REACH MODELLING FOR DRIVE-UP SELF-SERVICE

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People using a self-service terminal such as an automated teller machine (ATM) tend to adjust their physical position throughout a transaction. This is particularly apparent with terminals that are designed to be used from a vehicle (i.e. drive-up automated teller machines or ATMs). Existing predictive tools tend to focus on static reach and provide limited predictions for how far people are willing to stretch to complete a task. Drive-up self-service products have 3 main challenges; the variability of vehicles, people and driver behaviour. Such conventional tools are therefore of limited use in understanding how much people are willing to move to use a self-service terminal.

Work is described to build in-house predictive models based on 2 large empirical studies of reach in a drive-up installation. These 2 studies assessed comfortable and extended reach from 10 vehicle categories. Extended reach was defined as stretching/leaning as far as participants would normally be willing to in order to complete a drive-up transaction. Findings from these studies indicated that participants are prepared to adopt more extreme postures at drive-up than in other situations with extended reach at drive-up being significantly different to what might be seen at a walk-up kiosk.

Introduction

Self-service terminals (SSTs) such as automated teller machines (ATMs) or check-in kiosks are commonly used in a walk-up environment. Traditional models for workstation design and the models published in Smith and Coventry (2002) provide guidance and relevant reference material about product design for walk-up terminals. However, in some regions, these self-service terminals are also offered in a drive-up configuration with the consumer remaining in their vehicle to use the terminal. Typically these are found in North America (USA, Canada), and the Middle East (e.g. Saudi Arabia, Kuwait).

Using a terminal from a vehicle imposes significant pressures on the consumer and if traditional predictions of static reach were to be used it would be impossible to design a product to fit within the reach envelope predicted by these tools. However we know that these drive-up products are used and gaining in popularity.

For this reason further understanding is required of where a person can and will reach to from a vehicle for an infrequent and fast interaction such as collecting a ticket for car parking, ordering fast food, or getting cash from an ATM. Three key challenges in predicting reach for drive-up self-service consist of the variability of vehicles, people and driver behaviour. Our approach has therefore been to carry out studies to understand more about this environment. These studies have included the following:

- Studies of vehicle sizes
- Observations of people using live drive up ATMs
- Study of what drive-up users consider to be comfortable and extended reach in a drive-up environment
- Two studies using different prototype ATM layouts, with measurements of actual driver behaviour and user feedback on the acceptability of interface layout
- This work then led to development of predictive tools to be used for future design work.

Constraints for drive-up self service

Vehicle dimensions

Making a single solution that works for all shapes and sizes of consumers is difficult enough, but the variability increases dramatically when vehicles are involved. Not only is the size of the car important; the shape of the window and the ability of the driver to park close to the object they must reach must also be considered.

The first challenge to overcome is that vehicle dimensions vary significantly. In fact, the variation between key vehicle dimensions, such as seat pan height or height to window top and height to window bottom, is greater than the differences between human anthropometric variation. This is a particular challenge in markets such as North America as they have vehicles at both ends of the spectrum (e.g. very small, low sports cars at one end, and very tall pickup trucks at the other). For instance, when considering seat pan as an example, a small sports car, such as a Chevrolet Corvette, may have a seat pan height of 290mm from the ground whereas a large pickup truck, such as a Dodge Ram, may have a seat pan height of 970mm.

In addition to this variation in vehicle height, other key constraining factors include the vehicle window (height of bottom & top of window), position of the A and B pillars (where A pillar is the material that supports the windscreen at either side and B pillar is the pillar to the rear of the driver's window), proximity to the steering wheel, and the presence of seat belts.

Vehicle categories

In our research we have identified 10 vehicle categories as follows:

A. Sports car
B. Compact car
C. Midsize car
D. Fullsize (large) car
E. Minivan (Multi-purpose vehicle, or MPV)
F. Compact sports utility vehicle (SUV)
G. Midsize SUV
H. Fullsize (large) SUV

I. Compact pickup truck
J. Midsize & large pickup truck

Vehicle categories were derived primarily from US vehicle categorisations, and then harmonised across other national classification schemes (e.g. Euro NCAP, ACRISS car classification codes). When considering window height, the B pillar, window top and window bottom can be summarised graphically giving a clear view of the distribution of vehicle dimensions across the vehicle population. All of these factors combine to ensure that there is little overlap between the vehicle categories Figure 1 (or no overlap at all when considering sports cars and large SUVs or pickup trucks, Figure 2) and an extremely limited zone of reach for all consumers in all vehicles.

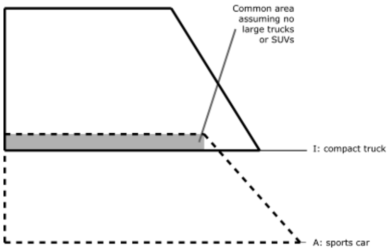

Figure 1:Compact truck to sports car windows

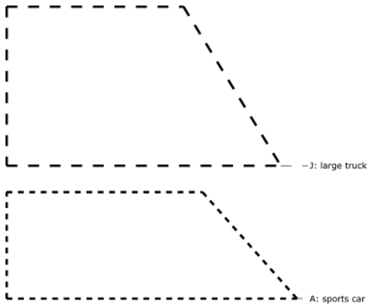

Figure 2: Large truck to sports car windows

Vehicle ownership

Data was gathered in 2006 regarding ownership of vehicles by NCR from available data for the previous two years. Sources included US Bureau of Transportation Statistics (2005), US Automotive parts industry annual assessment (2005), and the Road Ahead for the US Auto Industry (2005).

Table 1: US vehicle ownership 2004-2005

Vehicle Description	2005 (%)	2004 (%)
a: sports	4	3
b: compact car	16	15
c: midsize car	21	21
d: fullsize (large) car	5	5
e: minivan (MPV)	6	7
f: compact SUV	7	7
g: midsize SUV	16	16
h: large SUV	4	5
i: compact truck	4	4
j: medium & large truck	15	16
k: motorbike	0	0
l: large commercial vehicles	0	0
m: full size van	2	2

Drive-up evaluations

Two studies were conducted at an NCR facility in Duluth, Georgia. The first study with 104 participants (with at least seven participants for each of the previously mentioned ten vehicle categories) evaluated how far people were willing to reach to use a drive-up ATM, with measures being taken for comfortable and extended reach. In addition, this study also assessed two prototype ATM layouts, with measurements of actual driver behaviour and user feedback on whether or not aspects of the layout were acceptable. The second study, with 74 participants validated driver behaviour and user feedback on a revised ATM layout (which had been changed as a result of the first study).

Figure 3: Examples of reach from a range of vehicle types

Variability in parking

Our research has found that consumers vary significantly in their positioning of vehicles when using a drive-up facility. Parking position varied significantly both in terms of horizontal alignment on the drive-up terminal (i.e. how far along the interface they parked), and distance from the ATM to the vehicle. In one study (104 participants), it was found that distance from ATM to shoulder of participant (when sitting at rest) varied from 575 to 1084mm. This is a problem as this was beyond arm length for many participants. For example, a 5th percentile US female arm length shoulder to fingertip is 666mm (PeopleSize 2008). In the same study, horizontal alignment (position of shoulder along the interface) varied from 32 to 685mm (relative to the left hand edge of the interface) as illustrated in Figure 4.

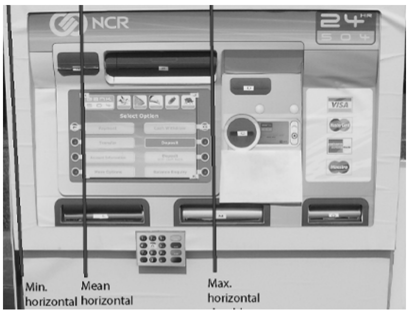

Figure 4: Horizontal parking position (showing min, mean and max shoulder)

Challenges of designing for a worldwide population

In addition to this variability in vehicle demographics there is the challenge of designing for a worldwide population, with a given percentile varying significantly between national populations. For instance, taking PeopleSize (2008) as a source, a 5th percentile female has stature of 1479, 1517 or 1559mm for Chinese (urban), British and Dutch (1986) female populations respectively. Arm length (shoulder to fingertip) varies in a similar manner with a British female having an arm length of 665mm and a Chinese female of 622mm. For this reason we use 7 worldwide anthropometric models for ambulant users as published by Smith and Coventry (2002).

Resultant postures

Figure 5: Examples of extreme postures at drive-up

As can be seen in Figure 5, consumers at a drive-up terminal are willing to reach far beyond what would be acceptable in other environments. In particular, the difference between what is acceptable in a walk-up environment (such as an ATM in the high street, or a self-checkout kiosk in a supermarket) and what is acceptable in drive-up are significant. For instance, in a drive-up environment some consumers are willing to not only lean beyond what would be considered comfortable, but are also willing to twist their torso, pivot about 1 arm, and sometimes even go to the extent of opening their vehicle door in order to reach the terminal. These findings were validated by field observations (before and after these studies) of actual behaviour at real drive-up ATMs, with similar postures being adopted by consumers at drive-up ATMs. For example, Figure 6 shows a consumer in a large pickup truck with their door open, pivoting on their left arm while reaching with the right to reach an actual drive-up ATM, with Figure 7 showing a consumer in a midsize SUV with their door open stretching with their left hand.

Figure 6: Large pickup truck

Figure 7: Midsize SUV

Main findings

Main findings from these two studies included recommendations and revisions of the ATM designs that were investigated, and information that could then be used to inform the development of a predictive reach tool for drive-up. A key finding was the importance of minimising depth in the interface.

Predicting reach with existing tools

The challenge of accurately predicting reach in an applied area from static anthropometry tables is known (see for example Pheasant, 1995, Robinette and Hudson, 2006) as is the need for subsequent fitting trials. Application areas such as drive-up, that tend to involve more extreme stretching postures are necessarily more challenging as is modelling these constraints effectively with existing tools. For this reason the authors have built in-house predictive models of reach for drive-up to overcome these challenges.

The traditional approach for predicting reach assumes a single parking position for one or two vehicle types, and then makes predictions based on static anthropometry for a number of percentiles, for example 5th percentile US female and 95th percentile US male (Psihogios and Swope, 1997). This assumed that people would park in the optimal position horizontally along the interface. An example of this can be seen in Figure 8. This approach does not cover the range of vehicles currently in common usage, and only gives predictions of what might be considered comfortable reach. In particular, the extreme postural adjustments that are commonly seen in drive-up are not readily predicted by such tools.

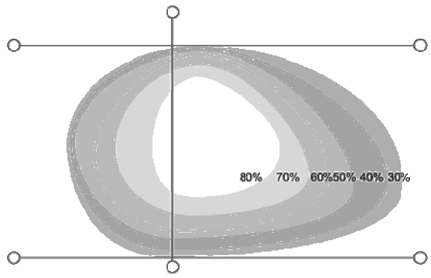

Figure 8: Comfortable reach, Psihogios and Swope (1997)

Predicting reach – our approach

As a result of the challenges previously discussed, a two-stage study was conducted with 104 and 74 participants respectively. This study was a self-reported comfort zone approach, rather than a classic marker-based dynamic anthropometric study, as one of the key challenges was that consumers appeared to reach beyond what would normally be acceptable. A new predictive tool for reach was derived from empirical data. Participants were recruited such that all 10 vehicle categories (from sports cars to large pickup trucks) were adequately represented (Table 2).

Table 2: Number of participants in each vehicle type

Sports	Compact car	Midsize car	Large car	Mini van	Compact SUV	Midsize SUV	Large SUV	Compact truck	Large truck	Bike
10	11	11	11	10	10	15	7	10	8	1

Comfortable and extended reach were measured separately. Comfortable reach was defined as involving minimal movement, just moving the arm; i.e. static reach. This was expected to give an indication of an optimal zone, which is useful in optimising the design and provides a best case for comparisons. Extended reach was defined as “as far as you would be willing to reach when using a drive-up ATM”; i.e. dynamic reach. This included leaning and lifting from the seat, and gives an indication of possible reach.

Key vehicle dimensions were measured including height to window top & bottom, width of window bottom, and parking distance and horizontal alignment. Parking position was also self-reported with participants tending to report that they aligned on the centre of the display, whereas their actual measured shoulder position was just inside the left-hand edge of the screen. Reach was measured by each participant parking next to a large sheet of paper, and were then asked to mark how far they could comfortably reach (in a circular manner about the shoulder), and then how far they would be willing to reach to use a drive-up terminal (see Figure 9 and Figure 10 for an example of some of the raw data obtained for compact cars).

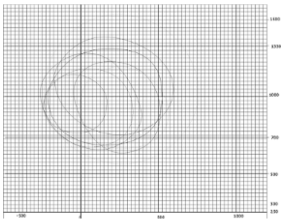

Figure 9: Comfortable reach - compact cars (raw)

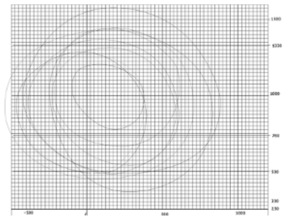

Figure 10: Extended reach - compact cars (raw)

These results were then combined for each vehicle category and normalised (so each vehicle category was weighted equally irrespective of how many vehicles were actually sampled). Predicted reach can then be combined across all 10 vehicle categories (e.g. for US and Canada) or for a subset of vehicle categories (e.g. for Europe). This results in percentage comfortable and extended reach for these populations (Figure 11 and Figure 12). Colour coding was added to give a quick graphical indication of predictions of reach and to help in readily communicating the findings.

Limitations

Although the study had good ecological validity as it was conducted in a car park, with drive-up ATM models laid out as if within a drive-up lane and participants in their own vehicle, there may be slight differences between what people reported they were willing to do, and what they actually do in practice. In addition, as this study was conducted in the US with US vehicles, there may be limitations when generalizing these results to other populations as there may be differences in culture, behaviour, driving position and willingness to accept extreme postures between the populations.

Conclusions and future work

Use of drive-up terminals often involves unusual and extreme postures. However, people find these acceptable (participants cited convenience and perceived security as two factors for this). Predicting what would be acceptable in terms of reach in these environments would not be possible with existing tools. New predictions of comfortable and extended reach were therefore derived from empirical data. Another key finding was to move from assuming a fixed parking position to gaining an appreciation of depth as a very important factor in a drive-up terminal interface. As a result we now design to minimize reach in all three dimensions, recognizing the significant additional benefits that reductions in depth of the user interface have in improving reach for all users.

These predictions have subsequently been applied to the development of a new drive-up ATM, initial feedback is that this drive-up ATM offers significant benefit over other designs as a result of applying this knowledge. Predictions have been demonstrated to confirm previously gathered knowledge in terms of challenges with existing products and are expected to provide a powerful tool in the development of future drive-up solutions.

An extension of this work is to use more detailed human modeling tools such as SAMMIE (Porter *et al.*,2004) and apply commonly occurring postures in order to provide more detailed 3-dimensional predictions of reach. Initial work demonstrated that this would be of particular benefit when considering tasks that require high levels of manual dexterity (e.g. use of a biometric fingerprint reader). However, this has not been explored further as it requires significant investment in terms of obtaining appropriate 3-dimensional models of the relevant vehicles.

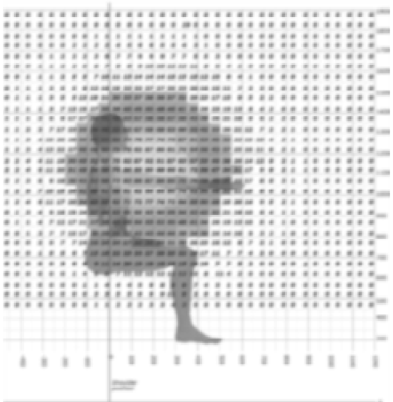

Figure 11: Comfortable reach (US)

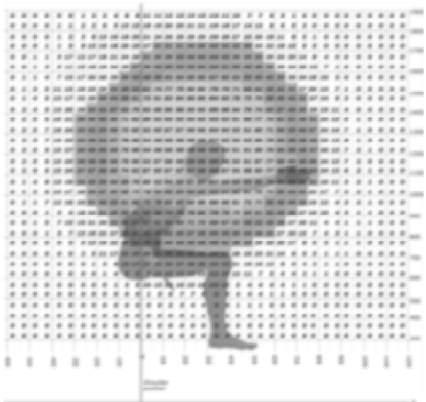

Figure 12: Extended reach (US)

Acknowledgements
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