Social camouflage: a survey of 143 students of their preference for assistive technology cutlery and the visual mechanisms being influenced

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ABSTRACT

Camouflage has been used extensively in modern military applications for over one hundred years. However, social camouflage has been used by artists and designers for even longer within clothing, body-worn accessories and more recently automotive and product design. Most practising designers learn this tacit heuristic through trial and error or passed on through master-student experience. This paper will provide the theoretical principles behind the heuristic and validate their application through evidence from different sources. A series of photographs was compiled of seven commercially available cutlery for people with limited grip strength or mobility in their hands that included a set that embodied the principles of social camouflage. The optimum shapes for grip in these sets highlights their unconventional shape, making them often less desirable to use in public. A survey of preferences for a range of cutlery was completed with 143 students using a semantic differential (SD) scale, with 'least medical' and 'most medical' as the polar nouns. A sample of eight students, four male, four females, completed the survey again using computer screen-based eye tracking. The areas of interest and the order of movement of fixations were noted. The SD scale order placed the perception of the social camouflaged cutlery as more medical than desirable in contradiction to current sales of the product. Eye tracking highlighted that students followed the outline of the highest contrast visual elements when viewing the socially camouflaged cutlery; being drawn away from the outline of the actual shape. In all others, the outline profile was prominent.

KEYWORDS

Design heuristic, Perception, Assistive Technology

Introduction

This article will highlight some deficiencies in current design practice and offer a heuristic, underpinned by principles from psychology and sociology, that was validated using mixed methods. These methods are described in detail to provide information for researchers new to the field to replicate the study, as well as to provide background information for practicing designers who may commission validation work.

The vehicle for this demonstration was the design of an assistive technology (AT) product; a set of cutleries for people with limited grip strength and or hand mobility. This is a product area that makes a substantial contribution to the UK economy. In the United Kingdom, the Institute of Export and International Trade states that, “The social care market, dominated by assistive technologies and private care homes, is set to grow from £2bn in 2012 to £6bn in 2020 due to the demand for delivery of care closer to home.” (The Institute of Export & International Trade 2018) Globally, more than one billion people need at least one assistive product. (World Health Organization 2018)

The social camouflage heuristic supports a social model of healthcare treatment (whole patient/client) over a medical model (symptom only). (Conway 2008) The field of assistive technology (AT) is a good example of well-engineered products delivering optimum functionality, but not always satisfying the social and cultural functionality for the target user. This form of design approach is closely aligned with medical model of treatment. A medical model of design can result in social stigma associated with the product, as it is often different in shape, colour, form and action to other everyday products used in UK society. This often results in AT product abandonment. (Verza 2006).

Practicing Industrial designers influence a consumer’s perception of a product through the application of tacit heuristics. These are often passed on as experience from master to student or learned through trial and error. In addition, validation is often through design outcome where the design solution is validated by success or failure in the marketplace. This can be seen most clearly in the working practices of industrial and graphic designers within fast moving consumer goods (FMCG). The open loop approach to design is not efficient at capturing the reasons behind the success or failure. Where products require more investment, it is critical to provide some means to predict and check a design solution before they go to market. Whilst this is done effectively by mechanical and electronic engineers, designers do not yet have a body of theory to underpin their decision-making.

This paper will provide the theoretical principles behind one heuristic and validate its application through evidence from different sources. The heuristic is social camouflage. This has been used for hundreds of years by artists to deliver an evocative image of an individual or object that has been modified to suit the purpose of the client. For example, making kings or queens taller, slimmer, or delivering semantic meaning such as being heroic, through their clothing and associated accessories. Artists used colour, form and texture to manipulate the viewer’s perception of the person in the picture or sculpture. More recently, social camouflage has been used by designers in automotive and product design to hide manufacturing blemishes.

Camouflage is used in nature by many animals for hunting or survival. A scientific approach has been extensively used in modern military applications for nearly one hundred years. Baumach, (2012: 79-102) provides a good introduction to the military application of camouflage. Key points from this summary are:

- Distance at which the object is being viewed will affect the choice of camouflage options;
- Blending of colours or patterns into the surround environment;
- Disrupting the outline of an object against the background;
- Baumach cites Burle Industries (1974) and Graham (1966) when defining resolution of lines at a set frequency in different lighting conditions through stereoscopic vision (0.5 minute of arc per line pair);
- Using a Farnsworth-Munsell 100 hue test, Baumach cites Graham again to highlight that the human eye is least sensitive to hue differences in the blue and red regions of the colour spectrum;

- The eye is least sensitive to chromatic change within the green region of the colour spectrum.

Baumach goes on to further discuss the processing and interpretation of what the eyes see through the brain and mind, citing the work of the psychologist Max Wertheimer. Wertheimer's principles of Gestalt are a good practical guide to how the mind interprets the world from vision. (Ellis 1997) The principles of Gestalt highlighted as being useful in camouflage are: Proximity, Similarity, Continuity, Closure, and Common fate. (Baumach 2012: 87-78)

In this study the main principle applied to the design of social camouflage with cutlery was disrupting the outline of the object. This heuristic is underpinned by David Marr's description of the mechanism of perception (Marr 1982) as well as Gestalt principles. The principles applied rely mainly on the understanding of 'Phase One' or 'bottom-up' visual processing within perception. Ware (2012) and Crilly (2004) have produced models of this mechanism of processing, leading to object recognition and assignment of meaning. Object recognition and assignment of meaning primarily involves 'Phase One' or top-down' processing. Whilst 'Phase One' processing takes 200-250msec to complete 'Phase Two' is parallel processed alongside 'Phase One', taking around 400msec to complete. This had an influence on the design of the survey, emphasising speed of decision-making in order to minimise the involvement of 'Phase Two' during this decision-making process. The main Gestalt principle applied within the social camouflage heuristic is the 'law of pragnanz' or 'law of simplicity', that states people will perceive and interpret ambiguous or complex images as the simplest form(s) possible. (Lidwell 2010: 144-5) This Gestalt law or principle is associated with other laws such as continuation and closure, already highlighted earlier. In terms of camouflage, the 'dazzle' pattern used on early 20th Century warships is a good example of breaking up the outer profile of a ship when viewed on the horizon.

AT cutleries are often well-design to support the needs of people with a range of difficulties but often at the expense of social acceptance. For example, a larger handle of high friction material is often prescribed by healthcare professionals (Selectagrip, Good grips, Ultralite). The outer shape of many AT cutlery handles (Caring cutlery, AMEFA) are unconventionally shaped, to match the 'wind-swept' grip patterns of people with rheumatoid arthritis. The unusual grip is due to the metacarpophalangeal joints of the digits being loosened during inflammation, resulting in poor posture of the hand with fingers dropping in deviation towards the ulnar bone of the forearm. One of the new cutlery designs (Etan) had a more conventional shape, all black handle, but high friction grip. Another new cutlery design (Kura Care) had the unconventional shape, suitable for people with arthritis, but used a white outer to frame a high-contrast black centre. The centre section was made to match a conventional straight, parallel sided cutlery handle where possible. The non-colour preference was chosen based on experience from undertaking other cutlery assessments, where most participants would accept a non-colour for the handle but had different preferences if a colour choice was offered. (Torrens *et al*. 2001, Torrens & Smith 2013)

The question to be answered in this study was: "Did the use of a high contrast non-colour section in the handle of the Kura Care cutlery set disrupt the viewer's perception of the handle profile?" A second question was: "Did this design intervention make the Kura Care appear more desirable compared to the Caring cutlery (which has the same outer shape)?"

Method

143 first year undergraduate design students were recruited to take part in the study. As a pilot study, their narrow socio-economic and age range was considered helpful to gain a consensus of opinions and statistically valid results. It was assumed that they all had experience of using everyday UK utensils, but limited experience of assistive technology cutlery. The purpose of the study was to identify if the student cohort noticed a difference between the two sets of cutlery that had the same shape, but different finishes (Kura Care and Caring Cutlery). The study conformed to the University ethics code of practice (Loughborough University 2018). This included compliance with the General Data Protection Regulation (Gov.UK 2018). The study was explained to them verbally as a group and a participant information sheet for the study provided. Each provided written confirmation of the study being explained to them and consent to take part.

Seven sets of cutleries (knife, fork, spoon) were photographed from the same front view and in the same lighting. These colour images were placed into a ranking sheet. The sheet was incorporated into a larger survey. The ranking sheet was shown twice in the survey, at page six and page ten of the ten-page survey. The order of images in the second presentation was reversed; and the images reversed as a control to see if the participants chose differently on the second viewing. The interweaving of the two studies provided the opportunity for the participants to forget their first choices made on each sheet. On each sheet the participants were asked to: “Without thinking about it too much, please rank the images of cutlery in order, 1 to 7, where 1 is the most medical looking to 7 the least medical looking.” The ten-page survey in total took 12-15 minutes to complete, with explanation and survey collection.

One week later, a sample of eight students, four male and four females, were asked to volunteer to take part in a second phase of the project. Participants were asked to complete the survey again. A further ethics approved protocol was used with this study, including participant information sheet and written consent document. A digital form of the hard-copy survey previously completed by the participants was used in a digital format on a Tracksys supplied SMI eye tracking system. The SMI RED 250 screen-based equipment gathers information every 10 milliseconds (ms). Experiment centre 3.6 software was used coupled with iView X™, to record the data at the rate of 120 Hz.

Visual perception remains an integral component to inspect the way users interact with an interface. Modern eye-tracking technology enables a researcher to track, capture and analyse real-time responses to a stimulus viewed by an individual. (Wang and Sparks, 2014, p. 591) During a visual interaction with stimuli, a participant fixates upon a specific region referred to as ‘fixation’. The fixation indicates an ‘Area of Interest (AOI)’ for a participant within the stimulus. Frequently used parameters for eye-tracking data are fixation counts, average fixation, first fixation, and saccades (the rapid eye movement between fixations). Targeted fixations, fixations duration and fixation counts, indicate the focus of attention within a visual stimulus and, therefore, offers information related to the most dominant element in the visual scene. (Wang and Sparks, 2014, pp. 591–592) The advances in eye-tracking technology have been linked with the development of understanding of cognitive processes and psychological theories. From this perspective, eye-tracking delivers insights into the user’s cognitive approaches and enables a researcher to see the viewing patterns, which users do not consciously see (Dong and Lee, 2008). The recent application of eye-tracking technology encompasses research in psychology, physiology, neurosciences and marketing; and, neuro-marketing, visual marketing and cross-cultural marketing. (Wedel and Pieters, 2008). In most of the interventions using eye-tracking, small sample sizes are common, but not statistically representative (Pan, Zhang and Law, 2013).

Eye-tracking movement was measured based on eye-tracking metrics such as fixation, fixation count, average fixation duration and in relation to the size of Area of Interest (AOI). The test was conducted with a 21.5-inch monitor (at 1680 x 1050 resolution). The distance between the computer screen and participants varied in the range of 40cm to 50cm. The size of the displayed map visual (stimuli) was 1680 x 1050 pixel to match with the monitor resolution.

Once sitting comfortably, the participants were asked to maintain their posture without moving their face or head; this was helped by the participant putting their hands onto the table in front of them. A calibration test was ran followed by a four-point validation test. Once achieved the .5 degree of X and Y variation, the mapping stimulus were presented. Each visual series of cutlery images was displayed for 90 sec. An operator asked the questions and put the answers on the physical sheets whilst the participant viewed the images digitally on a screen.

The objective was to answer the question "Did the use of a high contrast non-colour section in the handle of the Kura care cutlery set disrupt the viewer's perception of the handle profile?" This was to be analysed by tracking where each participant was looking/fixating when making their decisions about ranking. This was used to follow fixation pathways during completion of the survey. Points of interest were defined along the edges of the cutlery profiles to help provide more information about the number of fixations on a point within each image.

The surveys were entered in a spreadsheet using MS excel and subsequently processed and analysed using IBM SPSS Statistics 23. Charts were generated in MS excel. Each respondent was given a participant number and the names kept separately. The two sets of answers given by the respondents were reviewed to see if any had answered differently for the reversed sheet and analysed using the Wilcoxon Signed Rank test for ordinal, paired data. The evaluation of overall rating of the cutlery from least to most medical looking was made by considering the mean sum of ranks returned by a Friedman's ANOVA which also established whether there was a significant difference in the ranks across the 7 images in conjunction with ascertaining the most frequent (modal) ranking for each image

The recorded data from eight participants were processed by using the Tracksys supplied 'Begaze' ™ 3.6 software. As mentioned, the authors analysed eye-movement data for eight images based on the number of fixation (fixation count), time (average fixation duration), impression (first fixation) and size (area of interest). Normally, fixation lasts for a period ranging from 200-500 ms (Wedel and Pieters, 2008; Wang and Sparks 2014). The metric fixation count refers to the number of fixations made when attending a specific area in a visual scene (Rayner 2009). Those provide information relating to vital area in a visual scene. Fixation duration signified for how long the viewer maintained a higher-level focus on the same region. Lastly, the experts in eye-tracking posits that in a visual task individual grasp meaning of a scene within first few fixations and then assign other details (Duchowski, 2002; Rayner, 2009). In relation to this study, first fixation data was analysed by which the most insightful information could be examined.

Results

The outcome of the survey and subsequent eye tracking test are shown below. Figure 1 shows the set of cutlery images used in the survey. (Torrens *et al.* 2018) (Asghar 2018) These were reversed in order and mirrored in image on the page view later in the survey. Table 1 shows the rank order based upon the mean sum of ranks for the original images along with the modal rank in each case. The Friedman's ANOVA established that there was a significant difference in the rankings across the different images at the 95% confidence level (Chi-Square $_{(6,143)} = 80.557$, sig (p) <.05)

Figure 1 images of the seven cutlery types shown on page 6 of the survey.

Although there were some small changes observed to the rank order and the modal rank comparing the original and reversed presentation of the images, there is no statistically significant difference in the way in which respondents ranked the images between the two presentations at the 95% confidence level. (Wilcoxon Signed Rank Test showed sig (p) > .05 for each original – reversed cutlery pair or responses across respondents)

Table 1 Original and reversed rank order and modal rank

Original rank order least to most medical	**Mean sum of ranks**	**Original modal rank**
Etan =	4.61	7
Amefa =	4.61	6
Caring	4.31	7
Ultralite	4.26	3
Good Grips	3.87	4
Kura Care	3.58	1
Selectagrip	2.76	1

Considering therefore the results from the original presentation, the clustered bar chart (Figure 2) below shows the distribution of ranks assigned by the respondents for the cutlery with the highest modal rank (Etan and Caring) and those with the lowest modal rank (Kura Care and Selectagrip). This illustrates the substantially lower ranks assigned to Selectagrip and Kura Care showing they were clearly rated as the most medical looking.

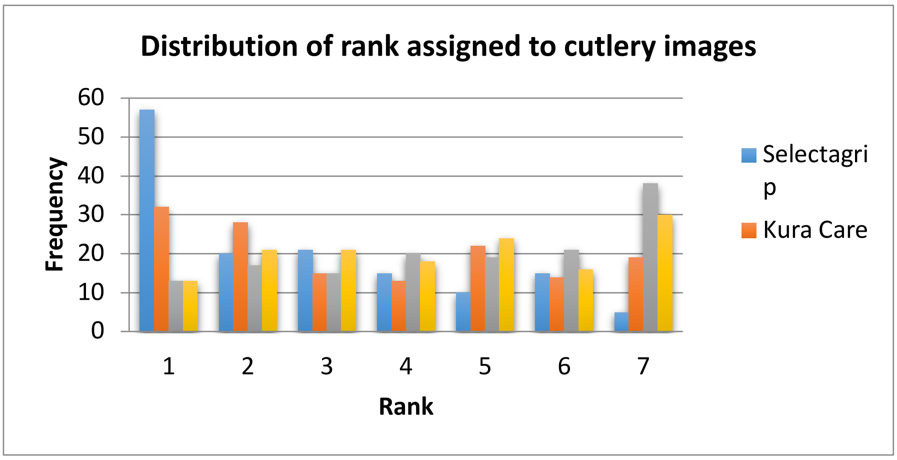

Figure 2 Distribution of ranks assigned to cutlery images

The data collected from the eye-tracking study can be accessed for additional detail (Torrens *et al.* 2018) The exclusive format of question (ordering least medical to most medical) appears to have incurred those larger fixation durations. The time taken for each participant was longer for this section of the survey than the other. However, the duration of first fixation remains consistent for all images. For means of all fixation patterns criteria, please refer to Table 2- Fixation chart. All participants appeared to fixate the lower region (handle) of the products, following by the upper areas. The heat map of fixation points can be seen in Figures 3 and 4; one, has a large fixation number, shown as a green tone heat map, in the top left-hand corner. This indicates that the combined viewers were thinking about their answer and engaging phase two cognitive processing and memory.

There was a focus around the connection between handle and utensil head. The Caring and Kura Care cutlery product images shown in page 06 and 10 of the survey, had the same size and shape, but different colour and contrast sections on the handles. The change of orientation appeared to influence the way people responded to the stimuli, as shown in Figures 3 and 4 (reversed series and mirrored images).

Discussion

Two very different sets of cutleries were chosen as most medical (Selectagrip and Kura Care) and least medical (Etan and Caring). This was in part contrasted with the expectation of the Kura Care being perceived as less medical than the Caring cutlery. The process was sound as the statistical analysis of the reversed answers and other variables inferred a similar response in order of ranking (see Table 1 and Figure 2). From the eye tracking results, most participants focused on the handle, with an emphasis on the joint between handle and utensil head. This central focal point suggests they were looking at the cutlery item as a complete object and its overall profile.

The visual makeup of the two least and most medical looking did not provide any obvious insights into why they were chosen. Etan and Caring are very different shapes and colour to each other. Similarly, Kura Care and Selecta grip are very different in profile and colour. Any future studies are needed that include either semi-structured interviews or, if an online survey, an option to give a reason for choice made. The differences between the two sets of polarised cutleries may provide some indication of the visual elements that influenced the perception of one being most or least medical looking. The Caring cutlery and Kura Care have the same outer form and joint configuration. The difference being the high contrast non-colour centre of Kura Care handle compared to the single cream coloured handle. The same additional question of why a choice was made should provide useful insights for both researchers and practicing designers. The Selectagrip has conventional utensil head to the cutlery set, as does the Etan set. The main difference is in the size and shape of the Selectagrip handle, (blue and oversized), when compared with the Etan, black and conventionally sized handle.

One of the authors designed both the Etan and Kura Care cutlery to be less noticeable in profile when viewed through low-involvement (cognitive, phase one) visual perception. The Etan followed the scale and proportion of 'everyday cutlery'; the Kura Care used social camouflage to alter the viewer's perception of the unusual outer shape, (social camouflage, underpinned by the law of simplicity principle). All the products used in the survey were available through an online retailer. The retailer has already indicated to the authors that the Kura Care cutlery set is one of their best sellers, with the Etan cutlery set now discontinued. The reasons underpinning choices made by consumers of this form of AT product appear to have the opposite effect on undergraduate design students. However, differences highlighted between the two polarised choices remained the same, indicating there had been some influence of the student cohort of their visual perception of the cutleries. A further larger online study is to be completed with a general population, with the addition of specific AT cutlery user groups; and, an opportunity to provide qualitative feedback on reasons for choice.

Table 2. Shows the details of fixations for the seven sets of cutlery.

Stimuli	Parameters	AOI_01	AOI_02	AOI_03	AOI_04	AOI_05	AOI_06	AOI_07	AOI_08	White Space	No. of Participants
Social Camouflage experiment_pg6	Average fixation [ms]	279.6	301.3	260.3	301.7	271.4	280.5	236.4	169.9	233.2	8
	First fixation [ms]	245.5	313.1	218.2	204.1	243.9	211	235.5	132	194.5	
	Fixation count	13.9	22	36.4	38.4	31.6	19.6	19.1	17.8	17.1	
	AOI area (px)	83544	86279	84609	82929	84966	86031	83647	107136	1064859	
Social Camouflage experiment_pg10 (reversed images)	Average fixation [ms]	251.5	309.7	260	256.9	230.8	239.3	245	172.2	204.3	8
	First fixation [ms]	257.1	224.7	224.4	273.1	171.1	244.5	234.5	223.5	204.5	
	Fixation count	10.9	21.5	24.9	25.8	24.8	14.8	13.4	14.1	13.3	
	AOI area (px)	83544	86279	84609	82929	84966	86031	83647	107136	1064859	

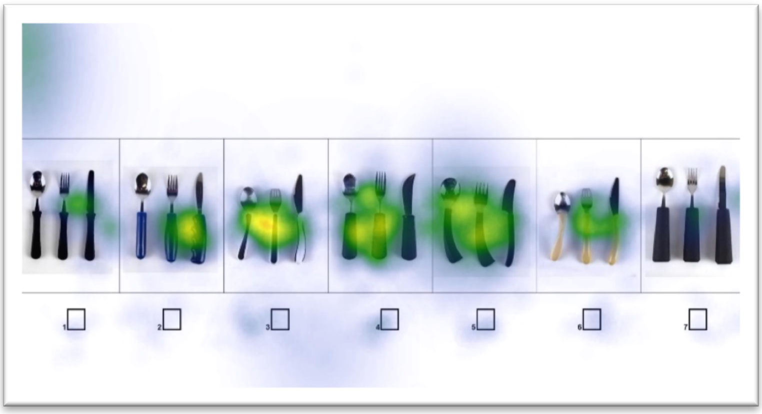

Figure 3. Shows the Heat map of fixations for the cutlery series

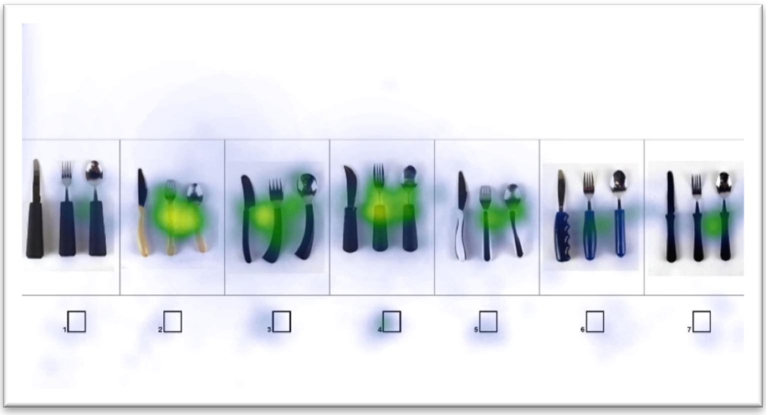

Figure 4. Shows the Heat map for the reversed mirrored image series.

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