ORDER PREFERENCES AS A FUNCTION OF SIZE AND ORIENTATION OF THE DISPLAY

Thomas Schinauer and Thomas Lachmann
Faculty of Social Sciences, Department of Psychology II, University of Kaiserslautern
D-67663 Kaiserslautern
<schinau@rhrk.uni-kl.de, lachmann@rhrk.uni-kl.de>

Abstract

Proposing a mere paper-and-pencil strategy for studying population stereotypes, Smith (1981) demonstrated that most subjects prefer to label the quadrants of a circle by using the Western "reading convention" (left-to-right, top-to-bottom). In this paper, problems of generalization and analysis of this order preference are discussed. A replication of Smith‘s (1981) study and two further experiments were conducted which showed that display-control compatibility may be influenced by physical constraints such as size and orientation of the display. A mere paper-and-pencil strategy might therefore be not sufficient. Instead an approach considering the influence of embodiment is suggested.

The present paper deals with the question how displays are represented in users and how this knowledge is being used in situated cognition rendering real action. In recent years, researchers in psychology (Glenberg & Robertson, 2000), philosophy (Clark, 1997; Prinz, 2002), robotics (Brooks, 1991), and linguistics (Lakoff & Johnson, 1999) have started to take seriously the notion that knowledge is “embodied” or grounded in bodily states. The main idea underlying all theories of embodied cognition is that cognitive representations and operations are fundamentally grounded in their physical context. Wilson (2002) notes that once knowledge is acquired (online cognition), a perceiver may represent it in absence of the particular stimulus situation (offline cognition). In performing a real task, however, this knowledge is being differentially used for action according to the brain’s modality-specific systems (Niedenthal, Barsalou, Winkielman, Krauth-Grubrer & Ric, 2005). For instance, when pushing a cue such as in a game of pool means that both the body and the cue must be precisely controlled, whereas moving a cursor in a game of computer chess seems to depend largely on the conceptual organization of the play itself (cf. Gomila & Calvo, 2008).

When we interact with real objects sensorimotor control is the basis of all actions: when we move our arms our body posture is being simultaneously adapted in order to meet the action imposing effects of the mass and gravity interactions. In real tasks at least part of the physical effects being involved in motor action are rather physiological in nature and thus need not to be conceptually driven (Kalveram, Schinauer, Beirle, et al., 2005). There must be a priori situation depending expectations, which influence the balancing motor-control parameters (Blakemore, Frith & Wolpert, 2001). Thus, when a subject is confronted with a certain action task an adaptation of the sensorimotor system is activated in order to select the adequate task specific parameters of motor control optimal for a given situation.

The question remains, however, whether perceiving display-control relations really guaranties an unambiguous specification of a whole perceptual-motor event. Although it has recently been pointed out, that the codes for event coding (Hommel, Müsseler, Aschersleben & Prinz, 2001) might be best represented within a kind of a habitual body map (Schubotz & von Cramon, 2003), an universal solution on how this body map physically interacts with the real world is a matter of contemporary discussions in the field of cognitive science (Sanz, Gómez, Hernández & Alacarcón, 2008; Calvo & Gomila, 2008).

It has long been known that stimulus-response relationships, which are contrary to the intuitive expectancies of the user, lead to slower and/or less accurate reactions (cf. Fitts and Seeger, 1953). Norman (1988) states that expectancy problems entailing serious human errors occur in everyday life as well as in complex professional settings, such as in the control of power plants or airplanes. If errors actually occur it is often supposed that designers and engineers did not consider enough the user's conceptual model of handling the object. Hence, Norman (1988) argues, psychologists should gain knowledge about the particular conceptual model of users for the sake of optimal construction. In this respect Smith (1981) already argued that display-control relations should be constructed as uniform as they meet users' expectations and thus reflect population stereotypes. According to Kantowitz and Sorkin (1983) a population stereotype can be determined by asking people "what response should go with a particular stimulus". The majority opinion is called a population stereotype. One problem, however, is that of generalization, for instance across different populations. For example, Courtney (1988) showed that Chinese exhibited some direction-of-motion stereotypes in a paper-and-pencil-test, which is not found in Western populations. This reduces the validity of stereotypes used for western technology to be exported to China. Therefore, testing the display-control relations on prototype equipment before implementing new display-control ratios should be the best solution (Smith, 1981).

In order to determine population stereotypes, Smith (1981) suggested using questionnaires as an economical measuring method of population stereotypes. However, this method entails a number of constraints (cf. Loveless, 1962; Brebner and Sandow, 1976; Tlauka, 2004). One problem is whether findings from questionnaires can be generalized as to constitute a valid population stereotype across various situations in the "real world", i.e., across individuals in different tasks settings and environments and thus being independent from where and when they were measured (Chapanis, 1988). The prognostic validity of questionnaires simply depends on the correlation between ratings and the performance in "real world" tasks, although a correlation does not guarantee a predictive value on performance in the real world, since an indicator derived from a theoretical model is required for the sake of prediction. A screening instrument made for obtaining population stereotypes like a questionnaire is naturally limited to capturing of mere attitudes about an imagined or anticipated situation.

The methodological facilities of questionnaires for predicting actions in real situations are even more challenged when an item itself suggests a certain tendency of response. For instance, if a person is asked to assign numbers to a spatial layout, a response-bias concerning the serial order of action could be activated. Daar and Pratt (2008) state that many theoretical models of cognitive psychology trust on concepts of spatial representations, such as in working memory (visuo-spatial sketchpad), mental rotations, and efference copy in motor programming. In the early 1990s, an interesting kind of population stereotype has been found collating numerical and spatial processing – it has been called SNARC effect (spatial-numerical association of response codes; Dehaene et al., 1993). Thus, assigning numerals to locations would simply bias the starting point to a preferred egocentric left side (see Gevers et al., 2005, for details about the relationship between SNARC and Simon; see also Boenke et al., 2009, for Garner effects). If an item implies some kind of association between space and order comparable to the SNARC effect, it could not be longer appreciated as an objective indicator. A response-bias would be uniquely implemented only because of using an item category such as numerals.

Another problem with questionnaires is that the researcher only sees the result but not its evolving process. If one is asked, for instance, to assign numbers to a row many people would probably implicitly assume ascending numbers from left to right according to the SNARC effect, although however, a count-down method with a descending order could also have been possible. Thus, a clear conclusion on a preferred strategy is not really impossible and potentially relevant information for the optimal construction of display-control relationships might be lost. To examine these problems, in Schinauer and Lachmann (in prep.) item no. 2 of Smith's questionnaire was chosen, in which subjects have to label the four quadrants of a circle in any way they prefer by using the letters A, B, C, and D. Theoretically, one has 24 possible orders (4! = 24). However, the participants of the Smith study only used about four of them. Smith termed the preferred four configurations ‘clockwise from upper left’ (ul-cw), ‘clockwise from upper right’ (ur-cw), ‘counter-clockwise’ (ccw), and ‘reading convention’ (from left to right and from top to bottom).

Replication of the Smith study

In Schinauer and Lachmann 300 students performed Item 2 adapted from Smith (1981). Our participants showed a strong preference for the reading convention with the questionnaire in assigning letters to the quadrants of a circle. This replicates the findings of Smith. However, as compared to his study, much more variability concerning the usage of other configurations was found in our study: 11% of the participants as compared to 3% in Smith.

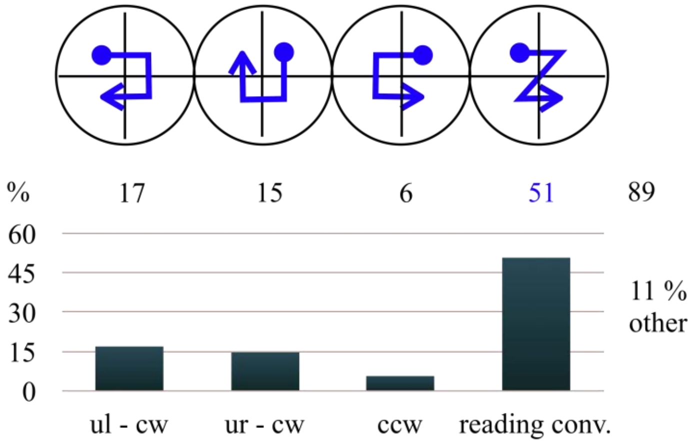

Figure 1. Order preferences in labeling the quadrants of a circle in the replication study (Schinauer & Lachmann, in preparation).

Extending study 1

The replication of the “reading convention strategy” suggests that this conceptual model is mandatory for the action control in this task. If this is true, for the same task a change of test material should not influence the ordering preference. In order to test this, in Schinauer & Lachmann a quad as display instead of a circle was used. This should not have any effect on ordering preference if the strategy is in fact mandatory.

A total of 290 students voluntarily participated in this study. Below the quad, four different shapes were displayed: a triangle, a circle, a cross and an equal sign. Sitting at a table, subjects were required to indicate in which order they would label the four-fold quad. They had to use the particular symbols to show their preferred orders. This procedure does not determine implicitly where the initial position will be. This contrasts to Smith’ study in which letters were used.

The data support the notion of an internal conceptual model of a reading convention also when shapes rather than letters are used for assignment. Thus, habits of writing seem to be so mandatory that they are used independently of the particular given display. However, 39% of our subjects used other categories than those introduced in Smith. Thus, we may ask whether more variation of order preferences would take place if display orientation and size are varied.

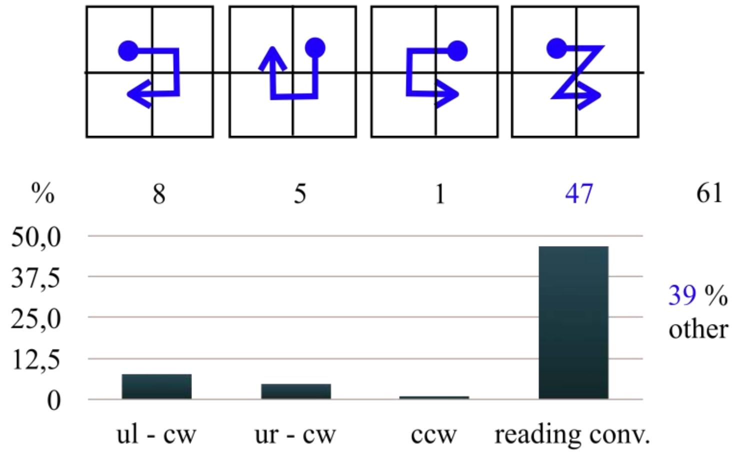

Figure 2. Order preferences in the paper-and-pencil-test using shapes instead of letters.

Extending study 2

This study investigated whether the preferences would change if tasks are more ecologically valid. Thus, in this study, both the size and the geometrical position of the display were altered and the instrument to execute the order task was changed.

A total of 223 volunteers participated in this study. None of them had participated in the first both studies. The set of quads had sizes with side lengths ranging from 60 to 100 cm. Participants had to place cylinders (8 x 8cm) to the centers of the four parts of the quad. There was a vertical and a horizontal orientation of the display, respectively. In the vertical orientation the display could be turned up and down like a tripod in order to adjust it to shoulder height. Standing behind the person, the conductor successively placed the cylinders into the participants’ right hands, and they placed the cylinders in their preferred location. In the horizontal condition, the square lay on a table, in the vertical condition the middle of the square was at the participants' shoulder height. Each participant performed the task only once.

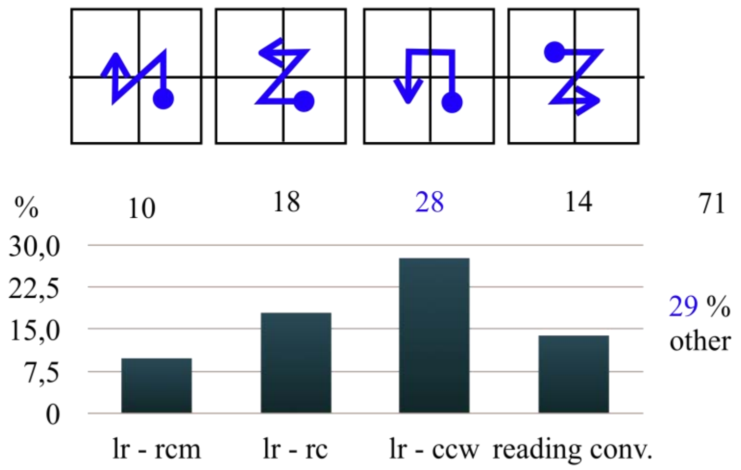

Figure 3. Order preferences by means of using horizontally oriented displays (0.64-1.0m^2).

Participants preferred the lower right quadrant as initial position and the second step was vertically related to the initial position. The lower left quadrant was used least of all. Configurationally, the square was labeled counterclockwise from lower right most often (see Figure 3). This configuration did not occur at all in the original Smith study. When participants had to label the large quads in the vertical orientation, they used the upper right quadrant most often for the initial position. The second step was vertically related to the initial position. Configurationally, the square was classified most often top-to-bottom from right-to-left (see Figure 4). Again, this configuration did not occur at all in the original Smith study.

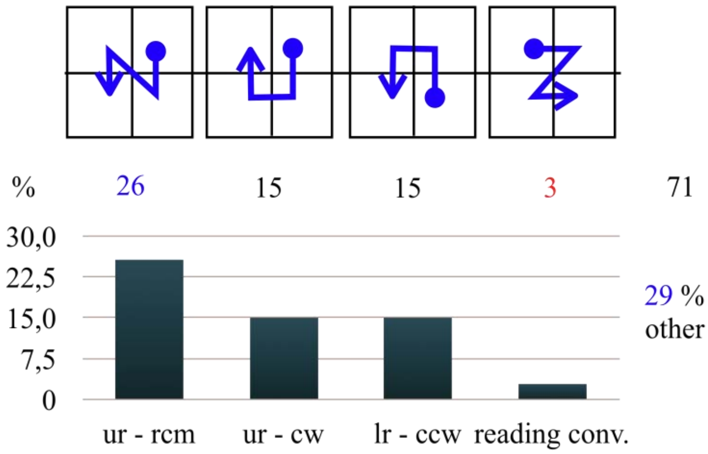

Figure 4. Order preferences by means of using vertically oriented displays (0.64-1.0m^2).

Discussion

When symbols or shapes with a small display according to the standard layout of a paper were used, such as in Smith (1981), our replication study and our first extending study, order preference according to the reading convention was chosen by the majority of the participants. With larger displays, as used in our second extending study the patterns of results changes: The conceptual model of reading convention is now least preferred.

It might, therefore, be concluded that preferences differ as a function of factors such as size and orientation as long as they entail factors of embodiment. Obviously, this was the case in our latter experiment. It can further be concluded that persons' actions are constrained both by the reciprocal relationship of the properties of the object to be acted upon, and the action capabilities of the actor.

References

Blakemore, S.J., Frith, C.D. & Wolpert, D.M. (2001). The cerebellum is involved in predicting the sensory consequences of action. *NeuroReport*, *12*, 1879–1884.

Boenke, L., Ohl, F., Nikolaev, A., Lachmann, T., & van Leeuwen, C. (2009). Different time courses of Stroop and Garner effects in perception - an Event-Related Potentials Study. *NeuroImage*, *45*, 1272-1288.

Brebner, J., & Sandow, B. (1976). The effect of scale side on population stereotypes. *Ergonomics*, *19*, 571-580.

Brooks, R.A. (1991). Intelligence without representation. *Artificial Intelligence*, *47*, 139-160.

Calvo, P., & Gomila, A. (Eds.) (2008). *Handbook of Cognitive Science: An Embodied Approach.* Amsterdam: Elsevier.

Chapanis, A. (1988). Some generalizations about generalization. *Human Factors*, *3*, 253-267.

Clark, A. (1997). *Being There. Putting Brain, Body, and World Together Again*. Cambridge, MA: MIT Press.

Courtney, A.J. (1988). Chinese response preferences for display-control relationships. *Human Factors, 30,* 367-372.

Daar, M., & Pratt, J. (2008). Digits affect actions: The SNARC effect and response selection. *Cortex, 44*, 400-405.

Dehaene, S., Bossini, S., & Giraux, P. (1993). The mental representation of parity and number magnitude. *Journal of Experimental Psychology: General, 122*, 371–396.

Fitts, P.M. (1966). Engineering psychology and equipment design. In S . S . Stevens (Ed.), *Handbook of experimental psychology*. (8th ed.) (pp. 1287-1340). New York: Wiley.

Fitts, P.M., & Seeger, C. M. (1953). S-R-compatibility: Spatial characteristics of stimulus and response codes. *Journal of Experimental Psychology, 46*, 199-210.

Glenberg, A.M., & Robertson, D.A. (2000). Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning. *Journal of Memory and Language, 43,* 379–401.

Gomila, T. & Calvo, P. (2008). Directions for an embodied cognitive science: toward an integrated approach. In P. Calvo & A. Gomila (Eds.). *Handbook of Cognitive Science: An Embodied Approach.* (pp. 1-25). Amsterdam: Elsevier.

Hommel, B., Müsseler, J., Aschersleben, G., & Prinz, W. (2001). The theory of event coding (TEC): A framework for perception and action planning. *Behavioral and Brain Sciences*, *24*, 849–937.

Kalveram, K.T., Schinauer, T., Beirle, S., et al. (2005). Threading neural feedforward into a mechanical spring: How biology exploits physics in limb control. *Biological Cybernetics, 92*, 229-240, 2005

Kantowitz, B.H., & Sorkin, R.D. (1983). *Human Factors. Understanding people-system relationship*. New York: Wiley.

Lakoff, G., & Johnson, M. (1999). *Philosophy in the flesh: The embodiedmind and its challenge to western thought*. New York: Basic Books.

Loveless, N. E. (1962). Direction-of-motion stereotypes: A review. *Ergonomics, 1,* 357-383.

Niedenthal, P.M., Barsalou, L.W., Winkielman, P., Krauth-Gruber, S., & Ric, F. (2005). Embodiment in attitudes, social perception, and emotion. *Personality and Social Psychology Re*view, *9,* 184–211.

Norman, D.A. (1988). *The Psychology of Everyday Things*. New York: Basic Books.

Prinz J. (2002). *Furnishing the Mind: Concepts and Their Perceptual Basis*. Cambridge, MA: MIT.

Sanz, R., Gómez, J., Hernández, C., & Alarcón, I. (2008). Thinking with the body: Towards hierarchical, scalable cognition. In P. Calvo & A. Gomila (Eds.). *Handbook of Cognitive Science: An Embodied Approach.* (pp. 395-421). Amsterdam: Elsevier.

Schinauer, T., & Lachmann, T. (2009). Order preferences as a function of embodiment. Manuscript in preparation.

Schubotz, R.I., & von Cramon, D.Y. (2003). Functional–anatomical concepts of human premotor cortex: evidence from fMRI and PET studies. *Neuroimage, 20*, 120-131.

Smith, S.L. (1981). Exploring compatibility with words and pictures. *Human Factors, 23,* 305-315.

Tlauka, M. (2004). Display-control compatibility: the relationship between performance and judgments of performance. *Ergonomics, 47*, 281-295.

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review, 9,* 625-636.