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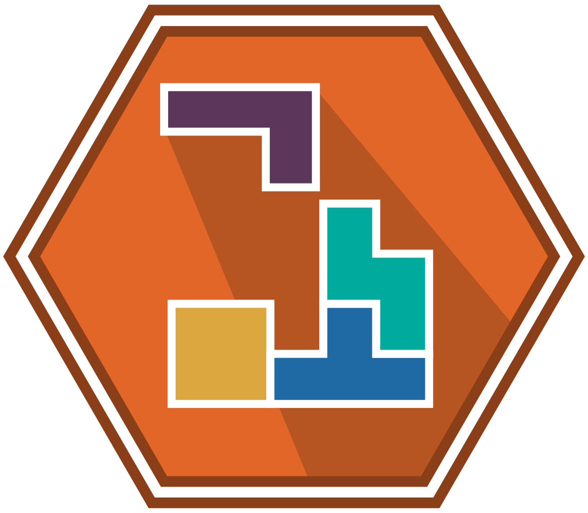

Methods for Change

Method Stacking

Kat Thiel
Manchester Metropolitan University
Dr Iveta Eimontaite
Cranfield University

Corresponding author
k.thiel@mmu.ac.uk

Method Stacking

Method Stacking is a new approach to data gathering that is based on a non-hierarchical, interdisciplinary collaboration between design researchers and the social sciences. It brings insider and outsider perspectives to the study of human-machine interactions in a design context via the iterative evaluation of data with participants.

Method Stacking focuses on these human-machine interactions and investigates workflows by assessing and reflecting on the output of data collection methods to co-construct knowledge with participants. In short, this approach shifts the focus from capturing the most 'truthful' data. Instead, it uses visual output generated by physiological methods as a jumping-off point to generate discussions with the participants who become active agents in the study. This slowly builds up nuanced evidence of participants' cognitive processes and task handling. As such, Method Stacking is useful as a vehicle for discussion, learning and generating feedback, as well as carrying out a research project in a creative environment.

It was developed to combine principles of Fashion Practice Research and Human Factors Research, namely the research of fashion fabrication processes while considering improvements to the physical, cognitive, and socio-cultural aspects of human-machine interactions. It is used most effectively in a Futuring context which involves analysing emerging technologies as well as social, economic, and environmental factors to forecast and envision possible technology solutions.

In Method Stacking, objective and subjective measures are stacked, which means that once completed, a method's output is probed by the same participants, forming the first layer of an iterative process. This allows the findings to gradually stack up by challenging and critiquing the outputs of the different methods, rather than seeing individual methods as conclusive collection points. A task, such as sewing an element of a garment, is set to be carried out by a sample of experts in a work environment that is only loosely controlled; for example, in their home studio or workplace. The research team first conducts the physiological data collection (i.e., biometric data, eye tracking). Then, they actively engage the same participants in the data analysis using qualitative methods (i.e., reflective interviews, hierarchical and cognitive task analysis) to capture subjective experiences, collect evidence of individual decision-making and receive feedback on the effectiveness of the capture devices used in the first step. This leads to a verification or reevaluation of the first visual data set, which is then followed by another iteration of testing and evaluation.

How does Method Stacking create or contribute to change?

From a research perspective, the method breaks down silos within research communities and therefore leverages collective knowledge, skills, and insights. This enables researchers to tackle challenges effectively and creatively by drawing on insights from within and outside of the field of enquiry. Method Stacking is especially suitable for research in work environments that are non-linear and fast-paced. As such, it is an approach that demands a high level of responsiveness from the team of researchers during data collection as conditions cannot be fully controlled and attitudes to processes may differ widely from worker to worker.

At first glance, this might seem like a disadvantage, but capturing variations of data has proven to have a positive effect on how data collection devices, such as eye tracking devices, can be deployed. Built to capture data as accurately and effectively as possible, eye tracking devices rely on stable, controlled environments which rarely occur in real life situations. Using them in unorthodox ways – i.e., in non-ideal light situations or for non-screen-based activities – opens room to interpret and discuss the captured data with participants. This provides the springboard for generating useful qualitative data, where participants assess their own actions in more detail. Using the limitations of the device as a source for rich feedback by the participants has led to novel and improved ways of using capture devices, and can engage participants as active, recursive agents in the research process.

This approach encourages experimentation and learning from failure. It encourages researchers to pivot, adapt, and make necessary adjustments based on participant feedback, ultimately leading to greater insight and improved use of capture devices. It fosters a culture of innovation and particularly supports the research of new tools and techniques, as it combines design-led prototyping and participation design with research of the interaction between humans and their environment, tools, systems, or products. Ultimately, an openness to experimentation and discovery supports the creation of work environments fit for Industry 5.0 which focusses on integrating advanced technologies with a focus on human collaboration and creativity.

What ideas or concepts influence this approach?

A line of enquiry that influenced the development of a collaborative method between Fashion Practice Research and Social Sciences is Design Anthropology, as it proposes that practitioners are not only concerned with transforming the practices of others but also transforming their own research practices. Design Anthropology therefore involves working in multidisciplinary teams, with members alternating between being researcher, facilitator, and co-creator in the design process. Method Stacking is further informed by notions of Practice-based Design Research and specifically draws on the concept of the Designer/Practitioner/Researcher. These hybrid performers are deploying their insider design expertise to further their field through research by inviting technological enquiry to transform existing systems that need re-evaluation through design.

Method Stacking acknowledges that data, however thoroughly captured, is likely to introduce a level of ambiguity which arises from the limitations of each method. It recognises that complex problems cannot always be fully understood or solved through a multi-method or mixed method approach. Instead, it urges the researchers to navigate uncertainty, challenge assumptions, and explore multiple possibilities, leading to more informed and nuanced findings. The method is therefore ideal to prevent Design Fixation, a concept which describes scenarios in which designers or skilled workers limit their creativity due to a tendency to rely on known elements, techniques and processes. Relying excessively on a specific knowledge base is directly linked to notions of psychological inertia which affects researchers and practitioners alike.

Countering these effects, Method Stacking works by critiquing, and reflecting on methods' limitations and therefore building strong feedback loops that invite revision and improvement rather than reliance on established methods. Introducing a level of ambiguity therefore acts as a catalyst to move from a problem space to a solution more effectively.

Method Stacking also combines principles of cognitive psychology, highlighting how perception and decision-making relate to behavior and as a result are reflected in physiological signals. By capturing objective data such as eye movement, heart rate, etc. which is then opened to challenge by participants reflecting on the data, researchers gain a detailed understanding of how participants approach tasks, what difficulties they experience and what mechanisms they deploy to successfully manage a task.

Why might I want to use Method Stacking?

- Method Stacking is ideal for a mixed team with backgrounds in design research and social science. In combining the strengths of scientific analysis with the flexibility and responsiveness of design research, the data gathered is rich and nuanced, informing solutions to a problem space in a work environment.

- The combination of the researchers' insider and outsider perspectives is critical, i.e., for a study on garment manufacturing the team consisted of fashion researchers and human factors researchers. This allows for a true multidisciplinary approach, where researchers are introduced to methods of other fields that they might be less familiar with and are able to assess and adjust to suit their own field of enquiry.

- This approach is well suited to be applied in any work setting or environment that is non-linear, creative, and fast-paced.

- The research is human-centric and relies on continued participant insight for in-depth data that captures their perspectives, experiences, and behaviors related to the design problem.

- As a highly reflective approach it encourages two types of reflexivity. The first is through participant feedback and reflection on the accuracy of the captured data. The second is by the research team themselves, where feedback on the usefulness and accuracy of the capture devices leads to constant improvement and adjustment to the methods used during studies. The method therefore encourages iterative data capture and constant re-evaluation of data output and an openness to risk-taking.

- Method Stacking ensures that the data of the initial physiological method is not taken at face value but further interrogated, as capture devices have their limitations in uncontrolled environments. Much like a mixed method approach, qualitative and quantitative data is collected throughout the study (i.e., biometric and physiological data as well as interviews and questionnaires). Crucially, the first biometric data set is critiqued and analysed by the participants which leads to granular and rich feedback on the validity of the captured data and more detailed descriptions of their own actions and intentions. Therefore, methods are stacked and not just mixed to capture the full complexity of a situation.

Step by step guide to using Method Stacking

1. **Identification of the problem space and selecting expert sample groups for:**

   a) studies/tasks and reflective interviews: Participants of this group are typically workers in a certain industry, they can be co-workers in the same company or hailing from different companies.

   b) optional: a group of expert practitioners who answer a survey which does not need following up and does not include a practical task.

   To begin with, the team of researchers have a goal in mind, e.g., to evidence a certain behaviour or occurrence in sample group A, but no hypothesis is formed.

2. **Desk-research:** In-depth desk research is carried out by the researchers, to give a clear picture of the reporting of the problem space and the knock-on effect this has on the sector under investigation. This can include literature reviews, reports and secondary data analysis. This enables the researchers to identify early directions to ameliorate the problem.

3. **Preparation:** The research team decides to study a practical task that would benefit from redesigning, and which is typically carried out by the workers, i.e., a sewing task that could be automated. Participants of sample group A are informed about the data that will be captured and sign consent forms, they are then equipped with data capture devices. This could be a combination of the following: FEA (Facial Expression Analysis), Motion capture, Eye-Tracking, EDA/GSR (Electrodermal Activity), EEG (Electroencephalography), ECG (Electrocardiography), EMG (Electromyography) or Cloud (ODC).

4. **Implementation:** Sample group A performs the task in a setting natural to them, changing as few of the usual settings as possible, i.e., if the participant is normally working on an assigned machine, they should use this exact machine during data collection. Videos of the tasks are taken either directly by the device or recorded complimentarily during task performance.

5. **Data Analysis:** In this step, the researchers analyse data sets that were captured during the task performance. This data heavily informs first indications for similarities and highlights variables in each participant's performance. At this stage, it is easy to identify anomalies, such as fluctuations in the pupil tracking, in the data sets which will form part of reflective interviews.

6. **Cognitive task analysis:** In this segment, the researchers meet with the participants in one-to-one sessions and present them with a play back video of their task. The participants' actions are clearly visible in the video, and they are asked to comment on their actions, reasons for adding certain subtasks, and how well the data has been captured, e.g., if the eye-tracking correctly represents where they were looking in each moment. The participants verify the data and in turn explain how they know that, for example, the pupil tracking is in or off focus by giving rich accounts on how they approached carrying out the task and where they were looking and why. The oral description of the activities, their complexities and the ad-hoc adjustment to problems during task performance give evidence of individual cognitive and haptic skills, information that could not have been collected via the devices alone.

7. **Iteration**: Based on the feedback gathered in Step 4, a new round of tasks is devised to address some of the anomalies found in the data sets. Here several new factors can be interrogated, including: the calibration of the devices, introducing new materials e.g., different type of fabrics and task environments (such as a new sewing machine with different light setting to previous data capture). Manipulating these variables will help finetune the capture devices but it will also add to gaining richer insights into task behaviour with independent variables. Again, reflective interviews are held with the participants.

8. **Questionnaire:** To gather more insight into topics relating to broader aspects of the problem space, the team devises a survey for sample group B, to collect data relevant to the larger culture under investigation. This is an ideal space to collect data relating to individual aspirations for change or stabilisation.

Examples of Method Stacking in social science research

Human-centric research of skills and decision-making capacity among technical workforce in fashion garment manufacturing.

Researchers:
Kat Thiel, Manchester Metropolitan University; Dr Iveta Eimontaite, Cranfield University; Dr Sarah Fletcher, Cranfield University and Prof Susan Postlethwaite, Manchester Metropolitan University

Method Stacking was developed as a joint methodology during a collaboration between design researchers from Manchester Metropolitan University and Human Factors researchers from Cranfield University. The initial aim was to investigate how social science methods can be used in a design context to investigate how technology solutions could enhance garment manufacture through new skills. The team worked closely with a small sample group of sewing machinists. Method Stacking developed organically, enabling the team to uncover the existing skills levels of sewing machinists. Participants were equipped with eye tracking devices and biomarker wristbands while they were tasked with sewing a standard sleeve placket using their preferred machine.

Researchers then invited the same sample group to review the captured eye tracking and reflect on their actions during task completion, additionally they were asked to comment on the accuracy of the eye tracking.

Seeing the limitations of the capture device, participants were able to better articulate what they were doing and why, and thereby evidencing their cognitive processes and decision making in more detail than if they had been asked to purely describe their course of action.

This enabled a richer qualitative data set and provided the research team with valuable insight into how to use the limitations of a method to their advantage. Participants responded very positively to being closely involved in the study and appreciated that they were asked to verify the accuracy of the captured videos and data. The researchers gained an understanding of the worker's needs, motivations, and behaviors, and were able to collect information on what constitutes skilled work and how the machinists thought it could be improved upon. Method Stacking helped to evaluate the manual processes and existing skills before considering how technology assistance can be implemented as a next step. The findings were then disseminated through several academic outputs (ASPECT report, AHFE 2023 conference proceedings: Human-centric research of skills and decision-making capacity in fashion garment manufacturing to support robotic design tool development. K. Thiel, S. Postlethwaite, Manchester Metropolitan University).

Examples of Method Stacking in social science research

CONBERGE and AI-PRISM (Multistakeholder European Council Research projects)

Researchers:
Dr Iveta Eimontaite, Cranfield University

The Cranfield University team are using Method Stacking in two European Council projects that focus on Social Science and Humanities integration in the early stages of technology solution. It was used in the initial research stages of CONVERGING (Social industrial collaborative environments integrating AI, Big Data, and Robotics for smart manufacturing; www.converging-project.eu/) and AI-PRISM (AI-Powered Human-Centred Robot Interactions for Smart Manufacturing; https://aiprism.eu/).

The same approach of objective data (which cannot be easily controlled by participants, i.e., heart rate, brain activity) and subjective data (data where participants provide their own evaluation, i.e. interview responses, self-report questionnaires) triangulation and being guided by the participants was used.

In both projects, Method Stacking contributes to technology solution development and ensures user needs and requirements are met, and constraints of the sector are considered. Both projects include over 35 partner institutions from academia and industry investigating and developing robotic and AI solutions for the manufacturing sector (i.e., aerospace, automotive industry, furniture producers, etc.). This work resulted in conference publications (publication list 2-4) and is the starting point of user engagement and co-creation with the operators.

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Where else could Method Stacking be used?

Method Stacking is an unusual approach in that it asks researchers to work with methods in a very flexible manner. It can be used in any work environment where there is human-machine-interaction and a desire to improve workflows, worker safety, ergonomics and technology use. One example where this is especially useful is the study of collaborative robotic work environments where workers have to adapt to novel techniques and processes and align their own expertise with the capabilities of the robotic tool. In a research context, it has mainly been used in a co-design context where researchers work with expert makers to study their skills levels and understanding of new technology and their willingness to adopt such systems. Method Stacking's field of application can be broadened to include other sectors like automotive, aerospace, agriculture and other fields of industrial production.

Top tips

- Always start by choosing a data capturing method that has visual output. This could be video, graphs, scans and so on. Physiological data works really well for this.
- Be flexible to flip a method on its head if need be and don't always take the output of a method at face value.
- Mix and match – be creative and brave in mixing methods to take the full advantage of the stacking concept.
- It is important to find participants who are willing and have the time to engage with the study at various stages in the process. Method stacking is therefore a fairly resource intensive technique, so bear this in mind when planning activities and schedules.
- Actively invite people to critique and challenge the output of methods - this will lead to richer data. The key here is to not rush and to ask many questions.

Further reading

- Eimontaite, I., Fletcher, S. R., Goławski, K., & Kołcon, T. (in print). Breaking the barriers: multilingual user engagement to increase process engagement and technology acceptance in manufacturing. Ethical and Psychological Human Factors in Industrial Robotics: *Proceedings of the AHFE 2023, July 20-24, 2023, San Francisco, USA.* Springer International Publishing, 2023.

- Godhania, S., Eimontaite, I., Fletcher, S., Gonzalez Segura, A., Ruiz, E. and Caro Ospina, A. (in press). To collaborate or not to collaborate? How to determine the most suitable level of automation to increase workforce sustainability and production efficiency. *Proceedings of the ICRES2023, July 17-18, 2023, Utrecht, Netherlands.*

- Sashidharan, V., Eimontaite, I., Fletcher, S., Dimitropoulos, N., Makris, S., Michalos, G., Israeli, I. and Tucker. S. (in press). How can human-robot collaboration improve operators' working conditions and wellbeing in aircraft fuel tank inspection: a mixed-methods user-centred approach. *Proceedings of the ICRES2023, July 17-18, 2023, Utrecht, Netherlands.*

- Thiel, K., Postlethwaite, S. (2023 in print). Human-centric research of skills and decision-making capacity in fashion garment manufacturing to support robotic design tool development. *Proceedings of the AHFE 2023, July 20-24, 2023, San Francisco, USA. Springer International Publishing, 2023.*

The Method Stacking was partially inspired by the past work:

- *Eimontaite, I. (2022). Human–Robot Collaboration Using Visual Cues for Communication. The 21st Century Industrial Robot: When Tools Become Collaborators, 71-85.*

- *Johnson, T. L., Fletcher, S. R., Baker, W., & Charles, R. L. (2019). How and why we need to capture tacit knowledge in manufacturing: Case studies of visual inspection. Applied ergonomics, 74, 1-9.*

To reference:

Thiel, K. & Eimontaite, I., (2023) 'Method Stacking' in Rodekirchen, M., Pottinger, L. Briggs, A., Barron, A., Eseonu, T., Hall, S. and Browne, A.L. (eds.) *Methods for Change Volume 2: Impactful social science methodologies for 21st century problems.* Manchester: Aspect and The University of Manchester.

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