Applying Bodystorming to Human-Robot Interaction Design

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Abstract. In human-robot interaction (HRI) design, it is critical to consider the needs of users early on in development. One ideation technique for doing so is bodystorming, in which participants act out the parts of humans and robots in a certain scenario. This practice allows potential users to draw on and express insights for how robot should help, or interact around, them in a given context. In this paper, we discuss our experiences applying bodystorming in industry across three different scenarios for two different robots. We focus on the methods and techniques of bodystorming, in order to help researchers most effectively apply this technique in the HRI design process. We give recommendations for choosing and preparing good participants, honing scenarios, keeping scenes on track, interrupting scenes to disrupt false assumptions, and embracing serendipity. We hope that these guidelines encourage and inspire more researchers to add bodystorming to their experimental toolkit.

Keywords: Bodystorming · Design Methodologies · Industry · Human-Robot Interaction

1 Introduction

Bodystorming is an active, embodied ideation technique that is particularly well-suited for human-robot interaction (HRI) research. According to Martin and Hanington, “Bodystorming situates brainstorming in physical experience, combining role-playing and simulation to inspire new ideas and empathic, spontaneous prototyping.” [8]. The basic idea is quite simple. A set of participants role-plays a given scenario, much in the manner of improvisational theatre, taking turns to act out the parts of the robot(s) and human(s) in the scenario. Researchers observe these improv scenes, and attempt to extract insight about the design of effective interaction strategies. Recently, bodystorming has been used successfully in multiple instances of HRI design in research settings, such as for navigation behaviors and robot personality design (see Section 2).

In an industry setting, where the robot is a product, bodystorming is in a unique position to help define the right set of features or interactions while minimizing risk and cost. For this setting, it is often time-consuming to program a robot to exhibit behaviors not already covered by the production software. Using an existing robot can also hinder the ideation of more future-forward ideas beyond the robot's current capabilities. Bodystorming circumvents these issues, since it engages humans to take the role of the robot. Through this practice, designers and developers can gain product insights without writing any new software or making any hardware changes. The exploratory method also enables much faster design-and-test iteration cycles within a single session, as well as participatory design, two important parts of innovative product development.

In this paper we describe our experiences using bodystorming in an industry setting, as part of the design process of two different robots. We exclusively focus on the *process* of bodystorming and on what we learned *about the process* over the course of several studies. The main contribution of this paper is to describe this process and give a list of specific guidance for readers interested in using bodystorming as part of a design research toolkit. We make recommendations to improve the practice in ways that would be consistently useful in the types of studies we ran, rather than establish an immutable set of rules for future ones. This guidance is likely of use not only to industry roboticists, but also academic researchers developing new human-robot interactions and paradigms.

2 Related Work

Bodystorming is not new technique, and it is relatively well-known in some disciplines. It is mentioned in a number of books and articles that summarize design and ideation techniques [8, 6], where it is often presented as one of many design methodologies. Schleicher, Jones, and Kachur [12] describe it as "prototyping in context." They characterize it as "supporting collaborative embodied congition", and link bodystorming and their own extensions to it, which they call "embodied storming" to theories of embodied cognition. Similarly, Oulasvirta, Kurvinen, and Kankainen [9] note that "bodystorming should be seen as a way of working (and playing) with data in embodied ways, 'being there'." Martin and Hanington [8] attribute bodystorming's origination to Burns *et al.* [3], who initially called the technique Informance Design.

Gray, Brown, and Macanufo [6] identify three stages to bodystorming: (1) Go Observe, where researchers observe real-world examples of the problem under consideration; (2) Try it Out, where participants role play to develop ideas and intuition; and (3) Reflect on What Happens, where participants and researchers analyze what happened in the role playing sessions. In this paper, our bodystorming approach closely follows this three-part characterization, although for the first part we often rely on real-world lived experience of the problem setting rather than observation. This leans into participatory design, in which researchers intentionally involve authentic stakeholders into the design process, rather than those who have simply observed the problem from afar.

This prior literature describes bodystorming quite generally and at a more superficial level. Our work builds on this general foundation, adding advice and insights specifically targeted at the HRI research and design process.

2.1 Bodystorming in HRI Research

Exploratory prototyping is key for robot design and development, and bodystorming has been previously proposed as promising for doing so. Zamfirescu-Pereira *et al.* [16] highlight bodystorming's flexibility and complementary nature to other methods, highly recommending its adoption in HRI. Abtahi *et al.* [1] propose bodystorming as a tool that roboticists can leverage from more general design metholodologies, presenting an analysis of HRI designer workflows and testing a role-playing workshop to communicate their needfinding insights.

Several papers also describe the use of bodystorming in the development of socially-appropriate behaviors for robots. For instance, Gallo *et al.* [5] used bodystorming for robot behaviors in elevators, beginning with an ethnographic study, the results of which were iterated into bodystorming scenarios to refine ideas. The process ended with animations and design rules derived from bodystorming. You, Chen, and Deng [15] used bodystorming to design a robot pet, conducting pilot studies and interviews. Alves-Oliviera *et al.* [2] used bodystorming with children to design robot personalities, leveraging participants' lived experiences. Bodystorming has also been used "in the wild." Smith [14] detailed its application in mobile interactive learning, while Segura, Vidal, and Rostami [13] explored bodystorming's psychological foundations, challenges like social anxiety, and suggested playfulness to overcome them.

Other work describes robot design frameworks and tools that include bodystorming as a key element. Pelikan, Porfirio, and Winkle [10] present a methodology, which they call Stop, Enact, Engage, and Reflect (StEER) for non-technical interaction designers that uses bodystorming as one of the steps (Enact). They also emphasize the importance of reflection on one's own lived experiences and a retrospective analysis of the bodystorming sessions. Porfirio et. al. [11] present Synthé that allows designers to bodystorm demonstrations of an interaction and automatically records, analyzes, and translates them into prototype behaviors.

The above work strongly highlights the promise of using bodystroming in HRI and motivation to expand its adoption. However, the majority of this literature is on the *results* of bodystorming, or as initial proposals for use of the method. This paper, in contrast, focuses on detailed guidance for implementing the *technique* of bodystorming. Our goal is to provide a concise introduction to how researchers can very practically perform the practice.

3 Our Bodystorming Sessions

In this section, we describe our experiences running bodystorming in three different contexts. All sessions lasted about 90 minutes, and followed a similar structure. First, the researchers introduced themselves and talked about the purpose of the session (5 minutes). Next, we ran improv warm-up exercises (Zip-Zap-Zoop and Freeze Tag [7]) until we felt that people were ready for bodystorming (about 10 minutes). The main bodystorming session lasted 30 to 60 minutes, depending on participants' energy level. Finally, in a debriefing session, we collected participants' thoughts and observations (15 minutes).

Sessions focused on how a robot would interact with humans in their environment. All participants were employees of Amazon, the company developing or using the robots. All three studies were approved by WCG IRB, an ethics board external to Amazon. Participation in the studies was voluntary, and participants were considered to be at work during the studies (and paid as such), but received no additional compensation for taking part in the studies. We video and audio recorded sessions in order to later asses in-depth.

In these sessions the participants were robot designers (session 1), robot users (session 2), and robot designers with lived experience of the robot in their homes (session 3). This illustrates that we can use bodystorming for participatory design, as an internal tool for design teams, or for a hybrid of the two.

3.1 Study 1: Astro in Homes

This study explored how Astro, a small household robot, could help in homes. The results were used to help Astro fit in at home and be useful.

Participants and Sessions: We ran three bodystorming sessions, with a total of six participants who were robot designers. Some participants were present for multiple sessions, and we had three or four participants per session. We did not collect data on ethnicity or gender. One researcher occasionally joined in the bodystorming, while a second researcher acted only as a facilitator.

Scenarios and Structure: Participants bodystormed solutions to scenarios involving Astro. Scenarios related to how Astro could help in the kitchen and stay out of the way, and to how it could ask if it should remember certain objects it saw around the house. We introduced both scenarios at a high level (e.g., how can the robot help you in the kitchen?). Participants brainstormed ideas, then acted out specific scenarios they had brainstormed.

Environment and Props: In a typical medium-sized conference room we created an abstract "kitchen" using conference tables, chairs, footstools, and pieces of paper with names written on them corresponding to parts of a kitchen (refrigerator, stove, etc). Participants used simple props, like a colander and a spatula. Participants and researchers could adjust this environment quickly when they needed something else from it, like a different size or layout.

3.2 Study 2: Proteus Motion

In this study, we examined how Proteus, a small mobile robot that operates in warehouses, should move through human-occupied spaces seamlessly with its human coworkers. The results were used in the design of robotic driving behavior.

Participants and Sessions: We ran six bodystorming sessions, with 20 participants of diverse gender and ethnicity: 17 warehouse workers, and three managers. Ten of the workers worked shifts during which they typically saw the robot driving through the facility for testing. The other participants had minimal familiarity with the robot. We provided information about Proteus before the session and showed the actual robots when they were available, and images and videos of them when they were not. We described the robots' capabilities to participants before the session began (e.g., the robot can drive forward and turn like a car, but cannot step sideways).

Scenarios and Structure: We used simple, concrete scenarios. We asked participants to bodystorm solutions to three of them: (1) you are approaching the robot head-on and need to pass it; (2) the robot is at an intersection and you are passing the area; and (3) the robot is depositing a cart in the loading area where you are also picking up a cart. We ran the scenarios with workers walking through empty-handed and while pushing carts.

We changed the overall procedure slightly, based on our experience with the first study. We had two researchers for five sessions and one researcher for one session. One researcher acted as the main facilitator, proposing questions and prompting participants, while the second managed the video camera, helped prompt participants to provide more details, and answered technical questions participants had about the robot. We sometimes switched the complex improv game (Freeze Tag) for a less complex improv game (Only Questions) [7]. We asked participants to write down their ideas throughout bodystorming, but they seldom did, despite holding clipboards.

Environment and Props: We ran the study in a large warehouse where workers moved carts of goods across the building. We ran the study in an active aisle to obtain high realism, to elicit more concrete suggestions. This area was loud (although within NIOSH and OSHA limits), and occasionally employees who were not part of the study moved through the area for their jobs. Props included carts to pull, colorful flags to represent robot lights, a laser to simulate the robot's projected lights, a bicycle bell to represent the robot's sound, and a blue hat to represent the robot moving with packages on it.

3.3 Study 3: Astro Asking Questions

In this study, we examined when and how Astro should actively ask questions of people in a home setting. The results influenced design choices and technical algorithmic development to make querying conversations more usable.

Participants and Sessions: Eight participants took part in four bodystorming sessions, each with two participants and two researchers. Some participants joined more than one session. All but one participant had extensive lived experience with the robot at home. All but one participant worked on the robot in some capacity (with the one who did not working in an adjacent technology area). Participant demographic information collected was limited.

Scenarios and Structure: Bodystorming involved three scenes: one in a kitchen, one while watching TV in the living room, and one in a home office. Each scene had several scenarios where the robot's goal was to ask humans questions and refine its model of where and when it could wait when not engaged in a task. We gave more instructions to participants acting the robot's part about what variables to change, than in the bodystorming in Section 3.1. These includes the specificity of questions, their follow-up questions, and their levels of persistence. After each scenario, we held a very short (two minute) debrief, to capture immediate thoughts and reactions. Scenarios lasted one to three minutes; researchers ended them when there was a natural lull in interaction. Ten to 15 scenarios occurred per session. After all scenarios, we instructed participants to write their key impressions on post-it notes and used them to guide a final discussion.

Environment and Props: Like Study 1, this study took place in a large conference room. Tables and chairs simulated a kitchen and a living room (with a "couch" and cardboard box "television"). We provided kitchen props like in Study 1, and a grocery bag played the role of a sleeping dog.

4 Guidance for Bodystorming Sessions

In Section 3, we described three bodystorming studies that we performed, related to two robots, with three user groups. Each of these studies, and each of the sessions within the studies included different opportunities and challenges. In this section, we discuss learnings about how (and how not) to run a successful bodystorming study, as guidance for readers interested in using the technique in their own research. As noted above, this paper focuses on what we learned about the bodystorming technique - not the scientific results we gathered from the process. We organize our guidance according to bodystorming phases: (1) introduction; (2) warm up; (3) bodystorming; and (4) debrief. We also include information on (5) operational and behind-the-scenes details. We have aimed this guidance to be use-case and robot agnostic, though some is noted to be variable based on the stage of robot development.

4.1 Introducing the Session

Frame the approach. For several groups, background information on studies with bodystorming was useful in adding scientific legitimacy to a process that some participants were wary of, likely because of its "make believe" structure. Reinforcing that the approach was proven, that we were looking for quantity of ideas and insights over "quality", and that even silly-seeming insights often proved useful and actionable helped some participants relax and more readily engage in the process.

Describe and frame the robot. For those not familiar with the robot, a concrete description of its capabilities was helpful. However, this needs to be coupled with an admonition to not be strictly bound by the current capabilities of the robot. In most bodystorming studies, framing the robot or product not as it *is* but as it *should* be is key. We do not want participants to be overly worried by implementation details, but we also do not want them to be overly optimistic such that the scenarios become impossible to implement. There is a fine line between reality and speculative future reality. Researchers can frame by example, by having the facilitators do the first scene to demonstrate the level of realism they want. This is also a process, and the facilitators can explicitly discuss and refine this between scenes via short debriefing sessions. The specific framing of the robot constrains the design insights that we can get from bodystorming. This is not necessarily bad; if the physical design is set and we are interested in software capabilities, then constraints on the morphology are appropriate. However, if bodystorming is being used earlier in the design process, framing the system more broadly might be appropriate. The scope and strength of the framing should match the scope and types of design insight being sought.

4.2 Warming Up

Help participants with various comfort levels become involved. Each group of participants is different, with some becoming energized and creative after a short warm-up and others needing longer to warm up. Researchers should run warm-ups until everyone participates enthusiastically. To encourage this, it helps to have some extroverts, improv enthusiasts, or prior bodystorming participants in each group, and to encourage quieter participants to join in. However, researchers also need to notice participants' needs and let them go if they are uncomfortable with the activities. It helped to have a few different types of icebreaker improv games that the researchers could choose between depending on participants' needs. Those with little improv experience picked up on some games more easily than others. Only after fully understanding the games could most participants move to enthusiastic engagement.

Researchers should be active participants. It was useful for researchers, or someone who had taken part in a previous session, to lead the first warm up exercise, to help break the ice in the group and to show (rather than explain) the games. Especially early in the warm up, some participants were reluctant to join in; enthusiastic involvement of others helped them to engage. Researchers could engage in the warm up to adjust the energy, ramping it up or down as needed, so that everyone was comfortable participating. We have no pre-set advice for this, since it relies on reading the energy of the group and avoiding being too stoic or too silly. As facilitators we found this to be quite straightforward in practice, especially after running a few sessions. Keep it positive; keep it encouraging.

Manage your expectations. Some participants had a hard time with the warm up games, and we had to dial them back. This was especially true in the warehouse setting, where some employees were more hesitant to take part in the warm up games, presumably because they were visible to their colleagues and saw it a serious place of work. We did not observe this reticence in the other sessions, which took place in office settings with knowledge workers. When running bodystorming sessions, the researchers should be sensitive to the natural inclinations of the participants, and the environment in which the activity is taking place. Less enthusiastic participation in the warm up exercises and brainstorming does not mean that the results are less valid or useful; it may just reflect the prevailing social norms at play. Indeed, with the warehouse workers suggesting robot behavior in their own work environment, the suggestions were very practical and applicable.

Keep the games simple. In the Freeze Tag improv game [7], even after seeing examples, some participants were confused and had difficulty engaging with it. Some people would never call "freeze," and if someone else called it for them to help them into the game, they sometimes did not play. Instead, they asked questions about the game rules and did not grasp the concept or the purpose in the time allotted to the warm up. In these cases, it is better to use to a simpler game that can get everybody engaged.

4.3 Engaging Groups

Keep people moving. Especially for more reserved groups, if there was individual brainstorming at the beginning of a session, it helped to have people write down their ideas on a whiteboard interactively as a group. If participants sat down at tables to write down ideas, the energy from the warm ups drained out of the room. In the bodystorming itself, participants tended to want to talk more and move less, likely because they are used to talking about their ideas rather than acting them out. Again, this drains the energy from the session. To get the full effect of bodystorming, when people suggest an idea, it helped to say something like, "Could you act that out for us?" Also, specifically prompting people, "You suggested something a little different. Could we see that?" worked well. The more time that passed between acting it out, the harder it was to get people to do it again.

Help participant with various comfort levels become involved. As discussed in the Improv section, some individuals and groups had an easier or harder time getting into bodystorming. For groups that are not feeling comfortable enough to open up, more improv time may help. For groups that have opened up a lot and are perhaps too silly, asking them to brainstorm and write down on their own paper may help them calm down.

Demonstrate first. To help participants more readily engage with scenarios that the researchers are looking for, researchers or prior bodystorming participants can first show an example of the scenario. Doing so helps set expectations and shows, rather than trying to explain abstractly, what the researchers need. Although participants often begin by running scenarios that look more like the example, with time they become more creative and use more of their own ideas.

4.4 Successful scenarios

Make scenarios specific and simple. It helped to provide specific scenarios. For example, "you're cooking," was too general, but asking participants to cook a favorite meal worked well. The key is to give enough structure to allow participants to immediately picture the scenario in their heads, but also fill it with their experience. “Watching TV” is general, but “watching Shark Week on TV after a long day” lets them channel their real-life experience (even if they’ve never watched Shark Week).

Broad vs. narrow prompts. Bodystorming has high flexibility, allowing designers and researchers to use it in many stages throughout the design process. If they are looking for new big ideas, having a more open-ended prompt (e.g., "you are cooking your favorite meal”) can help develop a large set of use cases or robot behaviors. As the robot is developed and the context narrows, more specific prompts can help refine robot behavior for a given context (e.g., "you are moving a cart in this aisle while the robot comes around a corner"). Facilitators can influence scenes by entering them or asking questions in the debriefing. The more targeted questions facilitators have in advance and between scenes, the more they can direct the scenes to a given context they are looking for. It can also help to have an engineering team member facilitate to ask more pointed questions that can help the engineering team meet the user’s needs.

Let scenarios evolve. It helped to let scenarios evolve as participants worked with them. To do so, researchers should begin with a concise prompt and instructions that are not too detailed. They should provide the prompts or verbally describe them, and then take the prompts away, rather than allowing people to read them in the middle of the scene, which can get them out of the bodystorming mindset or needlessly constrain them. Like in a semi-structured interview, following up on where participants went during the previous scene and delving into details about their new ideas created more dynamic scenarios. This helped researchers understand specific user needs or wants that they had not considered.

Change scenarios when the energy starts to drop. Rather than trying to get every bit of information from each scenario, researchers should switch to new scenarios when participants slow down on the current scenario. Bodystorming is not designed to answer all the questions in one session, and it is better to keep participants engaged, because this is when they generate the most insight.

Keep the scenarios short. For our scenarios across contexts, approximately 90 seconds was a good length. This allowed participants to invest in the scene. With longer scenes, participants sometimes got stuck doing something uninteresting or started to spiral to a level of silliness that was not useful. Occasionally, a scene would last several minutes and still elicit interesting insights. Researchers should use their own discretion about continuing a scene after 90 seconds. Don’t be afraid to cut things short if the scene is awkward or isn’t going anywhere.

Mix up scenario elements. In some scenes, a researcher introduced an unplanned interruption, like a child calling on the robot from another room, someone randomly wandering into the scene, or a robot-specific failure. Purposeful interruptions helped disrupt the scene and break implicit assumptions participants made, like having the robot all to themselves. Participants can brainstorm interruptions in advance, to create a deck to draw from, or researchers can throw them into the exercise without warning. Mixing things up is likely particularly useful when new robot interactions are already defined, either in the product development process or in a previous body-storming scene, and the goal is to learn how to improve them.

Add constraints. When role-playing the robot, we can introduce constraints that simulate limitations of the robot. Asking the participants to sit on the floor, pin their elbows to their sides, or limiting their range of motion were all effective in exposing potential limitations that might be faced by the actual robot.

4.5 Facilitating

Discuss between scenes. Sometimes it helped to discuss what people liked or found interesting about specific scenes. This can lead to exploring the ideas more in further scenes, often with a participant spontaneously asking for the scene to be rerun so that they could try an idea. This was a particularly fruitful source of insight. However, the between-scene discussion should be *short*; there is a tendency to over-analyze in the moment, killing the energy of the exercise and turning it into a more traditional round-the-table brainstorming session. It helped to ask for immediate reactions and thoughts, and then move on. Having one researcher remain outside of this conversation and cutting it short by calling for the start of the next scene was extremely useful. They can also note if certain participants are not engaging in discussion, and prompt them to share reactions.

Keep on track. Sometime participants got stuck asking what the robot can and cannot do, rather than discussing what they wanted from the robot. A good response was, “How would you want to use the robot if it could do that?”

Use several cameras. Capture multiple videos for later analysis and tape off the floor indicating what is in view of the cameras. This can help to cue the scene to stay within camera view and cue observers to not stand in front of the cameras. This was a problem for us in the first set of studies, because one researcher was so intent on watching a scene they did not notice that they were standing in front of the camera. Having one researcher in charge of the cameras also helped capture the scenes well.

Involve more than one researcher. Having two researchers, at least one with intimate knowledge of robot capabilities and what would be easy or difficult to develop, was particularly helpful. This helped guide ideas to be beyond the robot’s current behavior, while still being possible to develop in the near future. The second researcher could then also stay outside of the activities to run cameras, take notes, and keep time.

4.6 Debriefing

Use sticky notes and whiteboards. It helped to give participants extra time to write on Post-it notes things they learned or wanted to develop for the robot. In this time, they could add to Post-it notes they had previously written throughout bodystorming. Then, having them place the Post-it notes on a large board and rearrange or cluster them helped discover themes. This also can begin a good conversation about what they learned and want to develop next for the robot. In sessions with smaller groups, there were fewer people to write notes, resulting in fewer notes to put up during the discussion, and those notes tended to revolve around the last few things that the group discussed. To bolster the number of notes, researchers can make sure people had written notes before bodystorming began, which increased their likelihood to write notes during bodystorming or between scenes. Another way was to ask them to write a specific number of notes after bodystorming or between each scene (e.g., "please write 3 to 5 ideas on different sticky notes that you want to make sure our team remembers").

5 Operational Guidance

During the studies described above, we also learned about the operational details, or the behind-the-scenes, of running bodystorming. Although this is outside the context of actually running the study, these operational details can greatly affect the productivity and outcome of the sessions.

Lived experience with the technology and context. Because the purpose of bodystorming is to gather information on user needs and wants with robotic technology, it helps to have participants with lived experience with the robot or scenario. Our research questions dealt with improving specific, already-existing robots, thus this was particularly helpful. We found that when participants have lived experience, they more often suggested behaviors that were feasible for the robot in a current or near-future iteration. If participants don't have experience of the robot, it helps to ground their understanding of the robot's specifics before bodystorming, using actual interaction with it or videos of it. However, if ideating an entirely new robot, having participants with experience with a different robot might bias or limit their creativity. In these cases, it helps to ground their understanding of the new technology abilities and limitations at hand, as in [4]. Regardless of experience with the robot, participants must have experience with the context or task (e.g., it is difficult to shape a robot to help cook if you never cook food). Participants with no lived experiences came out of character more often or suggested ideas that were out of touch.

Lack of Realism is a Feature. For participants with a deep understanding of the robot or context, bodystorming can bring up memories or feelings from actual lived experiences. Because of this, having lower-fidelity "pretend" environments (e.g., using chairs for fridges), can better generalize across users than high-fidelity environments (e.g., using a specific kitchen); in low-fidelity environments, participants fill in the details with their own image of their kitchen, making the lab experience more familiar.

People not building the technology. People who are not building the technology were less constrained by its current limitations. They more readily played pretend and developed new ideas, which led to better sessions. They less often said, "but that will be hard to implement" or get stuck on how to technologically implement the features. This can be harder in smaller, more robot-focused companies, with fewer employees not working on the system.

Refine between sessions when needed. Because bodystorming is less structured than many other methods, it can help to refine prompts, techniques, and follow-up questions between sessions. Different user groups and scenarios require different levels of detail, duration of scenarios, and guiding or probing on particular topics. Pilot testing is not enough because needs are so variable across groups; however, researchers can hone study elements during and between sessions to improve each session. We recommend allocating time between sessions to process and refine the procedure to more precisely meet research goals.

Only a few sessions each day. Bodystorming can be draining for facilitators, as it calls for interactivity and quick thinking to ask useful follow-up questions. Facilitators need to keep their energy up to help participants reach and maintain a high level of energy and creativity. In our experience, three 90-minute sessions in a single day was a maximum, and two was ideal.

6 Discussion

In this paper we described bodystorming, an ideation technique that is particularly well-suited for HRI research and product development. We described three examples of using bodystorming in an industry setting, and discussed methodological considerations we learned about using this technique.

Bodystorming is useful because it allows us to gather design insights about robot behaviors without much engineering effort. It allows for early exploration before getting a robot or funding, and is a good choice for initial exploratory work. It also allows non-technical HRI researchers to perform studies without needing to partner with a large technical team and wait for them to implement a working system. In an industry context, it allows for nimble experimentation without disturbing software and hardware production.

Bodystorming, however, does have limitations when compared to other techniques. It often pushes participants out of their comfort zones and involves more planning, preparation, props, and documentation. This can be challenging in settings with limited support or access to the right participants. For purely technical solutions or selecting solutions from existing prototyped designs, bodystorming is also likely less valuable. However, for when early explorations are needed, and the interactions are beyond current prototype capabilities, it is an invaluable technique. We also acknowledge the limitations of our exploration of bodystorming in this paper. We use bodystorming as part of our design and ideation process and the insights discussed in this paper are a reflection of those experiences; this is a necessarily imperfect coverage of its (although we believe it is an authentic one).

Not all of the advice discussed here will apply to every session or every participant. Some of the advice is quite general (like keeping the energy up), but the facilitators play a crucial role in "reading the room" and determining when to modify the advice, and when to ignore it. In the sessions that we have run, we found it relatively easy to tell when things were going well, and when we needed to stop and reset. As a rule of thumb, if people are not adding ideas and writing on sticky notes, then stop the scenario and modify or reinforce the guidance, iterating until ideas start to flow.

We leave the reader with four overarching observations. First, we encourage the reader to be open to serendipity. While our sessions focused on answering a particular question using concise scene descriptions, we recommend modifying scenes depending on their content and energy. This will often drift away from the core questions being investigated, at least for a while, until the researchers nudge it back. Although this might be seen as a distraction, the emergent insights, although often tangential the the current question, were were interesting and often helped form the core of future investigations.

Second, every bodystorming group and every group of facilitators is different. Each session's results were different, largely because of differences in participants and researchers. Some sessions mostly gave insights about the core questions we asked, while others meandered and provided insights about other, sometimes only loosely-related, aspects of the system. We believe that this is inherent to the technique and should be embraced. If a session is not addressing the core question, despite redirection by the researcher, let it wander, to see if the researchers can gain other insights.

Third, specifically for industry designers, researchers, and practitioners, the robot is meant to be a product. Often this product has limited functionality, either because it is only meant to do certain things at the moment or because the engineering and programming team is in the process of developing the features. There is often a strong emphasis on not writing "throw-away code" or code that will not be used in the final product, and code that would be useful for user testing is sometimes perceived to be throw-away. This can make it complex, expensive, and difficult to change the on-device software or hardware needed to run studies with the robot itself. In these cases, bodystorming can be a powerful tool. It provides designers and researchers the ability to (1) Quickly and iteratively learn what users want from a product without competing for company resources tied to other production goals, and (2) Gain insight and evidence of what users want before committing significant engineering effort to creating it.

Finally, bodystorming can be fun! Both for participants and researchers. When it goes well, it becomes a delightful exploration of what a robot could be, and, for the authors at least, captures the spirit of why they first got into HRI research. The insights we gained with bodystorming have been unique, sometimes unexpected, and often profound. In an industry session, the session's playfulness spilled over into the discussion, and into the social interactions afterwards. Our bodystorming session acted as a team bonding experience and a shared source of inspiration about the robot products that we are developing. While this is something that is not often written about in academic papers such as this one, we believe that it is an added bonus worth noting, and we encourage the reader to consider adding bodystorming to their research toolkit.

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