# Cordless Screwdriver Inclusive Design

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# Persona(s)

**Name**: Richard **Age**: 67 **Gender**: Male **Location**: Stamford, CT

**Professional background**: Richard is recently retired. He lives with his wife. He was a lawyer and was used to working long hours so he has had a hard time settling into retirement. He wants to be able to keep himself busy and doing projects around the house is something he would find very fulfilling. Richard also has two young grandchildren who live nearby and often come over play games.

**Health**: Richard had stage 1 Parkinson's disease. He has tremors in his right hand which makes it difficult to keep items firmy gripped and in control. Since each stage of Parkinson's can last approximately 10 years, Richard is only looking for a screwdriver to be functional for stage 1 and maybe the early years of stage 2.

**User Motivation & Goals**:

- To feel competent in completing his own home repairs and have to apply minimal effort to do tasks he used to do with ease.
- Feel fulfilled by the projects he completes and valued for his work by his family.

# Persona Continued

**Tasks**:

- Richard's wife is an artist and he would like to be able to hang her paintings on the wall.
- Build a cornhole for him and his grandchildren to play with when they come over.
- Complete general home repairs

**Experience with Power Tools**:

- Richard has very average prior experience with power tools. He has used them throughout his adult years to make repairs to his home and complete simple tasks such as assembling flat pack furniture.
- His wife also has slightly more limited experience with power tools. She would not want to be the one performing these tasks for Richard's projects because she is not comfortable using them herself. She would be comfortable assisting Richard with a modified product and supervising him.

**Attitude Towards Product**:

- *" I am skeptical that motorized screwdriver could ever work for me because no power tools ever accommodate my needs"*
- *"I know a lot about my lifestyle is going to change as my Parkinson's progresses but I want to remain as independent as possible:*

# Customer Requirements/Needs

**Operational requirements:**

- To adjust fasteners with high user independence

**Functional Requirements:**

- Match the head shape to both slotted and phillips head fasteners
- Rotate in two directions
- Have multiple grip options
- Stop rotating quickly
- Store energy & convert into power
- Begin rotation with limited user force

**System Requirements:**

- Safety: user can save him/herself in event of mishap (mismaps would include missing the screw, dropping the entire product)
- Usability: require limited force/effort by user to operate
- Accessibility: needs to accommodate challenges presented by user disabilities (ie provide stability against tremors, be gripped/moved with limited force)

# Market Research

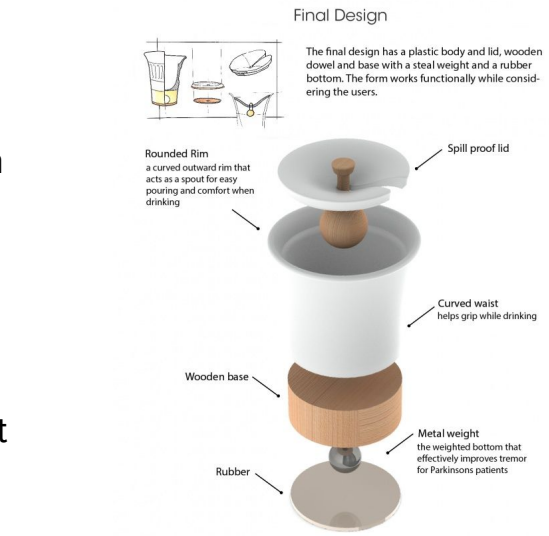
Both of these products won a James Dyson Award for inventive design and both were designed for people with Parkinson's.

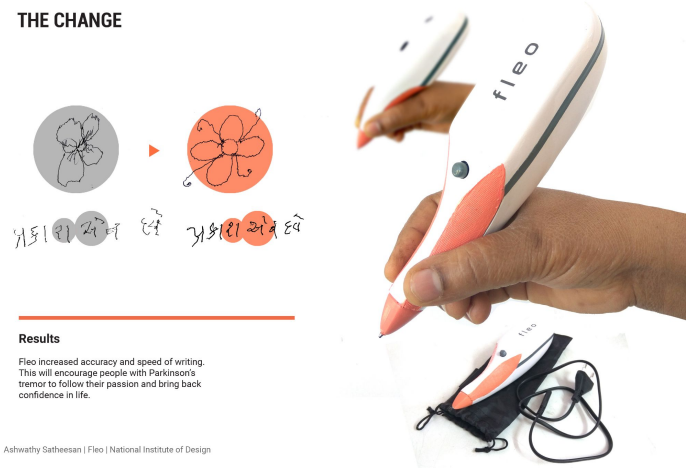
The cup (shown in the upper right) features a weighted base to reduce tremors and a spill proof lid as an active safety measure.

The pen (shown in the bottom right) also features a weighted hande. At first we found this very surprising because we assumed the added weight would be too much for someone with Parkinson's to hold. However, after reading more into the product it made a lot of sense to us that the added weight is small enough to not make the product but perfectly placed to help reduce tremors.

Adding weight to the handle of the screwdriver to reduce Richard's tremors is definitely a feature we will take inspiration from. It would allow him to be much more accurate with the placement of the fastener.

We could not find power tools that had been designed for people with Parkinson's or people in a similar age range.



# Product Issue #1

**Issue:** Richard's tremor makes it difficult for him to hold the screw still and insert the tip of the screwdriver into the head of the screw

**Solution:** Add a **MAGNETISED TIP** and a **CLEAR SCREW GUIDE** to the head of the screwdriver for easy fastener insertion and increased fastener stability.

**Justification:** In order to Richard to operate the screwdriver independently he needs to be able to align the fastener with the tip of the screwdriver. His tremor will make it particularly difficult to do so unless changes are made to the head of the screwdriver. Making the tip magnetised will allow the fastener to stay attached to the tip even if Richard needs to move the screwdriver to a new position. Although it will limit the types of fasteners Richard can use, we assume he will be buying mostly standard screws from his local hardware store that should all be compatible with a magnetic tip. The clear screw guide will help Richard more easily align the screw with the tip even with a tremor. Its round shape perfectly fits the round head of most standard screws which means the screw will be able to slide right onto the magnetised tip. These additions will make the **workflow** smoother because he will have a clear set of steps that can be completed instead of fumbling around with the screw to constantly have to align it with the tip. He will be able to insert the fastener into the screw guide and the magnetic tip will ensure he can complete the rest of his tasks without the fastener falling out.

**Note:** the key features highlighted in green match the features shown in the CAD model on slide 9

# Product Issue #2

**Issue:** Richard does not have enough strength to grip a product and hold it up while pressing the single finger trigger that activates the screwdriver.

**Solution:** Add a **LEVERED TRIGGER** to the screwdriver to replace the single finger button and **EXTRA GRIPPY RUBBER** to the handle.

**Justification:** Levered triggers as are often used for surgical linear cutters and staplers (as seen in the photo below). They require less grip strength from the user, which would be important for someone with Parkinson's because that is a function that deteriorates with age and with this disease. Adding a levered trigger is an **active safety measure**. Someone with a tremor might accidentally push the original button while trying to handle the screw driver. However, the levered trigger requires the entire hand to be placed over it which will help reduce the risk. The triggered lever is also a better replacement than other types of controls because it will automatically stop the screwdriver when the user releases, rather than requiring a manual stop. The extra grippy rubber will also help the user hold onto the screwdriver and keep them from dropping it. This also makes it an **active safety measure**. Because it reduces the probability of an accident.

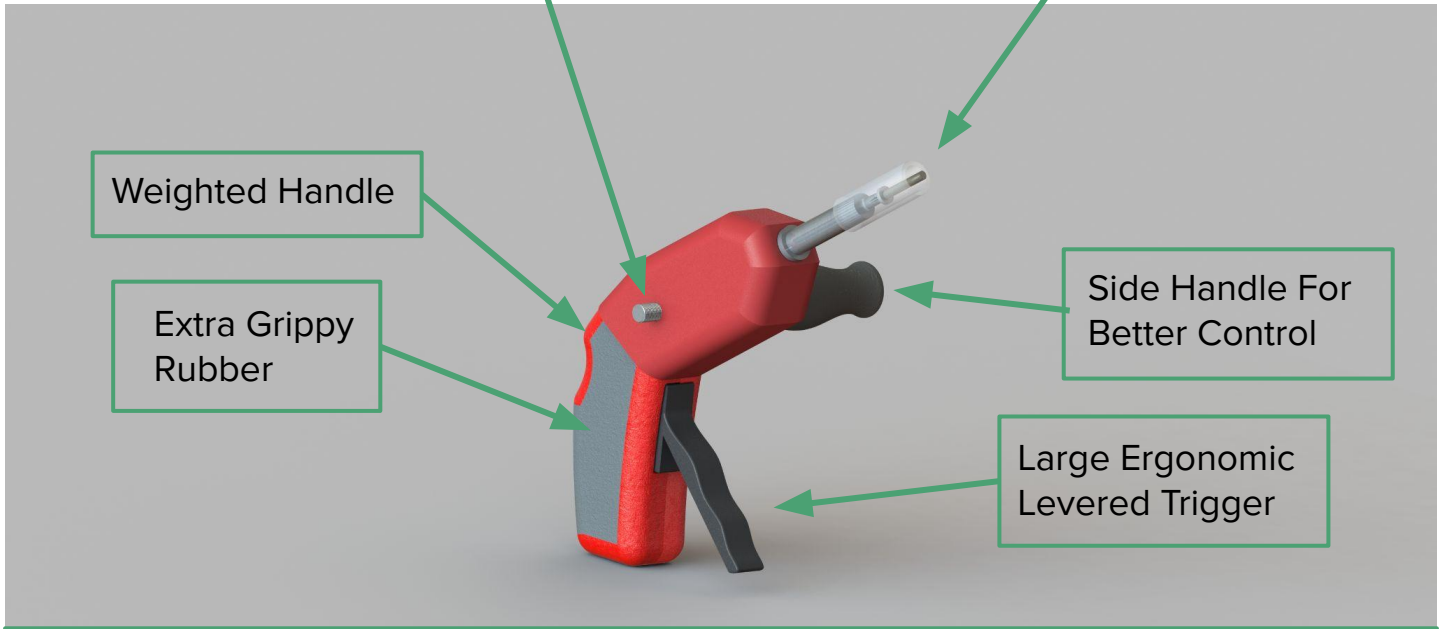
# Product Issue #3

**Issue:** The tremor will make it difficult for Richard to accurately place the fastener into the material he is using. He may miss his marked location or insert the screw crooked. This would be particularly important for him if he is hanging a framed art piece.

**Solution #1 & Justification:** **WEIGHT THE HANDLE** of the screwdriver above the extra grippy rubber. Although this may seem counterintuitive because of Richard's grip strength, a small amount of weight will not make the screwdriver too heavy to hold. It will reduce the impact of his tremors. Especially because the weight will sit above the hand when the screwdriver is in pistol grip it will make the screwdriver more stable by dampening the tremor.

**Solution #2 & Justification:** Add an **AMBIDEXTROUS SIDE HANDLE**. Similar to the handle shown on the right, but smaller, the side handle on the screwdriver will allow Richard to operate the product with two hands. This will improve stability by providing more force to counteract the tremors, allow him to use more force to hold the screwdriver, and be an **active safety measure** because he will not be able to accidentally miss his mark and screw the fastener into his second hand. The handle we add can be removed and reattached on the other side of the screwdriver so that people who are both left and right hand dominant can use it. Although the change of handle position would most likely need to be performed by a supervisor, it is a small price to pay for the independence the handle will provide once installed on the correct side.

# CAD Model:




More views of the model are available in the user testing powerpoint. Blair Horning and his Project I group gave us access to their CAD files to edit.

## Labels / Instructions

- The **AMBIDEXTROUS SIDE HANDLE** is one additional feature that will require thorough instructions. Without directions on how to change the side of the screwdriver it sits on, it would not be obvious to the user how to perform that task or that it is even possible.

- There are no added features that should require additional safety labels from what the product had to start out with.

- Since it is marketed for users with Parkinson's additional warning labels should be added instructing users to have a supervisor nearby or present because there is an increased risk associated with the disabilities of the user group.

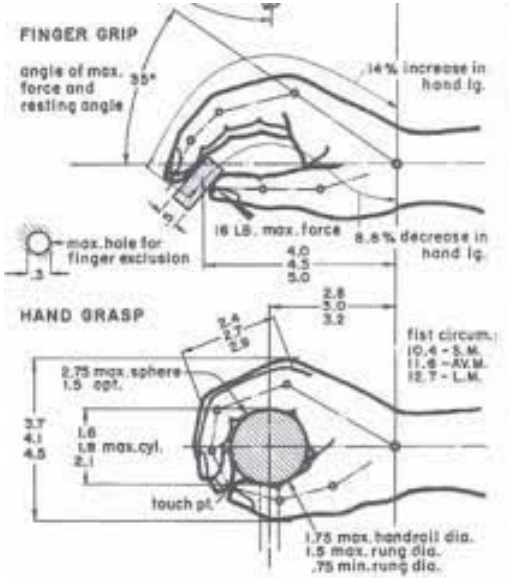
## Controls / Feedback

- The **CLEAR SCREW GUIDE** provides visual feedback to the user that the fastener is stable and ready to be inserted. If the fastener is not within the screw guide the user will not be able to employ it.

- The **LEVERED TRIGGER** provides resistance as it is pushed which tells the user that screw driver should be about to turn on. Additionally the sound of the motor running and the visual feedback of the screw spinning should let the user know the screw driver is on and that they have pulled the control far enough.

# Anthropometric Considerations

- Hand grip strength → will need to determine user's ability to squeeze grip/trigger such that the screwdriver does not fall out of the user's hands and the user has optimal control over the screwdriver even when pressure is being applied
- Hand grip size → user's will inevitably have varying grip sizes. The size of the **LEVERED TRIGGER**, **MAIN HANDLE**, and **AMBIDEXTROUS SIDE HANDLE** will need to account for users particularly at the smaller end of the range.
- Finger grip → Will dictate the user's ability to squeeze a trigger or hold a screw to be inserted into the screwdriver
- The aforementioned measurements will give us a good sense of the user's general hand and finger dexterity



# Anthropometric Considerations (grip strength)

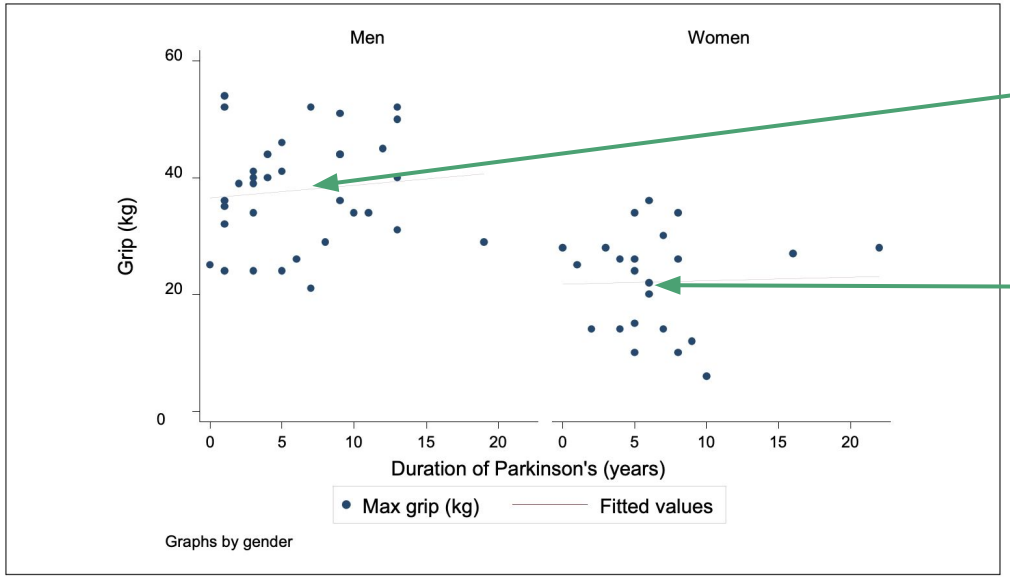



**Figure 4.** Association between grip strength and duration of Parkinson's in men and women.
Fitted values estimated from sex-specific simple linear regression models for grip strength as the dependent/outcome variable and duration of Parkinson's as the independent/predictor variable. Correlation coefficients between grip strength and duration of Parkinson's were $r = .11$, $P = .55$, for men and $r = .03$, $P = .88$ for women; partial correlation between grip strength and duration of Parkinson's among men and women combined but adjusted for gender was $r = .08$, $P = .56$.

Richard (5 years into Parkinson's Disease, ~38 kg of max grip strength)

Women have a much lower grip strength than men, with an average of closer to 20 kg

While this anthropometric measurement is an important design constraint. The screwdriver at most would weigh 2 kg, including the the added tremor weight. This means that all but the smallest percentile of elderly with Parkinson's should be able to grip the product.

https://journals.sagepub.com/doi/pdf/10.1177/1545968315570324

# Anthropometric Considerations (grip size)

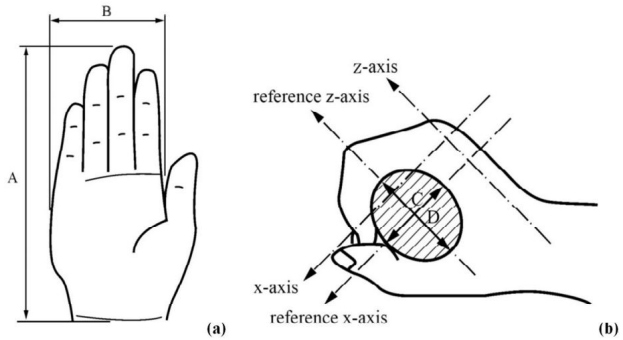



**Figure 1.** The definitions of the dimensional measurement of hand: (a) A, B, C, and D dimensions were measured with a caliper. (b) The grip gesture was determined by the biodynamic hand coordinate system defined in ISO 8727 [17].

**Table 1.** Definitions of hand measurements.

| item | definition |
|---|---|
| A hand length | distance from top of the middle finger to the distal crease of the wrist. |
| B hand breadth | maximum hand breath where the fingers join the palm |
| C grip breath inside width diameter | inside hand elliptical diameter with the length of major axis measured at grip breadth |
| D grip breath inside length diameter | inside hand elliptical diameter with the length of minor axis measured at grip breadth |

**Table 2.** The results of hand dimensions (unit: mm) (standard deviation of the mean in parentheses).

| item | | This study | | Wang et al. (2002) |
|---|---|---|---|---|
| male | A hand length | 187.9 | (7.9) | 183 |
| | B hand breadth (four fingers) | 83.6 | (4.8) | 86 |
| | C grip breath inside width diameter | 44.5 | (5.3) | - |
| | D grip breath inside length diameter | 35.6 | (4.9) | - |
| female | A hand length | 167.9 | (6.6) | 167 |
| | B hand breadth (four fingers) | 75.2 | (6.2) | 75 |
| | C grip breath inside width diameter | 32.2 | (4.5) | - |
| | D grip breath inside length diameter | 25.7 | (5.0) | - |
| all | A hand length | 177.9 | (12.4) | 175 |
| | B hand breadth (four fingers) | 79.4 | (6.9) | 80.5 |
| | C grip breath inside width diameter | 38.3 | (7.9) | - |
| | D grip breath inside length diameter | 30.7 | (7.0) | - |

For both males and females, the average grip breath inside width/length diameter values will be used to inform the size of the grip of our screwdriver

https://www.matec-conferences.org/articles/matecconf/pdf/2017/33/matecconf_imeti2017_01044.pdf

# User Testing Results

Both users were able to complete all of the tasks very quickly and with limited errors.

They reported high levels of satisfaction and said the designs were intuitive and easy to understand.

Both users thought the inclusive design solutions would make it easier for someone with Parkinson's to operate the screwdriver. In particular they liked that the handle had the ability to be ambidextrous. They could not think of recommendations for features  to change.

The test subjects  were able to recognize this function on their own with no instruction.

We were only able to test the clear screw guide, levered trigger and ambidextrous handle with these user tests because it is impossible to tell that the handle is weighted or that the tip it magnetised just from visual identification in the digital prototype.

**Caroline** -
age: 20
no engineering or design experience, standard experience with power tools

| | Errors: | Time: |
|---|---|---|
| Task 1 | 1 | 25 sec |
| Task 2 | 0 | 17 sec |
| Task 3 | 0 | 31 sec |
| Task 4 | 0 | 14 sec |

**Sami** -
age: 20
Engineering Psychology major,
limited power tool experience

| | Errors: | Time: |
|---|---|---|
| Task 1 | 1 | 28 sec |
| Task 2 | 0 | 15 sec |
| Task 3 | 0 | 22 sec |
| Task 4 | 1 | 37 sec |

# User Testing Reflections

It was very fulfilling to receive positive feedback from our user tests. However, that does not mean they were successful. Ultimately, our two users have none of the disabilities that come along with being an elderly human with Parkinson's disease so their feedback is still very biased.

The most confusing feature on the screwdriver was the clear screw guide. It wasn't immediately obvious to users that it would fit the fastener and hold it steady. However, both test subjects were eventually able to identify this feature after really observing the zoomed in view of on the digital prototype. This is a feature that will need clear instructions for its purpose and how to utilize it.

The interaction with our target audience would likely be very different than the user testing we performed in this project. Since our testing subjects were all very familiar with technology and powerpoint, in particular, they were able to quickly navigate through the digital prototype and identify the correct procedure for each task with only the initial instructions.

However, if the target user group were to perform testing it would likely take a greater amount of time and produce a wide variability of results. Not only would the target user group need more time to operate the digital prototype but it is likely not all subjects would even understand the what the digital prototype was showing. We tried to have Maddie's grandmother, who is 81 and has Parkinson's, perform a user test but she was unable to navigate the prototype virtually and therefore could not complete the outlined tasks. For other target users who are much older than Richard, they would probably perform better with a physical prototype. Some elderly might be able to operate the digital prototype with limited struggle and others might fail completely yielding varied results.

# Reflections

- This project certainly challenged our design capabilities and showed us just how difficult it is to create a product that is inclusive for many users
- Based on the operational and system requirements laid out for the product this redesign should be successful for our target user. The screwdriver meets the main constraint of offering a high level of independence for the user, takes into account active safety measures to reduce risk and utilizes a lot of visual and force feedback to help the user operate the product. Additional instructions and labels are needed, as with any redesign, but should be manageable to add to the original packaging.
- Since the screw driver uses many of the original dimensions, it should remain within the desired anthropometric constraints.
- That being said, we have no way to conduct accurate user testing. We were unable to build a physical prototype and did not have access to the target audience for user testing on the virtual one.