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Treasure Hunting: an exploratory study of how designers and scientists identify potential collaborative projects

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Abstract: Design and science collaborations are becoming increasingly common. Yet we have little understanding of how both designers and scientists identify what makes a good collaborative project brief, a phase we call treasure hunting. We conducted two studies with 18 designers and 10 scientists to better understand this mechanism: how do designers generate ideas from laboratories and how scientists perceive these ideas? We found that designers' strategies rely on identifying the uniqueness of the laboratory's research and their long-term vision. We also identified four strategies to ideate from the laboratories' research: finding new application domains, bringing the research to the hands of the end-user, styling and finding new research directions. In the second study, we presented the resulting ideas back to professors and results suggest that initial designers' ideas —sacrificial ideas— can be a powerful tool to support scientists reframing process.

Keywords: collaboration; interdisciplinarity; design brief

1. Introduction

Natural science and design collaborations are becoming increasingly common, from collaboratively developing a proof of concept for an oxygen-mask (Driver, Peralta, & Moultrie, 2011), to exploring the future of synthetic biology using a speculative design approach (Ginsberg, Calvert, Schyfter, Elfick, & Endy, 2014; Catts & Zurr, 2014; Sawa, 2016) or investigating novel ways to explain complex quantum physics' concepts (Gentes, Renon, & Bobroff, 2016; Bobroff, Azambourg, Chambon, & Rodriguez, 2014). To better understand these collaborations, a growing body of research has been focusing on identifying their potential benefits. Rust argued that "designers can act as provocateurs in the early stages of interdisciplinary work" (Rust, 2007) and foresaw that they could help scientist seeing things in a new light. In their study of three different collaborative projects between designers and scientists, Driver et al. (2011) identified three major contributions designers could bring to

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science, namely “supporting the commercialization of new technology, steering the research direction, and assisting with the communication of science”. Moultrie showed the different roles that design “demonstrators”, prototypes and mock-ups can have to support research (Moultrie, 2015). Beyond supporting research, Dance reported that collaborations also helped biologists broaden their perspective of what “design” could do (Dance, 2015).

In their review of design and science collaboration, Peralta and Moultrie proposed a model of design-science collaborations divided in four different levels of research engagement (Peralta & Moultrie, 2010). In the first level, designers work as executants, performing design tasks assigned by the research group, such as prototyping for example. In the second level, designers are part of the research group, but their contributions are focused on specific “design issues” such as exploring design concepts based on existing research. In the third level, design activities are related to the research questions, such as creating tools for scientists, but scientists still drive the research agenda. In the last level, designers and scientists “team up to define the research questions and to find its answers”. Peralta and Moultrie as well as Driver et al. who studied collaborations in the context of a technology transfer initiative call for developing this last type of collaboration. However, it is also the most challenging type of collaboration: as pointed out by Driver et al., full collaborations with designers are sometimes still received with doubts by scientists. In a series of interviews they conducted with scientists to gauge their initial perceptions of designers, they reported that “scientists were generally sceptical about the potential for industrial designers to contribute to early stages of scientific research” (Driver et al., 2011). Therefore, understanding how designers and scientists can identify project ideas for full collaborations remains an open challenge. In this paper, our aim is to describe the existing strategies for generating ideas for collaborative projects. This is a first step to help us develop tools and methods that better support the initial collaboration phase.

2. Background

This research project started in the context of a “design lab”. In 2017, a small team of graduates from the Royal College of Art was invited to reside within a large research institute of industrial sciences in Tokyo. The institute has over 110 laboratories spanning all natural and industrial sciences. The initial goal was to develop design-science collaborations aiming at, eventually, “turning science into deployable innovation”. To launch the project, the design team started by inquiring in the different laboratories to identify relevant research and generate collaborative project ideas. This activity was initially carried out in an ad-hoc manner with designers visiting different research laboratories. The term “treasure hunting” was coined by the design team to describe this emerging design activity. The most promising initial ideas were then developed further by a team of scientists and designers for a couple of months and the three resulting projects were exhibited at national (The National Art Center, Tokyo, 2018) and international venues (Ars Electronica 2017). As participant observers during the initial year, we identified the key role played by the “Treasure Hunting” phase in ensuring a fruitful collaboration and identified the need to better understand this process.

In most traditional approaches, as well as most design research, designers start ideating based on briefs provided by clients (Ryd, 2004; Gonçalves, Cardoso, & Badke-Schaub, 2016) or design problem statements (Silk, Daly, Jablokow, Yilmaz, & Berg, 2014) given in pedagogical contexts. Scientists have shown that these initial definitions of the project space can deeply impact designers' ideation process depending on the stimuli provided (Koronis, Silva, Kang, & others, 2018; Encinas et al., 2018) as well as according to the designer's perception of what is appropriate or possible (Eckert, Stacey, & Clarkson, 2004). However, as mentioned by Paton and Dorst "the activities associated with the creation of a brief and the negotiations for its (re)definition are not often examined" (Paton & Dorst, 2011). In fact, many designers are already creating their own briefs or even working without ones, using different strategies to initiate their project, including ethnography (Barab, Thomas, Dodge, Squire, & Newell, 2004), material-first approaches (Karana, Blauwhoff, Hultink, & Camere, 2018; Fischmeister, 1989), critical design approaches (Bardzell & Bardzell, 2013) or technology-driven innovation (Yoshioka-Kobayashi, 2018).

In the context of design-science collaborations, case study analysed by Driver and colleagues were originally selected by the university technology transfer office (Driver, Peralta Mahecha, & Moultrie, 2012). Scientists found this approach limiting as it prevents designers from participating in early stage research. While a few studies have explored the impact of briefs on creativity, we have very little insight into less conventional briefs, such as the initial project ideas we observed, especially when designers and scientists need to generate project ideas that show potential value for both communities of practice.

In this paper, we are interested in understanding what are designers and scientists' strategies for identifying promising ideas for collaboration. This first step will help us develop tools and methods to better support this initial phase. Grounded in our preliminary observations and interviews, we designed two complementary exploratory studies that operationalize the observed treasure hunting process. The first study focuses on understanding what are designers' strategies for identifying relevant research and generating ideas based on it. The second study focuses on analysing how scientists interpret and engage with designers' ideas. Given the current lack of understanding about the treasure hunting process, our goal is not to test hypotheses, but rather to create comparable conditions —structured observation— for identifying common patterns and differences that emerge, despite the highly individual nature of the activity (Garcia, Tsandilas, Agon, & Mackay, 2014; Ciolfi Felice, Fdili Alaoui, & Mackay, 2018).

3. Study 1 – Treasure Hunting

With this first study, we have two research questions: when first visiting laboratories, what are designers' strategies for identifying relevant research and what are their strategies to generate ideas from it.

3.1 Method

We recruited 18 professional designers living in Tokyo. Participants' ages ranged from 24 to 50 (average: 33). We used purposive sampling (Arber, 2001) to gather a relatively varied sample of designers in terms of design disciplines in order to elicit as diverse design views as possible. Design disciplines included graphic designers, UX/UI designers, product designers, space designer, service designer and character designer. In our pre-questionnaire, designers who enrolled reported having a strong interest in science (average: 4.44/5). However, most of them had never worked with scientists before (11 out of 16).

Figure 1 Each of the chosen laboratory presents their research through scientific posters, samples and demonstrations. Half of the designers (Da1 to Da9) visited the five laboratories of track A, and the remaining half visited the five laboratories of track B (Db1 to Db9)

We designed the study in the context of the “open-campus day”. During that event, laboratories open their door, using posters and demos to present their research to the public. The research institute is divided into five different departments working on particle, material, product, human and city scales respectively. Each designer visited one laboratory per department, in order to observe how different types of laboratory might influence the quantity and types of ideas generated by designers (Figure 1). To avoid having several participants present in the same laboratory at any given time, we devised two treasure hunting tracks and randomly assigned participants: half of the participants (Da1 to Da9) visited the five laboratories of track A, and the remaining half visited the five laboratories of track B (Db1 to Db9). To select two laboratories from each department, we sampled the laboratories who appeared to make the most effort for the open day.

Before the study, we asked participants to fill in a pre-questionnaire about their background

and their relationship with science. On the day of the study, we gave each participant a prepared itinerary with five laboratories to visit (figure 2). We instructed them to spend 10 to 15 minutes in each lab in order to be able to complete the study in 2.5 hours. In each lab, we asked them to engage with the research and sketch or write ideas that might stem from it on the dedicated idea sheets. We, on purpose, did not characterize the type of ideas we were expecting because we wanted to observe what types of ideas designers would generate. We also explicitly told them that it was not a problem if they didn't have any. We gave each participant an instant camera and asked them to take photographs of the things they found inspiring in each lab. Before exiting each laboratory, we asked them to fill in a one-page questionnaire sheet about this laboratory. After visiting all the laboratories, we asked designers to fill a post-questionnaire about their experience doing treasure hunting. We also conducted semi-structured interviews that lasted between 15 and 30 minutes each, using the ideas as starting point (Barton, 2015). We had two main goals: (1) eliciting their strategies for treasure hunting and (2) eliciting the origin of the design ideas. We audio recorded and took notes during interviews.

We analysed the collected material using the Braun and Clarke approach to thematic analysis (Clarke & Braun, 2014), where coding is flexible and evolves throughout the coding process. To answer our two research questions, we conducted two different analyses. We first analysed the designers' strategies for doing treasure hunting. We then analysed the rationale behind the ideas. Two authors respectively identified categories in an inductive manner and we regularly met to discuss the data, the coding and our interpretations, to ensure that they were coherent, comprehensive and reflective of the actual data. In the result section we provide counts of frequency, not as a way to rank strategies, but instead to "to guide the further interpretation of data" (Morgan, 1993).

Figure 2 After filling a pre-questionnaire, each participant visited five laboratories. In each laboratory they took photographs, generated ideas from the research and filled a questionnaire. At the end of the session, we conducted a semi-structured interview and participants filled a post-questionnaire.

3.2 Results

The key element in the treasure hunting process identified by designers was the conversation with scientists. In most cases (70%) designers engaged in conversations with scientists in the laboratories they visited. Overall, designers were more likely to find ideas when they talk with scientists (93%) than when they did not (73%). When we tried to understand why that was the case, Da2 explained about the posters on display: “It is like if I tried to read a research paper in 5 minutes”. This suggests that the type of visual prompts used by labs, mainly scientific posters or demos, are generally not sufficient to support designers’ understanding and ideation.

Designers identified key questions that would lead to interesting insights: one key strategy mentioned by half of the designers is understanding the uniqueness of the lab and the strength that distinguishes them from other labs. For Da3, for example, “There is a unique point in the technology, [...] ideas should critically use this unique point”. For example, in the intelligent mobility lab (Sb4) it was hard for Da9 to ideate because he thought that “this research is good, but [...] other research centres can do the same thing. It’s too common”. Similarly, Db1 explained about the liquid analysis lab (Sa1): “basically I understood the explanation from the researchers, [...] but I didn’t understand what the unique point of the research was”. A second strategy mentioned by 4 designers is to inquire about the scientist’s motivation to do this research and long-term vision: “why do they do this research?”, or “what is the researcher’s dream”.

One of the key questions we wanted to explore was how different laboratories might be more suited for designers to generate ideas than others. Designers generally managed to propose at least one idea per laboratory. They couldn’t find ideas in only 13% of the case. However, the number of ideas greatly varied according to the laboratory (from 3 to 17 ideas per lab, average: 9.2). We didn’t find evidence of differences between laboratories working at very large or very small scale, as none of the designers mentioned the scale of the research as being an issue to ideate. However, in the interviews, we identified two main factors that seem to influence designer’s ease of ideation.

We found that for designers, there is a “sweet spot” for getting ideas in laboratories as well as two difficulties of opposite nature (Figure 3). On one hand, if a laboratory has a too specific and narrow application area, it becomes difficult for designers to generate ideas. In that case, designers feel that there is not much left to design anymore: “as a designer it’s easier to think of idea if they don’t know how to use it, how to apply it for society. But here, I don’t know what to do for them as they already know what to do.” (Da9). On the other hand, when the scientists did not have any idea about potential applications for their research, it was also very difficult for designers to find ideas.

Figure 3 Representation of the correspondence between the level of applicability of the research and the designer's perception. Designers find it most difficult to ideate when they perceive the laboratory to have no application for their research, or if it has only one specific application. In the middle is the sweet spot for designers to ideate, when there are some potential applications.

For example, Da9 was facing this problem in Sb3 lab: "This (additive manufacturing) is a too basic technology that can be applied to everything. It doesn't create new things, but we can apply it to new things". In that case, the laboratory focuses on optimizing existing processes and technologies. This was also the main issue identified by designers about the experimental physics lab (Sb1) whose research was perceived as very fundamental by designers and had no direct connection with daily life applications.

The 18 participants generated a total of 91 ideas (Figure 4). In this section we focus on understanding designers' strategies for creating ideas from the laboratories' research. Our analysis revealed that the majority of ideas proposed by designers focused on bringing the research and technologies developed by the laboratories into the hands end-users (39 ideas). For example, in the metal recycling lab (Sb2), Da2 wanted to create "an iPhone grinder" that people could use to grind their used smartphone. Da2's idea was to embed the technology developed by the lab into a home appliance that could be used directly by people at home.

We identified 3 different strategies to bring the research in the hands of the users: changing the scale, changing the quality or creating new applications for existing research or technology developed in the laboratories (Figure 5). The most common way for designers to ideate was to find new applications for the technology or the research performed in the laboratories. In Sb4 laboratory, designers proposed many new applications for using Sb4's computer vision algorithms, including analysing what pet or babies think when their intentions are difficult to understand (Da4), showing the stress level of a person to understand which persons are "good for you" (Da3) or analysing which items customers took in the store (Da7).

Figure 4 Three examples of participants idea representations: Db1 used mainly sketch, Db5 described her thought process onto the idea sheet and Db2 preferred to use the questionnaire to express her ideas.

Another strategy is to change the scale of the technology. Using sensors developed in Sa2 lab, who is working at a very small scale, Db8 wanted to visualize the city personality from the river data. In this case, he scaled up the research to make it usable at city scale. Db5 wanted to apply Sa1's technique to prototype human-scale products such as chairs instead of their current tiny scale printouts.

A third strategy proposed by designers is to improve the quality of the research output to make it acceptable as a product: for example, in the computer vision lab (Sa4), Db2 proposed a way to improve the quality of the virtual reality demo presented to make it a product suited for end-users.

Beyond this first approach designers also used the research for its aesthetic qualities and wanted to display it in either art pieces or exhibition for helping people understand the research (16 ideas). The objective is here to promote the research by using its aesthetic qualities. From the interviews, we found that this was one of the common strategies when it was difficult to think of new use cases. For example, Da5 and Da7 had ideas about using lasers for creating interactive art or stage effect in Sb1 Lab. Db3, in the additive manufacturing lab (Sb3), wanted to create tiny 3D sculptures or jewellery.

Designers sometimes proposed reflections about the impact that the research (7 ideas) and technology would have on the world, proposing scenarios on how the technology would impact society. For example, Db5 speculated about how the computer vision lab (Sa4) changes the value of material. If things can easily be copied and reproduced, then what is the value of real materials? Similarly, when Db2 discovered Sa5 lab's research about disaster spreading, he thought that it could dramatically affect the price of house and land if people could easily have access to this data.

Figure 5 Summary of the designers' strategies for creating ideas.

In a few rare cases (4 ideas), designers proposed either new research directions or methods. For example, in the chemical sensor lab (Sa3), Db7 thought that by using machine learning, scientists in the laboratory would be able to find patterns of deterioration. Similarly, Db8 proposed a different strategy for collecting data for the computer vision lab (Sa4), by crowdsourcing data collection from individuals in their neighbourhood. In the remote sensing lab (Sb5), Da3 thought that creating a map that emphasizes the parts that changed a lot could help scientists understand the place at a glance and more easily analyse their data.

4. Study 2 – Going back to scientists

In study 1, we gathered ideas created by designer inspired by laboratories. In this second phase, we wanted to explore scientists' perception of designers' ideas: which ideas would they find interesting to develop and why. From Feast's observations (Feast, 2012), we know the importance of having tacit permission to critique ideas as necessary for constructing collective understanding in interdisciplinary collaboration, so we chose to act as proxy for presenting the ideas back to the professors.

4.1 Method

We conducted this study with the same ten laboratories we had selected for Study 1. We recruited either the head researcher of the lab or a senior researcher with at least 5 years of experience in the laboratory. Among the participants, two professors (Sb2 and Sb3) had already an experience collaborating with an industrial designer. In Sb5's case, the professor had also asked 5 PhD students to join the meeting, for education purposes.

Before the study, to facilitate the comparison between ideas and avoid bias caused by the different types of representation and their quality across designers, we redrew all of them. We generated representations of all the ideas created by the designers by either replicating the designer's illustration or creating one based on the textual description when designers had not drawn the idea. One author drew all the illustrations of each laboratory to ensure a coherent style across ideas. Each session lasted one hour. We first explained the purpose of

our study, the process behind the idea creation and introduced in random order all the ideas created for that laboratory. We first asked scientists to freely comment each idea during the presentation and we probed for the reasons behind their opinions. In order to elicit idea comparison, we also created two different scales: Research Understanding, ranging from “too far from the research” to “building on the research”; and Usefulness, ranging from “unusable” to “useful”. At the end of each session, we asked scientists to put all the ideas along the two scales printed on paper and we asked them to verbalize their reasoning.

We audio recorded the sessions and the two authors took notes during interviews. We also took pictures of the different steps of the scale exercise and we later transcribed the interviews. Following the same analysis protocol defined in the first study, we analysed the interviews using the Clarke and Braun approach to thematic analysis (Clarke & Braun, 2014), focusing on professors’ strategies to judge ideas. As we could observe with Sb5’s PhD students, judging ideas is not an objective task and two scientists from a same laboratory might have different perspectives on the same idea. Therefore, we focus here on uncovering the breadth of possible interpretations. In our scale exercise, we deliberately chose the ambiguous word of usefulness to foster the conversation with scientists. We wanted professors to tell us how, in their opinion, designers’ ideas could become useful for them. From the conversation and the scale exercise, we identified 2 main types of usefulness: usefulness for research: by providing new research direction, or usefulness for society: by disseminating the content of the research to a general audience, by deploying the research into products usable by the public or by establishing partnerships with other collaborators.

4.2 Results

Unsurprisingly, scientists judged the ideas as unusable when they felt they had already been done, or when they were perceived as too distant from the laboratory’s research (Sb3, Sb1, Sa5 & Sa4). In the experimental physics’ lab (Sb1) for example, one idea was about using visible lasers but Sb1’s research is about infrared lasers, which are not visible. Even when designers created ideas that were related with the research conducted in the lab, another difficulty for producing relevant ideas was understanding the unique weakness and strength of the research developed in the lab. For example, Sb2 lab works on recycling titanium and many designers proposed new applications for using titanium. However, in most cases, Sb2 found that the same idea could be developed using other metals for a cheaper price. This confirms the intuition that many designers had identified during the first study about the importance of understanding the uniqueness of the lab’s technology or research for establishing a good collaborative project brief. However, perfectly understanding the research was not necessarily a prerequisite for producing useful ideas. When designers had slightly misunderstood the research, they were sometimes able to generate ideas that professors had never thought about, but sparked interest for them. For example, a designer proposed to use laser for ID control. At first, the scientist was puzzled by the idea, but as he gradually made sense of it, he realized that this could become a new research topic.

Beyond research understanding, we identified a tension around the novelty of the ideas.

The ideas that were deemed most useful by the scientists were either the ones that were completely novel for them, such as the one we just described, or, on the contrary, ideas that aligned well with existing goals. When scientists had already had the same idea, they had already been assessing its potential from their perspective. Therefore, some of the most useful ideas were also ones that scientists had previously wanted to develop. For example, Sa4 found especially useful an idea about sensing and visualizing pollen using VR because several people had already suggested the idea to him before so he thought that it could become commercially successful.

During this second study, we found that scientists actively engaged with the ideas: interpreting them, drawing connection with their research and evaluating their potential from their perspective. In that sense, scientists engaged in reframing. Given the time constraint, ideas developed by designers were minimal, but their abstraction allowed scientists to interpret them in their own terms. They started inquiring about more specific details that they needed from designers in order to develop the ideas and identified key questions that designers would need to answer in order to proceed further with the project. For example, when an idea proposed to use tape to fix train and cars, Sa3 explained that he needs more detail, including: “should there be a remaining space between parts or not” and “is it ok if the connection is flexible”. Scientists also appropriated the ideas in their own terms, by providing more precise technical vocabulary and notions. Sa3, for example, wanted to better define the terms used in an idea about haptic feedback.

Ideas became steppingstones that allowed scientists to reflect about the next steps: if they were to develop this idea, what would they need to do, know or experiment on. In the experimental physics’ lab (Sb1), one of the ideas was very close to his “long-term dream”, which is to use lasers to fold molecules, a vision that is not directly understandable from his daily research. In that case, he explained the future steps and experiments needed to reach this outcome. Professors also tried to propose technical solutions to the ideas. Reacting to an idea that wanted to use laser for visual effects on stage and instead of rejecting the idea because the infra-red lasers he is using in his research cannot be seen, Sb1 proposed a technical solution: “using invisible light, it is sometimes possible to emit visible light with some material”. On the other hand, scientists also used their knowledge in the field to justify why some ideas could not work and, in doing so, they explained some of the current limits and constraints of their research. In that sense, designers’ ideas were instrumental in allowing scientists to define more precisely their research. For example, Sa2 explained the current limitation in realizing sensor sheets for supporting athletes: “We can measure the lactic acid, we are trying to achieve real time monitoring, but we haven’t succeeded yet”. Similarly, Sa3 explained that he had been trying to achieve the idea of extracting human skills to teach robots to perform the same task, but that not all human movements are necessary. Instead, if we could create better machining tools, we might be able to avoid using human movements altogether. In that case, the designer’s idea was not directly useful but helped Sa3 explain some of the critical constraints and opportunities in his research.

5. Discussion

In their paper on “miscommunication”, Torrisi and Hall showed how ambiguity can be a productive design trigger when it happens during the initial idea generation phase in interdisciplinary teams (Torrisi & Hall, 2013). Ambiguity played a crucial role at two moments. First, designers themselves felt that they did not perfectly understand the research when they visited the laboratories, especially because of the limited amount of time devoted for this phase. In some cases, this initial limited understanding of the research led them to produce ideas that were surprising to the scientists. This was the case, for example, for the idea about using laser for ID control in Sa1 lab that opened a potential new avenue for research for him. In that sense, ideas became probes (Mattelmäki, 2008; Bowen, 2007), tools that could be used to gain a better understanding of the research context. What matters most is not the intrinsic quality of the idea, but how well it could help to set up the conversation at the right level of detail about the research. This echoes the notion of “sacrificial ideas”, a strategy first developed by Bernstein (2011) where ideas are “meant to be jumping-off points for discussion and innovation”. Völk, Maudet & Mougenot’s exploratory study (Völk, Maudet, & Mougenot, 2019) also suggest that boundary objects play a critical role in designers and scientists’ conversations. While this initial research suggests that sacrificial ideas could become a useful tool in the treasure hunting phase, future research should investigate sacrificial ideas more thoroughly in order to understand its potential value as a design methodology for design and science collaboration.

6. Conclusion

In this paper, we presented two exploratory studies to investigate how designers and scientists can generate project briefs for collaboration. In the first study focusing on designers’ strategies for identifying relevant research and generating ideas from it, we found that the relevant information is generally not available in the materials produced by scientists and require deeper probing through conversation with scientists. Understanding the uniqueness of the laboratory as well as its vision beyond the daily work was especially important for designers. We also analysed some of the main strategies used by designers to ideate from the research, especially bringing the research into the hands of the end-user by adapting its scale or finding new potential applications for it. In the second study, we found that scientists engaged with the ideas as part of a reframing process during which they were able to appropriate the ideas from their perspective. We also observed how a medium research understanding can still lead to useful ideas by provoking surprise and nudging scientists into exploring novel avenues for their research. In this exploratory study, we operationalized the treasure hunting process into two distinct phases in order to facilitate a preliminary analysis. While this approach was productive for providing a first understanding of the strategies and challenges of treasure hunting, we need to complement this research with real case studies that will provide a better understanding of the collaboration. The effect of a longer period of time devoted to exploration and discussion will be especially interesting to observe. This first study also opens doors for developing methods and tools that can

support the treasure hunting process and facilitate designer and scientist collaboration. We identified two especially promising avenues: exploring strategies to present research in a format adapted to designers and exploring the role of sacrificial ideas in treasure hunting.

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