Reduced Climate Control Unit for Individual Interior Comfort

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Abstract. The climate control unit is one of the most important interfaces between user and vehicle. As a result of increasing attention in the field of user experience, topics as intuitive handling and customer satisfaction become more and more important for climate control as well. To create a new user concept in an easily comprehensive format the alteration of the operating philosophy to a more intuitive and plausible one is recommended. The presented concept offers the advantage that the customer does not necessarily need to grasp the climate control system or its operating philosophy respectively, but just his own experienced thermal discomfort. With the user's information concerning the discomfort as well as the allocation of these feelings in regard of his body, the climate control improves the interior comfort corresponding to his input.

Keywords: Climate control unit · Interface · User concept · Thermal comfort

1 Challenges for Interior Climate Control

In the course of digitization of passenger cars, as well as other mobility concepts, automatic user recognition and the realization of the passenger's individual preferences play an important role. Thereby, the customer places high demands towards air quality and interior comfort – irrespective to his way of locomotion.

With customer comfort being a growing concern within automotive industries, the climate control unit by now represents one of the most important interfaces between the user and the vehicle. Hereby, the usage concept plays a significant role since it enables the interaction between user and climate control.

However, due to the variety of hard and soft keys and multiple setting options, the interior climate control often cannot be operated simply and intuitionally. This way, the customer can realize simple comfort requests in certain circumstances only by a multitude of operating steps, where the keys have to be pressed singly and one after another. Hereby, the different setting options have to be understood and cognitively processed by the user to perform the desired settings, which implies an increased distractive potential from the actual driving task [1, 2].

Because of the many possibilities of key combinations there is a risk that entries are placed inconsistently and the air conditioning system cannot be handled as desired. If the worst comes to the worst, this may lead to a poor air conditioning result and an

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unsatisfied customer. As well, the main safety aspect of a good interior climate like support of the user's serenity and relaxation is annihilated [3, 4].

2 User Experience and Control of Thermal Comfort

In the course of individualization and generation of configurable user profiles the attention is increasingly on the so called user experience (UX), which is to be understood as the experience of a user in interaction with a product or system [5]. As a result, topics as intuitive handling, thermal comfort and customer satisfaction become more and more important for climate control as well [6, 7].

Since the subject takes up an important role in building physics for quite some time [8–10], automobile industries now also focusses very strongly on the topic of thermal comfort [11–13]. But while thermal comfort has an important part within theoretical investigations, climate control units as well as the subjacent control and regulation of air conditioning systems are still based on the average interior temperature. In order to better respond to the customer demands and reliably assure real thermal comfort, the transition to the so called felt temperature [14] or a degree of comfort (i.e. the Predicted Mean Vote (PMV) [15]) is advisable.

For use as a control value a continuous calculation of the PMV with a suitable simulation model that can be implemented in the climate control strategy is necessary. The active control by means of the calculated PMV has the advantage that existing climate-controlling actuators can be triggered more effectively. Thus, the PMV control unit can assure the thermal comfort more reliable as a conventional control algorithm and thereby cause a higher customer satisfaction.

3 Inversed Operating Philosophy

The current technology of interior climate control and climate control units require information about the user's desired interior comfort. Usually, these information have to be provided by operating the keys that are displayed at the control unit. This kind of operation and its philosophy is not without problems – as it was already described above – and does not necessarily lead to the desired result.

In order to avoid cognitive overload and prevent the user from these well-known problems, not only the reduction of the number of hard and soft keys but fundamental changes within the operating philosophy are needed. To realize a more intuitive handling of the climate control, the usual operating philosophy is altered and the new philosophy is oriented towards the user's actual state in regard of thermal comfort.

Instead of the desired state and the implicit question "How do you want to feel?", information concerning the user's actual state ("How do you feel?") are necessary to control the air conditioning system and provide the required thermal comfort within the vehicle's compartment. This concept offers the advantage that the customer does not necessarily need to grasp the climate control system or its operating philosophy respectively, but just his own experienced thermal discomfort. After the request of the

user's actual state, a downstream logic or artificial intelligence translates the actual state in a desired state and hands it over towards the climate control.

With the use of the PMV as control value the transition to a new user concept is crucial, so that the user's input required by the system can be reduced drastically. To create a new user concept in an easily comprehensive format the alteration of the operating philosophy to a more intuitive and plausible one is recommended.

4 Reduced Operating Concept

Modern displays are to become more and more important for vehicle cockpits and offer a large design flexibility in regard to new interior concepts [16]. In addition, user relevant information can be provided more clearly and a reduced operating concept can be developed without the need of any hard key. In the development phase of the reduced operating concept, the concept was to be expected to be intuitive and catchy for all ages. Furthermore, a reduction of the input data required from the user was specified, in the new concept only two information are necessary to provide a comfortable interior climate.

The altered operating philosophy should be clearly recognizable throughout the chosen concept and its visualization on the display. To realize these claims, a carefully designed and structured user interface had to be developed. Therefore it was considered to utilize symbols and icons for visualization, which ensures that the climate control can be used by anyone – regardless of age and origin.

The extreme climatic conditions *too hot*, *too cold*, *too drafty* and *too stuffy*, which can occur in the vehicle's compartment under certain ambient parameters, are graphically displayed in a definite way by corresponding icons. For use in the reduced climate control concept these extreme conditions are diametrically arranged in a so

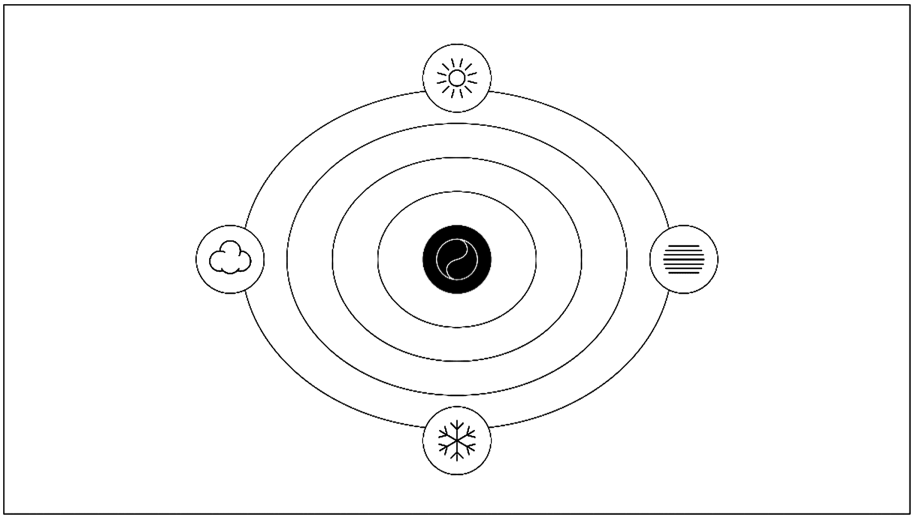

Fig. 1. Depiction of the reduced operating concept

called level of sense-perception, so that the conditions *too hot* and *too cold* as well as *too drafty* and *too stuffy* are lying opposite to each other. Figure 1 depicts the user interface of the reduced operating concept.

In the center of the perception level a symbol is located, which symbolizes the serene and relaxed user and is clearly recognizable by coloring and appearance. With a relocation of this symbol within the level the user can give a response in regard of the question how he feels just in the very moment. During the movement of the symbol its appearance changes accordingly, so that it displays the user a direct feedback concerning the information that was transmitted towards the climate control.

Hereby, the icons located on the rim of the perception level, which symbolize the extreme climate conditions, are of particular significance. As a function of the symbols position within the sensory level a change of size occurs and these icons become smaller and larger. When a user, for example, drags the symbol in the direction of *too cold* and *too drafty*, these icons expand, while the icons representing the conditions *too warm* and *too stuffy* recede into the background or rather disappear as it can be seen in Fig. 2.

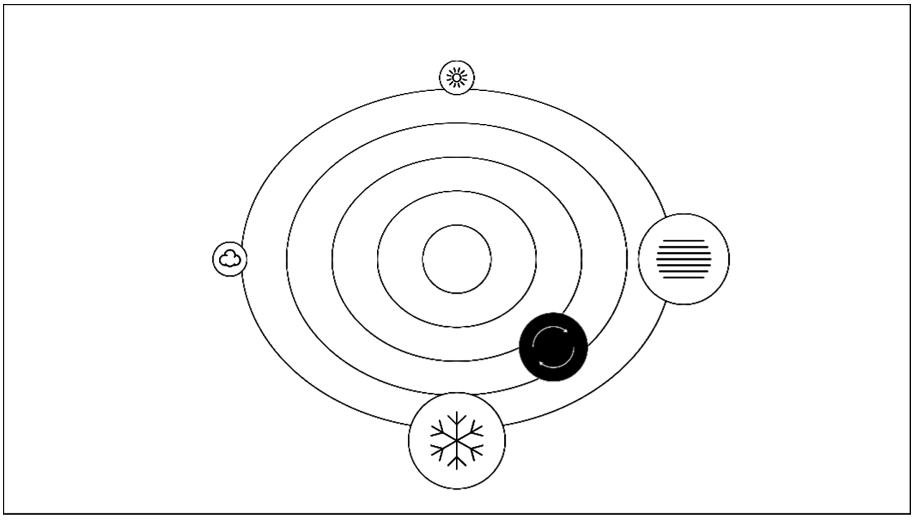

Fig. 2. Entering the actual state

By positioning the symbol between two conditions – e.g. *too cold* and *too drafty* - the user is able to give a feedback concerning the proportion between these conditions. If the conditions *too cold* and *too drafty* both apply equally to the user, the symbol needs to be located central between these conditions and the size of both icons remains even.

If the user needs to differentiate between both states because he feels significantly too cold and only marginally too drafty, the symbols has to be placed between both conditions but much closer to the state *too cold*. As a result, the icon representing the state *too cold* will clearly increase, while the *too drafty* icon decreases (Fig. 3).

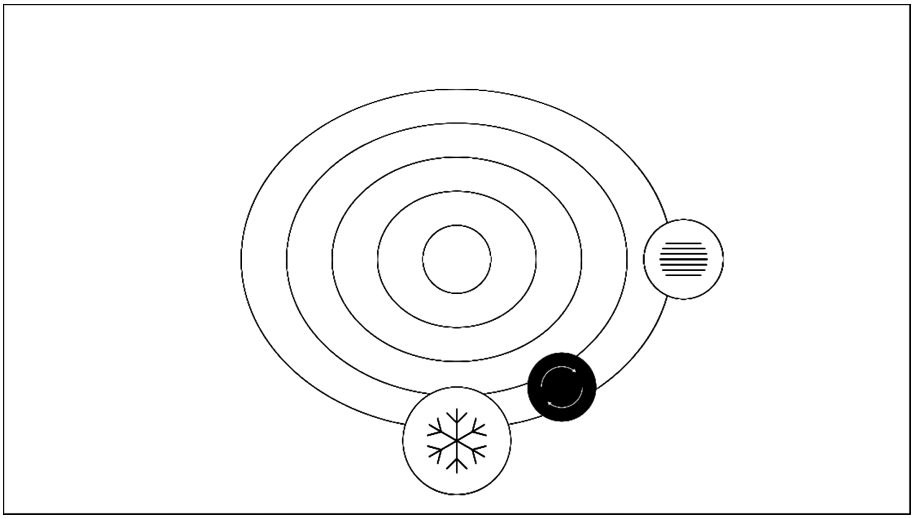

Fig. 3. Differentiation of the actual state

In addition to a statement about the experienced thermal comfort, which is given by the replacement of the symbol, a direct selection of the extreme conditions enables the user to give a feedback about significant discomfort. In this case the symbol automatically moves in the direction of the extreme state and positions itself right on top of the selected icon.

Once the user has entered the information concerning his actual state via the control unit, he is able to verify if his climatic impression refers to a specific region of his body. Therefore, an abstract representation of a human figure is displayed next to the level of perception, which illustrates the user's body.

By tapping on the different areas, a feedback concerning the user's personal perception in regard of his head, torso and legs can be differentiated. In addition, a feedback concerning the overall perception can be given by tapping the rim of the figure. When choosing one of the body regions or the overall perception the chosen region is indicated accordingly, e.g. by changing its color, as it is shown in Fig. 4.

With the information concerning the user's perception as well as the allocation of these feelings in regard of a body region, the climate control is able to adjust the control values air flow, temperature and flap position accordingly to improve the interior comfort corresponding to his input.

In order to give a visual feedback about the adjustment of the control values, the symbol moves back towards the center of the perception level and indicates its current activities during the regulating process with a steadily rotating frame at the rim of the symbol. If the symbol appears in the center again, an optimized interior climate was adjusted due to the underlying logic and the symbol represents once more the serene and relaxed user.

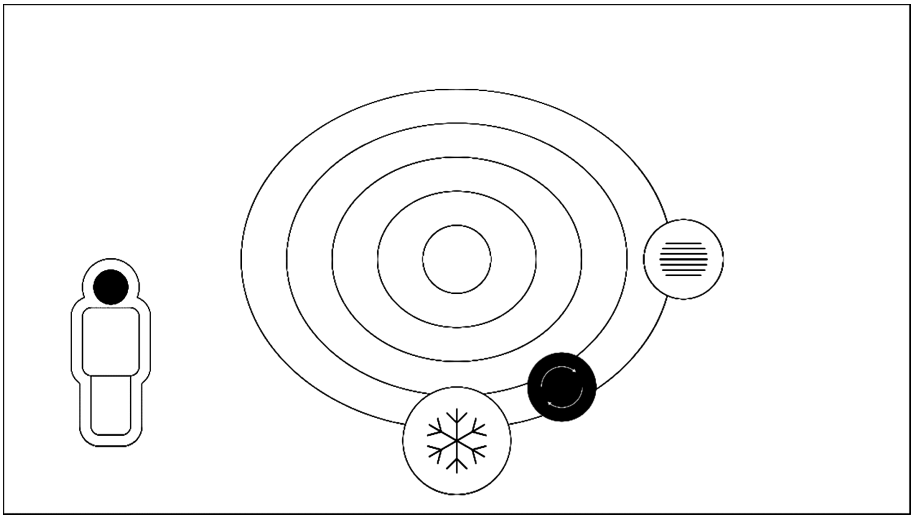

Fig. 4. Selection of a body region

The interaction between the user and the control unit is repetitive and can be repeated as often as required, so that the user can give a feedback concerning his current climate situation until the desired comfort state is finally achieved.

5 Application – Future Scenarios

To further reduce the operating effort of the user, a link between the user concept and an adaptive climate control as well as a recording of the desired settings in an individual user profile is practical. The basic idea is that predefined primary functions are adjusted and saved individually on base of the user's input and thus an individual climate profile is generated over time.

For the application in car sharing services an additional link to an automatic user recognition function, e.g. via smart phone, is imaginable. Thus, the user's individual climate profile can shift from one vehicle to another and is always available as usual – even after changing between vehicles of different brands. A connection to the vehicle's infotainment system also enables the availability of the familiar user interface and the user does not have to switch between different operating concepts anymore.

References

1. Spies, R., Blattner, A., Lange, C., Wohlfarter, M., Bengler, K., Hamberger, W.: Measurement of driver's distraction for an early prove of concepts in automotive industry at the example of the development of a haptic touchpad. In: Jacko, J.A. (ed.) HCI 2011. LNCS, vol. 6762, pp. 125–132. Springer, Heidelberg (2011). doi:10.1007/978-3-642-21605-3_14

2. Vollrath, M., et al.: Ablenkung durch Informations- und Kommunikationssysteme. Forschungsbericht Nr. 26, Gesamtverband der Deutschen Versicherungswirtschaft e. V. (2015)
3. Bubb, H., Bengler, K., Grünen, R.E., Vollrath, M.: Gestaltung der Konditionssicherheit. In: Automobilergonomie. ATZ/MTZ-Fachbuch, pp. 471–523. Springer Fachmedien, Wiesbaden (2015). doi:10.1007/978-3-8348-2297-0_8
4. Arminger, G., Bonne, T.: Einfluss der Witterung auf das Unfallgeschehen im Straßenverkehr. ATZ Automobiltechnische Zeitschrift **101**(9), 675–678 (1999). Jahrgang
5. Wu, L., Li, J., Lei, T.: Design entropy: a new approach for evaluating user experience in user interface design. In: Rebelo, F., Soares, M. (eds.) Advances in Ergonomics in Design. Advances in Intelligent Systems and Computing, vol. 485, pp. 125–132. Springer, Switzerland (2016). doi:10.1007/978-3-319-41983-1_53
6. Spanner-Ulmer, B., Leiber, P.: Fahrer-Fahrzeug-Schnittstelle – Interaktion des Menschen mit dem Produkt. In: Ebel, B., Hofer, M.B. (eds.) Automotive Management, pp. 319–337. Springer, Heidelberg (2014). doi:10.1007/978-3-642-34068-0_22
7. Bubb, H., Vollrath, M., Reinprecht, K., Mayer, E., Körber, M.: Der Mensch als FahrerAutomobilergonomie. In: ATZ/MTZ-Fachbuch, pp. 67–162. Springer Fachmedien, Wiesbaden (2015). doi:10.1007/978-3-8348-2297-0_3
8. Fabbri, K.: A brief history of thermal comfort: from effective temperature to adaptive thermal comfort. In: Indoor Thermal Comfort Perception, pp. 7–23. Springer, Switzerland (2015). doi:10.1007/978-3-319-18651-1_2
9. Willems, W.M., et al.: Raumklima/Behaglichkeit. In: Vieweg Handbuch Bauphysik Teil 1, pp. 356–376. Vieweg & Sohn Verlag, Wiesbaden (2006). doi:10.1007/978-3-8348-9123-5_4
10. Kordjamshidi, M.: House Rating Schemes. Springer, Heidelberg (2011)
11. Lee, D.W.: Impact of a three-dimensional air-conditioning system on thermal comfort: an experimental study. Int. J. Automot. Technol. **16**(3), 411–416 (2015)
12. Konstantinov, M., Wagner, C.: Numerical simulation of the thermal comfort in a model of a passenger car cabin. In: Dillmann, A., Heller, G., Krämer, E., Wagner, C., Breitsamter, C. (eds.) New Results in Numerical and Experimental Fluid Mechanics X. NNFMMD, vol. 132, pp. 383–393. Springer, Heidelberg (2016). doi:10.1007/978-3-319-27279-5_34
13. Thomschke, C., et al.: Bewertung der transienten thermischen Behaglichkeit in einer realen Fahrzeugumgebung. In: Fifth German-Austrian IBPSA Conference (2014)
14. DIN ISO/TS 14505-2, Ergonomie der thermischen Umgebung –Beurteilung der thermischen Umgebung in Fahrzeugen, Teil 2: Bestimmung der Äquivalenttemperatur (ISO 14505-2:2006); Deutsche Fassung EN ISO 14505-2:2006
15. DIN EN ISO 7730, Ergonomie der thermischen Umgebung – Analytische Bestimmung und Interpretation der thermischen Behaglichkeit durch Berechnung des PMV- und des PPD-Indexes und Kriterien der lokalen thermischen Behaglichkeit (ISO 7730:2005); Deutsche Fassung EN ISO 7730:2005
16. Reilhac, P., Moizard, J., Kaiser, F., Hottelart, K.: Cockpitkonzept für das teilautomatisierte Fahren. ATZ - Automobiltechnische Zeitschrift **118**(3), 44–49 (2016). Jahrgang