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Reinventing the (steering) wheel
A kansei design approach for novel driving experience

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Abstract: Over the last decades, the integration of digital technology in the automotive industry has caused important transformations for interaction design in regards with secondary controls, but much less in regards with primary controls. However, not only primary controls remain the dominant artefact to interact with in the driving experience, but also distracted drivers (i.e., interacting with secondary controls or other artefacts while driving) are a major reason of accidents. In this paper, we introduce a design project on the steering wheel, taken from a kansei design perspective. Based on a kansei design framework, structured by three stages (Expression, Gesture, Affect), we observed the way drivers interact with various forms of steering wheel in order to create design propositions for greater and safer driving experiences in the context of novel driving conditions, i.e., with novel technologies and recent driving techniques. This overall project aims at revisiting fully the driving experience, while inquiring further the framing of a direct kansei design approach.

Keywords: Automotive, driving experience, steering wheel, kansei design.

1. INTRODUCTION

In the last decades, a remarkable discord has announced in the automotive design context. The integration of digital technology has brought with it massive increase in functionality. Drivers can now
access email, browse thousands of audio files in their in-car stereo collection, adjust the duration their headlights will remain on after they have stopped on their driveway to illuminate their house front door, adjust suspension modes by the touch of a button, change throttle pedal mappings and so on.

To deal with this increase related to ‘secondary controls’ (Childs & Stobart, 2005, p235), the traditional one-switch-for-one-purpose interfaces are being displaced by menu-based interaction systems. Controls steadily move away from embodying ‘rich’ interactions, which were more of the muscle memory-based nature of interaction, towards more cognitively-based interactions. Primarily involving touch screens, multi-mode menu screens or other information-rich feedback to the driver. By contrast the ‘primary controls’ of the car (the steering wheel, pedals, gear change, indicator stalks, i.e., all things requiring immediate response / actuation) have remained fundamentally unchanged for a remarkably extensive period.

In 1894 Le Petit Journal (Parti social français, 1893) announced a competition for horseless carriages (Concours du ‘Petit Journal’ Les Voitures sans Chevaux) to stimulate interest in motoring and to develop French motor manufacturing. This event took place on the 22nd of July 1894 and featured the first car fitted with a steering wheel. Alfred Vacheron entered this event in his modified Panhard. The steering wheel offered greater control with reduced effort. Success in racing validated Vacheron’s design. Within five years (Greenhouse, 2008), the tiller and lever systems were universally consigned to the past and the steering wheel became adopted as the standard direction control in all vehicles with four wheels or more. Although some concept cars have made alternate propositions and some production cars now offer slight variations to the pure circle, the standard steering wheel has remained unchallenged now for 117 years.

Teaching methods for the manipulation of the steering wheel have also remained similar since the 1930s, despite engineering advances in the actuation of the steering inputs. While in the 1930s two hands and well applied leverage was required for slow-speed manoeuvring, most modern cars allow the wheel to be turned from lock-to-lock with little effort. Clutch pedals, footbrakes, hand / parking brakes remain therefore in accordance with their mechanical ancestry: more physical and embodying interactions.

The converse is true for the state-of-the-art secondary interaction systems. Screens require a division of visual attention for the driver. The eyes invariably must be dropped inside the vehicle. The focus must change from infinite parallax to close-in. Directional control of the car can only be maintained by peripheral awareness or careful scheduling of visual and cognitive attention while the secondary controls are attended. Greater flexibility, functionality, adjustability and features therefore come with an associated cost. According to the U.S.A. National Highway Traffic Safety Administration (NHTSA, 2014), 3,328 people were killed in crashes involving a distracted driver in 2012, compared to 3,360 in 2011. An additional, 421,000 people were injured in motor vehicle crashes involving a distracted driver in 2012, a 9% increase from the 387,000 people injured in 2011. In 2011, nearly one in five crashes (17%) in which someone was injured involved distracted driving (NHTSA, 2015). It is to be noted that at 70 mph (113 km/h) during a five second span of divided attention a vehicle will cover 515 feet (157 metres). Diverted attention can therefore be the source of an important risk over an unneglectable distance.

The ubiquitous smartphone undoubtedly has played a significant role, not only in incidents but in influencing design. Many present secondary car controls are analogous in operation. While the former is generally illegal to use while driving, the latter is now necessary to vehicle operation.
Touchscreens are cheap, flexible and attractive in selling feature-based products. This trend is unlikely to decrease by continuing with the present design direction.

This discord between primary and secondary controls suggests a field of design opportunities from a novel perspective. On one hand, primary controls are critically important, yet innovation on interaction seem to be largely neglected and the drivers’ attention is more and more diverted. On the other hand, secondary controls are less critical, yet demand more and more of the drivers’ attention and are subject of important innovations over the last decades. The design opportunities we foresee relate to the primary controls. Our aim is to reconsider them in the light of new design opportunities brought by recent technology advancements, and in the way they fit better to the actual driving experience. To explore the driving experience, the use of a kansei design approach seems appropriate.

Our research inquiry is therefore to address the driving experience based a kansei design framework, introduced in the following section, in order to assess new opportunities for the design of primary controls. In the present paper, we focus on the steering wheel, and explore the relation between structural and interactive qualities in car driving experience.

2. KANSEI DESIGN FRAMEWORK

2.1. Introduction

Based on previous work (Lévy, 2013a), we have identified three sets of kansei descriptors used to describe various level of kansei potentially at play while interacting with artefacts. We explain these three sets in this section, and then establish the premises of a kansei design framework to be used for our research. Fig. 1 depicts an overview of the elements of the framework. The following stages of a user’s interaction with the design artefacts - in order.

![Figure 1: Schema for a Kansei Design Framework](image)

2.2. Expression

Firstly the user’s experiential perceptions are considered on the Expression level. This concerns everything to do with the appearance, aesthetic, shape, colour and materiality, the texture, weight, feel and dynamics. All of these elements can be considered to be attached to the design artefact itself. This level is all about the thing - as perceived initially by the individual. This can begin at the
visual encounter and includes the first touch, experiencing with the hands and body and the initial impressions and appraisals of an individual. This layer is an appropriate first place to consider the Japanese notional aesthetic of *shibui* (astringent or subdued) (Kikuchi, 2004), although it is important to consider what stands behind this aesthetic on a human, international level rather than the particular expression which is known to be indigenous to Japan. Here we consider what the design artefact communicates from ‘inner thing’ - the nature of its essence.

2.3. Gesture

On the *Gesture* layer, we begin to observe the blending between user and design artefact. Here we observe what affordances, interaction possibilities and feedforwards a thing invites as interpreted by the user. The dynamics between person and artefact begin to become established. Here Gibson’s ecological psychology (1979), as well as Nishida’s active intuition (Wilkinson, 2009) are observed (not what’s inside your head, but what your head is inside of). How intuitive is the artefact? Is feedforward in accordance with expected interaction? Does the design invite a good bonding potential with the user and to what extent does the user want to explore the artefact.

2.4. Affect

At this final layer of *Affect*, we consider how a person achieves the activity provided by the design artefact at a layer beyond the separate components of user and artefact: the concept of transcending the barrier between a person and a thing. In the case of a steering wheel, we could argue with some conviction that the division between steering wheel and person is at the surface between the two: the hands and fingertips at the point where they contact the steering wheel’s covering. And this would be technically absolutely correct. From a kansei design perspective the experiential phenomenon paints a different picture. We can observe people doing incredible things with things, musical instruments, tools, artistic media and in the case of driving, pushing and keeping a car in apparently impossible levels of control. From this perspective the barrier between person and thing is no longer so clearly defined. Human beings are apparently able to experientially expand beyond these boundaries. In the case of driving, skilful or even simply experienced drivers are perceiving the remaining level of grip mid-corner. The sensorial perception of a user can be conducted through an artefact and beyond the limits of physicality. Thus Affect concerns the dynamic expressed between person and artefact in conjunction.

On this level of the framework the rituals which people develop over time are observed and considered. Thus the +Time dimension labelled on the left side of the diagram does not have a linear and uniform meaning. The Affect stage is both a long and short-term element of kansei design.

2.5. Summary

Practically these three stages are not as distinct, but rather they continuously relate and influence each other. The kansei design challenge is to address each of these stages while keeping in mind throughout the design process that the user’s experience concerns these three stages as a whole, in an inseparable way.

Progression in a design domain could be seen as going towards the clear and the obvious. Any novel, innovative or unconventional design proposition might at first appear strange or weird. As we become familiar, accept and like a new thing it becomes familiar and displaces the previous artefacts. It is not new, not strange and not provocative. It just is. Why wouldn’t it be that way? If a new solution makes one questions why elements of the previous solutions were the way they were or makes them appear old-fashioned or shows their limitations, then a meaningful step forward might be inferred. Until that solution is of course replaced itself.
The framework can also be applied to an iterative design process. A proposition should be user tested and the feedback gained from that iteration is fed-forward into the subsequent iterations. Each stage should ideally generate constructive input from user participants and unexpected ideas and discoveries.

3. DESIGN ARTEFACTS

The phase presented in this paper is the beginning of a larger design project based on an iterative process. This first phase of project work focussed on the reconsideration of the form and manipulations of the steering wheel. Radical redesign propositions (such as joysticks) were not considered in order to maintain backwards compatibility. Furthermore, design work is attempting to solve present, pressing societal impacts, i.e., the increasing incident of driving accidents attributable to distracted drivers. The proposition therefore was restrained according to the MAYA principal: Most Advanced Yet Acceptable (Hekkert, Snelders, & Van Wieringen, 2003).

The form of the wheel was designed with this limitation in conjunction with the latest research into hand positions and the method of manipulation (Coyne, Foundation, & Mares, 2007; Whitmore, 2010) which is in accordance with present doctrine in most motorsports. Especially the shuffling of hands or passing over of hands was considered to be outmoded by several decades, given technological advances in the actuation of the driver’s inputs at the vehicle wheel-end of the arrangement. Design solutions which encouraged the to hands maintain ‘correct’ position on the wheel where encouraged with affordance to invite that interaction. Bad habits - such as holding the wheel with one hand at the top of the wheel were conversely discouraged by anti-affordance: this hand position was made uncomfortable and incommodious to grip and manipulation. Furthermore, some advanced suggestions were explored pertaining to long driving sessions where driver fatigue begins to announce on situational awareness. The affordances of the steering wheel were developed with consideration to the forthcoming segment of work: investigating possibilities for secondary interaction created by this phase of design work.

The early stage of this design work was research-based to investigate the impact of these propositions of the users’ experiential perspective. The generation of the prototypes involved in the experiments were reached by informal considerations of the kansei framework and then used in laboratory-framed user testing as a formal experiment.

Three steering wheels were prepared for the experiment. First, a complete, round single spoke wheel with a diameter of 360-mm (cf. Fig. 2). This was used for a baseline, to explore what peoples present manipulations, habits and rituals were. Second, a yoke-like wheel which only provided affordances to support the suggestions from the last research (cf. Fig. 3). This ‘wheel’ had no top part of rim. Third, a non-round wheel with a complete pseudo-rim and affordance for arms to be rested in the lap on long, highway journeys (cf. Fig. 4). This one had a reduced diameter of 320-mm. These solutions had been arrived at by several intermediate explorations, some of which only consisted of a section of wheel to evaluate ideation.
Figure 2: Full, round steering wheel - baseline prototype single spoke

Figure 3: Steering Yolk

Figure 4: 3rd Wheel Proposition - closed rim, 7-5 hand position affordance and ridge to discourage
4. THE EXPERIMENT

4.1. Protocol

The experiment was performed in a laboratory context using constructivist interview techniques (Corbin & Strauss, 2007). Participants were asked to vocalise their experiences and impressions during the experiment. Each experiment was filmed. Participants, holding a driving licence, were asked to perform set steering wheel manipulations to act out the inputs required to perform certain manoeuvres. This included the head rotations needed. Three manoeuvres were enacted: changing lane on a motorway / highway setting, making a 90 degree turn out of a T-Junction, and finally parallel parking in reverse.

The three wheels were attached to a ball raced test jig in turn with a quick release mechanism to minimise disturbance of participants and maintain continuity. The test jig reproduced a steering column of 20 degree elevation - a common angle for passenger car steering columns. A suitable office chair was obtained which allowed the seat back to mimic a driver’s seat and the arms removed. Each test took approximately 25 minutes and 8 (n=8) were performed in total.
4.2. Results

Results supported very well the premise of the framework. User test participants were observed to move sequentially through the three stages of Expression, Gesture and Affect with each of the three artefacts. Less time was spent with the first wheel - the round one - which was already familiar and only used as a baseline. Significant variation however was noted. All but two of the participants had been taught to return to the 10-3 hand position. Two recently qualified drivers had been taught to hold at 9-3 to avoid a deploying airbag. All had been taught to shuffle the wheel or pass hand-over-hand. None of the participants reported they still did this and there was as much variation in methodology as there were participants. This outcome was unexpected and insightful: the qualified drivers who participated had apparently not continued with the technique they have been taught, they established their own.

The yoke, which had an incomplete rim was presented next. This also included the affordance to hold the wheel at the 7-5 hand position with the weight of the arms resting in the lap. This feature was readily accepted and some participants already did something similar, often with one hand, the other high up on the wheel, often with an elbow resting on the window ledge or armrest participants reported. This exploration again brought an unexpected outcome: the bottom segment designed to support this hand position had flat shapes in the interior. This was simply a relatively unfinished area in the interests of expedient prototyping. This unexpected outcome was incorporated into the final prototype for this phase of work: The whole 5-7 hand position affordance was rectangular in section.

The open top to this wheel was found to be unacceptable as especially when performing the reverse parallel parking activity, participants frequently lost the fixed positions and their hands often fell through the top of the wheel.

The third wheel offered the same affordances as the previous. A top section of rim was provided but of a truncated form and a cross section to discourage gripping here. A complete outer circumference was present and even though it did not form a circle participants were observed to still make steering inputs when looking backwards even when losing reference.

The smaller diameter was preferred by 6 of the 8, and 2 thought it was too small. All agreed gripping the top section of the wheel was discouraged, even the participant who routinely held his car’s wheel this way preferred to find a new grip on this prototype.

With especially this last prototype, participants were observed to spend a lot of time moving through the stages of Expression, Gesture and Affect. It was noticeable and unexpected that less and less visual attention was diverted as participants progressed through the stages. Initially there was a lot of looking as well as physical exploring. Towards the end of the tests users were no longer looking, they were performing the set tasks and making a lot of comment while only physically interacting.

To at least some extent during the relatively short user tests, initial rituals and individual expressivity could be seen. The Affect stage was the phase in which users displayed aptitude at finding their own method of use. Again it was notable that there was much variety in this stage between users. Commonly participants seemed to enjoy the Affect stage best of all – exploring how they would utilise the conceptual prototype as if it were incorporated into a real car.

The encouraging and discouraging of certain hand positions through thoughtful design propositions was therefore readily accepted if more comfortable or affording ones were available.
5. DISCUSSION

5.1. Further Design Work

This research was conducted in stage 1 of a longer project. The final outcome of this stage was a new steering wheel form incorporating knowledge gathered from this process. This form encouraged correct hand positions and manipulations in accordance with the last research found. A possible line of enquiry for a generic secondary interaction without the need to remove the hands from the wheel is made possible by encouraging grip in known positions. As opposed to a traditional round wheel where the hands must attend a large circumferential area which necessitates one hand to leave the wheel to access distant controls, e.g., on the centre console. Forthcoming work will focus on supporting a driver’s physical attention to be divided into gross and fine motor skills in a harmonious way.

Visual and cognitive division of attention is being approached with a novel approach: to support driving as a peripheral activity while a secondary task is attended with focussed attention. This sounds counterintuitive but there is evidence to support the proposition that people are adept at performing a task such as driving while their mind is somewhere else.

Mode selection is being explored with a rim mounted virtual rotary switch and an ideogrammatic display possibly projected onto the windscreen. This work will be conducted with an equal amount of rich interaction and attention theory, again both within the superset of the kansei design framework.

It is hoped a rather unconventional starting point might generate innovative solutions which may point the way to a new direction in automotive interaction design.

5.2. Reflections for the Kansei Design Framework

The experiment suggests that taking the user’s holistic experiential viewpoint is especially supported with this framework. With attention to Expression, Gesture and Affect, all things the user encounters in the interaction can be observed and considered for subsequent iteration.

While a conventional interaction design approach might support each interaction atomically, the kansei framework supports the locus of an individual interaction in the context of the whole experiential context. Thus, the moving of a hand to a switch is part of the whole experience and should not be ignored as a consideration of the complete design.

Because the kansei design framework encompasses the blending between person and design artefact over time, the ways human beings enjoy developing skill and expressing themselves ought to be accommodated. Expressivity is seen here as far more emotional than cognitive. That is not to imply there is a conflict between cognition and feeling: as psychological animals, we are both. Therefore, both aspects should be considered and catered for with a holistic process.

Further, people are not components in a chain of engineered solutions. An old-fashioned mechanical handbrake being an example. Its orientation is to align longitudinal cables or rods. The pulling up on the handle applies the necessary leverage. A ratchet is needed to hold the brake on. The solution has not been arrived at with considered from the user’s perspective. While handbrake operation is very familiar and usually not so frequent needed to become intrusive, the paradigm in general is not sympathetic to how we work as creatures.

Gibsonian theory, our ‘minds are in the world’ perspective may be a good counterpoint to a largely cognitive perspective. However, we also have models of the world in our minds and physical memory. We must construct these models to function in a cluttered and ‘noisy’ environment. When we experience a thing it is with previous experience, our ‘to-date’ model of the world, cognitively
processed and with intuition, feeling and emotion. On a creature level there is no conflict. Anything that helps is brought to bear. It appears the kansei design framework potentially offers a way to support all of these present elements. From a kansei design perspective it is hard to see the conflict between those elements. All things are unified. A transition from traditionally engineered solutions to designed solutions might be hallmarked by a corresponding movement from a quantitative to qualitative focus. This would be in accordance with what we are looking for with the kansei framework. Kansei design is a more qualitative and less quantitative thing.

Limitations with the framework presently are that it is difficult to evidence observances in user testing. Some kind of relative quantification is difficult especially given the wide diversity of people’s Gesture and Affect. People are explorative and diverse in nature. It is perhaps an interesting dimension to the framework to accommodate these difference and further indication of the point raised - it is difficult to make this process formalised. It does seem to support a rigorous design and research process but is by no means a formulaic recipe for sound design solutions. It is merely a way to guide a design process to maximise potential Affect considering the artefact and user together as a single entity.

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REFERENCES
Richard Kennedy is a final year Master’s student of industrial design at the Technical University of Eindhoven. Design work is approached from a kansei design perspective blended with an emphasis on the physical realization of innovative design concepts. Exploration and validation is thus shaped by the experiential aspects of the user’s perspective with an especial focus on the blending between user and design artifact. The aim is to explore the emergent qualities arising from this phenomenon. Converging on the automotive design context for several semesters, final project work centres on a holistic and provocative approach to driver in-car interaction.

Pierre Lévy is assistant professor in interaction design in the Designing Quality in Interaction group at Eindhoven University of Technology, The Netherlands. He holds a Ph.D in kansei science from the University of Tsukuba, Japan (2006), and focuses on kansei design as a novel perspective for direct interaction design. His main research interest is on the value of rituals on our affective relation to the world, looking at how everyday aesthetics enrich everyday life. Also, he is president-elect of the European Kansei Group (EKG) and coordinator of the KEER Executive Board.