has been provided, and then to release the button. This would suggest that the time should be at least as long as the time for a mental operation (1.35 s or 1.5 s), plus some additional movement time. Interestingly, the J2365 young-driver adjusted time (mean measured time x 0.71) is 1.57 s, rounded off to 1.55 s. This estimate is remarkably close to what one could expect, especially in light of the small sample size. However, given the very small sample size, this estimate is suspect.

L1

The L1 element occurs after a new screen is presented and the subject enters a first letter. There were 55 occurrences of this element with a mean of 2.7 s. The maximum was 9.6 s, most likely where the subject hesitated to type a first letter. There were no negative times, but times on the order of 0.5 s are unexpectedly brief. The log-normal distribution and two- and three-parameter Weibull distributions fit the data reasonably well (figure 16).

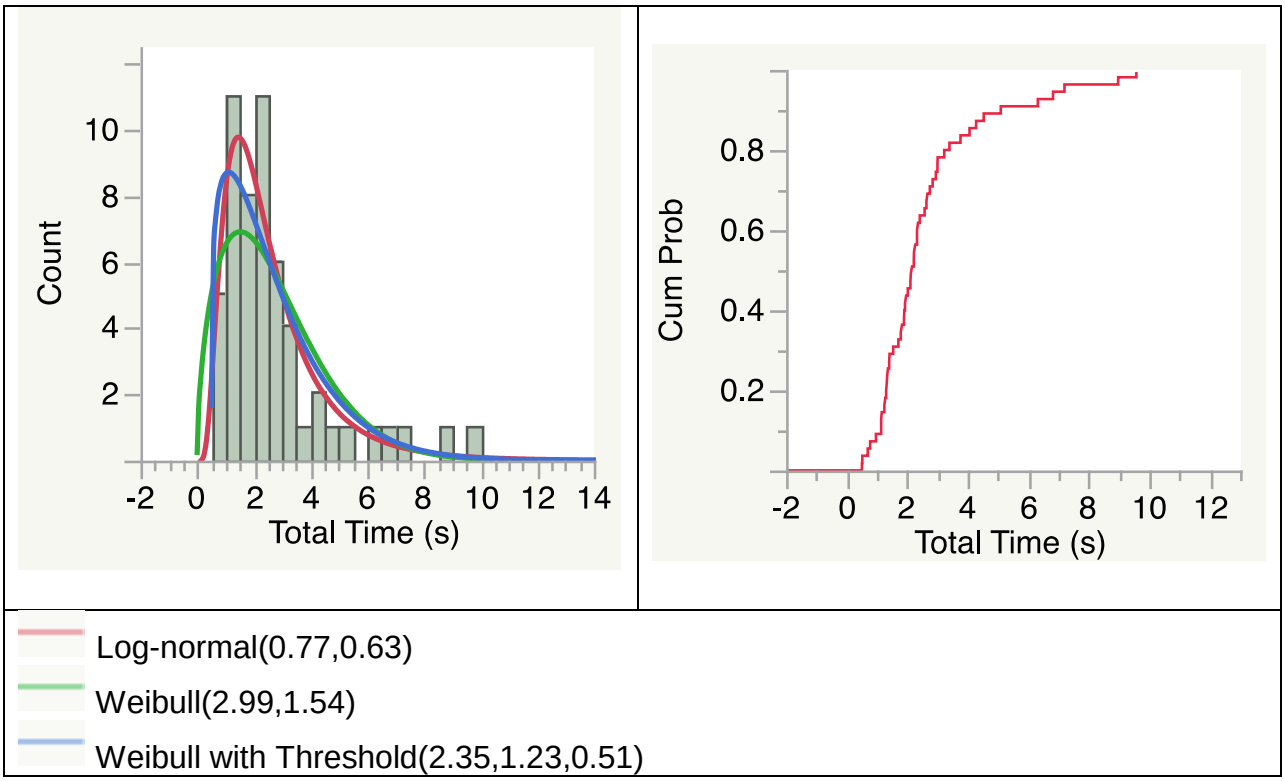

Figure 16. Frequency and Cumulative Distributions for L1

Adjusting for mean time for age (multiplying by 0.71), the estimated J2365 time is 1.89 s, rounded off to 1.90 s. This value seems reasonable and the Keystroke-Level Model indicates the time for typing random "complex" codes is 0.75 s/keystroke and the 1.2 s/keystroke is required for a "worst" typist unfamiliar with the keyboard, and that some mental time is needed to prepare the initial button press. In typing, the hands are often resting on the keyboard, reducing movement time. In SAE J2365, the time for this element for young subjects was estimated to be 1.0 s, but that was without a mental element.

L2

The L2 element occur after the subject enters a first letter in a sequence of letters, such as a name. There were 428 occurrences of this element with a mean of 1.5 s. The maximum was 12.6 s, most likely where the subject hesistated to type a first letter. For this element, there were also some negative times. There were also rare longer occurrences (in excess of 10 s and 12 s) that are not typical button presses. The three-parameter Weibull distributions fit the data reasonably well though the distribution does resemble a log-normal distribution visually (figure 17).

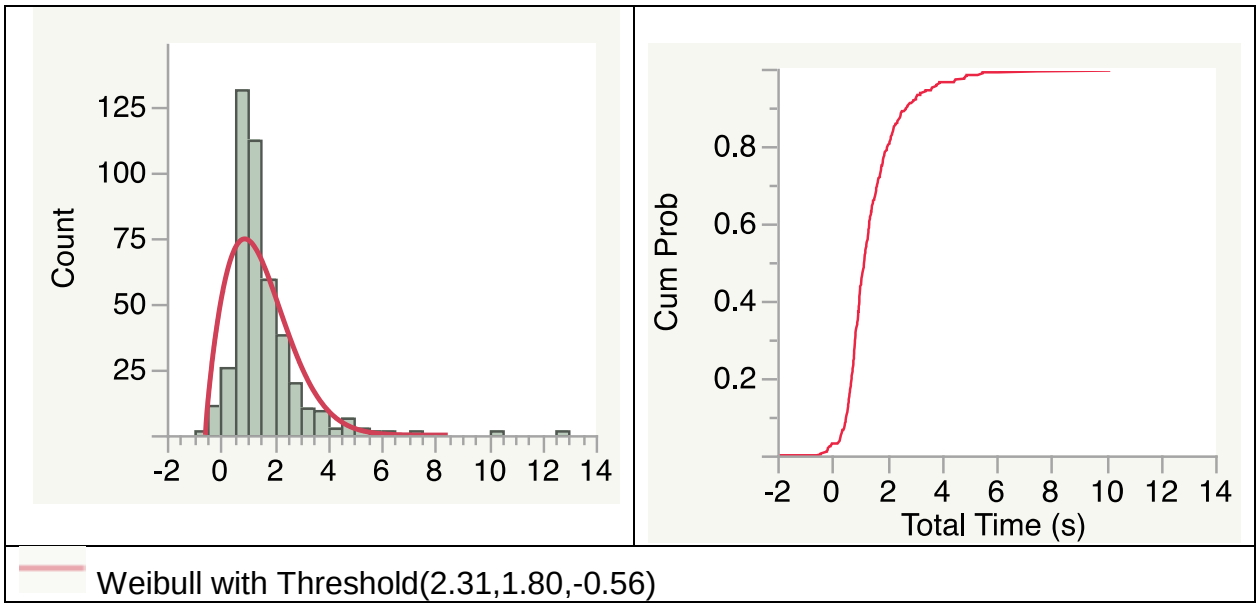

Figure 17. Frequency and Cumulative Distributions for L2

The estimated time for L2 is 1.05 s (1.48 x 0.71). Because the time for L1 is estimated to be approximately 2.7 s and a mental operation, the difference between L1 and L2 is about 1.5 s, and L1, L2, and M are all estimates, an estimated time for L2 of 1.0 s is reasonable. As a reminder, SAE J2365 estimates the time for the first letter to be 1.0 s and for subsequent letters to be 0.5 s, an estimate that is less than the number presented here.

N1

The N1 element occurs after the subject enters a first numerber in a sequence of numbers, such as a phone number. There were 191 occurrences of this element with a mean of 2.03 s. The maximum was 26.0 s, which does not make sense. All times were positive. The three-parameter Weibull distribution (with a threshold) as well as a two-parameter Weibell and log-normal distributions all fit the data reasonably well (figure 18).

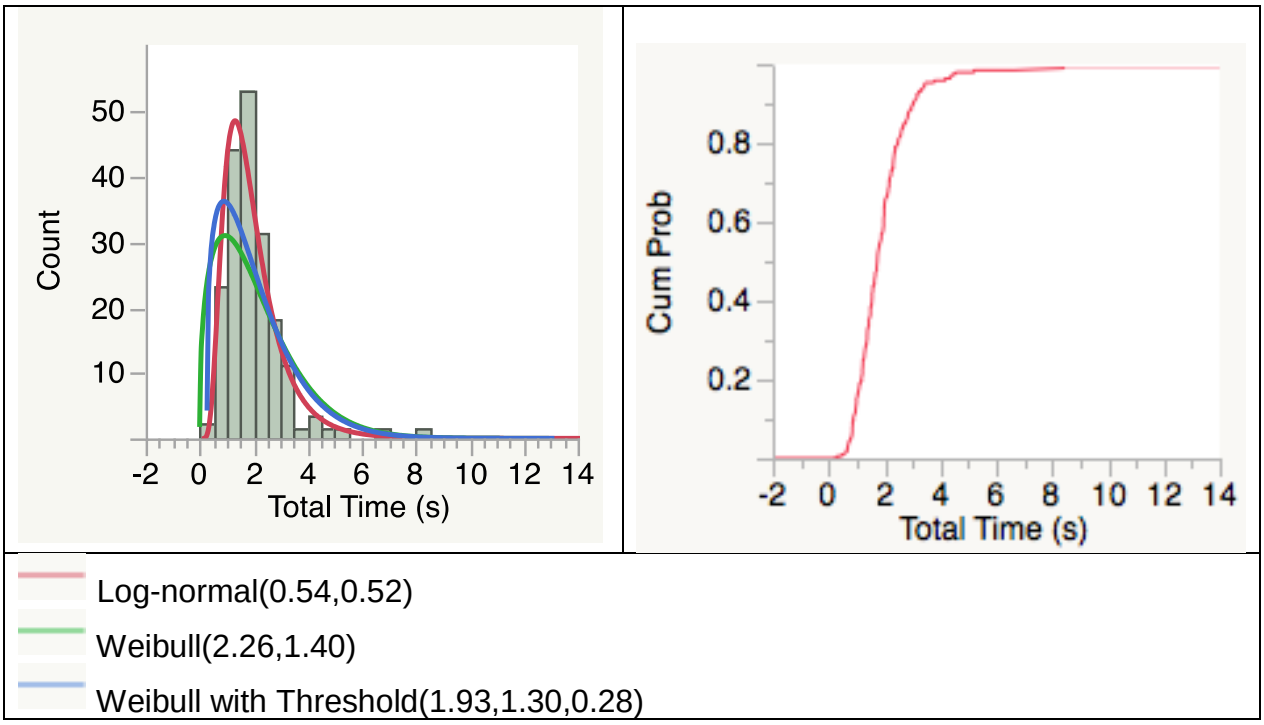

Figure 18. Frequency and Cumulative Distributions for N1

The estimated mean time for N1 is 1.44 s (2.03 * 0.71), rounded off to 1.45 s. Because the number keypad has fewer options than an alphabetic keypad, the time should be less than that of the alphabetic equivalent L1 (1.9 s), which it is. (According to Hick's Law, response time increase in proportion to the log of the number of equally likely choices.) The N1 time in J2365 is 0.9 s, but that time does not include any mental activity, which for number-pad entry should be brief.

N2

The L2 element occurs after the subject enters a first number in a sequence of numbers, such as a phone number. There were 1,470 occurrences of this element with a mean of 0.98 s. There was a large number of occcurrences because 6 of the 40 trials involved 10-digit phone entry. There were a few negative entries that did not make sense, but not too many excessively large values. The lack of large values was primarily due to number entry being a highly practiced and simple task. Consistent with the distributions for other elements, the N2 distribution was well fit the the normal distribution and the Weibull distribution with a threshold (figure 19).

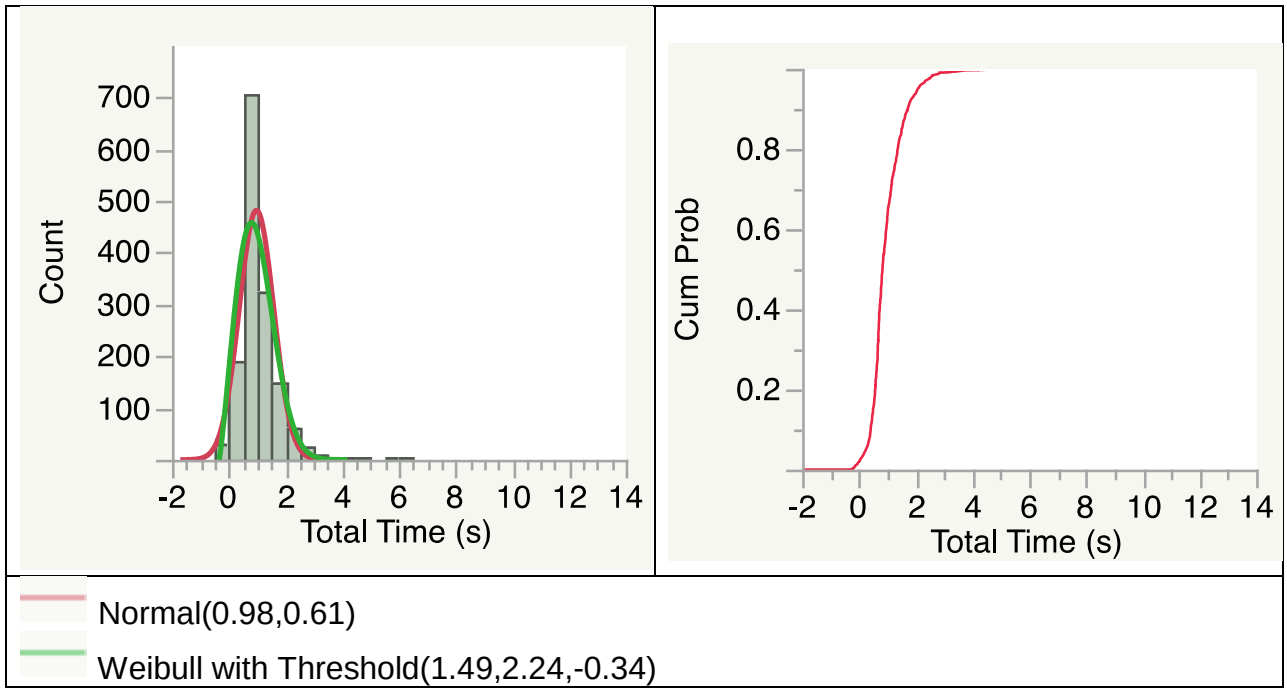

Figure 19. Frequency and Cumulative Distributions for N2

The J2365 estimated time for younger drivers is 0.70 s (1.0 x 0.71). That time is comparable to typing complex codes in the Keystroke-Level Model. As a reference, the time for typing random letters is about 0.5 s. Again, the difference is typing versus single-finger entry in a nonoptimal body posture. The time for N2 is 0.7 s less than N1, essentially the time for mental activity associated with number entry.

SL1

This element occurs when a new screen appears and the first action is to move a slider key to scroll the screen. This element is different from drag, where the movement distance is much larger and the movement is less practiced. There were 281 instances of this element with a mean time of 7.07 s. There were a few negative values and a few large values that are difficult to explain (include one movement of 38.8 s). Some of those long times were associated with determining how to use the slider or with moving it multiple times without release. Both the Weibull distribution with a threshold and the normal distribution fit the data, but, as shown in figure 20, which parts of the distribution the fit best varied. This may reflect the influence of a few excessively large element times.

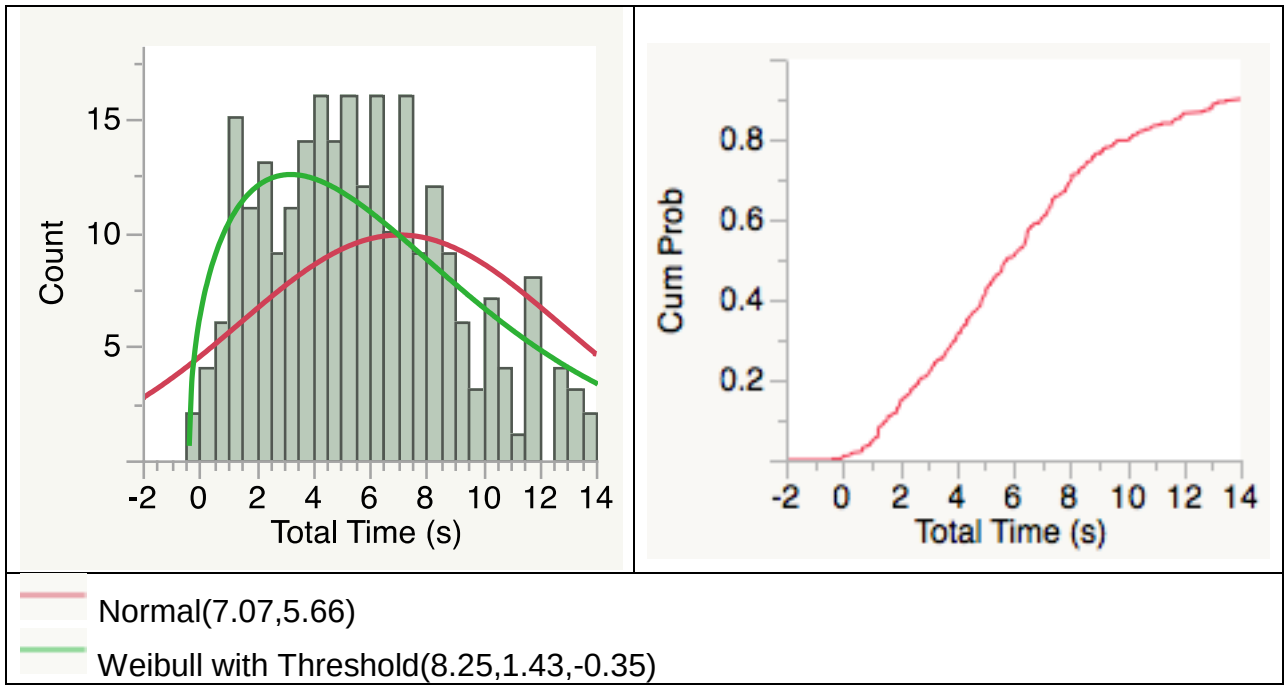

Figure 20. Frequency and Cumulative Distributions for SL1

The estimated time for this element is 5.01 s (7.1 * 0.71), rounded down to 5.00 s, the largest value of those in the new data set. This element shares with C1 (2.7) the decision to scroll and the move to the target. However, SL1 has a decision about how far to drag the cursor (a mental operation, call it 1.5 s) and the equivalent of a mouse action (p=1.1 s), for a total of 2.6 s. In fact, SL2 is 2.3 s greater than C1, suggesting the time estimated is reasonable.

SL2

This element is a slider movement that occurs after a slider movement to scroll the screen has occurred. The mean time was 3.49 s for 388 occurrences. As with SL1, there were some negative values and a few rather large values, including one trial for which the time was 31.0 s. Consistent with the SL1 data, the Weibull with threshold and normal distributions fit the data (figure 21), with the Weibull providing a much better fit, at least visually. Again, the normal distribution may be trying to fit the large values that are suspicious.

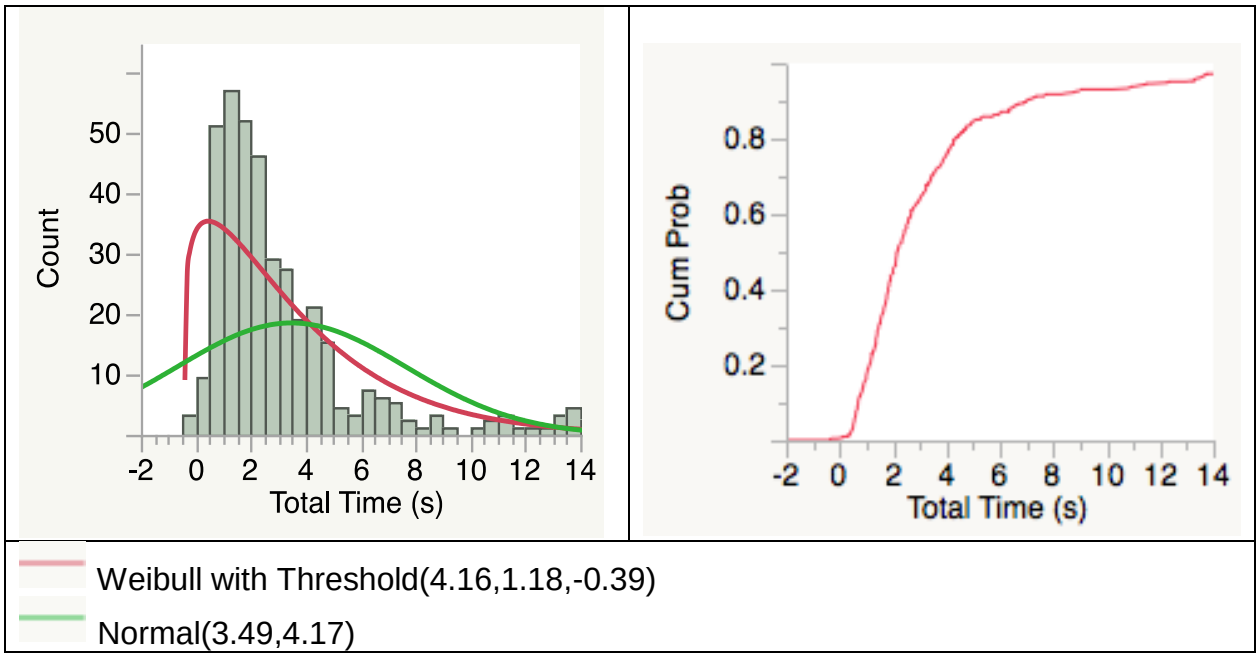

Figure 21. Frequency and Cumulative Distributions for SL2

The estimated time for a slider action is 2.48 s (3.49 * 0.71), rounded up to 2.50 s. This time is more than triple that of the C2 element (0.8 s), which makes sense because slider actions require feedback (which takes time) and mental processing (1.35 s or 1.5 s) of that feedback to make a next decision. Thus, one would expect SL2 to exceed C2 by at least 1.5 s. The difference, in fact, is 1.7 s, which is quite reasonable.

How can the correct number of arrow and slider elements be determined?

In the previously conducted experiment, subjects did not complete the expected number of arrow-button and slider elements. Sometimes they overshot and then needed to reverse course. In a few instances, they may have thought they overshot, reversed direction, and then reversed again. One could examine how that occurred and develop some complex rules to determine how many cursor and slider elements are needed.

In the J2365 calculations in the appendix, it was assumed that subjects made no mistakes. For cursor actions, they utilized the exact minimum number for button presses to reach the destination. For slider actions, exactly one action per screen was assumed to be needed. As was just noted, perfection did not occur. The approach taken here is the simple one, given resource constraints. It is assumed that one can count the actual number of cursor and slider actions that occurred, and comparing that number with the minimum number required, compute an overhead, which is the ratio of those two counts.

Table 12 shows (1) the total (actual) number of cursor elements that occurred for all subjects and trials regardless of whether or not it was needed, (2) the mean number of C2 (cursor) elements

per subject, (3) the predicted number of C2 elements using the new J2365 element scheme, and (4) the actual number per subject divided by the predicted number with the divide by zero cases (no predicted occurrences) removed. Where there were no predicted occurrences, the last column is blank. Note that for several tasks, subjects completed elements not required by the J2365 analysis. The table does not indicate the emergence of any simple rule to estimate the actual number of C2 elements. For small numbers of C2 elements (up to about six), the actual number is within a few button presses of the predicted number. However, when a large number of button presses is predicted (17, 33, and 34), the actual number is about one-third of that number, suggesting that subjects did not perform the task in the desired manner. Also note that there were many instances where C2 elements occurred where they were not predicted to occur. Further investigation of where, when, and why C2 elements occurred is beyond the scope of this project.

Table 12. Actual vs. Predicted Number of C2

Block & Trial	Description	Actual Total for 24 subjects	Actual /24 (per Subject)	Predicted per Subject per Task	Actual/24/ Predict, Divide by 0 Removed
b1t1	find the nearest gas station with "Diesel	5	0.2	0	
b1t2	in "recent calls" list, call "Neil Strickland"	190	7.9	3	2.64
b1t3	in "Rear Entertain…" select channel "119	184	7.7	17	0.45
b1t4	in "phonebook": find and call "Tammy Graham	0	0.0	0	
b1t5	find and play song "Mississippi Kid"	1	0.0	0	
b1t6	dial and call "248-359-1760"	0	0.0	0	
b1t7	find and listen to 11th message	6	0.3	1	0.25
b1t8	change airflow to face	0	0.0	0	
b1t9	change front left audio balance	0	0.0	0	
b1t10	Set clock to 11:59	286	11.9	34	0.35
b2t1	For artist Aerotrio" play song "Mega…"	101	4.2	0	
b2t2	dial and call "734-928-5501"	0	0.0	0	
b2t3	in "Rear Entertain…" select channel "40"	139	5.8	6	0.97

b2t4	find 5th message (from Bob Fedder)	32	1.3	0	
b2t5	adjust audio bass to "+3"	137	5.7	2	2.85
b2t6	change driver temp to 78 F	78	3.3	2	1.63
b2t7	In "recent calls" list call "Lorna Donlon"	60	2.5	0	
b2t8	dial and call "313-464-9979"	0	0.0	0	
b2t9	"tune" to AM 1530, save to Preset #11	16	0.7	0	
b2t10	set "Pass." "Heated Seat" to "LO"	0	0.0	1	0.00
b3t1	set "Pass." "Vented Seat" to "HI"	0	0.0	0	
b3t2	tune to AM 1570, save to Preset #2	1	0.0	0	
b3t3	"dial" and call "313-646-7797",	0	0.0	0	
b3t4	in "recent calls", find and call "Kevin Bishop"	0	0.0	0	
b3t5	adjust "Passenger" temp to 74 F	2	0.1	0	
b3t6	adjust audio equalizer to -5	135	5.6	4	1.41
b3t7	find and view "3rd" message from "Don Knotts"	0	0.0	0	
b3t8	in "Rear Entertain…" select channel "60"	0	0.0	0	
b3t9	"dial" and call "734-382-5503"	0	0.0	0	
b3t10	for artist "Barenaked Ladies" find and play song "If I had 1,000,000 Dollars"	2	0.1	0	
b4t1	set clock to 1:02	263	11.0	33	0.33
b4t2	drag audio balance to right rear	0	0.0	0	
b4t3	change air flow to feet	0	0.0	0	
b4t4	find and listen to "9th" message from "Lin Ford"	0	0.0	0	

b4t5	"dial" and call "248-157-3940"	0	0.0	0	
b4t6	find and play song "The Needle and …	0	0.0	0	
b4t7	in phonebook find and call "James Hardy"	0	0.0	0	
b4t8	In "Rear Entertainment" select channel "33"	0	0.0	0	
b4t9	in "recent calls" list find and call "Jenny Baxter"	1	0.0	0	
b4t10	find the nearest gas station with "Regular"	0	0.0	0	
Total		1639	68.3	103	0.66

Table 13 shows a similar analysis for the second slider element. Notice that there were a few tasks in which SL2 elements were not predicted to occur but they did (e.g., b3t4 and b3t5). In cases where they were expected to occur (b3t8 and b3t10), they occurred less often than expected. In fact, for these elements subjects attempted to complete that task in two or slightly more than two elements, not a much larger number. Again, evaluation of this element in greater detail is beyond the scope of this project.

Table 13. Actual vs. Predicted Number of SL2

Block & Trial	Description	Actual Total for 24 Subjects	Actual /24 (per Subject)	Predicted per Subject per Task	Actual/24/ Predict, Divide by 0 Removed
b1t1	find the nearest gas station with "Diesel	0	0.0	0	
b1t2	in "recent calls" list, call "Neil Strickland"	0	0.0	0	
b1t3	in "Rear Entertain…" select channel "119	0	0.0	0	
b1t4	in "phonebook": find and call "Tammy Graham	0	0.0	0	
b1t5	find and play song "Mississippi Kid"	0	0.0	0	
b1t6	dial and call "248-359-1760"	0	0.0	0	

b1t7	find and listen to 11th message	0	0.0	0	
b1t8	change airflow to face	0	0.0	0	
b1t9	change front left audio balance	0	0.0	0	
b1t10	Set clock to 11:59	0	0.0	0	
b2t1	For artist Aerotrio" play song "Mega…"	0	0.0	0	
b2t2	dial and call "734-928-5501"	0	0.0	0	
b2t3	in "Rear Entertain…" select channel "40"	0	0.0	0	
b2t4	find 5th message (from Bob Fedder)	0	0.0	0	
b2t5	adjust audio bass to "+3"	0	0.0	0	
b2t6	change driver temp to 78 F	0	0.0	0	
b2t7	In "recent calls" list call "Lorna Donlon"	0	0.0	0	
b2t8	dial and call "313-464-9979"	0	0.0	0	
b2t9	"tune" to AM 1530, save to Preset #11	0	0.0	0	
b2t10	set "Pass." "Heated Seat" to "LO"	0	0.0	0	
b3t1	set "Pass." "Vented Seat" to "HI"	0	0.0	0	
b3t2	tune to AM 1570, save to Preset #2	4	0.2	0	
b3t3	"dial" and call "313-646-7797",	0	0.0	0	
b3t4	in "recent calls", find and call "Kevin Bishop"	66	2.8	0	
b3t5	adjust "Passenger" temp to 74 F	61	2.5	0	
b3t6	adjust audio equalizer to -5	0	0.0	0	
b3t7	find and view "3rd" message from "Don Knotts"	27	1.1	0	
b3t8	in "Rear Entertain…" select channel "60"	54	2.3	10	0.23

b3t9	“dial” and call “734-382-5503”	0	0.0	0	
b3t10	for artist “Barenaked Ladies” find and play song “If I had 1,000,000 Dollars”	47	2.0	3	0.65
b4t1	set clock to 1:02	0	0.0	0	
b4t2	drag audio balance to right rear	0	0.0	0	
b4t3	change air flow to feet	0	0.0	0	
b4t4	find and listen to “9th” message from “Lin Ford”	0	0.0	0	
b4t5	“dial” and call “248-157-3940”	0	0.0	0	
b4t6	find and play song “The Needle and …	2	0.1	0	
b4t7	in phonebook find and call “James Hardy”	1	0.0	0	
b4t8	in “Rear Entertainment” select channel “33”	45	1.9	0	
b4t9	in “recent calls” list find and call “Jenny Baxter”	68	2.8	0	
b4t10	find the nearest gas station with “Regular”	13	0.5	0	
Total		388	16.2	13	1.24

CONCLUSIONS

What are some of the problems with J2365 and how it is applied?

SAE J2365 was developed when touch screens were not present in motor vehicles to any significant degree, so time estimates for touch-screen elements such as moving slides and dragging did not exist. Furthermore, the J2365 estimates were for physical buttons (hard keys) and there were concerns that the absence of tactile feedback for virtual buttons could increase the expected time, but to an unknown degree.

In addition, there were numerous issues with how to apply SAE J2365, for example when to insert mental elements (Ms) into a task sequence. Of the 20 trials examined in the two blocks of arrow button trials, seven used arrow buttons. Of the 20 in the two blocks in which slider tasks were included, there were only two trials that actually involved sliders. Thus, not having estimates for these elements makes applying J2365 to contemporary tasks challenging.

How can the J2365 predictions and measured time data be adjusted for age?

Using regression, predictions were developed to adjust the measured and predict times for other age groups. For SAE J2365, the older driver times (mean age =57.5) were 1.7 times those for younger drivers (mean age =24). The element times for any age are determined by multiplying the younger-driver times by an adjustment factor. That factor is:

Multiplier = 0.0209*Age + 0.4984 (J2365 age adjustment using young-subject data)

For the measured-time data, the relationship between age and task time was very linear.

Mean task time (s) = 0.1830*Age + 5.1294.

Reorganizing the data to match the J2365:

Multiplier based on age 24 = 0.0192*Age + 0.5387 (Measured-data age adjustment)

Thus, the effects of age on task time in J2365 are extremely similar to the effects of age in the measured data as indicated by their very similar slopes and intercepts. Furthermore, additional manipulation indicates that the times similar to the base values in J2365 (young drivers, age 24) can be estimated by multiplying the measured, mean, task times by 0.71.

Where do those J2356 analyses not agree with measured performance data?

The J2365 estimates do not agree with the measured times in a large number of cases. In many of the instances, there were not appropriate J2365 elements from which to develop estimates, so there was considerable extrapolation as to how times can be estimated.

What are some weaknesses of the performance data used for comparison?

The measured time data are the best available, but they are not without flaws. Careful examination of the data shows that there were some small recording errors. For example, button-hold-down times were negative. These problems were not readily apparent when the data were collected, and there really was not an opportunity to go back to the sponsor and have them ask the subcontractor who developed the interface in order to to revise it.

In many cases, subjects deviated from the requested method in completing tasks, sometimes because they made minor errors that required corrections, such as scrolling too far, or used shortcuts, such as entering only some of the characters for a name, and then selecting the name from a list. This deviation occurred when the autospeller recognized a name before the complete name was entered. The point at which subjects accepted the autospelled name varied from subject to subject, making it difficult to rely upon the same prediction as an estimate for all subjects.

Keep in mind that there are two ways these studies can be conducted. In the strict method, the subject performs the task exactly as instructed with no deviant keystrokes. This often means the task needs to be repeated several times in succession so that there will be no deviations. However, it may be that the particular sequence is done from rote memory, so the times are not representative of realistic task performance. Using a less strict method, as was employed in this study, there are minor corrections. However, to remove imperfections, a significant effort is required, beyond what was reasonable to do in this project.

What are some new elements in J2365 and what are time estimates for them?

The new time elements are shown in table 14. In contrast to elements in the current version of SAE J2365, these elements all have mental times embedded in them, making analysis easier and faster. Given the issues with this data set, addition validation is needed.

Table 14. New J2365 Elements

Code	Element Name	New J2365 Estimates (Young)
C0	cursor other – read entire screen, message from a person, when the list is in order of occurrence	2.40
C1	1st cursor action on a screen (e.g., scrolling list), list is in alpha or numeric order.	2.70
C2	>=2 cursor action on a screen, list is in alpha or numeric order.	0.80
D	drag from 1 place to another on a screen (e.g., audio balance)	3.50
F1	1st cursor action	2.00
F2	>= function key action on a screen	1.70
H	press and hold key (e.g., preset)	1.55
L1	enter 1st letter after screen change	1.90
L2	enter all letters after 1st	1.05
N1	enter 1st number after screen change	1.45
N2	enter all numbers after 1st	0.70

SL1	1st slider action after a new screen	5.00
SL2	all slider actions after the 1st	2.50

How can the estimates of the number of occurrences of cursor and sliders actions in J2365 analyses be improved?

As was shown earlier, the number of cursor actions that were predicted to occur (C2) was not reflected in the measured data. Furthermore, for slider actions, the limited data available suggest that subjects tried to complete tasks with two slider actions, not one per screen as had been postulated. However, additional analysis is required in future studies to determine how many C2 and SL2 elements actually occur when subjects complete tasks.

Overall, this report moves the analysis of driver interfaces forward, providing estimates for task elements, although admittedly based on a database that has some flaws. Given additional resources, further cleanup of the database is possible, as are improved estimates for element times. However, as is, the element times are reasonable and internally consistent as first-cut estimates.

What is needed is additional examination of the method by which tasks are completed. When do subjects go "off script"? When moving towards a target on a menu using arrow keys, how often do subjects overshoot and by how much? What is the process by which subjects use sliders to select a target in a menu? This research represents a big step in the desired direction, but there is much more to do.

Collecting experimental data on every driver-interface task to assess distraction often occurs too late in the design cycle, and when performed properly, is expensive and delays product release. More focus is needed on calculation approaches, such as this one, that are consistent with engineering practice and better understood by engineers than human-subject trials.

REFERENCES

Card, S. K., Moran, T. P., & Newell, A. (1980). The Keystroke-Level Model for User Performance Time with Interactive Systems. *Communications of the ACM, 23*(7), 396-410.

Kang, T.-P., Lin, B. T.-W., Green, P., Pettinato, S., & Best, A. (2013). *Usability of a Prototype Generation 4 Hyundai-Kia Navigation-Radio: Evidence from an Occlusion Experiment, and SAE J2365 and Pettitt's Method Calculations* (technical report UMTRI-2013-11). Ann Arbor, MI: University of Michigan Transportation Research Institute.

Lin, B.T-W., Green, P., Kang, T-P., Mize, A., Best, A., and Su, K. (2012). *Touch Screen Menu Selection Time, SAE J2365 Predictions of Them, and Driver Preferences for Selection Methods* (technical report UMTRI-2012-9), Ann Arbor, MI: University of Michigan Transportation Research Institute.

Manes, D., Green, P., and Hunter, D. (1997). *Prediction of Destination Entry and Retrieval Times Using Keystroke-Level Models* (technical report UMTRI-96-37). Ann Arbor, MI: University of Michigan Transportation Research Institute. (Also released as EECS-ITS LAB FT97-077).

Matias, A.C. (2001). Work measurement: Principles and echniques, (chapter 54) in Salvendy, G. (ed) (2001). *Handbook of Industrial Engineering* (3rd ed.), New York, NY: Wiley.

Pettitt, M. A. (2008). *Visual Demand Evaluation Methods for In-Vehicle Interfaces* (doctoral dissertation). Nottingham, UK: University of Nottingham.

Pettitt, M.A., Burnett, G.E., and Stevens, A. (2007). An Extended Keystroke Level Model (KLM) for Predicting the Visual demand of In-Vehicle Information Systems. *Proceedings of ACM conference on Computer-Human-Interaction (CHI),* San Jose, California, Association for Computing Machinery.

Society of Automotive Engineers (2004). *Navigation and Route Guidance Function Accessibility While Driving* (SAE Recommended Practice J2364). Warrendale, PA: SAE International.

Steinfeld, A., Manes, D., Green, P., and Hunter, D. (1996). *Destination Entry and Retrieval with the Ali-Scout Navigation System* (technical report UMTRI-96-30). Ann Arbor, MI: University of Michigan Transportation Research Institute.

U.S. Department of Transportation (2013a). *Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices*. Retrieved from http://www.nhtsa.gov/staticfiles/nti/distracted_driving/pdf/distracted_guidelines-FR_04232013.pdf.

U.S. Department of Transportation (2013b). *What Is Distracted Driving? Key Facts and Statistic*s. http://www.distraction.gov/content/get-the-facts/facts-and-statistics.html

APPENDIX A – PRACTICE TRIALS

#	Description	Training Goals – Learn to
1	"Radio" "tune" to AM 950, and using "browse" and arrow keys save it to Preset #10	• use the number pad to enter data • use arrow keys to scroll up and down • find a number in an ordered short list using the arrow keys
2	"Player" "browse" for artist "Celine Dion" using "Search", and play song "When I Fall In Love"	• find an artist using the "Search" function • use the qwerty keyboard to enter data • select an item in a list
3	"Player" "browse" "Songs", and using the sliders play song "Me And I"	• use the slide to find an entry in an alphabetically ordered long list • select an item in a list
4	"Player" "browse" "Songs", and using "search" play song "I Feel You"	• find a song using the "Search" function • use the qwerty keyboard to enter data • select an item in a list
5	"Player" In "audio" settings adjust the "Equalizer": Using +/- buttons set "Treb" to "+8"	• use "Buttons" to change state (e.g., Volume)
6	"Player" In "audio" settings drag audio balance icon to the "Left-Rear Seat"	• use the click, hold, and drag to change a setting
7	"Controls" Set the "Passenger" "Vented Seat" to "LO"	• use "Toggles" to change a setting
8	"Climate" Adjust the climate for "Driver" and "Passenger": Using sliders set to 78 F	• use a "Slider" to change a value (temperature)
9	"Phone" "Dial" your home number, "Call", and "End" call.	• use the number pad to enter data • make a phone call
10	"Phone" In "phonebook": Using "ABC" search find "Allan Little"	• use "Search" function to find a contact • use the alphabetic ordered keyboard to enter data
11	"Phone" In "recent calls" list: Using sliders find "Greg Wood"	• use a slider to find an entry in a long and random ordered list
12	"Phone" In "messaging": Using arrow keys find message from "June Roth", and "Listen" to message	• use arrow keys to browse a short and randomly ordered list
13	"More" In "Travel Link" find the gas station with the cheapest "Diesel" fuel	• use buttons to change status (sort options)

#	Description	Training Goals – Learn to
14	"More" In "Rear Entertainment" turn "power" on, "browse" for channel, and using the sliders select channel "128"	• use a slider to browse in a long and number ordered list
15	"More" In "Settings" adjust "Clock" to 08:30	• use "Arrow keys" to change status

APPENDIX B – NEW J2365 PREDICTIONS

For clarity, the text description of the task and the task time predictions using the new J2365 elements are provided. For those not familiar with J2365 calculations, providing these text descriptions is highly recommended as they provide clarity as to what the task is and reduce the time to provide the tabular task summaries in Excel.

As a reminder, all of the analyses that follow, in contrast to the previous analyses, start with the subject selecting a function key at the bottom of the screen. However, to determine element times, when the first key was pressed was used at the start point.

Dialing - Dial and call a phone #, and then end the call.

Previous	B1T6	Dial “248-359-1760” and call	4M + 2F + N1 + E + 9N2
	B2T2	Dial “734-928-5501” and call	4M + 3F + N1 + 9N2
	B2T8	Dial “313-464-9979” and call	4M + 3F + N1 + 9N2
	B3T3	Dial “313-646-7797” and call	4M + 3F + N1 + 9N2
	B3T9	Dial “734-382-5503” and call	5M + 3F + N1 + 9N2
	B4T5	Dial “248-157-3940” and call	4M + 2F + E + N1 + 9N2
Revised	All 6	Dial 10 digit phone # and call	4M + 3F + N1 + 9 N2
New	All 6	Dial 10 digit phone # and call	3F1 + N1 + 9N2 + Rt

From the player page, press the “phone” function button on the bottom horizontal menu. The phone screen appears. The screen will say “phone ready” in the center. Next, press the “dial” function key on the second menu from the bottom. The dial screen will appear and a dial tone will be heard. On that screen, enter the 10-digit phone number 1 digit at a time. Numbers appear as they are entered. When done, press the “call” function key. The screen will change (“calling…”) and after the first ring is heard, press the “end” call function key.
Note: For dialing, because all that changes is the phone number, only one text description is provided.

Example: B3T3 - Dial “313-646-7797” and call

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": "dial" phone number "313-646-7797", "Call", and "End" call.			Young	Old	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Radio" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "dial"					
	Mental	M	1500	2550	F1
	Push "dial" button	F	1200	2040	
	Next Subgoal				

		Subtotal	2700	4590	
Subgoal 3:: Dial phone number "313-464-9979"					
	Mental	M	1500	2550	N1
	Push "3" button	N1	900	1530	
	Push "1" button	N2	450	770	N2
	Push "3" button	N2	450	770	N2
	Push "6" button	N2	450	770	N2
	Push "4" button	N2	450	770	N2
	Push "6" button	N2	450	770	N2
	Push "7" button	N2	450	770	N2
	Push "7" button	N2	450	770	N2
	Push "9" button	N2	450	770	N2
	Push "7" button	N2	450	770	N2
	Mental	M	1500	2550	
	Next Subgoal				
		Subtotal	7950	13560	
Subgoal 4:: "Call" phone number					
	Mental	M	1500	2550	F1
	Push "Call" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: "End" call					
	Wait 1 ring	Rt	1000	1000	Rt
	Mental	M	1500	2550	F1
	Push "End" call button	F	1200	2040	
	End Goal				
		Subtotal	3700	5590	
from first button press		**Total**	17050	28330	

Radio Tuning - Manually tune to a station and set it as a preset

Set	Block & Task	Task	Equation
previous	B2T9	Tune radio to AM "1530" and save to "Preset 11"	6M + 2E + 2F + N1 _2N2 +C1 + Rm
corrected			7M +5F + P +N1 + 2N2 + C1
new			5F1 + N1 + C1 + H + 2N2
previous	B3T2	Tune radio to AM "1570" and save to "Preset 2"	6M + E +3F + N1 + 2N2 +2Rn
corrected			7M + 5F + P + N1 + 2N2
new			5F1 + N1 +2N2 + H

B2T9 - Tune radio to AM "1530" and save to "Preset 11"

From the player page, press the “phone” function button on the bottom horizontal menu. The phone screen appears. The screen will say “phone ready” in the center. Next, press the “dial” function key on the second menu from the bottom. The dial screen will appear and a dial tone will be heard. On that screen, enter the 10-digit phone number 1 digit at a time. Numbers appear as they are entered. When done, press the “call” function key. The screen will change (“calling…”) and after the first ring is heard, press the “end” call function key.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Radio": "tune" to AM 1530, and using "browse" save it to Preset #11.			Young	Old	
Subgoal 1:: Select "Radio"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Radio" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "AM"		0	0	0	
	Mental	M	1500	2550	F1
	Push "AM" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "tune"					
	Mental	M	1500	2550	F1
	Push "tune" button	F	1200	2040	

	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Enter radio frequency 1530					
	Mental	M	1500	2550	N1
	Push "1" button	N1	900	1530	N2
	Push "5" button	N2	450	770	N2
	Push "3" button	N2	450	770	N2
	Mental - realize "0" was autofilled	M	1500	2550	
	Push "GO" button	F	1200	2040	F1
	Next Subgoal				
		Subtotal	6000	10210	
Subgoal 5:: Select "browse"					
	Mental	M	1500	2550	F1
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 6:: Save to Preset #11					
	Mental	M	1500	2550	C1
	Push "down arrow" button	C1	800	1360	
	Mental	M	1500	2550	
	Push and hold "Preset 11" button	Rm	1500	1500	H
	End Goal				
		Subtotal	5300	7960	
from first button press		**Total**	19400	31940	

Possible rule: If an autofill occurs and the subject responds to it, add in an M.

B3T2 - Tune radio to AM "1570" and save to "Preset 2"

Note: Because the radio tuning tasks are so similar, a text description is only provided for the first task.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Radio": "tune" to AM 1570, and using "browse" save it to Preset #2.			**Young**	**Old**	
Subgoal 1:: Select "Radio"					
	Mental	M	1500	2550	

	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Radio" button	E	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "AM"		0	0	0	
	Mental	M	1500	2550	F1
	Push "AM" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "tune"					
	Mental	M	1500	2550	F1
	Push "tune" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Enter radio frequency 1570					
	Mental	M	1500	2550	N1
	Push "1" button	N1	900	1530	
	Push "5" button	N2	450	770	N2
	Push "7" button	N2	450	770	N2
	Mental - realize "0" was autofilled	M	1500	2550	F1
	Push "GO" button	F	1200	2040	
	Next Subgoal				
		Subtotal	6000	10210	
Subgoal 5:: Select "browse"					
	Mental	M	1500	2550	F1
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 6:: Save to Preset #11					
	Mental	M	1500	2550	H
	Push and hold "Preset 11" button	Rn	310	530	
		M	1500	2550	
		Rm	1500	1500	
	End Goal				
		Subtotal	4810	7130	
from first button press		**Total**	18910	31110	

Alphabetic entry

Set	Block & Task	Task	Equation
previous	B1T4	Use AZ jump call "Tammy Graham" using arrow keys	6M + 5F + L1
corrected			6M + 5F + L1
new			5F1 + L1
previous	B4T7	Use AZ jump call "James Hardy" using sliders	6M + 5F + N1
revised			6M + 5F + L1
new			5F1 + L1
previous	B1T5	Search song "Mississippi Kid" using arrow keys	4M + 3F + E + L1 + 14L2
revised			4M +4F + L1 + 14L2
new			4F1 +L1 +14L2
previous	B4T6	Search song "The Needle and the Spoon" using search	4M + 4F +L1 + 24L2
revised			4M + 4F + L1 + 24L2
new			3F1 + L1 + 24L2

B1T4 - Use AZ jump call "Tammy Graham" using arrow keys

On the bottom menu, press the "phone" button. The "phone ready" screen appears. On the second horizontal menu from the bottom, press the phonebook-function button. The phonebook appears with the names in alphabetical order. Then press the ABC function button and the alphabet keypad appears. Press T (for Tammy Graham). The alphabetic list that starts with T will appear. Tammy Graham is first on the list. Click on the bar with her name. Three phone numbers for her will appear. Find the home phone, indicated by the phone icon, and press that button function bar. The "calling Tammy Graham" screen will appear and the phone will ring. After the first ring, push the "end" button to end the call.

Although instructed to use arrow keys, they were not needed.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": In "phonebook": Using "ABC" search call "Tammy Graham" (home), and "End" call.			Young	Old	
Subgoal 1:: Select "Phone"		[redacted]			
	Mental	M	1500	2550	

	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "phonebook"					
	Mental	M	1500	2550	F1
	Push "phonebook" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "ABC" search					
	Mental	M	1500	2550	F1
	Push "ABC" search button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "T"					
	Mental	M	1500	2550	L1
	Push "T" button	L1	1000	1700	
	Next Subgoal				
		Subtotal	2500	4250	
Subgoal 5:: Find "Tammy Graham"					
	Mental	M	1500	2550	F1
	Push "Tammy Graham" Button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 6:: Call "Tammy Graham"					
	Mental	M	1500	2550	F1
	Push "Call" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 7:: "End" call					
	Wait 1 ring	Rt	1000	1000	Rt
	Mental	M	1500	2550	F1
	Push "End" call button	F	1200	2040	
	End Goal				
		Subtotal	3700	5590	
from first button press		**Total**	17000	28200	

B4T7 - Use AZ jump call “James Hardy” using sliders

On the bottom menu, press the phone button. The “phone ready” screen appears. On the second horizontal menu from the bottom, press the phonebook-function button. The phonebook appears with the names in alphabetical order. Then press the “ABC” function button and the alphabet

keypad appears. Press “J” (for James Hardy). The alphabetic list that starts with J will appear. James Hardy is first on the list. Click on the bar with his name. Three phone numbers for him will appear. Find the home phone, indicated by the phone icon, and press that button function bar. The calling James Hardy screen will appear and the phone will ring. After the first ring, push the “end” button to end the call.

Note: Although the block involves sliders, use of the AZ jump does not lead to any actual scrolling.

Goals	Tasks	Operators	Time (ms)		New
Goal:: Phone: In "phonebook": Using "ABC" search call "James Hardy" (home) and "End" call.			Young	Old	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "phonebook"					
	Mental	M	1500	2550	F1
	Push "phonebook" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "ABC" search					
	Mental	M	1500	2550	F1
	Push "ABC" search button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "J"					
	Mental	M	1500	2550	L1
	Push "J" button	N1	900	1530	
	Next Subgoal				
		Subtotal	2400	4080	
Subgoal 5:: Select "James Hardy"					
	Mental	M	1500	2550	F1
	Push "James Hardy" button	F	1200	2040	

	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 6:: Call "James Hardy"					
	Mental	M	1500	2550	F1
	Push "Call" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 7:: "End" call					
	Mental	M	1500	2550	F1
	Push "End" call button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	15900	27030	

B1T5 - Search song "Mississippi Kid" using arrow keys

Start in the player. On the second horizontal menu from the bottom, press the "browse" function button. After the screen changes, if the songs button has not been selected, press the "songs" function key. After the screen changes to the alphabetic list of songs, press the "search" function button above the list. A QWERTY keyboard will appear. Type in the name "Mississippi Kid" with a space. It handles capitalization automatically. When there is a match, press the "Mississippi" function bar.

Note: This analysis assumes the subject enters the entire name. However, it was often the case that it did not occur. For example, subject 1 entered only "Missi." Given the inconsistency in how it was executed, comparing this estimate with the measured time is not appropriate.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Player": "browse" "Songs", and using "Search" play song "Mississippi Kid".			**Young**	**Old**	
Subgoal 1:: Select "browse"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Songs"					
	Mental	M	1500	2550	F1

	Push "Songs" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "Search"					
	Mental	M	1500	2550	F1
	Push "Search" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Enter "Mississippi Kid"					
	Mental	M	1500	2550	L1
	Push "M" button	L1	1000	1700	L2
	Push "i" button	L2	500	850	L2
	Push "s" button	L2	500	850	L2
	Push "s" button	L2	500	850	L2
	Push "i" button	L2	500	850	L2
	Push "s" button	L2	500	850	L2
	Push "s" button	L2	500	850	L2
	Push "i" button	L2	500	850	L2
	Push "p" button	L2	500	850	L2
	Push "p" button	L2	500	850	L2
	Push "i" button	L2	500	850	L2
	Push "space" button	L2	500	850	L2
	Push "K" button	L2	500	850	L2
	Push "i" button	L2	500	850	L2
	Push "d" button	L2	500	850	L2
	Mental	M	1500	2550	F1
	Push "OK" button	F	1200	2040	
	Next Subgoal				
		Subtotal	12200	20740	
Subgoal 5:: Select "Mississippi Kid"					
	Mental	M	1500	2550	F1
	Push "Mississippi Kid" button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	20300	34510	

B4T6 - Search song “The Needle and the Spoon” using search

Goals	Tasks	Operators	Time (ms)		New

Goal:: Player: "browse" "Songs", and using "Search" play song "The Needle and the Spoon".			Young	Old	
Subgoal 1:: Select "browse"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Songs"					
	Mental	M	1500	2550	F1
	Press "Songs" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "Search"					
	Mental	M	1500	2550	F1
	Press "Search" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Enter "The Needle and the Spoon"					
	Mental	M	1500	2550	L1
	Press "T" button	L1	1000	1700	
	Press "h" button	L2	500	850	L2
	Press "e" button	L2	500	850	L2
	Press "Space" button	L2	500	850	L2
	Press "N"	L2	500	850	L2
	Press "e" button	L2	500	850	L2
	Press "e" button	L2	500	850	L2
	Press "d" button	L2	500	850	L2
	Press "l" button	L2	500	850	L2
	Press "e" button	L2	500	850	L2
	Press "Space" button	L2	500	850	L2
	Press "a" button	L2	500	850	L2
	Press "n" button	L2	500	850	L2
	Press "d" button	L2	500	850	L2
	Press "Space" button	L2	500	850	L2
	Press "t" button	L2	500	850	L2
	Press "h" button	L2	500	850	L2
	Press "e" button	L2	500	850	L2
	Press "Space" button	L2	500	850	L2

	Press "S" button	L2	500	850	L2
	Press "p" button	L2	500	850	L2
	Press "o" button	L2	500	850	L2
	Press "o" button	L2	500	850	L2
	Press "n" button	L2	500	850	L2
	Press "OK" button	F	1200	2040	F2*
	Next Subgoal				
		Subtotal	15200	25840	
Subgoal 5:: Select "The Needle and the Spoon"					
	Mental	M	1500	2550	F1
	Press "The Needle and the Spoon"	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	23300	39610	
* could be F1 or F2 (same page)					

The limitations to using the data from this task are the same as the prior task.

Search Long Song List

Set	Block & Task	Task	Equation
previous	B1T3	Browse channel “119” using arrow keys	5M +4F + C1 + 17C2 + S
revised			6M + 5F + C1 + 17C2
new			5F1 + C1 + 17C2
previous	B4T8	Browse channel “33” using sliders	5M + 3F + E + 6Rn
revised			6M + 5F + 6Rn
new			5F1 + SL1 + 5SL2
previous	B2T3	Browse channel “40” with arrow keys	5M + 4F + C1 + 6C2
revised			6M + 5F + C1 + 6C2
new			5F1 + C1 + 6SC2
previous	B3T8	Browse channel “60” using sliders	5M + 3F + 11Rn
revised			5M + 4F + 11Rn
new			4F1 + SL1 + 10 SL2

B1T3 – Browse channel “119” using arrow keys

From the home screen, press the “more” function key in the bottom menu. Of the six buttons on the next screen, press the “rear-entertainment” function key (top middle). The screen will say “rear passenger entertainment off.” Press the “power” function key above it to turn it on, and then at the lower left, press the browse-function button. A list of channels in numerical order appears. Press the down arrow to scroll through the list until 119 appears. Each scroll key press changes the screen. There are five channels listed per screen. Given that this is an ordered list, scrolling is fast. When at 119, press the 119 function bar.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "More": In "Rear Entertainment" turn "power" on, "browse" for channel, and using the arrow keys select channel "119".			**Young**	**Old**	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	

	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Rear Entertainment"					
	Mental	M	1500	2550	F1
	Push "Rear Entertainment" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Turn "power" on					
	Mental	M	1500	2550	F1
	Push "power" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "browse"					
	Mental	M	1500	2550	F1
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: Find channel "119"					
	Mental	M	1500	2550	C1
	Push "downarrow" button	C1	800	1360	
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Mental	M	1500	2550	F1**
	Search	S*	2300	3910	
	Push channel "119" button	F	1200	2040	
		Subtotal	14100	23970	
from first button press		**Total**	22200	37740	
*S is not used in new equations					
**consider F2 as well, same screen					

B4T8 - Browse channel “33” using sliders

From the home screen, press the “more” function key in the bottom menu. Of the six buttons on the next screen, press the “rear-entertainment function” key (top middle). The screen will say “rear passenger entertainment off.” Press the “power” function key above it to turn it on, and then at the lower left, press the browse function button. A list of channels in numerical order appears. Drag the marker to scroll through the list until 33 appears. Each drag movement changes the screen. There are five channels listed per screen. Given that this is an ordered list, scrolling is fast. When at 33, press the 33 function bar.

Goals	Tasks	Operators	Time (ms)		New
Goal:: More: In Rear Entertainment turn power on, browse for channel, and using the sliders select channel "33".			Young	Old	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Rear Entertainment"					
	Mental	M	1500	2550	F1
	Push "Rear Entertainment" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Turn "power" on					
	Mental	M	1500	2550	F1
	Push "power" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "browse"					
	Mental	M	1500	2550	F1
	Push "browse" button	F	1200	2040	
	Next Subgoal				

		Subtotal	2700	4590	
Subgoal 5:: Find channel "33"					
	Mental	M	1500	2550	SL1
	Reach	Rn	310	530	SL2
	Reach	Rn	310	530	SL2
	Reach	Rn	310	530	SL2
	Reach	Rn	310	530	SL2
	Reach	Rn	310	530	SL2
	Reach	Rn	310	530	SL2
	Mental	M	1500	2550	F1
	Push "33"	F	1200	2040	
	End Goal				
		Subtotal	4860	8280	
from first button press		**Total**	12960	22050	

Rule of thumb: Each reach element corresponds to moving one page to get to the target.

B2T3 - Browse channel “40” with arrow keys

From the player screen, press the “more” function key on the bottom horizontal menu, and after the screen changes, then press the “rear entertainment” button in the middle (1 of 6). There screen changes to show that the rear entertainment is off. Next press the “power” button near the top of the screen. The screen then changes to show the song being played. Next press the “browse” button on the second horizontal menu from the bottom. A list of channels then appears in ascending numerical order, of which five are shown. Repeatedly press the down arrow button until channel 40 is on the screen. Next, push the channel 40 button.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "More": In "Rear Entertainment" turn "power" on, "browse" for channels, and using the arrow keys select channel "40".			**Young**	**Old**	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	

Subgoal 2:: Select "Rear Entertainment"					
	Mental	M	1500	2550	F1
	Push "Rear Entertainment" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Turn "power" on					
	Mental	M	1500	2550	F1
	Push "power" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "browse"					
	Mental	M	1500	2550	F1
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: Find channel "40"					
	Mental	M	1500	2550	C1
	Push "downarrow" button	C1	800	1360	
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Push "downarrow" button	C2	400	680	C2
	Mental	M	1500	2550	F1
	Push channel "40" button	F	1200	2040	
		Subtotal	7400	12580	
from first button press		**Total**	15500	26350	

Note: There was an issue with “More” button in the previous analysis

B3T8 - Browse channel “60” using sliders

From the home screen, press the “more” function key in the bottom menu. Of the 6 buttons on the next screen, press the rear entertainment function key (top middle). The screen will say “rear passenger entertainment off.” Press the “power” function key above it to turn it on, and then at the lower left, press the browse function button. A list of channels in numerical order appears. Press the down arrow to scroll through the list until 60 appears. Each scroll key press changes

the screen. There are five channels listed per screen. Given this is an ordered list, scrolling is fast. When at 60, press the 60 function bar.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "More": In "Rear Entertainment" turn "power" on, "browse for channel", and using the sliders select channel "60".			Young	Old	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Rear Entertainment"					
	Mental	M	1500	2550	F1
	Push "Rear Entertainment" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Turn "power" on					
	Mental	M	1500	2550	F1
	Push "power" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "browse"					
	Mental	M	1500	2550	F1
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: Find channel "60"					
	Mental	M	1500	2550	SL1
		Rn	310	530	
		Rn	310	530	SL2
		Rn	310	530	SL2
		Rn	310	530	SL2
		Rn	310	530	SL2
		Rn	310	530	SL2
		Rn	310	530	SL2

		Rn	310	530	SL2
		Rn	310	530	SL2
		Rn	310	530	SL2
		Rn	310	530	SL2
		M	1500	2550	F1
	Push channel "60" button	F	1200	2040	
	End Goal				
		Subtotal	6410	10930	
from first button press		**Total**	14510	24700	

Rule of thumb: Each reach element corresponds to moving 1 page to get to the target.

Search Short Numeric List

Set	Block & Task	Task	Equation
previous	B1T7	Listen 11th message from "Beatrice Adams" using arrow keys	3M + 2F
corrected			4M + 3F + C1 + C2
new			3F1 + C1 + C2
previous	B4T4	Listen 9th message from "Lin Ford" using sliders	3M + 2F
corrected			3M + 2F
new			4M + 3F + C1
previous	B2T4	View 5th message from "Bob Fedder" using arrow keys	4M + 3F +?
corrected			4M + 3F + C1
new			3F1 + C1
previous	B3T7	View 3rd message from "Don Knotts" using sliders	3M + 2F + Rn
corrected			4M + 2F + C1
new			3F1 + SL1

B1T7 - Listen 11th message from "Beatrice Adams" using arrow keys

On the bottom menu, select "phone." After the screen changes, press the "messaging" function key on the second horizontal menu from the bottom. The list of messages then appears in reverse chronological order, with a number of the left side. Find message 11 then scan to the right, find the "listen" function button and press it.

Note: Although this was intended to be an arrow key task, the arrow buttons were not used.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": In "messaging", find "11th" message from "Beatrice Adams", and "Listen" to message.			Young	Old	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "messaging"					
	Mental	M	1500	2550	F1

	Push "messaging" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "11th" message from "Beatrice Adams"					
	Mental	M	1500	2550	C1
	Push arrowdown for next screen	C1	800	1360	
	Push arrowdown for next screen	C2	400	1380	C2
	Next Subgoal				
		Subtotal	2700	5290	
Subgoal 4:: Select "Listen"					
	Mental	M	1500	2550	F1
	Push "Listen" button	F	1200	2040	
		Subtotal	2700	4590	
from first button press		**Total**	8100	14470	

Note: In the original analysis, the down arrow tasks were missing.

B4T4 - Listen 9th message from "Lin Ford" using sliders

On the bottom menu, select "phone." After the screen changes, press the "messaging" function key on the second horizontal menu from the bottom. The list of messages then appears in reverse chronological order, with a number of the left side. Find message 9th then scan to the right, find the listen function button and press it. It is on the second screen.

Goals	Tasks	Operators	Time (ms)		New
Goal:: Phone: In "messaging" find "9th" message from "Lin Ford", and "Listen" to message.			**Young**	**Old**	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	

Subgoal 2:: Select "messaging"					
	Mental	M	1500	2550	F1
	Push "messaging" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "9th" message from "Lin Ford"					
	Mental	M	1500	2550	SL1
	Reach	Rn	310	530	
	Next Subgoal				
		Subtotal	1810	3080	
Subgoal 4:: Select "Listen"					
	Mental	M	1500	2550	F1
	Push "Listen" button	F	1200	2040	
		Subtotal	2700	4590	
from first button press		**Total**	7210	12260	

Note: Move slider (reach) was missing in the original analysis. As the message was on the first page, a slider action was not needed to get to the target.

B2T4 - View 5th message from "Bob Fedder" using arrow keys

From the player screen, press the "phone" button on the bottom menu. After the screen changes to the phone ready screen, press the "messaging" button on the second row from the bottom. A message list will appear in order from most to least recent. The most recent message is #7. As the message is on screen, the subject can just click on the "view" button for that message. They did not scroll. After the "view" button is pressed, the message appears.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": In "messaging", find "5th" message from "Bob Fedder", and "View" message.			**Young**	**Old**	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	

	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "messaging"					
	Mental	M	1500	2550	F1
	Push "messaging" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "5th" message from "Bob Fedder"					
	Mental	M	1500	2550	
	Push "downarrow" button	C1	800	1360	
	Mental	M	1500	2550	
	Next Subgoal				
		Subtotal	3800	6460	
Subgoal 4:: Select "Listen"					
	Mental	M	1500	2550	F1
	Push "View" button	F	1200	2040	
		Subtotal	2700	4590	
from first button press		**Total**	9200	15640	

Note: The 5th message appears on the first screen, so subgoal 3 is not needed.
However, there may be need for an additional mental operation to find that message.
Also, select phone was not in the original analysis.

B3T7 - View 3rd message from "Don Knotts" using sliders

From the player screen, press the "phone" button on the bottom menu. After the screen changes (to phone ready), press the "messaging" button on the second horizontal menu from the bottom. Next, the list of messages appears with the most recent first. Message 3 is on the second page, so press the down arrow to get the next screen. After the screen changes, find message 3 and press the bar associated with it. After the screen changes, press view.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": In "messaging" find "3rd" message from "Don Knotts", and "View" message.			**Young**	**Old**	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	

	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "messaging"					
	Mental	M	1500	2550	F1
	Push "messaging" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "3rd" message from "Don Knotts"					
	Mental	M	1500	2550	SL1
	Reach	Rn	310	530	
	Next Subgoal				
		Subtotal	1810	3080	
Subgoal 3:: Select "View"					
	Mental	M	1500	2550	F1
	Push "View" button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	7210	12260	

Reach is the stand in for the slider element. There is one Rn as one needs to go one page down.

Select phone was not in the original analysis. There were also differences in how reach was applied.

Search random long list

Set	Block & Task	Task	Equation
previous	B1T2	Call "Neil Strickland" in recent calls using arrow keys	4M + 4F + C1 + 3C2 + 5S
corrected			5M + 4F + C1 + 3C2 + Rt
new			4F1 + C1 + C2 + Rt
previous	B4T9	Call “Jenny Baxter” in recent calls using sliders	4M + 3F + E + 5S + 4Rn
corrected			5M + 4F + 4Rn + Rt
new			4F1 + SL1 + 3SL2 + Rt
previous	B2T7	Call “Lorna Donlon” in recent calls using slider	4M + 3F + E + S+ C1
corrected			5M + 5F + S + C1 + Rt
new			6F1 + Rt
previous	B3T4	Call "Kevin Bishop" in recent calls using arrow keys	4M + 3F + S + Rn
corrected			5M + 4F + S + Rn + Rt
new			5F1 + Rt

B1T2 – Call "Neil Strickland" in recent calls using arrow keys

On the bottom menu, press the “phone” function key to get to the phone screen (the sequence may start there, not at the home screen). On the second menu from the bottom, press the “recent calls” function key. The list of the six most recent of all calls appears. Using the arrows on the right side, scroll down until "Neil Strickland" appears. He is listed at the top of the fourth screen. Each screen needs to be search to see if his name is listed. When you get to his name, click it. His phone number appears. Then press the call “function” part of the bar on the right. After the phone rings once, press the “end” call function button on the left.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": In "recent calls" list call "Neil Strickland" (home) and "End" call.			Young	Old	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "recent calls"					
	Mental	M	1500	2550	F1
	Push "recent calls" button	F	1200	2040	

	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "Neil Strickland"					
	Mental	M	1500	2550	C1
	Search	S	2300	3910	
	Push "downarrow" button	C1	800	1360	C1
	Search	S	2300	3910	
	Push "downarrow" button	C2	400	680	C1
	Search	S	2300	3910	
	Push "downarrow" button	C2	400	680	C1
	Search	S	2300	3910	
	Push "downarrow" button	C2	400	680	C1
	Search	S	2300	3910	F1
	Push "Neil Strickland" button	E	1200	2040	
		Subtotal	16200	27540	
Subgoal 4:: Call "Neil Strickland"					
	Mental	M	1500	2550	F1
	Push "Call" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: "End" call					
	Wait 1 ring	Rt	1000	1000	Rt
	Mental	M	1500	2550	F1
	Push "End" call button	F	1200	2040	
	End Goal				
		Subtotal	3700	5590	
from first button press		**Total**	25300	42310	

Wait 1 ring was added. There are multiple items worthy of discussion for subgoal 3. The first S of subgoal 3 is not needed and other Ss could be Ms. What is important is that the calls are not listed by name but in order of occurrence, so the subject must read the screen. The Strickland button is part of the bar and more like a function key than a number or letter, so it is and F. The call button could be an F or E.

B4T9 - Call “Jenny Baxter” in recent calls using sliders

On the bottom menu, press the “phone” function key to get to the phone screen (the sequence may start there, not at the home screen). On the second menu from the bottom, press the “recent calls” function key. The list of the six most recent of all calls appears. Drag the marker on the right side until "Neil Strickland" appears. He is listed at the top of the fourth screen. Each screen needs to be search to see if his name is listed. When you get to his name, click it. His phone number appears. Then press the call function part of the bar on the right. After the phone rings once, press the “end” call function button on the left.

Goals	Tasks	Operators	Time (ms)		New
Goal:: Phone: In recent calls list call "Jenny Baxter" (cell) and End call.			Young	Old	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel device (located in nter console)	Rf	450	770	
	Push "recent calls" tton	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "recent calls"					
	Mental	M	1500	2550	F1
	Push "phonebook" tton	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "Jenny Baxter"					
	Mental	M	1500	2550	SL1
	Search	S	2300	3910	
	Reach	Rn	310	530	
	Search	S	2300	3910	SL1
	Reach	Rn	310	530	
	Search	S	2300	3910	SL1
	Reach	Rn	310	530	
	Search	S	2300	3910	SL1
	Reach	Rn	310	530	
	Search	S	2300	3910	F1
	Push "Neil Strickland" tton	F	1200	2040	
		Subtotal	15440	26260	
Subgoal 4:: Call "Jenny Baxter"					
	Mental	M	1500	2550	F1
	Push "Call" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: "End" call					
	Mental	M	1500	2550	F1
	Push "End" call button	F	1200	2040	

	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	23540	40030	

The searches could be Ms and the first search may not be needed. Note that items in list are names not in alphabetic order, so search is needed.

B2T7 - Call "Lorna Donlon" in recent calls using arrow keys

From the player screen, press the "phone" button on the bottom menu. The phone read screen appears. On the second menu from the bottom, press the "phonebook" button. The screen changes. On the second horizontal menu from the bottom, press the recent calls button. The recent call list (6 calls) then appears. Search for Lorna Donlon. She is not on the first screen, so press the down arrow. She is on the second screen. Press the bar with her name. The screen changes and her phone number appears. Push the bar for her home phone number. The calling screen then appears. After the phone rings, push the "end" call button.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": In "recent calls" list call "Lorna Donlon" (home) and "End" call.			**Young**	**Old**	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "recent calls"					
	Mental	M	1500	2550	F1
	Push "phonebook" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "Lorna Donlon"					
	Mental	M	1500	2550	C1
	Push "downarrow" button	C1	800	1360	
	Search	S	2300	3910	F1
	Push "Lorna Donlon" button	F	1200	2040	

	Next Subgoal				
		Subtotal	5800	9860	
Subgoal 4:: Call "Lorna Donlon"					
	Mental	M	1500	2550	F1
	Push "Call" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: "End" call					
	Wait 1 ring	Rt	1000	1000	Rt
	Mental	M	1500	2550	F1
	Push "End" call button	F	1200	2040	
	End Goal				
		Subtotal	3700	5590	
from first button press		**Total**	14900	24630	

Note: Added wait 1 ring to previous analysis.

B3T4 - Call "Kevin Bishop" in recent calls using slider

Starting at the player screen, press the “phone” function key on the menu at the bottom of the screen. After the screen changes, press the “recent calls” button on the second horizontal menu from the bottom of the screen. The list of calls from most to least recent will then appear on the screen. Kevin Bishop is listed on the second screen. Look for him on the first screen. As he is not listed, press the down arrow, and after the screen updates, find him on the second screen. Press the bar with Kevin Bishop on it. The screen changes to show his phone numbers. Next, press the “call” button.

Note: Added wait 1 ring to previous analysis.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Phone": In "recent calls" list, call "Kevin Bishop" (cell), and "End" call.			**Young**	**Old**	
Subgoal 1:: Select "Phone"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Phone" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	

Subgoal 2:: Select "recent calls"					
	Mental	M	1500	2550	F1
	Push "recent calls" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "Kevin Bishop"					
	Mental	M	1500	2550	SL1
	Reach	Rn	310	530	
	Search	S	2300	3910	
	Next Subgoal				
		Subtotal	4110	6990	
Subgoal 4:: "Call" "Kevin Bishop"					
	Mental	M	1500	2550	F1
	Push "Call" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: "End" call					
	Wait 1 ring	Rt	1000	1000	Rt
	Mental	M	1500	2550	F1
	Push "End" call button	F	1200	2040	
	End Goal				
		Subtotal	3700	5590	
from first button press		**Total**	13210	21760	

Note: Added wait 1 ring to previous analysis.

Search alphabetic long list

Set	Block & Task	Task	Equation
previous	B2T1	Search song "Megatrombosisciclica" using arrows	6M + 4F + 2C1
corrected			7M + 5F + 2C1
new			5F1 + 2C1
previous	B3T10	Search song "If I had 1,000,000 Dollars" using sliders	5M + 3F + 4Rn
corrected			7M + 4F + Rf + C1
new			4F1 + 2C1

B2T1 - Search song "Megatrombosisciclica" using sliders-> arrows

Starting on the Player screen, press the "browse" button on the second menu from the bottom. When the browse screen appears, press the "song" button if they are ordered by artists. (They were listed by song.)

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Player": "browse" artist "Aerotrio" using arrow keys, and play song "Megatrombosisciclica".			Young	Old	
Subgoal 1:: Select "browse"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "browse" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Artists"					
	Mental	M	1500	2550	F1
	Push "Artist" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Find "Aerotrio" using arrow keys					
	Mental	M	1500	2550	C1
	Push "down arrow key" button	C1	800	1360	
	Mental	M	1500	2550	F1

	Push "Aerotrio" button	F	1200	2040	
	Next Subgoal				
		Subtotal	5000	8500	
Subgoal 4:: Select "All Songs"					
	Mental	M	1500	2550	F1
	Push "All Songs" button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
Subgoal 5:: Find "Megatrombosisciclica" using arrow keys					
	Mental	M	1500	2550	C1
	Push "down arrow key" button	C1	800	1360	
	Mental	M	1500	2550	F1
	Push "Megatrombosisciclica" button	F	1200	2040	
	End Goal				
		Subtotal	5000	8500	
from first button press		**Total**	15400	26180	

B3T10 - Search song "If I had 1,000,000 Dollars" using sliders

Starting on the Player screen, press the "browse" button on the second menu from the bottom. When the browse screen appears, touch the slide and the letter "A" appears. Drag the slider down to select go three screens to select the artist "Barenaked Ladies." (They were listed by artist.) Then press "Barenaked Ladies." The screen will change and a list of options will appear. Press the "all songs" bar. A screen will appear listing their songs. Drag the slider to go to the next screen. Press the song title "If I had 1,000,000 Dollar" on the next screen.

Goals	Tasks	Operators	Time (ms)		New
Goal:: Player: browse for artist "Barenaked Ladies" using sliders, and play song "If I had 1,000,000 Dollars.			**Young**	**Old**	
Subgoal 1:: Select "browse"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	

	Push "browse" button	F	1200	2040	
	Next Subgoal				
Subgoal 2:: Select "Barenaked Ladies"		**Subtotal**	3150	5360	
	Mental	M	1500	2550	SL1
(3 screens)	Reach	Rn	310	530	SL2
	Reach	Rn	310	530	SL2
	Reach	Rn	310	530	SL2
	Mental	M	1500	2550	F1
	Select "Barenaked Ladies"	F	1200	2040	
		Subtotal	5130	8730	
Subgoal 3:: Select "All Songs"					
	Mental	M	1500	2550	F1
	Press "All Songs" button	E	1200	2040	
	Next Subgoal				
Subgoal 4:: Find "If I had 1,000,000 Dollars" using sliders		**Subtotal**	2700	4590	
	Mental	M	1500	2550	SL1
	Reach	Rn	310	530	
	Mental	M	1500	2550	
Subgoal 5:: Select song "If I had 1,000,000 Dollars"		**Subtotal**	3310	5630	
	Mental	M	1500	2550	F1
	Press "If I had 1,000,000 Dollar"	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	13840	23540	

Note: Sliders, 1 reach near per screen. For the alphabetized list, the assumption is no Ms or Ss are needed.

Change levels using buttons

Set	Block & Task	Task	Equation
previous	B2T5	Adjust “Bass” to “+3” using +/- buttons	3M + F + C1 + 3C2
corrected			3M + 2F + C1 + 2C2
new			2F1 + C1 +2C2
previous	B3T6	Adjust “Mid” to “-5” using +/- buttons	3M + F + C1 + 4C2
corrected			3M +2F + C1 + 4C2
new			2F1 + C1 + 4C2
previous	B2T6	Adjust “Driver” climate to 78 F using arrow keys	2M + C1 + 5C2
corrected			2M + F + C1 +5C2
new			F1 + C1 + 5C2
previous	B3T5	Adjust “Passenger” climate to 74F using sliders	2M + Rn
corrected			2M + F + Rn
new			F1 + SL1

B2T5 - Adjust “Bass” to “+3” using +/- buttons

From the player screen, press the “audio” button on the second horizontal menu from the bottom. After the screen changes, press the “equalizer button in the column on the left (1 of 5 buttons). To set the base to 3 (initially at 0), press the “+” button in the bass column (1 of 3) 3 times.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Player": In "audio" settings adjust the Equalizer: Using +/- buttons set "Bass" to "+3".			Young	Old	
Subgoal 1:: Select "audio"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Audio" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Equalizer"					
	Mental	M	1500	2550	F1
	Push "Equalizer" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	

Subgoal 3:: Set "Bass" to "+3"					
	Mental	M	1500	2550	C1
	Push "+" button	C1	800	1360	
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Mental	M	1500	2550	
	End Goal				
		Subtotal	5000	8500	
from first button press		**Total**	7700	13090	

Note: Only 3 presses needed, not 4 as in the original analysis. Also, a mental element may not occur after last +.

B3T6 - Adjust "Mid" to "-5" using +/- buttons

From the player screen, press the "audio" button on the second horizontal menu from the bottom. After the screen changes, press the "equalizer button in the column on the left (1 of 5 buttons). To set the base to -5 (initially at 0), press the "-" button in the bass column (1 of 3) 5 times.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Player": In "audio" settings adjust the Equalizer: Using +/- buttons set "Mid" to "-5".			**Young**	**Old**	
Subgoal 1:: Select "audio"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "audio" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Equalizer"					
	Mental	M	1500	2550	F1
	Push "Equalizer" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Set "Mid" to "-5"					
	Mental	M	1500	2550	C1
	Push "-" button	C1	800	1360	
	Push "-" button	C2	400	680	C2

	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Mental	M	1500	2550	
	End Goal				
		Subtotal	5400	9180	
from first button press		**Total**	8100	13770	

A mental element may not occur after last +.

B2T6 - Adjust "Driver" climate to 78 F using arrow keys

From the player screen, press the "climate" button on the bottom menu. Find the sliding scale on the left side (for the driver) and press the up arrow button 6 times to raise the temperature from 72 to 78 degrees. Each button press causes the temperature to change 1 degree.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Climate": Adjust the climate for "Driver": Using arrow keys set to 78 F.			**Young**	**Old**	
Subgoal 1:: Select "Climate"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "climate" button	F	1200	2040	
	Next subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Set "Driver" climate to 78 F.					
	Mental	M	1500	2550	C1
	Push "up arrow" button	C1	800	1360	
	Push "up arrow" button	C2	400	680	C2
	Push "up arrow" button	C2	400	680	C2
	Push "up arrow" button	C2	400	680	C2
	Push "up arrow" button	C2	400	680	C2
	Push "up arrow" button	C2	400	680	C2
	Mental	M	1500	2550	
	End Goal				
		Subtotal	5800	9860	
from first button press		**Total**	5800	9860	

Note: If the mental element at the end of subgoal 2 is needed is unknown.
The final mental operator may not be needed.

B3T5 - Adjust “Passenger” climate to 74F using sliders

From the player screen, press the “climate” button on the bottom menu. Find the sliding scale on the right side (for the passenger) and drag the marker to raise the temperature to 74 degrees.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Climate": Adjust the climate for "Passenger": Using sliders to 74 F.			**Young**	**Old**	
Subgoal 1:: Select "Climate"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Climate" button	F	1200	2040	
	Next subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Set "Passenger" climate to 74 F.					
	Mental	M	1500	2550	SL1
		Rn	310	530	
		M	1500	2550	
	End Goal				
		Subtotal	3310	5630	
from first button press		**Total**	3310	5630	

Note: If the mental element at the end of subgoal 2 is needed is unknown.

Toggles

Set	Block & Task	Task	Equation
previous	B2T10	Set “Passenger” “Heated Seat” to “LO”	2M + C1 + C2
corrected			2M + F + C1 + C2
new			F1 + C1 + C2
previous	B3T1	Set “Passenger” “Vented Seat” to “HI”	2M + C1
corrected			2M + F + C1
new			F1 + C1
previous	B1T8	Set air flow for “Front Seats” to “Face”	M + F
corrected			2M + 2F
new			2F1
previous	B4T3	Set air flow for “Front Seats” to “Feet”	M + F
corrected			2M + 2F
new			2F1

B2T10 - Set “Passenger” “Heated Seat” to “LO”

Starting on the player screen, press the “controls” button on the bottom horizontal menu. The screen changes and 8 buttons appear. In the passenger column on the right, press the “heated seat” button (set at hi) twice, once to change to off and once to change to “lo.”

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Controls": Set the "Passenger" "Heated Seat" to "LO".			Young	Old	
Subgoal 1:: Select "Controls"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Controls" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Set "Passenger" "Heated Seat" to "LO"					
	Mental	M	1500	2550	F1
	Push "Passenger" "Heated Seat" button	F	1200	2040	F2

	Push "Passenger" "Heated Seat" button	F	1200	2040	
	Mental	M	1500	2550	
	End Goal				
		Subtotal	5400	9180	
from first button press		**Total**	5400	9180	

The mental confirmation at the end may not be needed. The heated seat button is a function key, not a cursor key (as was in the prior analysis).

B3T1 - Set "Passenger" "Vented Seat" to "HI"

Starting on the player screen, press the "controls" button on the bottom horizontal menu. The screen changes and 8 buttons appear. In the passenger column on the right, press the "vented seat" button (set at hi) once to change to "hi."

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Controls": Set the "Passenger" "Vented Seat" to "HI".			**Young**	**Old**	
Subgoal 1:: Select "Controls"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Controls" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Set "Passenger" "Vented Seat" to "HI"					
	Mental	M	1500	2550	F1
	Push "Passenger" "Vented Seat" button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	2700	4590	

Notes: Removed mental operator from subgoal 3 and replaced cursor with function key.

B1T8 - Set air flow for “Front Seats” to “Face”

From the player menu, press the climate function button on the bottom row menu. After the screen changes, press the button showing the graphic of airflow to the face.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Climate": Change air flow for "Front Seats" to "Face".			Young	Old	
Subgoal 1:: Select "Climate"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Climate" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Set "Front Seat" air flow to "Face"					
	Mental	M	1500	2550	F1
	Push "Front Seat" "Face" air flow button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	2700	4590	

B4T3 - Set air flow for “Front Seats” to “Feet”

From the player menu, press the climate function button on the bottom row menu. After the screen changes, press the button showing the graphic of airflow to the feet.

Goals	Tasks	Operators	Time (ms)		New
Goal:: Climate: Change air flow for "Front Seats" to "Feet".			Young	Old	
Subgoal 1:: Select "Climate"					

	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "Climate" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Set "Front Seat" air flow to "Feet"					
	Mental	M	1500	2550	F1
	Push "Front Seat" "Feet" air flow button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	2700	4590	

The first goal and methods were missing

Complex tasks

Set	Block & Task	Task	Equation
previous	B1T1	Find nearest gas station with “Diesel” fuel using arrow keys	7M + 7F
corrected			7M + 7F
new			7F1
previous	B4T10	Find nearest gas station with “regular” fuel using sliders	6M + 6F
corrected			7M + 7 F
new			7F1

B1T1 - Find nearest gas station with “Diesel” fuel using arrow keys

To begin, realizing that that the function keys on the bottom of the menu are for specific function, press the “More” key on the far right. Then after the screen changes, of the 6 function buttons in the center of the screen, press the Sirius Travel Link button on the lower left. After the screen changes again, of the 6 buttons, press the “fuel prices” function key. Next a new screen appears showing a list of fuel prices sorted by priced from least to most. On the left side is a list of functions that includes “fuel type”. Press it. From this list of fuels, select diesel. Then, from the list of functions, press “find.” Finally, the get the sorted by price, press the “distance” function button. Find the station that is closest (the top of the list) and click on it. The address will then appear on the screen

Goals	Tasks	Operators	Time (ms)		New
Goal:: "More": In "Travel Link" find the nearest gas station with "Diesel" fuel.			Young	Old	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Travel Link"					
	Mental	M	1500	2550	F1
	Push "Travel Link" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "Fuel Prices"					
	Mental	M	1500	2550	F1

	Push "Fuel Prices" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "Fuel Type"					
	Mental	M	1500	2550	F1
	Push "Fuel Type" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: Select "Diesel"					
	Mental	M	1500	2550	F1
	Push "Diesel" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 6:: Select "Find"					
	Mental	M	1500	2550	
	Push "Find" button	F	1200	2040	F1
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 7:: Select "Distance"					
	Mental	M	1500	2550	F1
	Push "Distance" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 8:: Select "Thorntons"					
	Mental	M	1500	2550	F1
	Push "Thorntons" button	F	1200	2040	
	End Goal				
		Subtotal	2700	4590	
from first button press		**Total**	18900	32130	

Note: Although categorized as an arrows task, they were not used for this task.

B4T10 - Find nearest gas station with “regular” fuel using sliders

To begin, realizing that that the function keys on the bottom of the menu are for specific function, press the “more” key on the far right. Then after the screen changes, of the 6 function buttons in the center of the screen, press the Sirius Travel Link button on the lower left. After the screen changes again, of the 6 buttons, press the “fuel prices” function key. Next a new screen appears showing a list of fuel prices sorted by priced from least to most. On the left side is a list of functions that includes “fuel type”. Press it. From this list of fuels, select regular. Then, from the list of functions, press “find.” Finally, the get the sorted by price, press the “distance” function button. Find the station that is closest (the top of the list) and click on it. The address will then appear on the screen.

Goals	Tasks	Operators	Time (ms)		New
Goal:: More: In Travel Link find the nearest gas station with "Regular" fuel.			Young	Old	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Travel Link"					
	Mental	M	1500	2550	F1
	Push "Travel Link" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "Fuel Prices"					
	Mental	M	1500	2550	F1
	Push "Fuel Prices" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Select "Distance"					
	Mental	M	1500	2550	F1
	Push "Fuel Type" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 6:: Select "Find"					
	Mental	M	1500	2550	F1
	Push "Find" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: Select "Regular"					
	Mental	M	1500	2550	F1
	Push "Distance" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 5:: Select "Thorntons"					
	Mental	M	1500	2550	F1

	Push "Thorntons" button	F	1200	2040	
		Subtotal	2700	4590	
from first button press		**Total**	16200	27540	

Note: Although categorized as a sliders task, they were not used.

Drag

Set	Block & Task	Task	Equation
previous	B1T9	Drag audio balance to “Front-Left seat”	2M + 2Rn
corrected			2M + 2F + P
new			21 + D
previous	B4T2	Drag audio balance to “Right-Rear seat”	2M + 2Rn
corrected			2M + 2F + P
new			2F1 + D

B1T9 - Drag audio balance to “Front-Left seat”

Starting on the player screen, push the “audio” menu button on the second menu row from the bottom. After the screen changes, push and hold the audio balance icon and drag it to the left rear seat and then release it.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "Player": In "audio" settings, drag audio balance icon to the "Front-Left seat" (Driver's).			Young	Old	
Subgoal 1:: Select "audio"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "audio" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Drag audio balance icon to "Front-Left Seat"					
	Mental	M	1500	2550	F1
	Push, hold, and drag the audio balance icon to "Left-Rear Seat"	P	1100	1870	D
	End Goal				
		Subtotal	2600	4420	
from first button press		**Total**	2600	4420	

Although some have tried to model this as Rn, P is better.

B4T2 - Drag audio balance to “Right-Rear seat”

Starting on the player screen, push the “audio” menu button on the second menu row from the bottom. After the screen changes, push and hold the audio balance icon and drag it to the right rear seat and then release it.

Goals	Tasks	Operators	Time (ms)		New
Goal:: Player: In "audio" settings, drag audio balance icon to the "Right-Rear seat".			Young	Old	
Subgoal 1:: Select "audio"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "audio" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Drag audio balance icon to "Right-Rear seat"					
	Mental	M	1500	2550	F1
	Push, hold, and drag the audio balance icon to "Right-rear Seat"	P	1100	1870	P
	End Goal				
		Subtotal	2600	4420	
from first button press		**Total**	2600	4420	

2Rn and M were replaced in previous analysis with P.

Set Clock

Set	Block & Task	Task	Equation
previous	B1T10	Set clock to 11:59	4M + 2F +2C1 + 34C2
corrected			5M + 3F + 2C1 + 34C2
new			
previous	B4T1	Set clock to 01:02	4M + F + E + 2C1 + 33C2
corrected			5M + 3F + 2C1 +33C2
new			3F1 +2C1 +33C2

B1T10 - Set clock to 11:59

From the player screen, press the "More" function button on the menu at the bottom of the screen. After the screen changes, press the "settings" button, 1 of 6 in the center of the screen. A scrollable list of objects that can be set will appear. Press the "clock" tab, the second in the list. The tab reverses contrast and then a list of settings appears (set time in hours, set time in minutes, etc.). Press the plus sign on the "set time in hours" bar to increase the hour value until it equals 11. The value is shown at the top of the window. The press the plus sign on the sign on the "set time in minutes" bar to increase the hour value until it equals 59.

Goals	Tasks	Operators	Time (ms)		New
Goal:: "More": In "Settings" adjust "Clock" to 11:59.			Young	Old	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Settings"					
	Mental	M	1500	2550	F1
	Push "Settings" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "Clock"					
	Mental	M	1500	2550	F1
	Push "Clock" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	

Subgoal 4:: Set hours to "11"					
(assume start at 6)	Mental	M	1500	2550	C1
	Push "+" button	C1	800	1360	
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Next Subgoal				
		Subtotal	4300	7310	
Subgoal 5:: Set minutes to "59"					
(assume start at 30)	Mental	M	1500	2550	C1
	Push "+" button	C1	800	1360	
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
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	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	Push "+" button	C2	400	680	C2
	End Goal				
		Subtotal	13500	22950	
from first button press		**Total**	23200	39440	

Note: The system used the current time as the starting point that could not be set. Thus, the actual number of button presses varied between individuals.

B4T1 - Set clock to 01:02

From the player screen, press the "More" function button on the menu at the bottom of the screen. After the screen changes, press the "settings" button, 1 of 6 in the center of the screen. A scrollable list of objects that can be set will appear. Press the "clock" tab, the second in the list. The tab reverses contrast and then a list of settings appears (set time in hours, set time in minutes, etc.). Press the plus sign on the "set time in hours" bar to increase the hour value until it equals 11. The value is shown at the top of the window. The press the minus sign on the sign on the "set time in minutes" bar to increase the minute value until it equals 02.

Goals	Tasks	Operators	Time (ms)		New
Goal:: More: In "Settings" adjust "Clock" to 01:02.			Young	Old	
Subgoal 1:: Select "More"					
	Mental	M	1500	2550	
	Move hand from wheel to device (located in center console)	Rf	450	770	
	Push "More" button	F	1200	2040	
	Next Subgoal				
		Subtotal	3150	5360	
Subgoal 2:: Select "Settings"					
	Mental	M	1500	2550	F1
	Push "Settings" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 3:: Select "Clock"					
	Mental	M	1500	2550	F1
	Push "Clock" button	F	1200	2040	
	Next Subgoal				
		Subtotal	2700	4590	
Subgoal 4:: Set hours to "01"					
(assume starts at 6)	Mental	M	1500	2550	C1
	Push "-" button	C1	800	1360	
	Push "-" button	C2	400	680	C1
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2

	Next Subgoal				
		Subtotal	3900	6630	
Subgoal 4:: Set minutes to "02"					
(assume starts at 30)	Mental	M	1500	2550	C1
	Push "-" button	C1	800	1360	
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
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	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	Push "-" button	C2	400	680	C2
	End Goal				
		Subtotal	13100	22270	
from first button press		**Total**	22400	38080	

Note: The system used the current time as the starting point that could not be set. Thus, the actual number of button presses varied between individuals.