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Introduction

The correct method to fixing a flat tire is not commonly known, resulting in very dangerous situations. Fixing a flat tire is a rather complex task and is not done often, making it difficult for drivers to know what to do. It is a task that is and may be done by a diverse group of users in many different types of environments.

The users of such a task include all people who drive a car. This includes a rather large and varied group, from young to old and weak to strong. The task of fixing a flat tire is already hard enough as is, but for many people it is beyond hope due to their strength or height or many other reasons.

Having a tire go flat can happen anytime, anywhere and definitely not when you would want it to. A person could end up any place, such as a dark street or on the side of a highway, or in the middle-of-nowhere. This piles on the stress for the car driver making a difficult task even harder.

In an effort to make the task of fixing a flat tire easier and safer for all people and during all situations, one must explore all that is involved with fixing a tire, the possible users, possible environments, and finally test actual users. From all of this, problems will be found and interpreted by human factors issues so that suitable solutions can be made.

The pictures that follow are of a Mistubishi Galant 1995 and is the car for which the study of fixing a flat tire is being done on.

Pictures

Picture 1. Mistubishi Galant ’95

Picture 2. Tire with Wheel Cover in the middle

Picture 3. Inside of Trunk

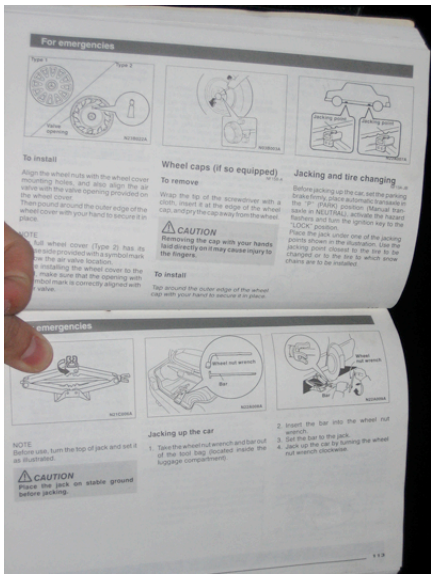
Picture 4. Jack and Tools covered up by junk

Picture 5. Holding up floorboard to access spare tire

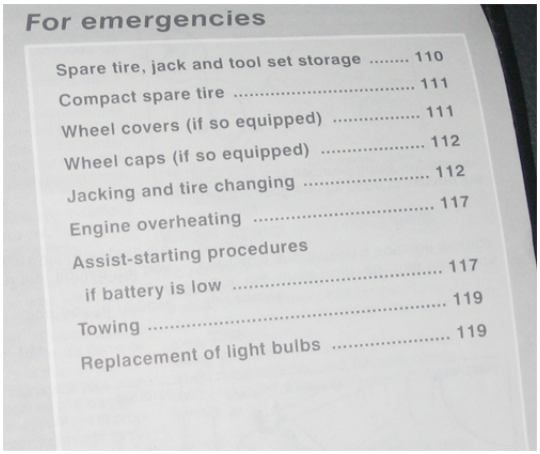
Picture 6. Spare Tire screwed in

Picture 7. Jack and toolbag

Picture 8. Rusty jack. Top of jack is parallel to rest of jack.



Picture 9. Confusing Manual



Picture 10. Should actually start reading at beginning of emergencies to fix a tire not at jacking and tire changing

Correct Task Analysis

This section focuses on the analysis of the correct order of steps to fix a flat tire. This task order was actually retrieved from the owner's manual, although it was not explicit and had to be inferred from the random instructions given.

Task Analysis for Replacing a Flat Tire

1. Pull Car Over
    a. Turn on Hazard Lights
    b. Pull to side of road to flat, hard surface
    c. Set Parking Brake
    d. Place car in Park
    e. Turn ignition key to the "LOCK" position.
    f. Exit Car
2. Review what to do to fix flat tire
    a. Retrieve Owner's Manual
        i. Open Glove Box
        ii. Remove Owner's Manual
    b. Find Instructions for Fixing Flat Tire
        i. Open Owner's Manual to first page
        ii. Find page number for "For Emergencies"
        iii. Turn to that page
        iv. Find page number for Changing Tire
        v. Turn to that page

    c. Read Through Instructions

3. Retrieve Materials for Fixing the Tire
    a. Open Trunk
    b. Pull up the Floor Board
    c. Remove wooden block
    d. Remove Spare Tire
        i. Remove the Installation bolt
        ii. Pull out Spare Tire
    e. Remove Jack
    f. Remove Tool Bag
    g. Pull out wheel nut wrench from bag
    h. Pull out bar from bag
4. Place wooden block at the tire diagonally opposite the jacking point
5. Place spare wheel under car
6. Remove Wheel cover
    a. Wrap tip of bar with a cloth
    b. Insert deeply into notch in the wheel cover
    c. Pry the wheel cover away from the wheel
7. Loosen wheel nuts
    a. Place wheel nut wrench on nut
    b. Turn wrench counterclockwise
    c. Turn so nut is loose yet not removed
    d. Repeat for all nuts

8. Turn top of jack so as perpendicular with rest of jack
9. Find placement for jack
    a. Place hand under car near flat wheel
    b. Move hand along the underneath of car
    c. Stop when feel notches
10. Place jack under car
    a. Move Jack directly underneath notch
    b. Move jack until notch is parallel with car bottom
    c. Move Jack up
        i. Place bar into wheel nut wrench
        ii. Place bar into jack
        iii. Turn the wheel nut wrench clockwise
    d. Stop jack when touches car
    e. Move jack around until top fits into the notch underneath the car
11. Jack up the car
    a. Turn the wheel nut wrench clockwise
    b. Stop turning when tire is slightly off the ground
12. Remove Wheel Nuts
    a. Place wheel nut wrench onto wheel nut
    b. Turn counterclockwise until nut is off
    c. Repeat for all nuts
13. Take Wheel off
14. Put Spare tire on hub

15. Install wheel nuts
    a. Face tapered end inward
    b. Place nut into wheel
    c. Turn nut clockwise with hands until wheel is no longer loose
    d. Repeat for all nuts
16. Lower car
    a. Place bar into wheel nut wrench (if not already done so)
    b. Place bar into jack
    c. Turn wheel nut wrench counterclockwise until car is on ground
17. Tighten nuts
    a. Place nut wrench onto nut
    b. Turn clockwise until nut is tightened to 90 to 110 N-m
    c. Repeat for all nuts
18. Remove jack
    a. Place bar into jack
    b. Turn wheel nut wrench counterclockwise until jack is loose from car
    c. Pull jack out from underneath car
19. Store Materials
    a. Open Trunk
    b. Open floorboard
    c. Store flat tire
        i. Place flat tire under floorboard
        ii. Place installation bolt on tire

iii. Turn bolt clockwise until tire has no more play

d. Store Jack

i. Turn top of jack to be parallel with rest of jack

ii. Place jack under floorboard

e. Store Tools

i. Place bar into tool bag

ii. Place nut wrench into tool bag

iii. Place tool bag underneath floorboard

f. Place wood blocks underneath floorboard

g. Close floorboard

h. Close Trunk

20. Check tire inflation pressure

a. Look at specification on the label which appears on driver's side door

b. Retrieve pressure gauge

c. Turn air valve cover counterclockwise until it comes off of air valve

d. Place pressure gauge on air valve

e. Compare value to specification found on driver's door

f. If pressure and specification are not equal, try to get to nearest gas station to fix

i. once on the road

g. Turn air valve cover clockwise until tight

h. Replace pressure gauge

Now understanding what the task involves and how to correctly perform the task of fixing a flat tire it is important to know who the users are and will be and in what environment this task will take place.

User Study

A user study was done to record all the types of people who have and who could replace a flat tire, the environment in which this task does and may occur, and finally a task analysis of actual users.

The user task analysis involved three users of varying age, size, and gender who were observed while performing the task of fixing a flat tire. The users' methods, errors, and problems were recorded and then human factors issues were used to expound upon these problems.

Users

Drivers

- Age 16 and up.
- All genders, all races, all nationalities
- For this study, which is done in America, users will most likely be American. This should not exclude people of other countries, though, and it is also important to keep in mind that there are people in the US who are illiterate, at least in the English language.

Environment

All conditions – rainy, sunny, snowy, dark, light.

Most often happens while driving, so have to pull over.

The worst cases are when it is wet, cold, and/or dark.

It is also very dangerous and very common to have to change a tire on the side of a busy road. There is often little room on the sides of the road and cars are driving past at high speeds.

Even when there are not cars, is also a stressful and dangerous situation. Have the fear of being mugged, especially if in an unknown are and in the dark.

It is now important to find what type of issues could occur because of the certain type of people who do and could fix a flat tire and the environment in which this task does and could occur under.

Human Factors Issues

These human factors issues that relate to the type of users and environment involved in the task of fixing a flat tire come from the Wickens et al. book, a couple of articles, and some simple intuition.

Contrast Sensitivity

Contrast sensitivity is the minimum contrast between a lighter and darker spatial area that can be noticed. It is important to have high contrast sensitivity so that users can read instructions, find tools, and perceive varying types of information under degraded conditions which can often be the case when a tire goes flat. Several factors that affect contrast sensitivity are spatial frequency, eyesight, and illumination.

Spatial Frequency

The greater the frequency of spacing the easier it is to distinguish objects. That is up to a certain point though– too great of a frequency may start to be detrimental. Also, the higher the contrast of objects the easier to differentiate them. ("Contrast Sensitivity", Wickens, p. 70).

Eyesight

The lens of the eye becomes less flexible as we grow older, especially within the field of farsightedness. ("The Lens", Wickens, p. 67) Also, with age, the amount of light that passes through the cornea decreases, which greatly reduces contrast sensitivity. ("Contrast Sensitivity", Wickens, p.71)

Illumination

Rods are very sensitive to light, whereas the cones are not as much. On the other hand the cones have higher acuity than rods. So as it gets darker, the more the eyes rely on what the rods see and less on the cones. As a result, the acuity of what is seen is greatly decreased. ("The Visual Receptor System", Wickens, p. 68)

Loss of acuity also results in loss of bottom-up processing which is important in processing information. Deficiencies in this processing is often compensated by Top-Down Processing, which involves perceiving what should be there. ("Bottom Up Processing", Wickens, p. 74). This can create great problems for unexpected or unknown information that needs to be perceived correctly.

Rods cannot discriminate different wavelengths of light; they are particularly insensitive to long lengths such as red. Rods also rapidly lose their sensitivity when

stimulated by light and it takes a long time for them to regain their sensitivity once darkness has returned. This results in what is called "temporary blindness."
On the other hand, cones may become hypersensitive when they have received little stimulation ("The Visual Receptor System", Wickens, p. 68-69). So when a car drives by with its lights on it will cause a glare.

Another problem with dim illumination is that discrimination is greatly reduced, which is similar to contrast sensitivity. Similar objects are harder to discriminate as it gets darker and as stress increases ("Discrimination", Wickesn, p. 87).

Since the users of the system of fixing a flat tire range from 16 year olds and above, it is important to take into consideration the physical disabilities that occur as one ages. Even without any disabilities of the eye, darkness is very detrimental to seeing clearly. This needs to be taken into consideration since a tire can become flat at any time of the day.

Noise

The level of irritation and stress caused by noise increases along with the intensity level of the noise, type of noise, time of day, time of year, and frequency of the noise. Noise is the worst when it is high intensity, high frequency, at night, and during the summer ("Environmental Noise", Wickens, p. 115). When standing by a road trying to fix a flat tire, noise can be of rather high intensity with cars zooming by next to the user. Flat tires can often occur during the night and during the summer since this type of problem is independent on time of day or year. Therefore it is important to keep in mind the stress induced by noise when developing a system for people to use to fix a flat tire.

Information Processing

Salience is a factor that captures attention ("Selective Attention", Wickens, pg. 123). Car horns, cars driving by, and glare of lights are very salient and can easily capture one's attention. The problem with this is that working memory is resource-limited. ("Attention and Similarity", Wickens, pg. 131). If resources are diverted to another, concurrent source, rehearsal will stop and decay will be more rapid and the ability to carry out other mental activities will be degraded. The diversion of attention need not be conscious and intentional in order to disrupt working memory. ("Attention and Similarity", Wickens, pg. 131). Fixing a flat tire is a problem that needs to be solved, which imposes heavy cognitive activity and limits human performance (Wickens & Hollands, 2000; Casner, 1994; Teague & Allen, 1997). A user of a system of fixing a flat tire will be using his or her working memory to the max to keep in memory what needs to be done next and what has already been done. Therefore, it is important to help prevent the working memory from being overloaded.

Language

With some users not being able to understand English, it is important to keep in mind that if English instructions are offered, some users will not be able to use them. The find the prominence of English-illiteracy, some research will need to be done.

Stress

As the sense of danger or threat is imposed, attentional narrowing, a.k.a. cognitive tunneling, occurs. The person concentrates on one thing and ignores surrounding information sources. The noise, pressure of time, and feeling of loss-of-control (Bowers et al., 1996) adds to this stress which can cause people to be less capable of using working memory to store or rehearse new material or to perform attention-demanding mental activities (Wickens et al., 1991; Stokes & Kite, 1994; Hockey, 1986).
Also under stress, people tend to engage in the most available thoughts and actions, even if they are incorrect for the situation at hand, which can result in poor decision making and dangerous choices ("Performance Changes with Overarousal", Wickens, pg. 332.

Decision Making

Time stress and cognitive resource limitations lead people to use simplifying decision-making heuristics (Janis, 1982). The most frequent and recent hypotheses are retrieved and under stress people end up just considering only a single one of the hypotheses (Anderson, 1990; Cook & Woods, 1994). Because people are overconfident and think that they are correct more often than they actually are, they end up getting stuck on the initial hypothesis even if it is an incorrect one (Flin et al., 1996; Klein, 1993).
The most recent and most frequent actions from long-term memory are the ones that are retrieved, which then form the initial hypothesis.

Another view on decision making is that of Rasmussen's Skill, Rule, Knowledge model (Rasmussen, 1983, 1986, 1993). According to this model, under novel situations a person does not have any rules that have been stored from previous experiences to call upon. Therefore, this person has to operate at the knowledge-based level. The person

assigns meaning to the available and perceived cues, integrates these cues to identify the situation, and then processes these cues as symbols that relate to the goals and to an action plan. This analytical process of cue integration relies heavily on mental simulation to help assess the hypothesis, action, or plan under consideration (Orsanu, 1993). The decision maker uses mental simulations to identify information needed to evaluate his understanding and to search the environment for this information. Development of accurate mental models, which creates these mental simulations, is critical for making successful decisions.

Poor decision making can result in dangerous results. Fixing flat tires is not a common activity for most people, so any information that one would have of this process would be infrequent, old memories that probably do not have many or strong associations within memory. As a result, correct solutions will not likely come to mind. During stressful situations (e.g. time pressures, cars driving by fast, darkness, noise stress) decision making gets even worse, which is very important to keep in mind while designing a product. With the added stress, the less likely cues will be captured and mental simulations will occur to get a mental model of the problem at hand.

These issues are derived from the type of users who are users of the system of fixing a flat tire and also the environment in which the use of such a system can occur. While designing a system for fixing a flat tire, it is important to keep these issues in mind so as to help the users in the best way possible by aiding them in correctly, efficiently and wisely fixing a flat tire. Dealing with a car, especially when having to lift it off the ground, is a very dangerous action to take, so it is of utmost importance to consider these

issues so as to keep the user protected and safe through the entire process of changing a flat tire.

Task Analysis of Users

Task: Fix a flat tire.

Comparison with correct task analysis

To do the task correctly not everything has to been done in order as laid out in the correct task analysis. For example, turning the top of jack perpendicular to the rest of the jack does not have to be done after removing the wheel cover. This can be done anytime before the jack is placed under the car. There are parts that must be done in necessary order, though. This order is detailed below:

1. Pull car over
2. Take out materials for fixing the flat tire
3. Prepare car for jacking

   (Can be done in any order)

   a. Place jack under car, underneath the notches

   b. Take off wheel cover

   c. Place block under diagonal tire from flat
4. Loosen Nuts
5. Jack car up
6. Finish loosening nuts and take off
7. Replace flat tire with spare
8. Tighten nuts with hand
9. Lower car
10. Tighten nuts all the way
11. Place all materials back

User Study: Task Analysis

The context of the user studies was in front of the researcher's house in broad daylight on a freezing cold day. Therefore the users did not have to pull the car over or have the stress of an actual occurrence of a flat tire.

The problems that each user had or errors that he/she did are highlighted in red for the task analysis and then reviewed after the task analysis.

User 1

21 year old female

Novice: Never fixed a flat tire before

Task Analysis

1. Car is already pulled over for user
2. Take out materials for fixing flat tire
    a. Open up the trunk
    b. Find Jack
        1. Not sure where the jack is, looking around
        2. See the jack, not sure though if it is the jack
        3. Settle on that it is the jack
    c. Look for rest of tools
        1. Looking to see if there are anymore pieces
        2. Decide to look for manual and see what those instructions say
        3. While looking for manual, find some more pieces
    d. Open manual to emergency section
        1. Read about spare tire
        2. Read over what pieces to get for spare tire
        3. Read that need to remove the spare tire
    e. Retrieve Spare tire
        1. Go back to the trunk

2. Pull up bottom panel of trunk
3. See spare tire
4. Turn the screw holding tire in counter-clockwise
    - Turn for a very long time
    - Holding up floor panel with one hand and turning screw with the other hand
5. Pull out tire
    - Tire is heavy so it is difficult to pull out while keeping panel up

3. Prepare car for jacking
    a. Go back to the manual
        1. Read about installing spare wheel
        2. Read about removing original tire
        3. Need to remove wheel cover
        4. Manual says to wrap screwdriver with a cloth and pry off wheel cover
    b. Searches for cloth
    c. Wrap screwdriver with found cloth
    d. Try to pull off hub, but not working
    e. Realize that there is a wheel cover
    f. Pull at that but just end up ripping the cloth
    g. Try using different tools but none of them work
    h. Cannot get the wheel cover off

i. Give up on wheel cover and turn to jacking up the car

j. Read manual on what to do next

1. Set the parking brake – does it
2. Activate hazards – does it
3. Set keys in locked position – doesn't do it

k. Now use jack

1. Not sure if first connect parts together or place jack under car
   - Read that place jack under car
   - Where is the point to place jack?
   - Why isn't that spot highlighted?
   - What is a jacking point and what does it look like?
   - See the notches underneath the car – looks like picture
2. Place jack underneath these notches

l. Put jack together

1. Have two pieces but no clue how go together
2. Keep trying at it
3. Manual is no help
4. Picture in manual is not understandable
5. Eventually get it just by trial and error

m. Does not place block at diagonal tire

1. Cannot find block

4. Does not loosen nuts before raising

a. Cannot get wheel cover of so cannot get to the nuts to loosen

5. Jack Car Up
    a. Raise car with jack
        1. Top of jack is parallel with rest of jack which is incorrect
        2. Jack is not stable
        3. Hard to turn the jack to raise the tire
        4. Wonder how high tire needs to be
            - Turns back to the manual and reads along
            - Now the manual says there needs to be a block, but don't have a block so use spare tire
    b. Have wheel raised
    c. Cannot open wheel cover still, so cannot do anything else
    d. Try using all the available tools pulling desperately
6. Give Up

Problems

- Difficulty in finding and identifying jack
- Difficulty in finding other pieces
- Have difficulty pulling tire out
- Having difficulty unscrewing spare tire
- Do not notice block
- Do not apply block
- Try to pull off hub
- Cannot pull off wheel cover

- Do not loosen nuts before jacking up car (result of not pulling off wheel cover)
- Sets parking brake and activates hazard but not at the beginning
- Do not set keys in locked position
- Confused as to where jack needs to be placed under the car
- Do not know how to create jack handle from provided pieces
- Cannot understand the instructions for the process of constructing jack handle
- Takes trial and error to put jack handle together
- Do not move top of jack perpendicular from the rest of the jack
- Still cannot open wheel cover
- Cannot finish replacing the tire

Overall analysis of User 1:

The user was smart to use the manual. Unfortunately, the manual was not very clear and did not provide instructions in an understandable order. The user was unable to remove the wheel cover after much work and was losing patience. Without removing the wheel cover it is impossible to change the tire. Not giving up yet though, the user was able to raise the car safely, though with much difficulty with using the jack. Still without the wheel cover removed nothing could be done from there.

User 2

Male 58 years old

Previous owner of car

Intermediate – Expert: Has changed flat tires many times

Task Analysis

1. Car is already pulled over for user
2. Take out materials for fixing the flat tire
    a. Open the trunk
    b. Pull out the jack and tools
        i. Looking around, not sure if have all of the necessary tools
        ii. Continue on
    c. Open bottom panel
    d. Unscrew the spare tire
        i. Unscrewing takes awhile
    e. Pull out spare while holding bottom panel up
        i. Use one hand to pull tire out
    f. Place spare onto the ground
    g. Pull out the block and place it under the diagonal tire of the flat
    h. Go over to the wheel
3. Prepare car for jacking
    a. Take off wheel cover

i. Try to take wheel cover off of the wheel using one of the jack rods

ii. Not working so start looking for a screwdriver

iii. With screwdriver puts in a lot of effort to remove wheel cover

4. Loosen nuts
    a. Retrieves the nut wrench
    b. Loosens the nuts, doing opposite nuts first
    c. Must kick on the wrench to loosen the nut
    d. Realizes that one of the nuts is different, it has a lock so the wheel can't be stolen
    e. Must find the key for the lock
        i. Look in the utensil bag, inside the trunk
        ii. Finally look in glove compartment
        iii. Find the key
    f. Put key over nut and then put nut wrench on top of that
5. Finish preparing car for jacking
    a. Extend jack by rotating the movable part clockwise
    b. Place the jack underneath the car
    c. Place it under the notches below the car
    d. Line the top of the jack to be parallel with the notches
    e. Attach the top of the jack while turning the movable part with the hand
        i. The top of the jack is not perpendicular with rest of jack
    f. Jack handle
        i. Try several different methods – trial and error

    ii. Find one that actually works

6. Lift Car
    a. Very hard to turn the movable part to raise the jack
    b. Car falls
        i. Worried that jack broke
        ii. Confused as to why car fell
    c. Continue with raising jack but very nervous
    d. Stop car when tire is just a little above the ground
        i. Don't want to get it off the ground more than is necessary
7. Loosen nuts all the way
    a. Take the nuts off
        i. Do opposite sides
    b. Realize that didn't loosen one of the nuts beforehand
    c. Loosen it now but worried
        i. Loosen nuts beforehand because if try to loosen them while the wheel is off the ground could cause the car to move or jiggle off of the jack
8. Replace flat tire with spare
9. Tighten nuts with hand
10. Lower car
11. Tighten nuts all the way
12. Place all materials back

User Study: Task Analysis: User 2

Problems

- Does not read manual
- Not confident have all necessary utensils (utensils scattered about)
- Initially uses incorrect tool for taking wheel cover off
- Takes a tremendous amount of effort to take wheel cover off
- Must kick on wrench to loosen nut
- Do not know where key is for lock nut
- Do not turn head of jack perpendicular to rest of jack body (not doing so makes it difficult to raise car)
- Great difficulty in figuring out how to put jack handle together
- Great difficulty in turning jack handle
- Car falls a little while jacking
- Forgot to loosen all nuts initially
- Must apply a lot of pressure to loosen nut while car is in the air, causing car to move

Overall Analysis of User 2

This user seemed to know what he was doing. There were some difficulties along the way, but the user was able to successfully replace the wheel. The two dangerous problems that occurred, though, was while the user was jacking the car, the car fell a bit. This was due to the fact that the top of the jack was not fit securely onto the car. The other dangerous problem was that the user forgot to loosen one of the nuts before raising the car, so he had to put a lot of force on the nut while the car was in the air, providing a

prime opportunity for the car to come off of the jack. Other than those two problems, the user was rather correct in all that the he did.

User 3

Male 28 years old

Novice: Has never fixed a flat tire before

Task Analysis

1. Car is already pulled over for the user
2. Take out materials for fixing the flat tire
    a. Open the trunk
    b. Pulls up bottom panel
    c. Sees the spare tire
    d. Unscrews the screw
    e. Pull tire out and place it nearby
    f. Pulls out tools
        i. Pulls out the jack
        ii. Pulls out the toolbag
    g. Sees block but don't know what it is or what it is supposed to do
3. Prepare car for jacking
    a. Place jack under car
        i. Try to extend the jack by the hand but cannot do it
        ii. Read words on jack but in Japanese
        iii. Go back to the trunk and look at block again (confused as how to make jack open so searching for solution)

- Still not sure what the block is for but doesn't seem as though it will help with the jack

iv. Figure out the moveable part and how to use it

v. Place jack underneath the car

4. Did not place block under diagonal tire
5. Did not loosen nuts before jacking car up
6. Jack car up
    a. Start to twist moveable part of jack with hand
    b. (Intervention: The user wanted to lift the car with the jack in an incorrect position, since this would be dangerous for the car and the user to continue with this action, some help was given. This was done to get more information on how the user would have continued but without the risks. But it should be taking into consideration that the user would have continued in his ways and caused great damage to the car and himself)
    c. Place jack under notches
    d. Keep top of jack parallel with rest of jack
    e. Cannot figure out any tools that could be used so just use hands to move the moveable part
    f. Figure out that one tool fits the jack but doesn't really help
    g. Realize that the lugnut wrench can be used on the jack to raise it
    h. Stop raising the car once it is off of the ground
7. Loosen Nuts
    a. Try to take off the hubcap with hands

b. See the wheel cover so try to take off with hands

c. Hands do not work so find screwdriver and try that

d. Screwdriver doesn't initially work so use all possible tools

e. Eventually use screwdriver with piece of jack handle to pop wheel cover off

f. Remove nuts

    i. Place wrench on nuts

    ii. Push hard onto nuts

    iii. Nuts not budging have to push even harder

        - (It is dangerous to push too hard on the nuts while car is raised up. Doing so can cause the car to roll and/or move off of the jack.)

    iv. See different nut

        - Search car and glove compartment for key for this different nut

        - Find key for different nut

    v. Loosen the different nut

8. User was stopped here since

    a. Had placed jack in wrong spot

    b. Put a lot of pressure on nuts to loosen them while car was in the air

These things would have caused great danger, so the user was allowed to stop so as not to cause any harm or danger.

User Study: Task Analysis: User 3

Problems:

- Sees block but do not know what it is
- Do not use block
- Greatly confused about how to use the jack
- Initially use hands on jack
- Place jack at incorrect part
- Places the handle together incorrectly
- Does not turn the top of the jack perpendicular to the rest of it
- Try to remove hub
- Try all tools to remove wheel cover
- Push hard on lugnut wrench while wheel is in the air
- If it wasn't for the intervention of the researcher, the user would have raised the car in an incorrect spot causing harm to the car and/or the user. Therefore, the user would not have been successful in replacing the flat tire.

Overall Analysis for User 3:

This user appeared totally clueless of what to do. Even so, the user was able to get the wheel cover off and able to get the jack to increase in size. Other than that, though, the user did several things that were dangerous. First, the user placed the jack in the incorrect spot and second, the user did not loosen the nuts first and had to slam down hard on the wrench when connected to the nut and the tire in the air. Either of these actions could result in loss of car or life.

Overall Problems for all Users

After having observed all three users, a list has been made that incorporates all their errors and problems.

- Nobody twisted the top of the jack to be perpendicular with the rest of the jack, therefore it was extremely difficult to raise the car
- Two of the users did not know how to get to the nuts. They tried pulling off the hub (which could damage the tire). Only the previous owner of the car knew that there was a wheel cover.
- Users were confused of how to take wheel cover off
- Wheel cover was extremely difficult to get off. Couple of the users were afraid of braking something
- Nobody knew right away how the handle for the jack fit together. It took a lot of time and effort to get the correct combination
- Loosening the nuts was not an obvious thing to do before lifting the car but is an extremely important thing to be done
- The manual was hardly used and even when it was it was difficult to follow and understand
- The floorboard had to be held up by one hand while unscrewing spare tire and while pulling spare tire out from trunk
- Unscrewing spare tire took a very, very long time
- Only one user knew what the block was and used it

- If the users were under pressure and stress then doing this task would probably cause in a lot of harm and definitely not be as successful
- Loosening the nuts required applying a lot of pressure to the point of jumping on the lugnut wrench
- Key for locked nut was very difficult to find
- Everybody's initial response was to call AAA

Human Factors Incorporation

Having constructed this list, it is now interpreted through a human factors view. Human factors issues that could be the cause of these problems are what follow.

Serial Search ("Serial Search Model", Wickens pg. 79)

All of the users searched the trunk of the car for necessary tools and materials for fixing a flat tire. There are targets that are already in the user's mind, but since the users were not confident of knowing all the necessary tools, they were also keeping their eyes open for possible targets. The users had to inspect nontargets to make sure they are not a desired target and then move on. As can be seen from the provided pictures, the trunk of the car contained many nontargets, such as a tennis racket, papers, first aid kit, and many more items. The users had to go through a serial search, which is just inspecting each item in turn to determine if it is a target or not. What makes this even worse is that the visual search space is not organized at all, causing the searching to be considerably more random than when searching organized spaces. This unorganized space also results in users not exhaustively examining all locations (Wickens, 1992; Stager & Angus, 1978).

What is worse is that if the targets are not readily visible then there are diminishing returns for the more time spent searching. In other words, after awhile, the probability of finding a target remains constant, so spending more time is not going to be very productive especially when time is at a premium (Drury, 1975).

Decision Making – SRK Model (Wickens pg. 171)

A major problem that most of the users faced was the fact that fixing a flat tire was a novel problem. When a situation is novel, decision makers do not have any rules in long term memory from any previous experiences upon which to call on. According to the SRK (skill, rule, knowledge) model, when faced with a novel situation one has to operate at the knowledge-based level. At this level, a person assigns meaning to sensory input and cues and integrates these to identify with what is happening. These cues and inputs are processed as symbols that relate to the goals and to an action plan (Rasmussen, 1983, 1986, 1993). At the knowledge-based level mental simulations are heavily relied upon to assess the hypothesis, action, or plan that is under consideration. The mental simulations are used to identify information that is needed to evaluate one's understanding and leads one to search the environment for this information. Since mental models make mental simulations possible it is important for people to have accurate mental models.

As could be seen in the user experiments, all the users did not have accurate mental models of how the jack handle is put together and how to use the jack correctly. This resulted in causing great difficulty for the users to raise the jack and therefore increased the amount of time to raise the car. One user had fixed a flat tire before but for

the other users, they did not have a mental model or schema for fixing a flat tire due to its novelty. As a result, they had to come up with a model from the sensory input and create some meaning to this input that could be applied to the problem state.

Problems to Solutions

Now that the possible user types and environments have been discussed and user studies have been conducted, there have been many problems discussed and many human factors issues found. It is now time to find ways in which to correct these issues and provide a better product that is easier and safer to use.

Solutions

The human factors issues and problems perceived from the user task analyses, the environment and the users of the product allows one to see many possibilities for solutions.

Several human factors principles will be given from which the solutions will be created. After these are discussed, visual representations of the solutions will be given, and then the solutions will be listed along with their tradeoffs.

Conspicuity ("Conspicuity" Wickens, pg. 80)

If a target is conspicuous enough it will "pop out" no matter its location in the visual field. As a result, the nontarget items do not need to be inspected and searching for targets becomes extremely fast (Yantis, 1993; Treisman, 1986). Conspicuous items can also be described as being salient and causing attentional capture. Ways in which to increase conspicuousness is to use distinct stimuli, increased visibility of stimuli, and tactile stimuli. (Spence & Driver, 2000; Sklar & Sarter, 1999).

The tools found in the car used in the experiments were not salient at all; all of the users had difficulty in finding the tools and jack and were also unsure if there were anymore tools that needed to be found. The tools are in a black bag in a darkened trunk and the jack is also black and hidden in a cluttered corner. The solution for this is to place the tools and jack right next to the tire, in their own separate compartments. Above each of the items there will be a title of what the compartment holds and also how to use the items in the compartment. There will be four compartments, one will hold the spare tire, another will hold the jack, a third will hold a flashlight that will be discuss later, and

lastly there will be a compartment for the tools. The jack, tools, and flashlight will be in bright contrasting colors. Since the tools will need to be in a tool bag so as not to get lost, the bag will also be in a bright contrasting color. The trunk is grey and the car is a dark burgundy, so the colors of choice is a bright yellow for the jack, bright orange for the tools, and a bright pink for the flashlight. The reason for the different colors is so that the items can be differentiated much more easily and so that when these items are discussed in the instructions colors can also be used to reference to these items.

For the titles and instructions above each compartment to be salient they will use a white background and black text. Surrounding the background will be the color of the item that the text is discussing. The compartment below will also match that color. This is so that it is easy to map the instructions to the tool and also to know where to place the tools back to. More on instructions will be discussed under the decision making section.

One other part of the car that was very difficult for the users to find was the notch that the jack is supposed to be placed under. This notch is underneath the car but is very difficult to see or even know what one needs to be looking for. To make that more salient, the area where the jack needs to be placed under will stick out a little from the rest of the car and be colored in a distinct and contrasting color from the car. Also it needs to be associated with the top of the jack, so it should be the same color as that. Since the jack is already yellow, its top needs to be a different color so as to better associate the top of the jack with the notch replacement. As a result of all this, bright green will be chosen as the color of the top of the jack and of the notch replacement.

Decision Making

When approached with a novel situation one generally has to work at the knowledge-based level, where a person creates his/her own hypotheses and action plans from the input stimuli. A way in which to make novices more accurate in their decisions, rules can be given. In such a situation where rules are given, the novices will be working at a rule-based level. This involves interpreting the stimuli input and cues and figuring out how the rules can be applied to them (Rasmussen, 1983, 1986, 1993). As a result, the user should be provided with clear and understandable instructions since they cannot work at a knowledge-based level.

As discussed earlier about stress and decision making, stress causes the user to tend to fixate on one hypotheses, fall into cognitive tunneling where not all cues are taken in, and working memory is greatly decreased. To fix these problems of stress and decision making it is important to design procedures that are as simple as possible, make emergency instructions easy to locate and salient, actions to be taken should depend as little as possible on holding information in working memory, and actions to be taken should be explicitly instructed.

To apply this to the problem of fixing a flat tire, instructions should be salient and explicit. They should be simple and take the burden of memory off of the user and instead have the knowledge necessary be in the world (Norman, 1988). Currently, the emergency instructions are in the manual which is in the glove box. That is not salient whatsoever. To make the instructions more salient the solution is to have the instructions on a plastic panel. This panel is the top that covers the compartments for the spare wheel,

jack, tools, and flashlight. When the users open the floorboard they will see this plastic top. On this top will be instructions. There are three levels to these instructions to make sure the users what is needed. The first level are simple instructions. Next to these simple instructions are more detailed explanations of what to do. The simple instructions are used to help the user have situation awareness and to not lose their place in the process. Next to the detailed explanations are diagrams. This uses redundancy both in visual field and semantic field. The diagrams will show the user how to apply the instructions rather than leaving the user to figure it out on his/her own. The top can be pulled out and placed wherever needed. This fact, that the top can be pulled out, will be explicitly stated on the top in salient words. To make the instructions simple and easy to read, high contrast letters and words will be used with clearly defined steps. There will also be diagrams to guide the users through each step. To also increase contrast sensitivity, a light will turn on at the top of the panel when the panel is pulled out from the trunk. This light will illuminate the text. When the panel is in the trunk, the light is recharged by the car's battery.

To make the instructions even more salient and redundant they will not just be placed on this plastic top. Above each compartment in the trunk, which houses the spare tire, tools, and jack, there will be titles of what is in the compartment. Along with these titles will be an explanation of what the compartment contains and what the device is to be used for and how it should be used. These instructions will be kept simple considering the limited amount of size and desire to increase contrast sensitivity. Instructions will also be placed on the toolbag, flashlight, and on the jack.

The spare tire will also have instructions. There are two sides to a spare so it is important to tell the user which way the spare needs to be placed. The instructions will be on the side that will face the inside of the car. On the side facing the outside there will be a label letting the user know that the instructions for how to place the spare tire are on the other side. This label is used so that there isn't a large white box with black text on the outside of the tire (purely an aesthetic reason).

These instructions will be very simple just giving an explanation of what the device is and how to use it. All of the instructions will be black on a white background and will be given font sizes according to the highest contrast sensitivity for the space available.

Lastly, just as the instructions placed on panels and tools are easy to understand and simple, so should the manual. Currently the manual is not organized well for fixing a flat tire, as one user quickly found out. The solution for this is to have the manual organized in a logical and easy to understand manner, with clear diagrams to go along with each step.

Anthropometry

Since having to fix a flat tire can happen to any driver, this results in a very large and diverse user population. Short and tall, young and old, and many more variations exist. In order to accommodate all these users, the process of fixing a flat tire will need to be designed for the smallest and weakest users ("General principles for workspace design" Wicken, pg. 259). The problem right now is that the spare tire is deep down in the trunk of the car, the floorboard does not stay up on its own so users must use one

hand to keep it raised, and the spare tire is heavy. People with short arms and people who aren't strong enough to lift the tire will have a very difficult time getting the spare tire out of the trunk. To add to these problems, lifting heavy objects, bending, and twisting the torso can cause low-back pain ("Low-back problems" Wickens, pg. 276). It is recommended to lift with one's legs but due to the design of the trunk the spare tire must be lifted solely by the arm and back, which worsens low-back pain.

Not only is the user in a bending position for lifting the spare tire, but they also take this position while unscrewing the spare tire from the car. This unscrewing takes a very long time considering that the screw used must go through the spare tire and into the under part of the car.

The users who were studied were of various heights and strength and they all had to bend over to pick up the spare tire, pull the spare out with one hand while the other held up the floorboard, and use just arm muscle and back muscle to get the spare tire out. These users were not even on the extreme ends of possible users. If it was this difficult for them it can only be imagined how hard it must be for people who are not as strong or whose arms are shorter.

Users also had great difficulty in putting together the handle for the jack and also in using the jack. The jack handle process was very complex with no hints. The awkward handle is difficult to put together since it is a novel task, as discussed under thre decision making section. To fix this, just get rid of the handle.

The jack itself involved rotating the handle clockwise several times. While doing this the user needs to be bending down because the jack is so low to the ground. Bending over is bad for the back as already explained. Finally, rotating clockwise is bad for the

arm. Working with fast and repetitive arm movements may cause shoulder pain and injuries ("CTDs at the Shoulder" Wickens, pg. 292).

Lastly, the wheel cover of the car is extremely difficult to get off. It requires a lot of strength and a lot of determination. The users were unsure if they were pulling the wheel cover off right and were afraid of damaging the car and also of the wheel cover flying off. As a result of the wheel cover being difficult to come off, injuries ensued as the screwdriver used would fly out of the wheel cover due to all the force placed on it. Also, one of the users had such a hard time with the wheel cover that this user had to give up. Without being able to take off the wheel cover one cannot get access to the nuts and therefore cannot take off the tire.

From these problems, the solution of using a clamp, a ramp, new floorboard, no wheel cover, and a new jack are used.

Clamps – Instead of using a screw, plastic clamps will be placed over the edge of the tire. The clamps come off and on easy so that all people of all strengths can use them. Since the screw exists so that the wheel remains still while the car is moving, these clamps will be sufficient to accomplish this job without the need of a screw. The reason plastic is used is because it can be easily molded to have grip and is not as dangerous as metal in hurting people.

Ramp – A ramp is stored underneath the floor that the spare tire rests on and above the bottom of the trunk. The ramp can be pulled out and is constructed to go over the edge of the trunk and down to the ground. This is done to help people to easily pull the spare tire out without bending and lifting. There will be a label where one is to start

pulling the ramp from, using contrasting label with white background and black text of course.

Floorboard –To make things easier for the users, the floorboard will automatically stay up like the trunk top. Another feature that will be added is that when the floorboard is raised a light will turn on and illuminate the compartments below. This is to increase contrast sensitivity, which is affected by level of illumination.

No Wheel Cover –The wheel cover seems to exist for the sake of aesthetics, but it is not worth it if it injures people and prevents them from fixing a flat tire. To make it easier for all types of people to remove the wheel cover, no wheel cover will be used.

Jack – The jack requires first, to put together an awkward and confusing handle, second, rotate the jack clockwise for quite awhile, and lastly, bend over while rotating the handle. As a result of these problems, a new kind of jack will be used. This one will involve a pumping action. There will be a pedal that users can just push with their foot and as they pump the pedal the car will rise. To lower the car, there will be another foot activated pedal. When the user presses this, the car will lower itself at a safe and slow speed. The pumping pedal will stick out and be a different color than the rest of the jack. It will have the label "Press down and Pump to Raise Jack." The lever that lowers the jack will be smaller and require more accuracy so that it is not pressed accidentally. It will also be a different color and be labeled "Press down to automatically lower car." This jack will also not require the user to turn the top perpendicular to the rest of the jack, since it will already be oriented that way. This was something the users never did and created such difficulty in using the jack and raising the car.

The spare tire will also not be so deep into the trunk. If this is too difficult to deploy, then there can be a hydraulic device that can raise the compartment that contains the tire, tools, flashlight, and jack when the floorboard is raised.

Labels ("Labels" Wickens, pg. 193)

Wickens, Lee, Liu, & Becker (2004) discuss several principles that should be applied to labels. Those are:

1. Visibility/Legibility – This relates to contrast sensitivity which has been discussed earlier in this paper. The important information that should be derived from the concept of contrast sensitivity is that the stroke width of lines and contrast with background must be sufficient that the label can be discerned under the worst expected viewing conditions. In this case, those conditions are in the night with very little light.

Contrast Sensitivity

An influence on contrast sensitivity is the level of illumination that exists. To increase this level of illumination and therefore increase contrast sensitivity, a flashlight will be provided in a compartment next to the tools and jack. The flashlight will be mechanically powered, as in one that lights up after being shaken or by doing a pumping action with the hand.

As discussed previously, there will also be a light above the instruction panel and a light that turns on when the floorboard is raised. All of this is to aid in increasing contrast sensitivity.

2. Discriminability- Confusability between labels increases with the ratio of shared to distinct features. So to decrease confusability it is important to decrease shared

features and/or increase distinct features. A previous solution discussed having labels above each compartment for the tools, spare tire, jack, and flashlight. The labels need to be distinct since they refer to different devices. Not only do the labels need to be distinct from each other but they need to match the device of which they are for. The solution to aid in this is to use differing colors. The labels will be black text on white background and this background will be surrounded by a certain color. This color will be the color of the corresponding compartment and device. The labels will also be distinct by containing symbols representing each device they correspond with.

3. Meaningfulness – Icons do not necessarily trigger the appropriate meaning into the user's mind. The designer of the icon is assuming that the user will have a certain mindset from when observing the icon, but that only covers some of then proportion of the actual users. Labels help add meaning to icons, but icons do provide quick understanding of meaning from a quick glance. The label gives assurance that the meaning the user retrieves from the icon is correct. Icons will be used with the labels to help display which compartments and instructions belong to which devices. Since it has already been stated that labels will exist there should not be a problem. The icons of course should be made to look like what they represent but not too detailed to the point that contrast sensitivity will be reduced. More detailed icons are harder to understand especially under low-light conditions.

4. Location – Labels should be physically close to and unambiguously associated with the device of which they refer to. This adheres to the proximity compatibility principle, which generally states that sources of information that are related to the same task should be have close display proximity. This is achieved by nearness in space,

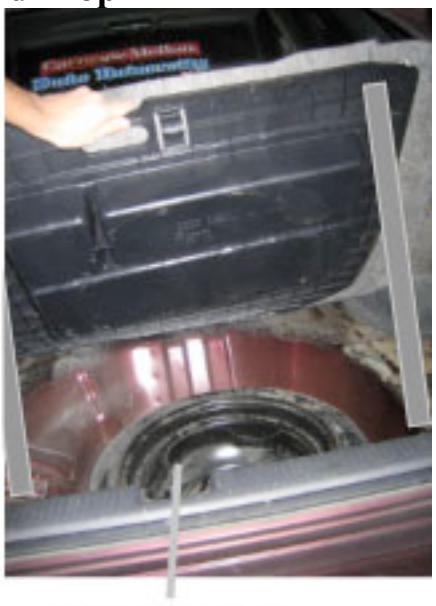
common color, and/or linking together with lines. This gives reinforcement of the solution of having the labels of each device above the compartments and having the area around the labels and compartments the same color as the device. There will also be labels on the devices themselves to let the user know what the device is and how to use it.

The idea of proximity was also used in a solution of having the place where the jack needs to be placed under the car (the notch replacement) be the same color as the top of the jack. The common color matches these two areas to show that they belong together.

Finally, in the instructions in the manual and on the instruction panel, when a device is referred to the color of the device will be shown along with a picture of the device. This will also increase proximity between the instructions and the device itself.

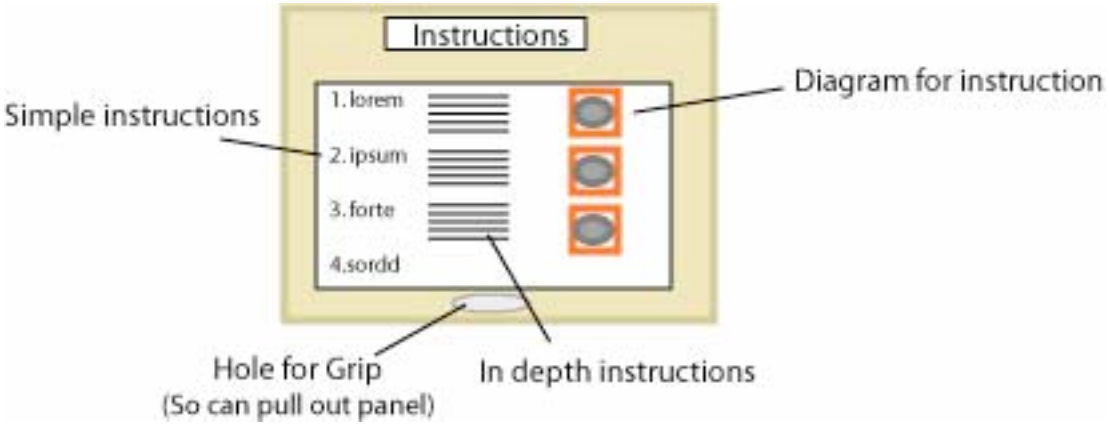
Pictures of Solutions

Floorboard Prop

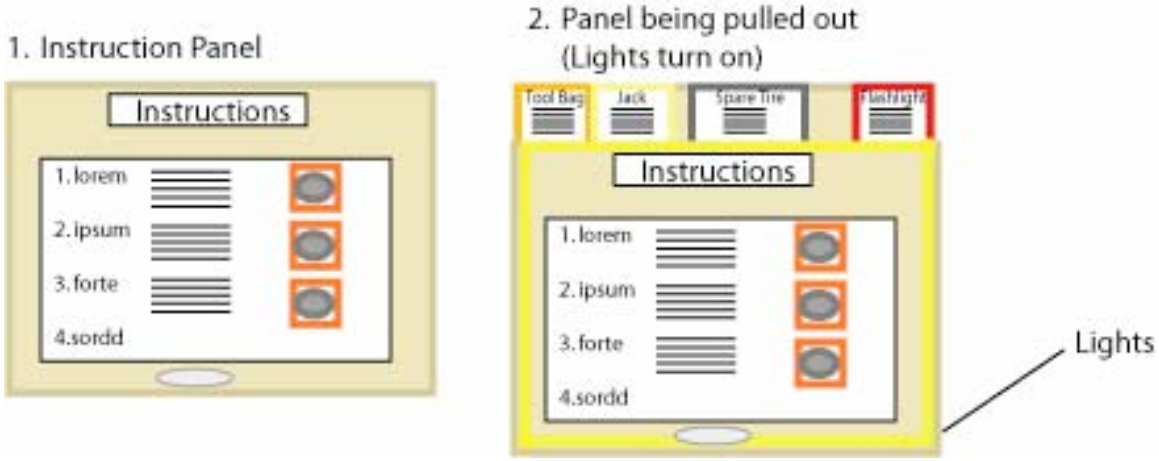


If I could draw, the instruction panel would be here with the compartments underneath

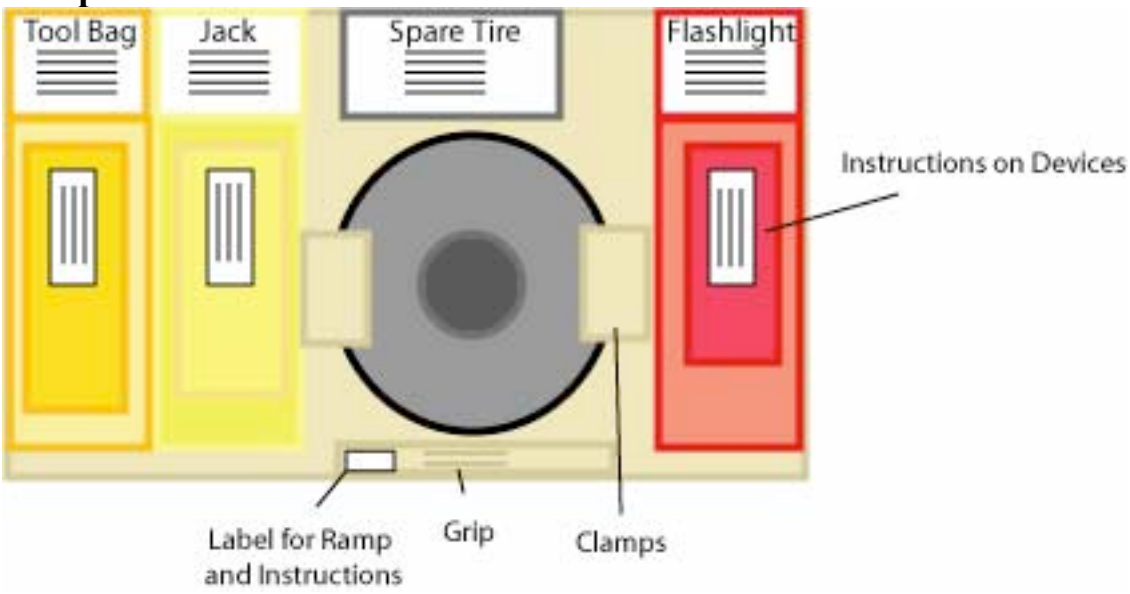
Instruction Panel



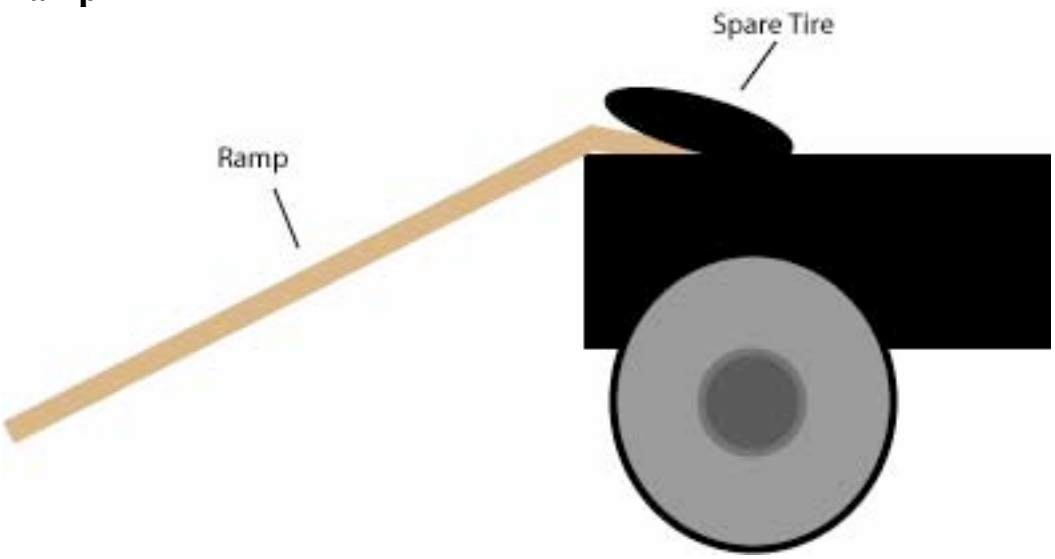
Instruction Panel Pull Out



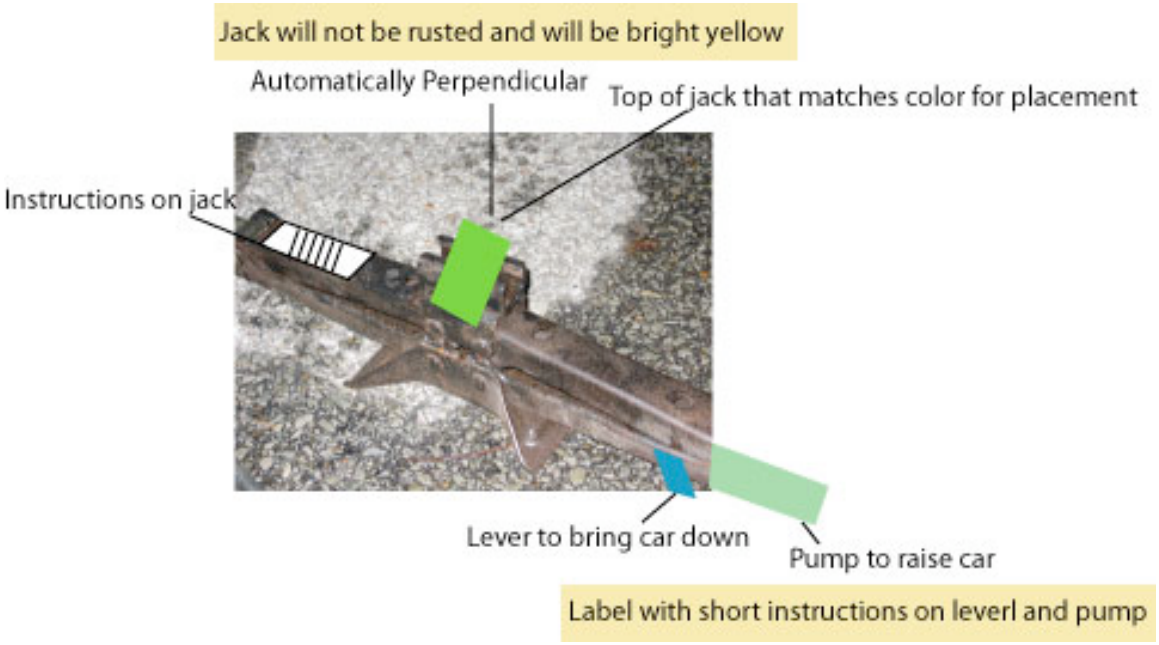
Compartments



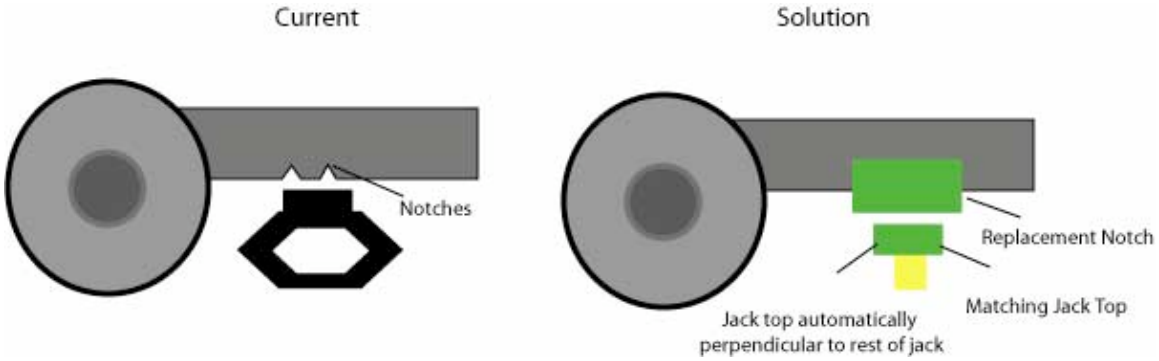
Ramp



New Revised Jack



Notch Replacement



List of Solutions and Tradeoffs

So as to get a better understanding of the solutions, they are listed along with their tradeoffs.

Solutions

Floorboard

The floorboard will stay up on its own. When the floorboard is opened it will turn on a light that illuminates the instruction panel below.

Tradeoffs

- Would have to use a plastic or metal floorboard rather than just cloth so that it could be held up by some device. This will increase costs.
- The light may run out and be difficult to replace.
- The light may run the battery dead (of course could apply the idea that the light recharges when floorboard is down and when the floorboard is open, the light runs on its own power)

Instruction Panel

When the floorboard is open the user will see a panel that contains instructions on how to fix a flat tire through the use of simple instructions and diagrams. There are three levels to the instructions: simple instructions, more detailed instructions, and diagrams. The detailed instructions are next to the simple instructions of which they are associated with. The panel has a handle to pull it out along with instructions to pull the panel out to get to the spare tire and other necessary devices. It will also give instructions on which devices are needed, so that if the devices are not in their compartments then the user will know to search for them. When the panel is pulled out a light will come on at the top and around the panel so that it is still visible under low-illumination conditions. The light will be recharged by the cars battery when the panel is in the car.

Tradeoffs

- User may not understand that spare tire is below the instruction panel
- User may think that spare tire is elsewhere since just see a plastic panel
- Panel could get lost when taken out of the car
- Panel may be difficult to get out if it is too large.

Compartments for tools

Compartments exist for each device: spare tire, jack, tools, and flashlight. Each compartment is color coded with the device it corresponds with. Each device is a different color. There is a label above each compartment explaining what the compartment holds and how it should be used. Icons are used to give a quick display of what should be in the compartment. The compartments will be next to each other so that the user does not have to go searching for all of them.

Tradeoff

- Users may not place tools back into the compartments
- Compartments may get filled and covered by junk in the trunk
- Very expensive to add compartments, must change the shape in bottom part of trunk. This may require a redesign of the metal part of car.
- May not be possible to change shape of trunk due to gas lines and other parts of the car

Flashlight

Flat tires can occur at night, resulting in low illumination situations. A flashlight will be provided that is powered by shaking it or through a hand pumping action. The

flashlight will also be in a compartment next to all the other compartments that contain the spare tire, jack, and tools.

Tradeoffs

- User may have a hard time understanding how to get the flashlight to light
- User may not be able to see the flashlight or read instructions on how to use it until the flashlight comes on.
- Flashlight could get lost by being forgotten when brought out to fix the tire
- Flashlight could get lost in the junk in trunk.
- User may not be strong enough to produce enough mechanical power for a strong light.

Color Coding

The devices are color coded with the compartments they belong to and also to the instructions on the instruction panel and in the manual. Each device is a different color so as to differentiate them. The top of the jack is the same color as where the jack needs to be placed underneath the car, which is also a separate color from the other devices.

Tradeoffs

- Run out of colors to use.
- Need to use high contrasting and distinct colors – may be difficult to find enough of those. Also have to use colors that will be easy to see in the dark, which reduces even more the number of possible colors to use.
- Colors can be non-aesthetically pleasing.

- Color blind people may not be able to see the colors.

Raising of Compartments

The compartments that contain the spare tire, jack, tools, and flashlight will be raised higher so that users do not have to bend over to reach the tire.

Tradeoff

- Greatly reduce space in trunk

Another idea would be to have the compartments rise when the floorboard is lifted up. Hydraulics could be used to lift the compartment.

Tradeoff

- Expensive and hard to deploy
- Hydraulics may not be strong enough to lift compartments so user will then have to use some of their own strength to lift it.

Clamps

Clamps, instead of screws, will be used to keep the spare tire from moving around while the car is driving. The clamps will be easy to open and close and will have grips on them. The clamps will also be made of plastic.

Tradeoffs

- The clamps could break
- The clamps may not be able to hold the tire down as well as a screw under certain conditions

- It may not be easy to understand how to get the clamps off of the tire

Ramp for Tire

A ramp can be pulled out from underneath the compartments and will go over the end of the trunk down to the ground. There will be a label to let the user know what the ramp is and how to get it out. There will also be a hole at the front of the ramp so it can be pulled by the user grabbing it.

Tradeoff

- This ramp will take up space in the trunk. It will probably have to fold over itself to fit in the trunk so that will make it take up even more space.
- Trunks get full of random junk, so the label and ramp may get covered up and the user would not know about it. (A possible solution for this is for the instruction panel to explain that there is a ramp and how to used it.
- The car may be on a hill, so the tire may not be able to be pulled along the ramp and if it does it may still be hard for the user to keep the tire from falling off of the ramp.
- The ramp is dependent on the size of the car, so it would have to be made specifically for types of cars, resulting in higher costs to implement this device in all cars.
- The ramp may cause users to have to bend over even more than usual to reach the spare tire, causing more bending and less stability as the user pulls out the spare tire.
- The user still has to pull the tire up the ramp initially

Solutions

Instructions everywhere

There is a panel that the user sees once the floorboard is raised. Instructions are on this panel. Instructions are also on the labels above the compartments of devices. Instructions are also on the devices themselves. And, of course, instructions are in the manual.

Tradeoffs

- Users may get confused which instructions to read.
- Users may feel the need to read all of the instructions and waste time.
- Instructions being placed everywhere may cause users to not pay attention to the instruction panel, which contains the steps and order for fixing the flat tire.
- All of the instructions may distract the user, since reading is automatic.

Notch Replacement

Currently, there are two notches underneath the car where the jack should be placed. There are four places where these notches exist, all of them next to one of the four tires. The notch solution is to use a color to point out where to place the jack and also make that area be wider and stick out from the rest of the metal bar that the previous notches are on. Lastly, the notches' color will match the color of the top of the jack.

Tradeoffs

- Expensive to add extra metal.
- Have to make top of jack fit this metal piece.
- Color may get covered with mud and therefore not be visible.
- User may still not figure out that colored area is where jack needs to be placed, unless read it in the instructions.

New Jack

The new jack will be a pump jack that raises the car by pumping a pedal. The jack will lower the car by pressing down on a different, smaller lever. The pedal and lever will be different and contrasting colors from the jack and from each other.

Tradeoffs

- Pumping action is repetitive and therefore may cause CTD in the knees.
- User may accidentally press the lever that lowers the car.
- User may have a hard time pressing lever down.
- User may press lever down with hand resulting in the car coming down right near his/her head.
- Car may come down too fast and fall off jack or cause injury to user or car.
- User may not understand that he/she needs to press down on the pedal to have the car go up – action is not compatible with results.

No Wheel Cover

There will be no wheel cover on the wheels. The nuts will be exposed and easy to see.

Tradeoffs

- Could make the tires more tempting to steal.
- Makes the tires not as aesthetically pleasing
- Results in the nuts rusting or getting damaged

All Solutions

It should be noted that all solutions will add costs through adding parts and doing redesigns. There is a cost/benefit tradeoff, but considering how helpful and possibly life-saving these changes could be, hopefully a car company would choose to pay the costs.

The solutions have been drafted and created from the principles of human factors. These solutions need to be taken into the whole picture to understand how important they are and how effective they will be.

Conclusion

A flat tire does not happen that often, but when it does it is a very stressful and scary situation. Since fixing flat tires is not something most people do all the time, people won't know what to do when a flat happens to them If it was not for AAA what would people do?

Fixing a flat tire can be an extremely dangerous task considering the possible environment of low-illumination, a bad neighborhood, snowy and freezing outside, humid and hot, speeding traffic just inches away, and many, many more dangerous situations. This will result in stress which reduces people's ability to problem-solve. Even if a person knows how to fix a flat tire they would have a difficult time accomplishing this with all the stress going on. The emergency instructions in the manual, the information that is supposed to help someone in such a situation as a flat tire, has no logical order and results in causing even more confusion.

Not only does the environment cause problems, but even the users themselves. People are of varying sizes, ages, gender, and strengths. Some people may not even be strong enough to pull the spare tire out of the trunk or jack up the car. Others may have difficulty bending down to crank the jack or loosen the nuts on the wheel.

With the goal of making this task easier to do for all users, a study of the task and users was done. First, the correct task analysis was done to know what actually needs to be done to be successful at the task of fixing a flat tire. Next, the type of users and environments for this task were gathered and considered. Three users were tested by giving them the task to fix a flat tire and were observed while performing the task. From these observations problems and errors were found. These problems were interpreted and

expound upon by human factors issues and issues were also formed from the possible user types and environments. Finally, with all of these human factors issues and problems noted, solutions were created based on human factors principles. These solutions are just the beginning of ideas that will help make fixing a flat tire an easier and safer task. There is much more that could be done and developed, but that will require more research and user task analysis. As is, these solutions that have been presented are considered to be effective and beneficial ones.

The in-depth study of the task of fixing a flat tire has allowed the researchers to come up with effective and safe solutions that will help all people to fix a flat tire during unexpected and stressful situations. Hopefully, these solutions will be considered as more important than their costs of deployment. It may cost more to make these solutions happen, but it will bring safety and help to many drivers.

References

Anderson, J. R. (1990). *Cognitive psychology and its implications* (3rd ed.). New York: W. H. Freeman.

Bowers, C. A., Oser, R. L., Salas, E., & Cannon-Bowers, J. A. (1996). Team performance in automated systems. In R. Parasuraman & M. Mouloua (eds.), *Automation and human performance: Theory and applications* (pp. 243-263). Mahwah, NJ: Erlbaum.

Casner, S. M. (1994). Understanding the determinants of problem-solving behavior in a complex environment. *Human Factors, 36,* 580-596.

Cook, R. I., & Woods, D. D. (1994). Operating at the sharp end: The complexity of human error. In M. S. Bogner (ed.), *Human error in medicine* (pp. 255-301). Hillsdale, NJ: Erlbaum.

Drury, C. (1975). Inspection of sheet metal: Model and data. *Human Factors, 17,* 257-265.

Flin, R., Slaven, G., & Stewart, K. (1996). Emergency decision making in the offshore oil and gas industry. *Human Factors, 38,* 262-277.

Hockey, G. R. J. (1986). Changes in operator efficiency as a function of environmental stress, fatigue, and circadian rhythms. In K. R. Boff, L. Kaufman, & J. P. Thomas (eds.), *Handbook of perception and human performance, vol. II* (pp. 44-1/44-49). New York: Wiley.

Janis, I. L. (1982). Decision making under stress, In L. Goldberger & S. Breznitz (eds.), *Handbook of stress: Theoretical and clinical aspects* (pp. 69-87). New York: Free Press.

Klein, G. (1993). A recognition-primed decision (RPD) model of rapid decision making. In G. Klein, J. Orasanu, R. Calderwood, & C. E. Zsambok (eds.), *Decision making in action: Models and methods* (pp. 148 – 147). Norwood, NJ: Ablex.

Norman, D. A. (1988). *The psychology of everyday things*. New York: Harper & Row.

Orsanu, J. (1993). Decision-making in the cockpit. In E. L. Weiner, B. G. Kanki, & R. L. Helmreich (eds.), *Cockpit resource management* (pp. 137-168). San Diego: Academic Press.

Rasmussen, J. (1983). Skills, rules, knowledge: Signals, signs, and symbols and other distinctions in human performance models. *IEEE Transactions on Systems, Man, & Cybernetics, 13(3),* 257-267.

Rasmussen, J. (1986). Information processing and human-machine interaction: An approach to cognitive engineering. New York: Elsevier.

Rasmussen, J. (1993). Deciding and doing: Decision making in natural contexts. In G. Klein, J. Orasallu, R. Calderwood, & C. E. Zsambok (eds.), *Decision making in action: Models and methods* (pp. 158-171). Norwood, NJ: Ablex.

Sklar, A., & Sarter, N. (1999). Good vibrations: Tactile feedback in support of attention allocation and human-automation coordination in event-driven domains. *Human Factors, 41(4),* 543-552.

Spence, C., & Driver, J. (2000). Audiovisual links in attention: Implications for interface design. In D. Harris (ed.), *Engineering Psychology and cognitive ergonomics.* Hampshire: Ashgate.

Stager, P., & Angus, R. (1978). Location crash sites in simulated air-to-ground visual search. *Human Factors, 20,* 453-466.

Stokes, A. F., & Kite, K. (1994). *Flight stress: Stress, fatigue and performance in aviation*. Brookfield, VT: Ashgate Aviation.

Teague, R. C., & Allen, J. A. (1997). The reduction of uncertainty and troubleshooting performance. *Human Factors, 39(2),* 254-267.

Treisman, A. (1986). Properties, parts, and objects. In K. R. Boff, L. Kaufman, & J. P. Thomas (eds.), *Handbook of perception and human performance*. New York: Wiley.

Wickens, C. D., & Hollands, J. (2000). *Engineering psychology and human performance* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Wickens, C. D., Stokes, A. F., Barnett, B., & Hyman, F. (1991). The effects of stress on pilot judgment in a MIDIS simulator. In O. Svenson & J. Maule (eds.), *Time pressure and stress in human judgment and decision making.* Cambridge, UK: Cambridge University Press.

Yantis, S. (1993). Stimulus-driven attentional capture. *Current Directions in Psychological Science, 2,* 156-162.