Assessment of a clothes iron with respect to the needs of the elderly

Contents

Introduction

The purpose of this report was to analyse a previously unknown product based on a checklist designed to consider the needs of elderly users.

There are multiple definitions for 'the elderly' from different organisations. For the purposes of this report, they shall be characterised as people aged over 65. This is based on WHO (2002) (and use in literature for UK populations (eg Smith, Norriss and Peebles, 2000). 'The elderly' as a group are in many ways more vulnerable than their younger counterparts, and while they will be referred to here by this group for the sake of simplicity, it should be noted that it is far from homogenous (Fisk, 1993).

Carroll (1993:8) defines ability (synonymous with 'capability' for this report) as "the possible variations over individuals in the liminal levels of task difficulty… at which… individuals perform successfully on a defined class of tasks" - the *limits* of how an individual performs in a given measure.

Following inclusive design principles, it is not the average case that should be considered, but those with the least capabilities in each dimension - if a product becomes usable for people who would otherwise struggle most (up to incapability), it will become even easier for those who previously did not struggle. Good inclusive design expands the range of potential users by lowering product demands without being stigmatizing. (Persad, Langdon and Clarkson, 2007a). The General Product Safety Regulations (GPSR; 2005) states that the elderly "shall be taken into account in particular", making their consideration a legal necessity.

The elderly tend to have limited capability in sensory, cognitive, and motor-based dimensions (better specified later). Many also suffer from articular (joint-related) problems, commonly osteoarthritis (OA) - "the leading cause of disability in later life" (March and Bachmeier, 1997).

Assessment Method

Checklist development

The checklist was influenced by 2 key principles from Weiser et al. (2010): “[support] clinical practice without attempting to substitute a rigid algorithm for professional judgement”, and “focus on items that are… high risk and known to be recurrently overlooked or missed”. As the product was unknown, the approach would have to be able to appraise a wide variety of possible product types.

Persad, Langdon and Clarkson (2007a) provide a model of usability wherein a product has certain demands of a capability, a user has a set of capabilities, and usability problems occur at the interface between these. As such, it was decided that the approach should iterate through the interfaces and determine which capabilities may be challenged at each one. As the brief specifies a focus on elderly users, their capabilities will be matched against the product demands.

The first iteration of the checklist comprised the Seven Principles of Universal Design (Story, 1998). These principles could all be considered ‘user requirements’. They are useful as a framework for describing design issues, but do not (when used alone) present a methodological process for analysing a product.

Interface type

Product evaluation methodologies were found that emphasized different approaches. Some of these are shown together in Table 1. Together, these provided multiple dimensions from which to analyse a given product.

#	7 Principles of Universal Design	Honeywell (1992)	Vanderheiden and Vanderheiden (1991)	Persad, Langdon and Clarkson (2007b)
1	Equitable Use	Controls	Output/Displays	Product chassis including handles
2	Flexibility in Use	Visual displays	Input/Controls	Displays and indicators
3	Simple and Intuitive Use	Auditory displays	Manipulations	Controls and Control Groups
4	Perceptible Information	Functional allocation and panel layout	Documentation	Material and media input and output
5	Tolerance for Error	Operating protocol	Safety	Connectors for energy and data
6	Low Physical Effort	-	-	Software interfaces
7	Size and Space for Approach and Use	-	-	-

*Table 1: **Comparison** of approaches to breakdown of analysis*

Although providing useful categories to analyse, both Honeywell (1992) and Vanderheiden and Vanderheiden (1991) mix different axes of measurement within their list of features to analyse (e.g. ‘Safety’ and ‘Input/Controls’ are not of the same category). They also primarily consider the more abstract topic of interaction type. Persad, Langdon and Clarkson (2007b) improve on this by decomposing analysis into just the interface *features* between product and user. Their analysis conspicuously lacks assessment of documentation so that was added to the checklist as well.

User Capabilities

Persad, Langdon and Clarkson (2007a) - present a bottom-up hierarchical model of capabilities. Dimensions from that paper comprise 1-3 in Table 2, accompanied by references demonstrating the elderly’s reduction in capacity therein.

Characteristic	Reference(s)
1. Sensory	
a. Visual	
i. Visual acuity	Pinto *et al*. (1997); Haigh (1993)
ii. Contrast sensitivity	Haigh (1993)
iii. Colour perception	Haigh (1993)
iv. Useful field of view	Scialfa *et al.* (1994)
v. Stereopsis (depth perception)	Haigh (1993)
b. Auditory	
i. Pure tone detection thresholds	
α. (High) Frequency	Haigh (1993)
β. Volume	Haigh (1993)
ii. Speech recognition (for men)	Dubno *et al.* (1997)
iii. Sound localisation	Cranford *et al.* (1993)
2. Cognitive	
a. Working memory (WM)	
i. Storage capacity	Salthouse and Babcock (1991)
ii. Processing speed	Salthouse and Babcock (1991)
b. Long-term memory (LTM)	
i. Recall	Craik and McDowd (1987)
ii. Recognition (to lesser extent)	Craik and McDowd (1987)
c. Mental models (based on WM & LTM)	*Cañas, Antolí and Quesada (2001)**
d. Language processing speed	Brébion (2001)
3. Motor	
a. Upper limb capabilities	
i. Reach ranges for each arm	Smith, Norris & Peebles (2000)
ii. Force exertion	Goodpaster *et al.* (2006)
ii. Grasping, dexterity	Carmeli, Patish and Coleman (2003)
b. Gross body movement capabilities	
i. Bending ranges	Smith, Norris & Peebles (2000)
ii. Locomotion	Prince *et al.* (1997)
4. Anthropometrics	Smith, Norris & Peebles (2000)
5. Errors	Reason (2000); Norman (2002)

Table 2: Age-related characteristics with design consequences.
**N.B. Cañas, Antolí and Quesada (2001) discusses the relationship between WM, LTM and mental models, not the influence of age directly*

As the analyst was familiar with these characteristics, using the complete list erred towards verbosity with diminishing gains. Including the first 2 levels (*1*… and *a*....) seemed an appropriate compromise.
Another question is whether the design accounts for the anthropometric dimensions and variation of the elderly population. Dimensions that seem suspect for fit, reach, clearance, posture, entrapment, exclusion (Smith, Norriss and Peebles, 2000: 23) should be measured for later evaluation. (4. on Table 2)
Although not framed as a capability, errors may be induced/exacerbated by interface/design features (Norman, 2002). (5. on Table 2)

Context/Stage/Modes of Use

Product demands may be different at each stage of use.

GPSR (2005) requires consideration of “putting into service, installation and maintenance”, and a product’s “composition [and] packaging”.

BS EN ISO 26800:2011 suggests “consideration of usability issues at all stages of the life cycle, including... long-term use, maintenance, disposal”. As well as the other modes mentioned, long-term use could include storage, charging, learning to use, experienced use, among other product-specific modes, such as stopwatch/alarm setting/time on a wristwatch.

Combined checklist

Thus the checklist will comprise the 3 orthogonal (but not independent) axes of analysis - interface, capability and context - along with a redundant 4th axis that cuts across the others: user requirements.

Equipment

The equipment taken to the assessment was minimal:

- Checklist (see Appendix A)
- Pen, spare paper - for making notes
- 30cm ruler - for making basic measurements
- String - combined with the ruler for measuring curves

- Camera - for illustrating issues

Procedure

A procedure emerged naturally from the decided dimensions:

1. Identify all the interfaces of each type on the product
2. For each of the interfaces, in each context of use:
    2.1. Go through each of the capabilities:
        2.1.1. Consider demands vs capabilities in that dimension (this may involve physical measurement)
        2.1.2. Note (and photograph) any issues
3. For each of the 7 principles of universal design:
    3.1. Go through each sub-guideline
        3.1.1. Determine whether any violations occur that are not already mentioned

Results and Discussion

The scope of this report does not permit an in-depth analysis of every issue found. Multiple issues will be mentioned to demonstrate their range, with only the most serious (with regard to effect on the elderly) analysed in more detail. See the evaluation notes in Appendix B for more issues and their interface-categorization.

Handle

– Parallel with base of iron - requires ulnar deviation or extension of wrist (or change in shoulder angle and drastic reduction of mechanical advantage) - painful with OA, and diminishes effective strength.

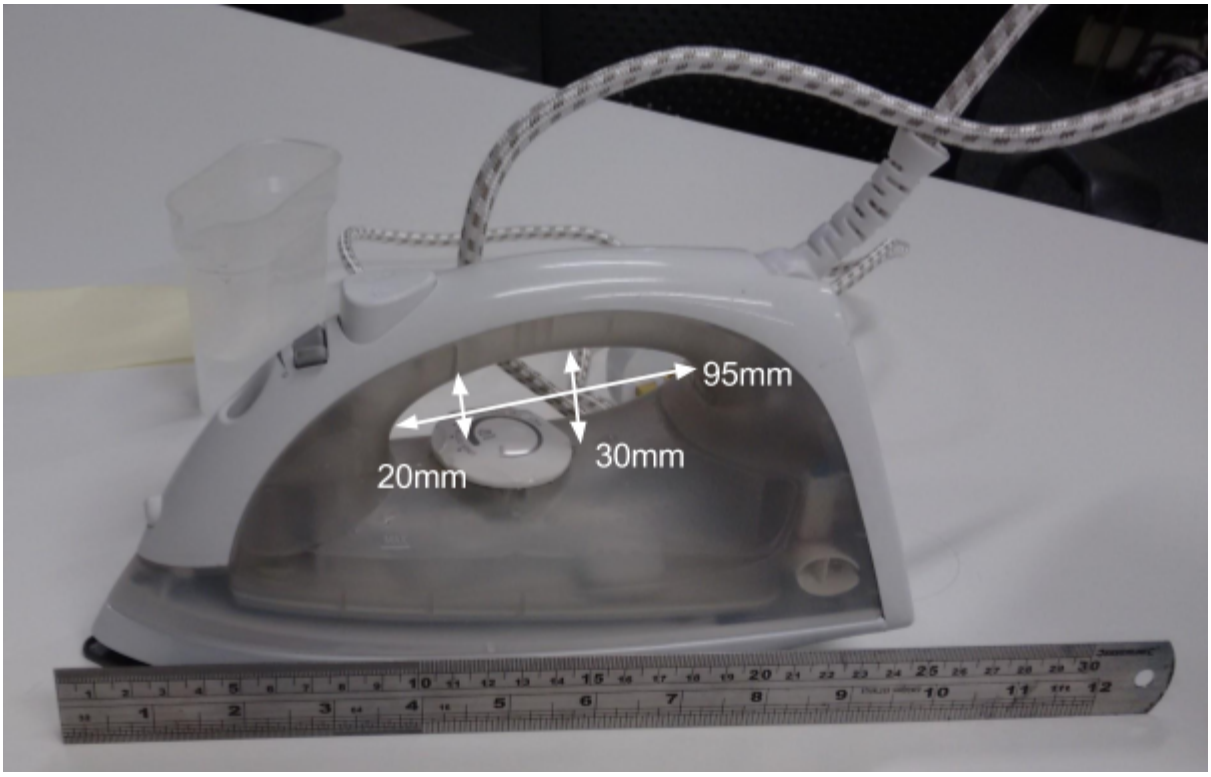


Figure 1: Side view of iron, with dimensions

– Only usable with 1 hand - there is neither the handle length (95mm) for adjacent hands nor the clearance (20mm between dial and handle) for overlapped hands.
– The lack of clearance also prevents flexibility in lifting technique - a power grip is required. This is difficult for those with OA (Zhang et al., 2002), particularly

aggravating metacarpophalangeal pain (Dominick *et al.*, 2005). This is exacerbated by the fact the handle is slippery when wet.

Packaging

- Requires full hand stretch (again, a problem for those with OA) or 2 hands to lift.
- Tab requires pressure from a the nail/tip of a single digit to manipulate. This requires dexterity, and force leads to OA pain (Dominick *et al.* 2005).

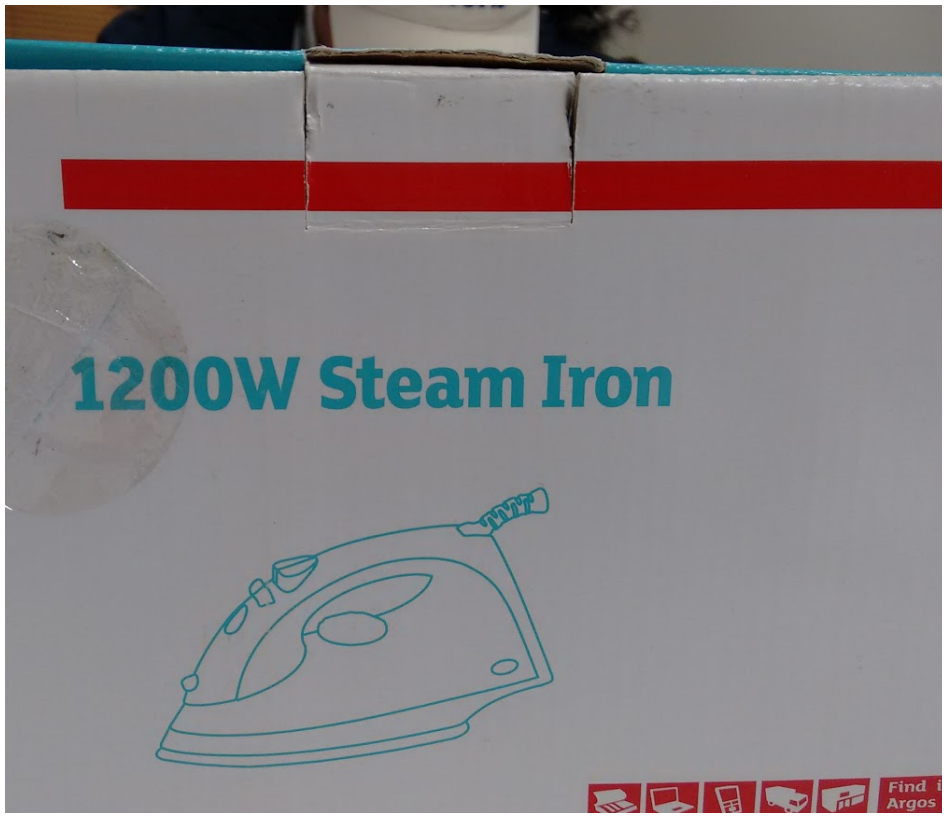


Figure 2: Difficult to open tab

Visual Demands

– Text on the body of the iron, the jug, the instructions and the standard compliance labels is too small - the demands on visual acuity are too great. (Figures 3, 5, 6, 8, 9)

Figure 3: Small standard compliance text on plug

– The contrast sensitivity demands of the in-/outdents on the button icons and jug text are too high. (Figures 4, 6)

Figure 4: View of buttons, steam selector and water inlet

– The contrast of other text is better, but diminished by the reflectivity of the material. (Figure 5)

Figure 5: MAX volume text small; low contrast with reflection

Steam/Spray Buttons

– Some finger strength required to push steam/spray buttons.
– Same colour as handle surface - no contrast (Figure 4).

Water Level

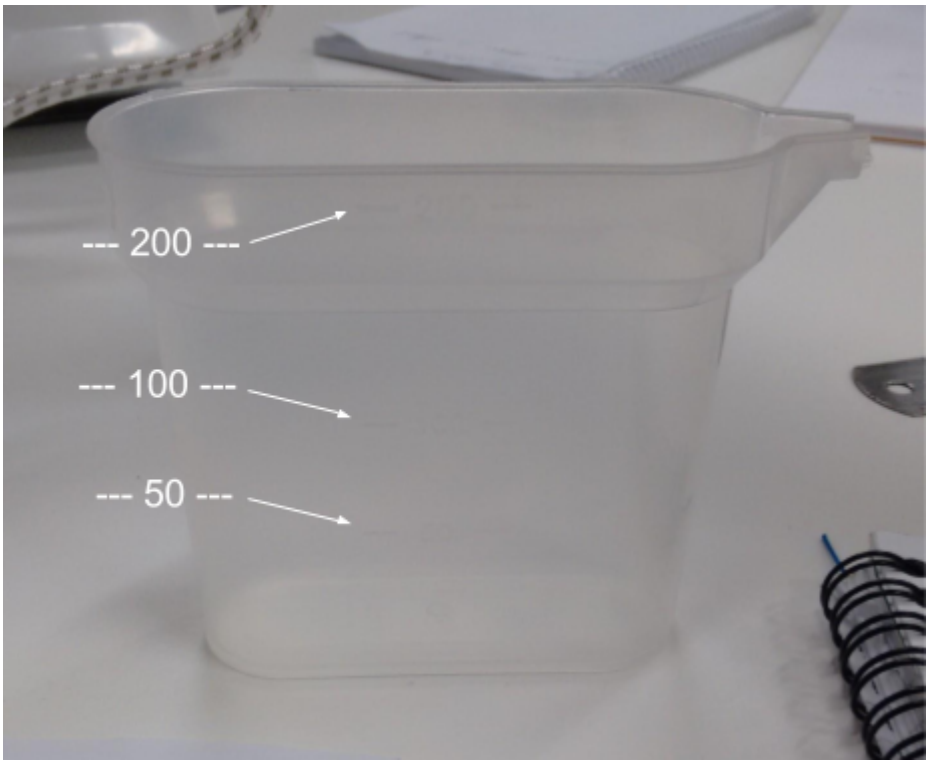


Figure 6: Markings difficult to read on jug (annotated with markings for legibility). Difficulty slightly overestimated by photo

- There is no obvious relationship between the demarcated levels in the jug and the ‘MAX’ level in the iron (Figures 6, 7)
- Water level hard to determine behind plastic - too little contrast (Figure 7)
- MAX volume line only on right side of iron, affording filling with the jug in the left hand. (Figure 7)

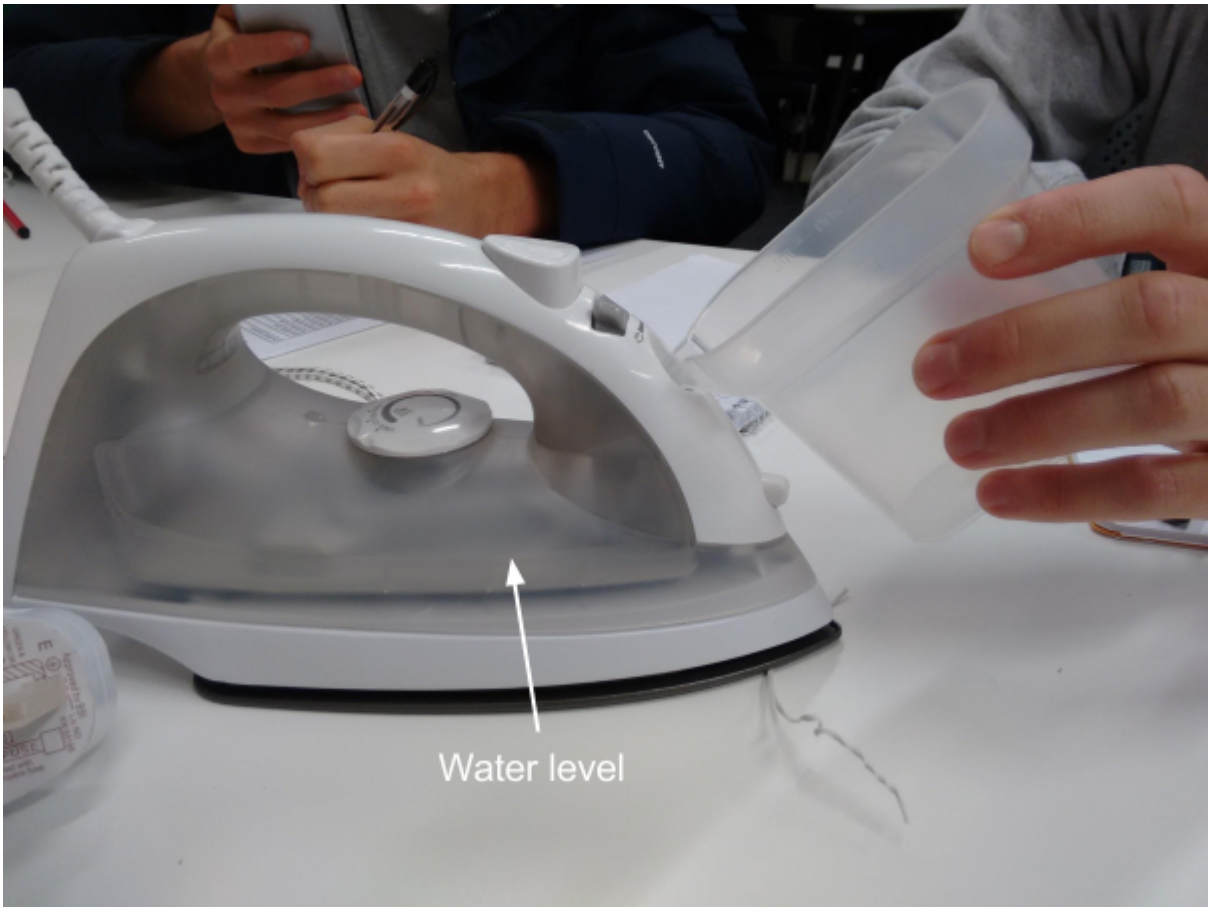


Figure 7: filling the kettle with water from the jug with left hand; no MAX level indication on this side; water level difficult to see

- Water inlet difficult to pour into even with steady hand (increased difficulty with shake/poor dexterity). (Figure 7)
- Inlet has no iconic/textual indication (Figures 4, 7)
- Cannot fill iron while on end - extra attentional step required to turn off, or risk overheating surface/awkwardly coordinating both hands.

Temperature Control Dial (Figure 8)

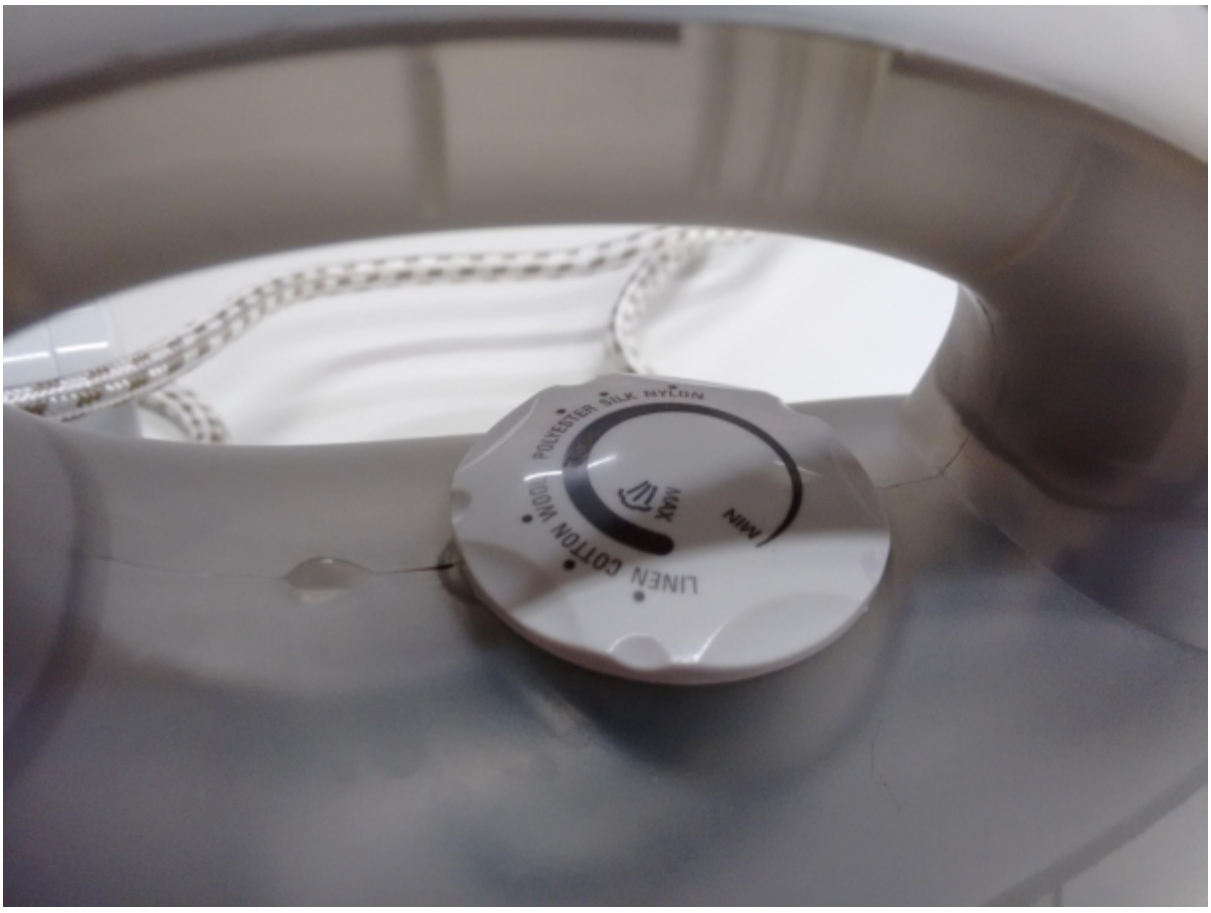


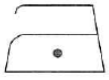
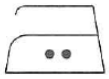
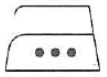
Figure 8: Temperature dial and marker

- Marker for dial is not obvious, visually or cognitively. The bump and background are the same material - resulting in no contrast and minimal indication that it should be attended to.
- Line-of-sight is obscured by the handle.
- No icons accompany text.
- Does not match category names or ordering in the instructions (Figure 9)
- Stiff - no leverage, needs finger strength in a pinch grip, which is associated with increased carpometacarpal OA pain (Dominick *et al.*, 2005)
- No option for flexibility of using palm/assistive tools: access is blocked by handle above.

Instructions

PREPARATIONS

Soft the laundry to be ironed according to the international symbols on the garment label, or if this is missing, according to the type of fabric.

GARMENT LABEL	FABRIC TYPE	THERMOSTAT REGULATION
	synthetic	● low temperature
	silk - wool	●● medium temperature
	Cotton - linen	●●● high temperature

Start ironing the garments requiring a low temperature.

This reduces the waiting times (the iron takes less time to heat up than to cool down) and eliminates the risk of scorching the fabric.

Figure 9: Instructions - Temperatures for different fabric types

– Multiple typos.
– Words used that are either unexplained or do not make sense in context.

Heating/hot feedback

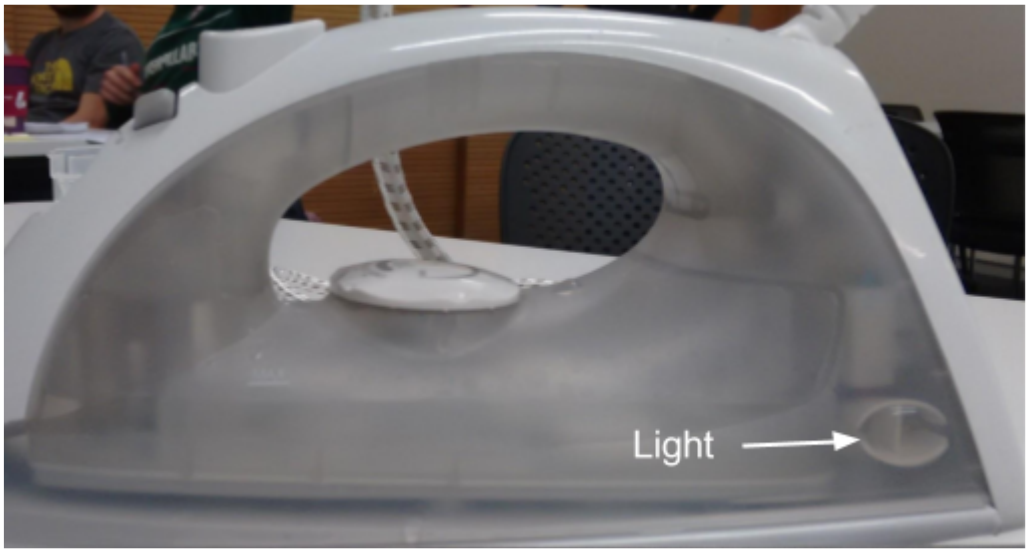


Figure 10: Location of ‘heating’ light

Light (Figure 10)

- Only on left side - less likely for left-handers to see.
- Shows ‘heating’ not ‘hot’; it turns off when it has reached its target temperature. There is no indication of ‘hot’. This loads working memory storage in keeping track of whether plate is dangerously hot, potentially causing burns if forgotten. Given the danger and ease of solution, this may be illegal.

‘Finished heating’ click

- May not be heard by those with hearing difficulty.

Conclusions and Recommendations

A non-exhaustive set of changes follows:

Simple changes

- Sensory difficulties are mostly cheap and easy to fix - increase text size to, improve contrast by making foreground a drastically different colour from the background (changing one or both).
- Handle grip could be improved with a rubber exterior that remains grippy when wet.
- The packaging could have a handle.

Temperature Feedback Changes

- Put temperature lights on both sides of the iron.
- Add a second (distinguishable) colour light that indicates that the plate of the iron is nearing, or above, the burn threshold for skin in contact with bare metal for 4 seconds (delayed reaction time for the elderly) - 58°C - with appropriate adjustments for any coating (BS EN ISO 13732-1:2008).
- Audio alert when target temperature reached, with signal-to-noise ratio at least 10dB (200-5000Hz) at the user's ear (DoD, 2012).

Temperature Dial Changes

A lever extension (with non-slip surface and rounded edges (Bordett, Koppa and Congelton, 1988)) should be added. This would have 3 major benefits:

- No particular grip style would be required, minimising OA pain and improving **flexibility options**
- Minimises Force/torque required (Bordett, Koppa and Congelton, 1988)
- Improves visual, and adds redundant tactile, feedback

This motivates changing from moving-scale-fixed-pointer display to a fixed-scale-moving-pointer display, which is generally preferred (Sanders and McCormick, 1993) and obviates the need for the separate marker.
The dial should be moved to the front of the kettle, improving line-of-sight, making temperature changes easier when the iron is on end, and further improving flexibility by ‘removing’ the handle as a barrier.
Scale text should have accompanying symbols mirroring those described in the instructions - 3 ranges bracketed off and marked with the appropriate number of filled black circles (Figure 9). The documentation should break synthetics into polyester and nylon to match the iron.

Water inlet

Change the orientation of the inlet so that the iron can be filled on end.

Methodology

Overall, the methodology was successful: focusing on concrete aspects of the product provided a helpful structure, and orthogonal axes led to a more thorough inspection of possible flaws. Comparison would be needed to determine the quality and range of issues exposed.

The scope of problems found could be improved with empathic modelling as described by Cardoso and Clarkson (2012) and complementary empirical evaluation methods (Persad, Langdon and Clarkson, 2007b). Task analysis could be performed beforehand, providing a known set of functions to be performed, rather than requiring speculation on-site and afterwards.

A formalised statement of the cutoff point for acceptable demand levels could improve consistency, but it would endanger making the process too rigid, allowing the analyst to follow steps unthinkingly and miss other issues. This could require a better quantification of physical phenomena - force, light and sound.

It was useful to consider errors, however more prompting could assist here, to make sure all types are thought about Norman (2002) and Reason (2000) provide taxonomies.

The bottom-up approach, although successful, may have benefited from incorporating top-down recommendations for each interface from standards and literature.

Word Count: 1991

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Appendix A: Checklist prompts

Interface features

1. Product chassis including handles
2. Displays and indicators
3. Controls and Control Groups
4. Material and media input and output
5. Connectors for energy and data
6. Software interfaces
7. Documentation

User Capabilities/Product Demands

1. Sensory
    a. Visual (V)
    b. Auditory (Au)
2. Cognitive (C)
    a. Working memory (WM)
    b. Long-term memory (LTM)
    c. Mental models (Mo)
    d. Language processing speed(L)
3. Motor (M)
    a. Upper limb capabilities (U)
    b. Gross body movement capabilities (G)
4. Anthropometrics (A)

(5.) Errors (E)

Contexts of use

1. Installation
2. Packaging
3. Maintenance
4. (Product-specific) modes of use
5. Storage
6. Disposal

Principle 1: Equitable Use

1a. Provide same means of use for all users: identical whenever possible; equivalent when not
1b. Avoid segregating or stigmatizing any users.
1c. Provisions for privacy, security, and safety should be equally available to all users.
1d. Make the design appealing to all users.

Principle 2: Flexibility in Use

2a. Provide choice in methods of use.
2b. Accommodate right- or left-handed access and use.
2c. Facilitate the user's accuracy and precision.
2d. Provide adaptability to the user's pace.

Principle 3: Simple and Intuitive Use

3a. Eliminate unnecessary complexity.
3b. Be consistent with user expectations and intuition.
3c. Accommodate a wide range of literacy and language skills.
3d. Arrange information consistent with its importance.
3e. Provide effective prompting and feedback during and after task completion.

Principle 4: Perceptible Information

4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential info.
4b. Provide adequate contrast between essential information and its surroundings.
4c. Maximize "legibility" of essential information.
4d. Differentiate elements in ways that can be described (i.e., easy to give instructions/directions).
4e. Compatible with a variety of techniques or devices used by people with sensory limitations.

Principle 5: Tolerance for Error

5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
5b. Provide warnings of hazards and errors.
5c. Provide fail safe features.
5d. Discourage unconscious action in tasks that require vigilance.

Principle 6: Low Physical Effort

6a. Allow user to maintain a neutral body position.
6b. Use reasonable operating forces.
6c. Minimize repetitive actions.
6d. Minimize sustained physical effort.

Principle 7: Size and Space for Approach and Use

7a. Provide a clear line of sight to important elements for any seated or standing user.
7b. Make reach to all components comfortable for any seated or standing user.
7c. Accommodate variations in hand and grip size.
7d. Provide adequate space for the use of assistive devices or personal assistance.

Appendix B: Evaluation notes

Product Analysis of Clothes Iron

1) Chassis (inc. handles)

Handle - parallel to (ironing board) surface
M(W)/6a ↳ requires ulnar deviation
A - only fits one hand (but could equally be left or right)
A - only space for fingers to fit under handle
A &2a ↳ can't lift with closed fist | 9.5cm at widest pt.
A/7c 102mm handle circ., ~3cm clearance in middle, 2cm at smallest
M(U) - slightly textured, could be grippier; smooth on top | (Cover dial)
M(W) Packaging - packaging requires full hand stretch or 2 hands to lift
M(U) - opening tab requires strength & dexterity in individual finger

2) Displays / indicators (less visible w/ glare (shiny surface))

V Body text - small, medium contrast, could be greater
V - All caps - less recognizable
V Button indicator symbols - just indentations, no contrast
V/C(L) Dial text - no accompanying symbols
V - v. small
V Water vol. marks on filling jug - small
4b/V - just 'outdents' - no contrast
V Dial marker - some material bump - no contrast
C(Mo?) - not obviously a marker, even when seen (cognitive load?)
2b/V/M Light - only on left side
C(Mod) - turns on to represent 'heating', not 'hot'
C(WM) - no constant indicator of 'hot' - need to remember
Au Slight click on finished heating - not v. loud
V BS text on plug v. v. small
2b/M Max water line only on one side → assumes left-handed
M/6a Awkward angle to see dial status - bend? filling?
↳ particularly when iron on end
V Packaging - caution text v. v. small; text on all sides - ok size & contrast

3) Controls

V — Top buttons - same colour as handle - min. contrast
- Left (steam) - 6mm depression, no click
- Right (spray) - 8mm " , click

M (U) — - some finger strength (/thumb...) req'd to push
- compress both by accident (dexterity)

M(U)/6b — Heat control dial - stiff, no leverage - needs finger strength

M (U) — - difficult wide pinch grip at awkward angle (wrist ext.?)

2a — - no option for flexibility - handle above

C (No) — Steam level - looks continuous, but 4 graduations

V→C (No) — - high contrast → more important?

E — Spray nozzle affords pressing, but is fragile

4) Media in/out

M(U)/2c — Water inlet - too small (or jug too imprecise) even w/ steady hand

M(U) — ↳ much more difficult w/ shake/poor dex

V — - could be better indicated - no markings to say how it should be used on the body of the iron

E/5c — - nothing to stop water coming out if dropped

E/C/M — - no cap/valve | - can't fill when iron on and ↳ hot side on surface for time

M — - not much strength req'd

V — - water level difficult to see through iron's side

C (No) — Jug - no obvious relationship between measurements & iron's max

C/E/5c (WM) — 'Steam holes' - open even not on - leaks water if stored on iron
↳ only if steam setting not 0

5) Connectors

M (Co) — Cable - ~1m - short reach from socket - requires more adjustment
- fireproof (error tol.) & flexible

M (U) — Plug - difficult to pull out (as normal)

6) No Software interface

7) Documentation

C (WM) - references to figures that don't appear until end.
↳ other images not labelled with numbers

C (WM/MO) - heat settings table doesn't match dial
↳ different images
↳ inconsistent names (incomplete)
↳ different order? polyester after silk?

C (L) - some sentences make no sense in context
↳ specialist use(?) of the word 'size'? → error? confusing

M (V) - suggests emptying by inverting & shaking - difficult motion

C (WM) - figures labelled differently in text vs on image
↳ "[Fig. 4]" vs "4"; no label "Fig"/"Figures" on page
↳ different font on Figs

V - small text

C (WM) - Figures unlabelled (descriptions earlier)

4a - could be more modes on dial - currently visual; could add tactile
Maintenance - not intended to be done by typical user
↳ specialist screwdriver req'd to open back