Modifying Gesture Elicitation: Do Kinaesthetic Priming and Increased Production Reduce Legacy Bias?

Lynn Hoff, Eva Hornecker, Sven Bertel
Bauhaus-Universität Weimar, Faculty of Media, Bauhausstr. 11, 99423 Weimar, Germany
{lynn.hoff, eva.hornecker, sven.bertel}@uni-weimar.de

ABSTRACT

A common issue in gesture elicitation studies is that participants are influenced by interaction with digital products, imitating touchscreen gestures or WIMP icons. In our study, we adapted and experimentally tested two of Morris' et al.'s suggestions for reducing legacy bias: increased production of gestures and covert kinaesthetic priming. Our findings indicate that the practical effectiveness of these strategies might be limited, given we only found medium effect sizes and a wide variance between participants that overshadows any effects. Our work contributes to reflection on, and indirectly, by experimentally testing potential variations, to future improvements of the gesture elicitation method.

Author Keywords

Embodiment; priming; gesture elicitation; legacy bias; study design; movement.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

Gesture elicitation studies have become a common method of devising intuitive gesture sets for specific domains, concerning hands-free, touchscreen gestures, or gestures made holding objects [7, 14, 17, 22, 27]. These studies ask participants to demonstrate gestural commands they find suitable to achieve a specific effect. The aim is to derive intuitive and memorable gesture sets that consist of the most commonly suggested gestures per command, while eliminating potential ambiguities and conflicts.

These studies frequently note a 'legacy bias', that is interaction methods or signs/icons from the digital world are emulated, which have no analogy in the physical world [18, 24, 27]. These may become out-dated with the referent technology, and often do not exploit the potential of full-body and 3D gesture. To reduce legacy bias, Morris et al. [18] suggest several changes to the standard gesture elicitation study protocol. In our study, we adapted two of these suggestions and explored whether the number of proposed legacy gestures can be reduced by 1) kinaesthetically priming participants via physical activity (unbeknownst to them) and 2) having them produce several gestures per command/function referent, instead of just one (increased production). Our results indicate that covert kinaesthetic priming only has a small effect, with an effect size that means there is only little practical relevance. In particular, interpersonal differences between participants outweigh any assumed effects of kinaesthetic priming. In addition, our study revealed no effect of having participants produce more gestures. Our work contributes to reflection on, and indirectly, by experimentally testing potential variations, to future improvements of the gesture elicitation method.

TEI '16, February 14 - 17, 2016, Eindhoven, Netherlands

ACM 978-1-4503-3582-9/16/02…$15.00
DOI: http://dx.doi.org/10.1145/2839462.2839472

BACKGROUND

Gesture elicitation studies have become a standard approach in HCI for the definition of gesture command sets for novel input technologies. In short, users suggest gestures for a set of tasks and common non-ambiguous gestures are identified from this. This is based on the guessability study procedure first described by Nielsen et al. [20] and introduced into HCI by Wobbrock et al. [26]. It is assumed that if a symbol (or gesture) has been suggested by many people, it will be easy for others to guess its meaning without prior learning. The approach has been utilized to derive user-defined gesture sets for a number of areas: multitouch surfaces [16, 27], mobiles [23], the steering wheel [1, 9], deformable displays [14, 24], even foot gestures, and for tasks such as controlling a music player [11], or connecting devices [7, 13].

The common procedure is that an effect or function is shown to study participants (e.g. via animation), avoiding any indication of the trigger interaction. The participant then demonstrates a gesture deemed appropriate, and explains his/her thoughts (think-aloud). Later, they rate their gesture suggestions regarding ease of use, memorability, and fit. Usually, the demonstration of gestures is video-recorded and analysed. Gestures often are classified according to which parts of the body are used, whether they are static postures or dynamic, whether one or both hands are used, and what kinds of metaphors and mental models underlie them [11, 27, 22]. Finally, the research team compiles a solution gesture set, integrating the most common suggestions based on agreement or consensus metrics [27], while eliminating conflicts. Metrics can be roughly summarized as: the more often a gesture is suggested compared to its competitors (for a specific effect), the higher the agreement score.

The original procedure by Nielsen et al. [20] includes a post-hoc evaluation of the resulting gesture set to determine if it is indeed intuitive and memorable for new users, but sadly, this is rarely done in HCI gesture elicitation studies. Recently, it was found that self-generated gestures tend to be more memorable and are considered less effortful than gesture sets generated by others using the gesture elicitation method [19]. This indicates a limit to the general utility of gesture elicitation studies, in terms of the creation of gesture sets that can be utilized by a greater population without requiring personalization and adaptation. Studies frequently find that users prefer natural mappings [14, 22, 27], for example, when direction is involved, people gesture in that direction, or they suggest symmetrical pairs for functionally opposite tasks (e.g. volume up-down, plus-minus). Common are also real world metaphors, the emulation of physical actions on objects, symbolic gestures that depict symbols, as well as abstract, arbitrary mappings (cf. [23, 27]).

Despite efforts to remove factors that may bias participants, user's gestures are frequently influenced by technological aspects [14, 16, 27] such as WIMP interface actions, and more recently, Kinect or touchscreen interaction [17, 22, 24]. Existing technology thus has a 'legacy'. This might be due to a transfer of experience from one technology domain to another, or to a desire to suggest gestures that current technology can detect. Thus, interactions that might be better suited are at risk of not being uncovered [18]. While legacy gestures benefit from their familiarity, they rely on an abstract relationship. As technology evolves, they may grow out-dated and hard to guess. Moreover, from a researchers' viewpoint, richer gestural interactions that exploit the full scale of 3D interactions and sensing capabilities are preferable [18], which could be more suited to the medium of gesture (faster, physiologically easier, etc.). While legacy elements might ease the initial transition for the introduction of new technology, they risk turning into a new standard that over time loses its rationale (compare the discussion about metaphor in interfaces). Participants tend to be very aware of the influence of own prior experience [17, 14]. This eases the identification of legacy bias.

Morris et al. provide several suggestions to improve the elicitation protocol: (1**)** Letting participants produce more gestures per referent may boost creativity. The implicit assumption seems to be that legacy gestures are more straightforward and thus tend to be suggested first. (2) Group-brainstorming could increase creativity. (3) Priming may reduce legacy bias; for example, North [21] found that prior physical object manipulation reduced pointing interactions on a multi-touch table. Morris et al [18] thus suggest letting participants view or even imitate videos of creative gestures so that they may be inspired to utilize a wider range of movements in the elicitation exercise. Their pilot study with 17 participants indicated that the priming and production strategies had potential, resulting in rich and diverse gestures. Those participants who saw videos of movement scenarios, and were asked to carry out physical actions, performed larger, room-sized gestures. In particular, participants tended to prefer the gestures they suggested third. Yet given the small number of participants (with only a subset doing the physical activity), no significant effects could be shown.

In our study, we further pursue this direction and investigated the effect of increased production and priming, focusing on kinaesthetic priming, inspired by research from cognitive science on embodiment-related effects. Priming is an established concept from psychology for an effect where a prior stimulus sub-consciously influences the processing of and responses to future stimuli [25]. Frequently, priming concerns semantic processing (a concept pre-activates processing of further stimuli with a bias towards the concept) [25] and can affect performance, such as improve recognition speed for words or images related to prior stimuli. Priming people with a stereotype can also affect their bodily behaviour, for example, after reading words related to old age, people move slower [2]. Recent research also investigated bodily priming of emotional reactions. In particular, body posture and movement can regulate emotional attitude, such as via induced smiling, frowning, and positive approach or negative avoidance gesture [3, 5; 8]. Letting a study participant adopt a posture can induce changes in affective or attitudinal states and social perceptions (see [3]). There is also evidence for other kinds of non-semantic priming, for example on a visuomotor level (priming of motor responses) in response to prior visual stimuli [6] or following observation of action [15], as mirror neurons imitate and thus pre-activate the action. This motivates our hypothesis that prior physical activity may stimulate more 'physical' gesture via a similar kind of pre-activation.

STUDY PROCEDURE

We developed a seemingly standard procedure for a gesture elicitation study, with a twist, using a between-subjects design with a total of 30 participants. Given the definition of priming as an sub-conscious effect, we decided to 'hide' the priming manipulation. The control of a music playlist was chosen as application, and 14 commands were selected. These include basic core commands, plus a few of more abstract nature (likely to result in more metaphoric gesture suggestions). Besides the basic commands of *play*, *pause*, *stop* (of a song), and change of *volume* (up, down), there are four navigation commands. One can *start the next or previous song*, or *navigate up and down* the playlist while another song runs. In addition, the playlist can be manipulated with commands to turn the *shuffle* mode on or off, mark the current selection as a *favourite*, ask for *information* about the selected song, *delete* it from the playlist, and *save* the changed playlist.

Figure 1: Screenshot of the Playlist Animation

A flash animation (with music playing) of the player was developed and pre-tested with three participants to ensure animations could be interpreted correctly. These three participants did not take part in the main study. The animation deliberately avoids typical music player icons for commands such as play and stop, and illustrates the effects with a moving timeline for the current track and corresponding audio output, and colour highlighting (see figure 1).

Participants

The study involved 30 participants (20 male, 10 female), mostly students from various degree programs, aged 19-30, with an average age of 23. All but one were right handed. All had extensive experience with smartphones, computers and media players. 11 reported having played Wii, 3 Eye-Toy, and 3 Kinect games. 19 participants regularly did sports.

Procedure

After participants signed informed consent forms, the experimenter explained the study goal as 'developing a gesture set for this domain', and showed a video of all animations to the participant on a large computer screen, while stating the name of each function. Then, one at a time, the 14 animations of the effects of a command were shown on the same screen (in random order) and participants were prompted to suggest and demonstrate three gestures per referent and to explain these. Finally, participants rated their gesture suggestions on 7-point Likert scales on how suitable these are, how easy and how memorable.

In addition, half of the participants were subjected to kinaesthetic priming. Given that priming is a sub-conscious effect, it was important to not make them aware of the manipulation. We felt that letting them emulate movements from a dance/sports video, as suggested by Morris [18], might raise suspicion. Thus, participants arrived to find the room full of cardboard boxes and were asked to help clear up to generate space for the study. As the study took place in a new building that was not yet in full use, with deliveries arriving regularly, the pretence was believable. Participants helped to lift boxes onto cabinets, and to shift a heavy table to make space in front of the camera. In addition, under the pretence of finding the best camera angle for all of their movements to be visible, participants were asked to jump up, bend down and stretch out to the sides. The deception was laid open once participants were done, and most found it amusing. None had suspected anything. The other half of participants found the room ready for the study. They first filled in a demographic questionnaire on a PC (primed participants filled it in at the end of the activity).

FINDINGS

General categories were discussed and decided upon by two researchers. One author reviewed all data, and then discussed categorizations and reviewed borderline cases with another of the authors. Gestures were characterized in similar ways as in previous work, (e.g. [1, 11, 13, 15, 23, 27]) in terms of mapping (underlying mental model): whether they enact *direction* (position or shape of hand are not relevant), depict *symbols* (e.g. draw a triangle and square for 'play' and 'stop'), imitate *button/widget* use (e.g. emulate use of a remote), imitate *physical manipulation* of an object (crumple paper), rely on *metaphor* (opening an imaginary book for 'information', shaking one's body to activate shuffle), use an *abstract* mapping (clap to navigate up), and furthermore on physical characteristics, whether they used static or dynamic poses or path. Figure 2 depicts some of the most frequently suggested gestures for commands and their categorization. In addition, gestures were categorized as *legacy* gesture if explanation related to or mentioned prior technology. As this is the topic of our study and of this paper, we here focus on our findings regarding legacy bias, while also providing a short overview of our general findings on differences between the two resulting gesture sets.

Most button and symbolic gestures have legacy bias. As in other studies in the literature, we largely relied on participants' verbal explanations of the gesture choice rationale as indicator of the underlying mental model. Only explanations such as: "swiping, like on my phone", "clicking", "the play button shape", "the 'X' on a window button", "shake it like an iPhone", or: "thumbs up – as if to 'like' something" that explicitly refer to legacy technology were taken to reveal legacy bias (whereas "the thumbs up gesture" or "X,

Info: Open book (metaphor) | play: clap hands (abstract) | delete: crumble paper (physical manipulation) | Favourite: thumbs up or heart (symbol)

Figure 2. Some of the gestures favourited by participants. In some cases categorisation depends on how the gesture was described, to determine which mental model or analogy is taken, in particular for categorisation of legacy bias.

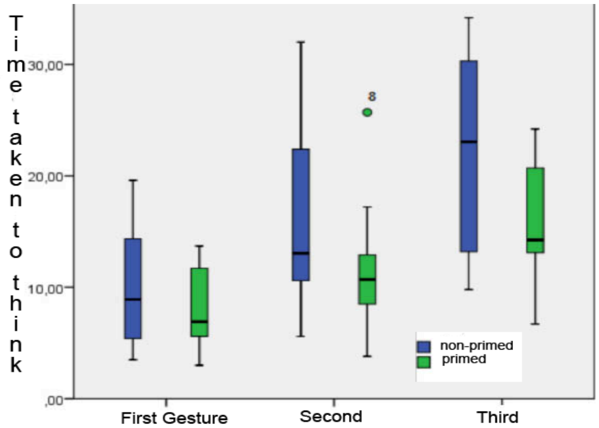

Figure 3. Box plot for time needed to think of a gesture. Note the variation of time to think across participants.

like crossing something out" were counted as a symbol without technology bias).

The Resulting Gesture Sets. No differences were found between primed and non-primed participants in the frequency of static and dynamic poses and paths, and underlying mental models. This is notable, as one might assume that prior extensive movement might affect the style of suggested gestures (e.g. movements rather than poses). Moreover, the two resulting gesture sets did not differ much; for most functions, the three most common suggestions are identical and only vary in order. Navigation commands and volume control were generally associated with directional gestures and playlist commands with metaphorical gestures. Deleting a song was primarily connected to physical metaphors of 'throwing something away'. Participants further suggested simple and quick gestures for the 'play' command, given it is most frequently used.

Priming Effects on Legacy Bias. Shapiro-Wilks tests indicate that legacy gestures are sufficiently normally distributed, right skewed (p=0.228 for non-primed, p=0.269 for primed participants). Although primed participants suggested less legacy gestures on average (∅ 4.8, σ=2.48) than non-primed participants (∅ 6.47, σ=3.42), this difference was not significant (t(30) = 1.527, p=0.138). Figure 4 illustrates large variances across participants. Non-primed participants suggested between 1 and 11 legacy gestures and primed ones between 2 and 15. We found a medium effect

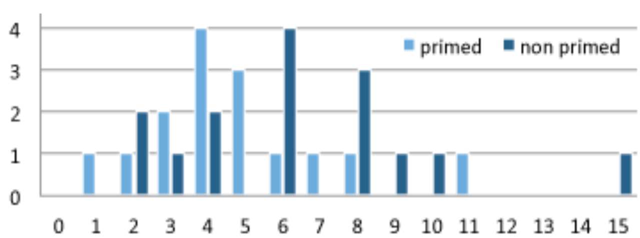

Figure 4: Number of legacy bias gestures in kinesthetically primed (light blue) and comparison condition (dark).

size of d=0.56. A G*power test (www.gpower.hhu.de) reveals that it would have required a sample 170 participants to expect to find statistically significant differences.

Thus, while there might be a significant difference if testing with a large enough sample, the effect is very small and highly influenced by interpersonal differences.

Production Effect on Legacy Bias and Preferences. Morris' et al. [18] suggest that producing more gestures reduces legacy gestures. Legacy bias thus should be most likely at the first suggestion per command. This appears not to be the case. The percentage of legacy gestures remained roughly the same for the respective first, second and third gestures suggested per command, independent of condition. For primed participants, legacy gestures only slightly reduced from 13.8% to 10% and 10.5%, whereas for non-primed participants, numbers jumped from 16.7%, to 13.3% and back to 18%.

Furthermore, participants across conditions rated their first gesture suggestion for a command as significantly more suitable (Median= 2.07) than their next two suggestions (Median = 2.79 and = 3.14) (Friedman's two-factor analysis of variance, $X^2(2)=25.25$, p=0.00; using non-parametric tests as the data was found to be largely not normally distributed). Follow-up, pairwise Wilcoxon signed-rank tests revealed significant differences between 1st and 2nd (T=437 p=0.00 r=0.77) as well as between 1st and 3rd gesture suggestion (T=445,5 p=0.00 r=0.8). Participants also rated their 1st gesture as more memorable than the 2nd (T=420 p=0.00 r= 0.7) and 3rd gesture (T=449 p=0.00 r=0.81). There was no significant effect of condition.

Effects on Time Needed. We also measured how long participants needed to come up with a gesture (Figure 3). This took 14 seconds on average across conditions. Primed participants were faster than non-primed participants (12.1 vs. 15.8 seconds), particularly for 2nd and 3rd suggested gestures, but this difference was not significant. In general, participants needed significantly more time to come up with alternative gestures (Friedman's two-factor variance analysis, $X^2(2)=45.27$ and p=0.00) (Friedman's ANOVA for primed 1st to 2nd: p=0.032, r=0.47; 1st to 3rd: p=0.00, r=0.83; for non-primed 1st to 2nd: p=0.019, r=0.5 and 1st to 3rd: p=0.0, r=0.9).

This finding is according to expectations and confirms that participants need to think more about further gestures for a command, which then might have them resort to different metaphors. It remains an open question whether legacy bias becomes more rare with further successive suggestions per command. While our results are inconclusive, it would be worthwhile to investigate whether kinaesthetic priming eases this creative process as indicated by the quicker process and lower variation (see figure 3) observed in our study.

DISCUSSION AND CONCLUSION

Our study is probably the first attempt to adapt and experimentally test Morris' [18] suggestions for a revised gesture elicitation protocol. We investigated whether increased production and sub-conscious kinaesthetic priming reduces the impact of legacy bias from prior technology experience. Priming resulted in less legacy gestures and a quicker generation of ideas, but the difference was not of statistical significance. With the effect size observed, it would require a large-scale experiment (170 participants) to expect to find statistically significant differences. We argue that given the smallish number of participants that typically partake in elicitation studies (10 to 20!), any potential effect of priming will be overshadowed by the rather high variance between participants illustrated in Figures 3 and 4. Subconscious priming thus is not utile on a practical level. Moreover, our study indicates that increased production does not reduce legacy bias, and revealed that participants (different to Morris' pilot study) preferred their first suggestions over later ones.

The between-subjects design is a limitation of our study. A within-subjects study would be less susceptible to user variation, but would take around twice as long per participant, and require a 2x2 design that would have to 'undo' effects of priming when counterbalancing. Further, it is possible that letting participants suggest more than three gestures (Morris et al. [18] do suggest five) might reduce legacy gestures. But this would impact on practical utility of gesture elicitation, as it would severely increase the time needed per participant (impacting logistics, but also participants' ability to concentrate). Moreover, it remains an open question whether later ideas for a gesture are better. Further, we have only tested whether a relatively modest amount of body movement has an unconscious effect. Further studies could utilize different types of kinaesthetic priming and more extensive physical activity, or, closer to Morris et al.'s original suggestion [18], conscious exploration of rich body movement to counteract functional fixedness [10]. But will explicit and conscious 'priming' be more effective and not suffer from the high variability across participants found in our study? Most of the questions raised towards the end of Morris et al.'s interactions article [18] remain open, which call for a larger series of user studies.

Another limitation of our study is that participants, having to produce three gestures per command, towards the end of the session might run out of ideas and resort to legacy bias gestures. Future work could focus on one strategy on its own or could compare the impact of both strategies against each other in a comparative experiment. Given that our study focussed on legacy bias, we also did not perform a post-hoc evaluation of the intuitiveness and memorability of the resulting gesture sets for 'new' users. Such a study might reveal whether kinaesthetic priming improves the quality of user-defined gestures. As the three most common suggestions for most commands were identical and only varied in order, we found little indication that the two resulting gesture sets might perform differently.

Ruiz and Vogel [22] propose another approach. They constrained participants' movement by attaching weights to their wrists, which then refrained from the typical 'swipe', pinch, or Kinect-style gestures. But their analysis is based solely on visual similarity to touchscreen and Kinect gestures, and does not take account of underlying mental models. Future research aiming to evade legacy bias might also take a different approach: Research on embodied cognition emphasizes that our bodily experiences influence language and thinking. A strong interface metaphor can provide a consistent embodied metaphor that has users suggest gestures which all derive from one embodied schema [4], with less legacy bias and higher agreement scores. Kirsh [12] notes that the mental imagery of dancers and choreographers creates kinaesthetic and somatic feelings that guide movement. Thus, priming participants with movement may be most effective if this movement is semantically related to the application context and if it creates meaningful mental imagery/metaphor.

While our own study has not provided a solution for legacy bias in gesture elicitation, with many questions remaining open, it helps us to exclude some and narrow down on other potential avenues.

REFERENCES

1. Leonardo Angelini, Francesco Carrino, Stefano Carrino, Maurizio Caon, Omar Abou Khaled, Jürgen Baumgartner, Andreas Sonderegger, Denis Lalanne, and Elena Mugellini. 2014. Gesturing on the Steering Wheel: a User-elicited taxonomy. In *Proceedings of AutomotiveUI '14.* ACM, NY, Article 31, 1-8, DOI=http://dx.doi.org/10.1145/2667317.2667414
2. John A. Bargh, Mark Chen, and Lara Burrows, L. 1996. Automaticity of social behavior. *JPSP Journal of Personality and Social Psychology Vol. 71 No. 2 (1996):* 230-244
3. Lawrence W. Barsalou, Paula M. Niedenthal, Aron K. Barbey, and Jennifer A. Ruppert. 2003. Social embodiment. In *The Psychology of Learning and Motivation Vol. 43,* Brian H. Ross (eds). Academic Press / Elsevier, 43-92.
4. Francesco Cafaro, Leilah Lyons, Raymond Kang, Josh Radinsky, Jessica Roberts, and Kristen Vogt. 2014. Framed guessability: using embodied allegories to increase user agreement on gesture sets. In *Proceedings of TEI '14.* ACM, NY, 197-204. DOI=http://dx.doi.org/10.1145/2540930.2540944
5. David B. Centerbar, and G.L. Clore. 2006. Do approach-avoidance actions create attitudes? *Psychological Science 17, 1*, 22-29.
6. Laila Craighero, Luciano Fadiga, Giacomo Rizzolatti, and Carlo Umiltà, C. 1998. Visuomotor Priming. *Visual Cognition, 5 (1/2*), 109–125
7. Ming Ki Chong, and Hans W. Gellersen. 2013. How groups of users associate wireless devices. In *Procee-*

dings of CHI '13. ACM, NY, 1559-1568. DOI=http://dx.doi.org/10.1145/2470654.2466207

8. Nele Dael, Marcello Mortillaro, and Klaus Scherer, 2012. Emotion Expression in Body Action and Posture. *Emotion 12*, 5 1085-1101. doi: 10.1037/a0025737
9. Tanja Döring, Dagmar Kern, Paul Marshall, Max Pfeiffer, Johannes Schöning, Volker Gruhn, and Albrecht Schmidt. 2011. Gestural Interaction on the Steering Wheel – Reducing the Visual Demand. In *Proceedings of CHI'11*, ACM NY, 483-492, DOI=http://dx.doi.org/10.1145/1978942.1979010
10. Karl Duncker, 1945. On problem solving. *Psychological Monographs, 58:*270, 1-113
11. Niels Henze, Andreas Löcken, Susanne Boll, Tobias Hesselmann, and Martin Pielot. 2010. Free-Hand Gestures for Music Playback: Deriving Gestures with a User-Centered Process. In *Proceedings of MUM'10,* ACM NY, Article 16, 10 pages, http://doi.acm.org/10.1145/1899475.1899491
12. David Kirsh, D. 2011. Creative Cognition in Choreography. *Proc. of the 2nd Int. Conference on Computational Creativity,* http://iccc11.cua.uam.mx/proceedings/the_cognitive/kirsh_iccc11.pdf
13. Christian Kray, Daniel Nesbitt, John Dawson, and Michael Rohs. 2010. User-defined gestures for connecting mobile phones, public displays, and tabletops. In *Proceedings of MobileHCI'10.* ACM, NY, 239-248, DOI=http://dx.doi.org/10.1145/1851600.1851640
14. Byron Lahey, Audrey Girouard, Winslow Burleson, and Roel Vertegaal. 2011. PaperPhone: Understanding the Use of Bend Gestures in Mobile Devices with Flexible Electronic Paper Displays. In *Proceedings of CHI'11,* ACM NY. 1303-1312. DOI=http://dx.doi.org/10.1145/1978942.1979136
15. Roman Liepelt, and M. Brass. 2010. Top-Down Modulation of MotorPriming by Belief About Animacy. *Experimental Psychology Vol. 57(3*): 221–227. doi: 10.1027/1618-3169/a000028.
16. Mark Micire, Munjal Desai, Amanda Courtemanche, Katherine M. Tsui, and Holly A. Yanco. 2009. Analysis of Natural Gestures for Controlling Robot Teams on Multi-Touch Tabletop Surfaces. In *Proceedings of ACM International Conference on Interactive Tabletops and Surfaces (ITS'09)*, ACM NY, 41-48. DOI=http://dx.doi.org/10.1145/1731903.1731912
17. Meredith Ringel Morris. 2012 Web on the wall: Insights from a multimodal interaction elicitation study. In *Proceedings of ITS'12.* ACM NY. 95-104. DOI=http://dx.doi.org/10.1145/2396636.2396651
18. Meredith Ringel Morris, Andreea Danielescu, Steven Drucker, Danyel Fisher, Bongshin Lee, m. c. schraefel, and Jacob O. Wobbrock. 2014. Reducing legacy bias in gesture elicitation studies. *ACM interactions 21, 3 (May 2014)*: 40–45. DOI=http://dx.doi.org/10.1145/2591689
19. Nacenta, M., Kamber, Y., Quiang, Y., Kristensson, P.O. Memorability of Pre-Designed and User-defined Gesture Sets. *Proc. of CHI'13*, ACM 2013. 1099-1108
20. Nielsen, M., Störring, M., Moeslund, T.B., Graunum, E. A Procedure for Developing Intuitive and Ergonomic Gestures Interfaces for HCI. *Proc. of Int. Gesture Workshop 2003*, Springer LNAI, 409-420.
21. Chris North, Tim Dwyer, Bongshin Lee, Danyel Fisher, Petra Isenberg, George Robertson, and Kori Inkpen. 2009. Understanding multi-touch manipulation for surface computing. In *Proceedings of Interact'09, Part II.* Springer. 236-249. DOI=http://dx.doi.org/10.1007/978-3-642-03658-3_31
22. Jaime Ruiz, Yang Li, and Edward Lank. 2011. User Defined Motion Gestures for Mobile Interaction. In *Proceedings of CHI'11,* ACM NY. 197-206. DOI=http://dx.doi.org/10.1145/1978942.1978971
23. Jaime Ruiz and Daniel Vogel. 2015. Soft-Constraints to Reduce Legacy and Performance Bias to Elicit Whole-body Gestures with Low Arm Fatigue. In *Proceedings of CHI '15*. ACM NY, 3347-3350. DOI=http://dx.doi.org/10.1145/2702123.2702583
24. Giovanni Maria Troiano, Esben Warming Pedersen, and Kasper Hornbæk. 2014. User-Defined Gestures for Elastic, Deformable Displays. In *Proceedings of AVI'14*, ACM NY, 1-8. http://doi.acm.org/10.1145/2598153.2598184
25. Dirk Wentura, and Juliane Degner. 2010. Practical Guide to Sequential Priming and Related Tasks. In *Handbook of implicit cognition,* B. Gawronski, B. K. Payne (eds.) New York: the Guilford Press, 95-116.
26. Jacob O. Wobbrock, Htet Htet Aung, Brandon Rothrock, and Brad A. Myers. 2005. Maximizing the guessability of symbolic input. In *CHI '05 Extended Abstracts*, ACM NY 1869-1872. DOI=http://dx.doi.org/10.1145/1056808.1057043
27. Jacob O. Wobbrock, Meredith Ringel Morris, and Andrew D. Wilson. 2009. User-Defined Gestures for Surface Computing. In *Proceedings of CHI'09.* ACM 2009, 1083-1092. DOI=http://dx.doi.org/10.1145/1518701.1518866