**REVIEW**

# TOOL AND TASK DESIGN CHALLENGES FOR LEFT HANDERS: A BRIEF REVIEW

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## ABSTRACT

Left-handed users are often overlooked by equipment and hand tool designers. Designers may assume that left handers will eventually learn to adapt themselves in a right-handed environment. However in reality left handers face a lot of difficulties when trying to perform tasks meant for right-handed users. Medical personnel are most affected by this issue, followed by workers in non-medical field such as services and manufacturing. This review aims to highlight the issues faced left handers by analysing common household product examples as well as hand tools in occupational settings. Discussions are centred on the differences between the right-handed tools versus left-handed tools, as well as task/procedural challenges faced by left handers. In summary, the notion of designing an ambidextrous tool may not be a realistic recommendation for tool manufacturers and designers.

***Keywords:*** *Left hander, handedness, product design, medical*

## INTRODUCTION

Sidedness or laterality refers the preference shown in human for one side of the body compared to the other, typically right or left, such as handedness and footedness. Handedness is the most significant behavioural asymmetry as it is intimately related to brain specialisation with language (Zverev & Chisi, 2004). Three forms of handedness exists namely right-handedness, left-handedness, and mixed-handedness, also known as ambidexterity. The majority of human population worldwide is right-handed while left-handers are in a constant minority approximately ranging from 10 to 25% of people in most societies (Schmauder, Eckert, & Schindhelm, 1993; Zverev & Chisi, 2004). Historically, left-handedness was considered a disability and a social stigma as it is negatively associated in many languages such as the devil depicted as left-handed (Tchantchaleishvili & Myers, 2010). These misconceptions were proven to be untrue due to advances in neurology and psychology.

The left-handers community still faces several challenges nowadays especially involving right-handed instruments and tools. Since commercialisation favour mass production for the majority, left-handers are at a disadvantage when using the products tailored for right-handers as they have to learn quickly and adapt as much as possible to use the tools which would affect performance. Most emergency machine controls favour the right-handed persons and this may have safety implications (Mackenzie & Peters, 2000).According to a study on agricultural farm tools by Parvez and Shahriar (2018), 67% of occupational injuries were caused by poor hand tool design. Poorly designed hand tools can cause hazards in the workplace, despite the fact that they were designed for right-handed users and therefore left handers will face a lot more difficulty in this regard.

Training left-handers for task designed for right-handers using instruments is also a major concern (Tchantchaleishvili & Myers, 2010). Left-handed females are even more disadvantaged since their grip strength can be reduced by almost 2/3 (Miller & Freivalds, 1987). Existing product design guidelines only states the fact that any product should be designed for the usage of either hand. However in reality, many left handers face a lot of difficulty manipulating products or tools designed for right-handed users, especially in the medical field (Adusumilli et al.,2004; Bernstein, 1988; Burdett et al., 2016; Kaya & Orbak, 2004).

In the current guidelines of hand tool design, handedness is not discussed in detail. Contents of the hand tool guidelines primarily focuses on design of handle grip, effective weight of the tool, design of trigger, vibration characteristics, user characteristics and general characteristics as described in the guideline by Mital and Kilbom (1992). Three different

solutions are available namely work redesign, reduction of exposure time to task, and reduction of exposure by tool redesign. Handedness is included in the design of trigger and user characteristics. The trigger should be designed for use by distal phalanges of the fingers of either hand especially for tasks requiring precision for prolonged duration. Both left-hander and right-hander should be able to use the tool equally. However, there are not many examples of ambidextrous tools in the market currently.

Some products are left-handed solely for aesthetics and not for functional purpose such as mugs, pen, and pencil with logos or brand stamps facing left-handed users upright instead of upside-down traditionally. However, the application of correct orientation of left-handed tool such as measuring tape and ruler provides convenience upon usage as the numbers on the scale could be read easier upright. Left-handed products are designed for better grip and dexterity for left-handers since conventional tools required them to use non-dominant hand which has lower grip strength such as baseball mitt and pencil grips. Accessibility is also a concern as left-handed users could not access button and software feature easily on devices such as swiping or pressing out-of-reach button on one-handed smartphone when holding using the left hand.

A brief review related to issues pertaining left-handedness is presented here in the paper, illustrating some common hand tools in medical and non-medical settings. This review was written with the aim of determining the current state of knowledge on left-handedness and product design, focusing on medical and non-medical applications, and pointing out further research work required. The review starts with the discussion of the current left-handed products in the market and the reasons for their demand, followed by issues and examples from the medical field. This paper concludes the discussion with areas for further research.

This paper is primarily aimed at looking at the broad overview of the issues related to left-handedness in relation to product and task design challenges, by describing various examples of left-handed products available in the market, with focusing on hand tools. Researches on left-handed tool design are not very common; therefore this brief review can be used by researchers as a starting point to further their work. Before embarking on a research focusing on left handers, an understanding on the issues faced by left handers concerning hand tools is needed.

**Left-handed vs Right-handed Products: A Comparison**

Left-handed products gain attention by product designers as some products would not function using left hand. For instances, typical plasterer's float could only be moved in one direction, normally from right-to-left for a right hander and angled face of a golf club has to be reversed to face the direction of the swing for left-handed golfer. Cutting instruments such as scissors, sickle, scythe, knives, and peeler have reversed blade arch from right-handed ones to allow left-handers to use them comfortably in best natural cutting motion instead of using their non-dominant right hand, which lowers risk of injury. The examples below illustrate the major differences of left-handed tool designs, as well as the how they function as compared to right-handed tool equivalent. Examples from medical and non- medical settings are described.

**Task and Tool Design Challenges in Medical Settings**

The small population number of left-handers is widespread to every work field, creating challenges only encountered by the group adapting to working environment favouring right-handed design. In medical field, a survey showed that left-handed preference by practitioners in performing surgery was in 9.3% (Makay, Icoz, & Ersin, 2008). The low number created problems in training of new surgeons as surgical instruments are not adapted to left-handed use and the lack of mentoring on laterality (Tchantchaleishvili & Myers, 2010). The lack of ambilaterality training by professionals led to significant pressure for left-handed trainees to change hand laterality during training, resulting in anxiety among trainers and residents. Only a small fraction of left-handed surgeons received specialized laterality training (3%) due to lack of programs provided by trainers (10%) and more costly left-handed instruments (13%) (Adusumilli, Kell, Chang, Tuorto, & Leitman, 2004). However, left-handers adjusted to the condition after experiences enrolling in work field. The study also revealed that 86% of surgeons agreed laterality had no adverse effect in surgery performance. Although not prominent, stigma of left-handers has fewer competencies than right-handers persisted as 14% of surgeons refused to be operated on by a left-handed surgeon in the study. Left-handed dental students performed significantly better when working on the left side of the patients than on the right side, even better than right-handed students from the right side (Kaya & Orbak, 2004). The better performance might be due to left-handed preference in dentistry as observed when transferring and picking the instruments (Singh, Jain, Sinha, Chauhan, & Rehman, 2014).

Certain surgical operations such as situs inversus or left lower limb operations might present an advantage for left-handedness (Tchantchaleishvili & Myers, 2010). In addition, according to Tchantchaleishvili (2010), surgical instruments, both conventional and laparoscopic, are not adapted to left-handed use and require ambilaterality training from the resident. There is significant pressure to change hand laterality during training. However, left-handedness might present an advantage in operations involving situs inversus or left lower limb operations.

### *Surgical Tools: Needle Holders*

A more detailed explanation on left-handed issues can be found in the surgical field where scissors and needle holders are extensively used by surgeons. Challenge in handling traditional instrument is observed when opening right-handed needle holders, hemostats, and other locking instruments as left-handers must either reverse the usual motion or learn to use with their non-dominant hand (Bernstein, 1988).

Detailed examples were elaborated in a study on standard medical instruments which cause left-handed surgeons difficulties during surgical procedure (Burdett, Theakston, Dunning, Goodwin, & Kendall, 2016). One example is needle holders. Usually needle holders are held in place by a mechanism which consists of toothed serrations near the handle, and it is often locked and unlocked using the thumb and fingers. Left-handed surgeons usually face difficulties to push the upper handle of needle holders further enough to unlock them. Instead, they have to perform an awkward manoeuvre of pulling the needle holder causing discomfort to them. Left-handed needle holders alleviate this problem by reversing the unlocking mechanism so it can be unlocked by pushing using left fingers, just like the users of the right-handed needle holders.

## Task and Tool Design Challenges in Non-Medical Settings

### *Scissors and Pliers*


**Fig. 1 Left and Right-handed Scissors [Digital Image]. (n.d.). Retrieved from quora.com**

For left-handed cutting tools such as scissors and pliers, the left blade is designed in such a way that the left blade will be on top. The left blade will be responsible for initiating the cutting action. Left handers will use their thumb and fingers in a more natural way. Compared to using the normal right-handed scissors, left handers have to move their thumbs and fingers in an awkward way, which causes discomfort.

The case of right-handed scissors is similar to typical scissors as the right blade is on top whichever way up they are held. When closing the scissors, the thumb placed through the top handle pushes gently while the fingers in the bottom handle pull towards the thumb. This is clearly illustrated in Figure 1. A typical cutting operation can be described as follows: the thumbs will operate the upper handle by pushing it to the right while the fingers will pull the other handle to the right. So the right blade is counteracted by the left blade moving to the right resulting in a straight cut. In this manner, surgeons or any other users will be able to see the cutting line and thus cutting can be performed precisely. Conversely, when the normal right-handed scissors are held by left-handed users, the upper blade remains on the right side. The fingers pull the lower handle from the left to the right, resulting in the blade to move to the right. The thumb pushes the upper handle to the right, causing the lower blade move to the left. The final result is right blade moves right and the left blade moves left. To compensate the resultant gap which causes the material being cut to fold between the blades, more force is applied upon cutting by placing the thumb far into the ring of the upper handle so that they can pull (rather than push) it, whilst jamming their finger against the inside wall of the lower ring to push rather than pull. This technique still has limitations as smaller hands are less effective and thicker material requires greater force. Unconventional cutting method is also developed by left handers by moving their left hand across their body and holding the scissors to the right of the midline, which is still less comfortable and inefficient than typical method due to limited muscle groups involved. Left-handers can alternatively angle the top blade angled away from them but as a result they are cutting at a slant. The design solution is to reverse the blades of the scissors (Fig. 1).


**Fig. 2 Left and Right-handed Pliers [Digital Image]. (n.d.). Retrieved from optazoom.com**

Pliers in general also work by similar principles like scissors, but with a slightly additional purpose. Gripping and cutting are the two main tasks performed by pliers, unlike scissors which only perform cutting tasks. However, pliers are mostly suitable for cutting wires or cables, and they are not suitable for cutting sheet metal or cloth like scissors. Since gripping pliers do not perform cutting tasks like scissors, their jaw grippers are always on top of each other. However, their handle designs are critical when it comes to laterality. Typical pliers are designed with symmetrical curved handles such as in Figure 2. However, left-handed pliers are designed in such a way that the right handles are curved to fit the left hand grip better as compared to the typical plier design in Figure 2. This ensures a better grip for left-handed users, leading to a better task performance overall.

***Knives***

A right-handed knife has the serrations on the left side of the blade to counteract the natural twisting motion of the hand resulting in a straight cut when slicing. A left hander often gets curved slice when cutting using the knife as the serrations exaggerate the natural hand twisting. In order to solve this problem, a left-handed knife has serrations on the right side of the blade instead. Similar in the way that the left-handed scissors are designed in a unique way, the knife for left-handed users are only most effective for left handers and not the right handers.

**Spanners**

Compared to the cutting tools described above, spanners are used for tightening and loosening bolts and nuts. The head of the spanner fits tightly around the fastener and grips the fastener. When the spanner handle is turned torque is produced resulting in the loosening or fastening the nuts or bolts.

The issue with the right-handed spanners being used by left handers lies with the orientation of the spanner itself. Tightening or loosening fasteners require the spanners to be in a particular position. Referring to Figure 3 the correct way to turn is to place the spanner so that the force on the movable jaw is directed towards the wrench body. By placing the spanner in the right position and pulling the handle towards the user, a greater amount of torque can be produced hence making the task easier. The right way of handling the spanner places the resultant force on the fixed jaw as compared to the wrong way which puts the resultant force entirely on the movable jaw. Operating the spanner in a wrong way can cause the movable jaw to break. This is precisely where the problem lies with handling the spanner in the left hand, where the possibility of using the spanner in the wrong way increases. The left handers have to move their left hands away from their body (adducting their arms) instead of pulling the spanner towards them like right handers. This may reduce the amount of torque being produced, resulting in more exertion for left handers.

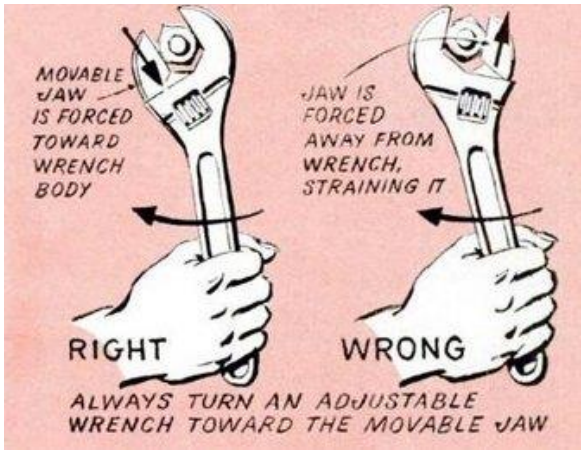


**Fig. 3 Correct way of using spanners [Digital Image]. (n.d.). Retrieved from https://www.artofmanliness.com**

**Can opener**

**Fig. 4 Left-handed can opener (Right) [Digital Image]. (n.d.). Retrieved from amazon.com**

Among the kitchen utensils, can opener is the most challenging tool to operate in the hand of left-handers. Conventionally, the user places the sharp wheel of the can opener onto the lip of the can. As the left hand squeezes the tool upper and lower levers towards each other, the can opener clamps the lip of the can while the

sharp wheel digs into the lip of the can piercing it. The dominant right hand then twists the knob with force which turns the sharp wheel around the lip of the can in a clockwise motion till finally the can is cut open. The entire process could not be performed conveniently by left-handers as the knob is on the right side of the tool and must be rotated using the right hand. Gripping the levers with the left hand puts the user in an awkward posture when reaching the knob with the left hand on the right side of the can. The solution to the design for left-handers is to reverse the right side and left side of the can opener placing the knob on the left side and thus could be rotated counterclockwise (Fig. 4) which is the opposite direction from the standard tool, the sharp wheel rolls in similar fashion around the lip of the can resulting in an overall counterclockwise rotation.by the left hand. As the knob rotates the sharp wheel opens the can easily for the left-handed users.

**Computer mouse**

A left-handed mouse is the mirror image of the right-handed mouse. The shape of the mouse fits the left palm better as the groove on the sides is suited for the thumb and the ring finger to rest when holding it. The two clicking buttons are switched to function similarly the right-handed mouse clicking gesture in which the index finger clicks to perform most gesture such as selecting icons, dragging files and opening windows while the middle finger clicks are for showing secondary option menus. A gaming mouse also has additional buttons for thumb placed above the thumb rest which could not be accessed by left-handers with right-handed mouse as the lengthy ring finger is that thumb rest instead. The user could reach these buttons by bending the ring finger and pinky finger onto the buttons but it would result in bending all fingers simultaneously and tilting the mouse to right when moving it which causes awkward hand posture. The reason for the typical mouse to be used by the right hand is the precision of the dominant hand to move the mouse according the cursor on the desktop. When the non-dominant hand is used instead, the mouse user takes more time to point the cursor which in turn lowers user performance.

**Ambidextrous tools**

A call for ambidextrous tools availability has been long sought for by left-handers since they accommodate both hands, eliminating the bias for right-handed design. However, the actualization of this concept is complicated for current hand-specific tools. Some existing tools are ambidextrous by nature without alteration of traditional design. Tools with a long handle such as broom, mop, and shovel require both dominant and non-dominant hands to function properly. Small one-handed tools such as toothbrush, spatula, syringe, and hammer could be used by either hand. Ambidextrous redesign is not necessary for these tools as switching hand does not impact the usability but hand-specific tools require unconventional redesign to fill this need. Some previously right-handed exclusive tools already exist in the market as ambidextrous tools such as fruit peeler and can opener by placing the placing the blade in the middle of the tool design. The new design deviates from the conventional design which raises a concern in user preference based on familiarity and skill learning of new tool usage.

**CONCLUSION**

Left handers face a significant challenge in their lives as well as in the working environment, due to the fact that not many equipments and tools can be suited for left handers. The idea of designing an “ambidextrous tool” does not seem to fit the reality for left handers since the working principles of hand tools and products are primarily meant to be operated by right handers. The examples of household products such as scissors, knives, and writing instruments illustrate the difficulties faced by left handers when using the products. The success of task performance is highly apparent on how the product is being operated by left handers versus the right handers, since the tool or products utilize the finger and hand grip strength to produce optimal task performance. Similar issues are seen in the medical field in terms of their tool design, where the usage of a right-handed scissors by a left-handed surgeon causes the surgeon to exert more cutting force while performing the same procedure as compared to the right-handed surgeon.

**COMPETING INTERESTS**

There is no conflict of interest.

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