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Prototypes as Identity Markers: the Double Edged Role of Prototypes in Multidisciplinary Innovation Teams

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1 Introduction

Multidisciplinary teams often collaborate using prototypes to facilitate new product development (NPD), creativity, and team working. Prototypes include a wide portfolio of artifacts and visual representations, such as functional representations of a product (e.g., Elverum & Welo, 2016), early mock-ups made of different materials (e.g., Donati & Vignoli, 2015), visual representations or live enactments of a service (e.g., Dell'Era & Landoni, 2014), business models (e.g., Täuscher & Abdelkafi, 2017), or prototypes to support behavioral and organizational change (e.g., Coughlan, Suri, & Canales, 2007). Indeed, prototypes can support the work of innovation teams (BenMahmoud-Jouini & Midler, 2020), as they trigger interaction and enrich conversations, help in generating joint ideas and identifying opportunities, and enable the testing and evaluation of assumptions (BenMahmoud-Jouini & Midler, 2020). The use of prototypes limits the common cognitive biases that hinder innovation processes (Liedtka, 2015). Furthermore, prototypes help teams in communicating across disciplines (e.g., Bechky, 2003), functions and hierarchies (e.g., Bogers & Horst, 2014), and organizations and stakeholders (e.g., Moultrie, 2015).

While the importance of using prototypes is well recognized, more recently, innovation management and organizational literature have started to inquire into potential drawbacks of their use. The literature on the phases of innovation and on boundary objects has recently assessed that, if not properly managed, prototypes can become inhibitory elements to innovation processes. For instance, prototypes can be strategically used by subgroups of a multidisciplinary team to shape the decisions that the team as a whole takes (Barley, Leonardi, & Bailey, 2012) or they can engender conflict within a team when concept unity is not achieved across team subgroups (Seidel & O'Mahony, 2014). In relation to team subgroups, organizational literature has already established that the tensions across the diverse subgroups of a multidisciplinary team can be detrimental to team functioning (e.g., Durnell Cramton & Hinds, 2004; Mattarelli & Gupta, 2009). More specifically, following an identity-based perspective (Hornsey & Hogg,

2000), the presence of different subgroups, characterized by different identities, i.e. different values and beliefs often related to the affiliations of different work and professional groups (e.g., engineers, technicians, designers, Bechky, 2003; practitioners and researchers, Ungureanu & Bertolotti, 2018), can create us vs them dynamics that hamper coordination and knowledge sharing. The development of a higher level and overarching team identity can help in mitigating and possibly overcoming such differences (Mattarelli & Tagliaventi, 2010). Unfortunately, the literature streams on prototypes and identities have evolved separately over time, and we thus do not have a clear picture of how team and subgroups identities interplay with the creation, interpretation, and use of prototypes. We believe that filling this gap is particularly relevant to fully understand the use of prototypes in multidisciplinary teams and provide practical implications for team members and managers who want to effectively use prototypes to speed up and improve innovation processes.

This paper considers the relationship between identity processes and prototypes through a field study of a multidisciplinary team in an emergency department, in charge of redesigning the layout of the unit. Results show that prototypes can become identity markers of different sub-groups, i.e. their use makes subgroup identity values salient, especially when the prototype is characterized by high tangibility, fidelity, and viability. When this happens, conflicts arise in the team. When prototypes become identity markers of the whole team, they act as an alignment force that facilitates conflicts resolution. We unravel the use of prototypes in innovation processes in multidisciplinary teams and show how prototypes as identity markers can both inhibit and facilitate teamwork.

2 Theoretical Background

A prototype is an artifact that represents a functional form of a new design (BenMahmoud-Jouini & Midler, 2020), as it typically embodies some essential elements and features of what will later become a final product or service. Engineers use prototypes to test these essential features.

Designers tend to consider prototypes as concrete representations of part or all of a system that can stress interactions with different stakeholders (Yu, Pasinelli, & Brem, 2018).

Innovation management and organizational scholars have recognized the fundamental role of prototypes in favoring innovation processes and bridging boundaries across subgroups in multidisciplinary teams. As innovation today happens in complex multidisciplinary and multisectoral cooperative environments (Alves, Marques, Saur, & Marques, 2007; Ungureanu, Bertolotti, Mattarelli, & Bellesia, 2020), prototypes act as supporting tools for team learning (Liedtka, 2015), team coordination and communication (Okhuysen & Bechky, 2009), and team knowledge sharing and integration (Bogers & Horst, 2014). Research around prototypes tends to focus on how prototypes help multidisciplinary teams to work *more effectively,* and largely underestimates the potential drawbacks of prototypes for innovation outcomes. Recently a few studies have started to problematize the use of prototypes. In the following paragraphs we illustrate the initial findings on the 'dark side' of prototypes by referring to two bodies of literature: innovation management and organization studies.

2.1 Processual View of Prototypes in Multi-Disciplinary Teams

The emergent innovation management literature on prototypes' inhibitory roles focuses on NPD teams and inquiries into prototypes' drawbacks adopting a processual view (e.g., Christiansen & Gasparin, 2016). Specifically, it investigates how prototypes evolve over the NPD phases, e.g., problem exploration, concept generation and evaluation, and detailed development (Ulrich & Eppinger, 2003; Yu et al., 2018). Accordingly, different types of prototypes can support different thinking processes, but, if wrongly selected, prototypes can inhibit the necessary cognitive capabilities required by a specific phase (BenMahmoud-Jouini & Midler, 2020; Fixson & Marion, 2012; Täuscher & Abdelkafi, 2017).

Fixson and Marion (2012) identify two processual drawbacks of prototypes. The first drawback relates to prototype creation and the 'thinking mode' that the prototype activates. If in

the early phases the team develops a prototype that looks too complete and ‘too precise’ (e.g., a high definition 3D CAD model), the team will not be able to develop divergent and explorative thinking. The team will thus oversee concept development with an early jump into detailed design. The second drawback deals with the ‘comfort zone’ that the team experiences when using prototypes. When the team is at ease with the use of prototypes, it tends to postpone design decisions, leaving several paths open as long as possible. Last-minute changes will then be made when the project requires more detailed decisions (e.g., more iterations during tooling and production ramp-up), introducing sub-optimal decision-making behaviors. The two drawbacks described by Fixson and Marion (2012) happen unconsciously and often go unrecognized by the team.

A few authors specifically further detail how and why different types of prototypes should be used or not used during different phases. For example, BenMahmoud-Jouini and Midler (2020) develop a synthetic view of prototypes roles in early phases of NPD, to help overcome prototypes’ overdesign and over-trust. They identify three prototypes’ archetypes. Stimulators help the team conceive the specifics of the solution and should be used in the early idea generation phase; demonstrators help the team define the specifics and engage stakeholders with concept evaluation; validators test the specifics during detailed development. The authors underline that using a demonstrator, instead of a simulator, very early in the design process inhibits the exploration phase. However, later on, using a validator, without having previously engaged with a demonstrator, inhibits the further elaboration of a concept, which would then result in limited design options. At the same time, using a demonstrator too late in the process (instead of a validator) inhibits decision making, as demonstrators help identify potential decisions, rather than decide on specific elements.

In a similar vein, Täuscher and Abdelkafi (2017) analyze how business model prototypes support the cognitive abilities of managers during different innovation phases. In particular, they

identify what types of visualization can best support each phase of business model innovation (i.e., initiation, ideation, and integration). They suggest that the business model initiation phase - that requires absorption of complexity and problem reframing - is best achieved with conceptual maps. The business model ideation phase, which requires taking distance from the dominant logic, is best achieved with brainstorming webs. The integration phase - where it is essential to integrate and align all pieces of the business model and share knowledge across boundaries - is supported by artifacts that focus attention for thinking in-the-box, such as graphic organizers (e.g., business model canvas). The authors highlight the inhibitory role of such prototypes, for instance suggesting that the largely used business model canvas (Osterwalder & Pigneur, 2010), if used too early, may inhibit innovation.

2.2 Object View of Prototypes in Multidisciplinary Teams

Besides the processual-view of prototypes rooted in the innovation management literature, organizational scholars adopt an 'object' view for understanding the roles of prototypes in multidisciplinary teams. The object view focuses on the role of a prototype as an artifact used by multidisciplinary teams and on the team meaning making processes associated to prototypes as objects of collaboration. Prototypes, here, are often interpreted as *boundary* objects, i.e. '*objects which are both plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites […] The creation and management of boundary objects is a key process in developing and maintaining coherence across intersections of social worlds*' (Star & Griesemer, 1989, p. 393). Nicolini et al. (2011) proposed different possible theoretical frameworks to interpret the use of objects in cross-disciplinary collaboration. In this perspective, prototypes are presented as 'activity' objects that foreground conflicts because they are seen as a trigger of contradictions and negotiation in cross-disciplinary collaboration.

Two streams of organizational research openly problematize the use of prototypes in multidisciplinary teams. First, Barley et al. (2012) and Barley (2015) observe that previous research treats objects in general, and prototypes in particular, as 'tabulae rasae', whose meanings develop in an unplanned and emergent way. However, '*objects may enter cross-boundary collaborations with a planned form aimed at engendering particular meanings*' (Barley et al., 2012, p. 281). Barley and colleagues unravel the *strategic* nature in the preparation and use of boundary objects carried out by members of heterogeneous subgroups. A second recent stream of organizational research that adds complexity to our understanding of prototypes is the work on NPD teams by Seidel and O'Mahoney (2014). The use of prototypes as concept representations of products does not guarantee that teams will develop an innovative and coherent product. On the contrary, when the team does not engage in three activities (i.e., continuous scrutiny of prototypes, linking prototypes to design constraints, and active editing of prototypes), it produces concept 'disunity', i.e. disparate understandings of desired product attributes, with negative implications for team coordination.

Overall, our literature analysis on prototypes in multidisciplinary teams brings us to three main insights. First, scholars are starting to problematize the use of prototypes, identifying the elements that define when a prototype, instead of being a facilitator, becomes an inhibitor of innovation processes. Second, so far the literature has adopted a processual view and investigated the use of different prototypes in the different phases of the innovation journey (innovation management literature) or has focused on prototypes as objects that help cross boundaries in multidisciplinary teams (organizational literature). Third, in both views, it is clear that what happens within teams (how teams evolve their use of prototypes or how teams manage boundaries through prototypes) is fundamental. However, in none of these bodies of literature can we find an investigation of how the different constituencies of a multidisciplinary team (i.e. the different subgroups) interact in the creation, interpretation, and use of artifacts. In the

perspectives analyzed so far, the presence of different subgroups is mentioned both as positive (e.g., associated with more points of view to be embedded in the prototypes and, potentially, more creativity) and as negative (i.e., more boundaries to cross when creating and managing prototypes). We claim that, if we want to gain a full understanding of the innovation processes associated with prototypes, we need to have a more fine-grained understanding of how the differences across subgroups are related to and influence prototyping processes.

2.3 An Identity Based View of Prototypes in Multidisciplinary Teams

We thus propose to consider the literature on social identities and subgroups dynamics as a new perspective to comprehend the innovation processes of multi-disciplinary teams while prototyping. Social identity theory (Tajfel, Turner, Austin, & Worchel, 1979; Turner, 1999) proposes that individuals define themselves through their affiliations with multiple social groups (e.g., their family, employer, team, profession) by recognizing themselves in the values and beliefs characteristic and representative of those social groups (Elsbach, 2004). In this study we focus on the *work related* identities that are relevant during the prototyping process of a multidisciplinary team, i.e. subgroups and team identities.

A multidisciplinary team is in general composed of subgroups, i.e., subsets of the entire team whose members share some common values and beliefs, often related to their functional background (e.g., nurses, doctors, and technicians in a hospital multidisciplinary team). Sharing common values and beliefs in subgroups makes the affiliation to the subgroup important for individuals, and can prompt conflictual ‘us vs. them’ dynamics within the team (Durnell Cramton & Hinds, 2004). At the same time, a team identity, if strong enough, can make team members perceive that their self-definition is tightly linked with the successes of the team (Hinds & Mortensen, 2005; Mattarelli & Tagliaventi, 2010), and thus inspire them to make extra effort to help the team and solve conflicts. Overall, multidisciplinary teams present multiple identities in a dual categorization process: a superordinate identity as a team and several sub-group

identities (often related to the functions, professions, or disciplines team members belong to) that are prone to conflicts (Hornsey & Hogg, 2000).

The literature on work identities has observed that the values and beliefs associated with subgroup and team identities are represented in artifacts, such as dress code (Pratt & Rafaeli, 1997) or workplace characteristics such as office decor (Pierce, Gardner, & Crowley, 2016). These artifacts are used to distinguish the members of different subgroups or different teams. When this happens, the artifact is called a physical identity marker, defined as a material artifact that cues and/or affirms a person's social and/or personal identities (Elsbach, 2004). For instance, the work of Pratt and Rafaeli (1997) in a hospital setting shows that multiple forms of dress (e.g., scrubs and street clothes) were used to represent different perspectives on being a nurse (e.g., rehabilitation nurse versus nursing professional). In the workplace, identity markers such as pictures, prizes, or office décor, are used to communicate one's subgroup identity in terms of professional affiliation (Elsbach, 2003), creating turmoil when the possibility to expose them is removed, e.g., when organizations use 'hot-desking', i.e. flexible workspaces, instead of fixed offices (Millward, Haslam, & Postmes, 2007). This literature, however, has never investigated if and how different identities also get represented in artifacts that are more fluid and temporary, such as the prototypes that the subgroups of a multidisciplinary team create together.

Any investigation of the interplay between social identities and prototypes would represent a significant challenge to the actual positions in the literature. If subgroup identities are reflected in prototypes, prototypes could activate 'us vs. them' dynamics in multi-disciplinary teams, as it happens with identity markers such as office decor or dress codes. The presence of 'us vs. them' dynamics means that prototypes become elements that spark intra-team conflicts instead of scaffolding team working. In this case, we should include subgroup and team identity dynamics as a variable that impacts the facilitating or inhibiting role of prototypes.

Our objective is thus to inquire how team and subgroups identities get represented in prototypes and interplay with the creation, interpretation, and use of prototypes in multidisciplinary innovation teams.

3 Data and Methods

Given the exploratory nature of our research and our interest in social construction processes related to identities and prototypes, we conducted an interpretive field study (e.g., Walsham, 1995, 2006). Our focus was on accessing the meaning of participants through repeated interactions between researchers and context members (Orlikowski & Baroudi, 1991).

We selected a context where identity dynamics and prototypes played a significant role, i.e. the Emergency Department (ED) of a prominent Italian hospital. Healthcare is indeed a multi-disciplinary context, where different professional identities create subgroups within multidisciplinary teams and play a substantial role in influencing outcomes both at the team and at the organizational levels (Mattarelli, Bertolotti, & Macrì, 2013; Dosi, Iori, Kramer, & Vignoli, 2020). When we entered the field, the ED was facing a complex re-design process, guided by a multidisciplinary team composed of internal and external professionals. The external professionals adopted a design approach and the team made extensive use of prototypes.

3.1 Research Context

The ED treated about 70.000 patients per year and employed 100 unit members. When we started our study, the ED was in the initial stage of a significant change in the unit layout, aimed at innovating the internal processes and spaces in order to improve unit performance, such as reducing patients' length of stay, waiting time, and staff burnout. The unit head assigned the change project to a multidisciplinary team composed of 6 designers (management engineers and service designers), 13 medical professionals (3 doctors and the head doctor, 6 nurses, 2 aid nurses, and the head nurse), 2 professionals from the hospital technical department (2 civil

engineers) and 2 IT engineers. We participated in and observed the whole design activity. One author was involved in the team as a designer.

The conceptual idea behind the new redesign represented a dramatic change in the ED working habits: triage professionals were asked to send patients to different areas of the ED using a 'service' coding system instead of the more traditional 'medical' coding system. Following the service coding system, if patients are able to walk by themselves they are sent to the 'vertical' area despite how adverse their medical conditions are. Our interpretative study focuses on the redesign of the area for the 'vertical' patients during the first 7 months of the project. Two main elements represented the turning point of the new service. First, doctors were not conducting visits in their offices anymore, but in an open waiting area where patients were seated in chairs, supported by mobile technology. Second, space was organized into 3 main areas with a 'soft' separation (a removable tent). The space was intended to host patients in the different phases of their treatment process, so that patients could 'physically' progress while their treatment process was being updated.

3.2 Data Collection

Our data collection took place before, during, and after the change project. We were granted full access to the context, e.g., we participated in the design sessions and observed clinical ED work in real-time, and to documentation on patients and healthcare processes.

More specifically, our data include i) interviews, ii) a survey to grasp the values of the subgroup identities, iii) non-participatory observations of routine organizational activity (e.g., équipe visits in the ED), iv) minutes and observations of design activities meetings and organizational plenary discussions, v) project-related documents. More specifically, we conducted 15 preliminary interviews with team members to have a better understanding of the context, how work was conducted before the redesign process, and the social identities of the

team members. Following our analysis of the preliminary interviews, we collected data on team and subgroup values through a structured survey (details provided in section 3.3).

Then, we conducted 85 observations of work before and during the prototypes test, which resulted in around 300 hours of field notes. During observations we were often able to talk with professionals and team members, i.e. to conduct ethnographic interviews (Spradley, 1979). We also recorded and transcribed all the meetings that the team organized to design the solutions (33 meetings in 7 months). In each meeting, at least two professionals were present for each subgroup (designers, technicians, doctors, and nurses). During observations, at least one researcher was taking notes (Spradley, 1979).

Finally, we accessed documents related to the redesign effort, such as minutes of meetings, organizational documents related to existing and new procedures defined by the team, official communications , prototypes and final and intermediate versions of decisions related to the solution (e.g., sketches, blue prints, charts).

3.3 Data Analysis

In a preliminary stage, we focused on obtaining an initial understanding of the different sub-group identities within the ED. First, we transcribed the first preliminary interviews and we coded them to identify the recurrent values of subgroup identities (e.g., innovation, adaptability). Following Dutton and Dukerich (1991), we then listed those values in a questionnaire, and we asked each professional of the organization to answer how much (from 1 to 7) each value defined her role in her professional subgroup (i.e. the value importance). We submitted the questionnaire at the beginning of the project to all the 103 healthcare professionals of the ED, and we collected 91 completed questionnaires (88% respondent ratio). The data from the questionnaire helped us to identify the most significant differences among subgroup identities. We used the information from the survey to verify with the team members whether they felt represented by those values (in terms of importance and ranking). More specifically, we asked sub-groups of the team

(nurses, aid-nurses, doctors, designers, technicians) to comment on the main differences between the professional identities that we collected and to specify whether they felt they were representing their subgroup in the multidisciplinary team. We found no inconsistencies between professional identities in the organization and the sub-groups identities of professionals involved in the multidisciplinary team. When team members commented about their subgroup identities, they also made reference to the values of their team. During these discussions we were thus also able to identify the values of the multidisciplinary team identity (e.g., experimentation, innovation), that were further corroborated through the observational data.

To code our qualitative data, in a first stage, we availed ourselves of the coding techniques described by Miles and Huberman (1994) and Strauss and Corbin (1998). We first conducted open and axial coding on all the transcriptions at our disposal. We open-coded to identify recurrent categories in the data (e.g., subgroup identities and conflictual episodes). To increase the reliability of our analysis, two of us read all the field notes to gain a comprehensive overview of the data. Secondly, by disclosing similar statements, we traced different phenomena that emerged from the transcripts back to emergent categories, i.e. first order themes. We further aggregated first order themes into higher level, more abstract, second order themes. Table 1 summarizes our data structure, i.e. our first order and second order themes and provides examples of field notes (Gioia, Corley, & Hamilton, 2013). The same table includes definitions of all the second order themes. We then looked for evidence to support links between the categories. For instance, we looked for evidence supporting how and when the values of subgroup identities were linked to different elements of the solution to be tested with the prototypes (see Appendix for the table connecting the values of subgroups identities to elements of the solution). During multiple meetings, the authors discussed their analysis and reconciled their disagreements.

---- insert Table 1 about here -----

From the first stage of data analysis, prototype *characteristics* emerged to play a role in the relationship between the sub-group identities and the prototype. In a second stage, we further coded, after an extensive literature review, tangibility, fidelity, and validity as main characteristics to focus on. As for tangibility, following Lauff et al. (2018), we assumed that the higher the number of dimensions of the prototypes, the more similar to real-life experience the prototype is likely to be. In order to code for prototype fidelity, we followed Elverum & Welo (2016), who define fidelity as the resemblance to the final solution. We coded prototype validity following Blomkvist & Holmlid (2011). Validity depends on how similar the test and implementation contexts are. For example, if two prototypes with the same tangibility and fidelity are tested in-situ with real users versus in-lab with senior users, the prototypes differ in terms of validity. Table 4 reports more details about these definitions.

Figure 1 represents the grounded theory that emerged from our analysis. To further corroborate our findings, in particular the categories and relationships in our grounded model, we conducted follow up presentations and conversations with our informants (Gioia et al., 2013). Specifically, in line with the grounded theory approach, we shared the preliminary results of our analysis in order to see if our informants recognized themselves in the theory that we were developing. Their feedback was used to confirm and refine our interpretations (Mattarelli et al., 2013).

4 Empirical Results

We use the grounded model in Figure 1 to guide the presentation of our empirical evidence.

---- insert Figure 1 about here -----

4.1 Subgroups Identities

The team is composed of subgroups with very different professional identities that are summarized in Table 2. Table 2 contains the most and least important values for the different

subgroups in the team. The central values for designers were experimentation and innovation, scientific research, adaptability, and trust. Individuals from technical offices (i.e., civil and IT engineers) shared the values of safety and privacy, speed, and adaptability. Nurses defined themselves as adaptable professionals, devoted to continuous learning and being updated, with a work ethic based on the capability of concentrating under stress, speed in decision making, experimentation, and innovation. They pointed to the importance of work clarity, i.e., having processes, rules, and procedures shared and codified between them and within the hospital. Doctors defined their job as something that requires high levels of concentration under stress, adaptability to diverse situations, and speed, but within the boundaries of security and privacy. Doctors often underlined the importance of presenting their work and the ED as a safe and private environment to the people in the social community. It is interesting to underline that adaptability and speed were the values that all the subgroups in identified as relevant. Besides those shared values, a clear difference emerged between subgroups, in particular between nurses and doctors. The values of safety and privacy were recognized as of utmost importance for doctors and technicians but were not central to nurses and designers. Finally, it is interesting to notice how the value of innovation is ranked among the least important in the professional subgroups' identities of doctors and technicians.

------Insert Table 2 about here-----

4.2 Prototypes

Once the team reached an agreement on the preliminary concept of a solution (i.e. the re-definition of the layout of the ED), the team iteratively discussed and defined all the elements or features of the solution in about two and a half months, developing several prototypes in parallel. The use of the prototypes facilitated team meetings, and the team made design decisions while working around those prototypes. The prototypes used by the team are: sketches, a video, a process simulation, and a 'live prototype'. Sketches include drawings and blueprints of the new

service. The team created a 3 minutes video, showing the whole process with a (fake) patient. The actors were real nurses and doctors using real tools and the video was shot in the ED. The process simulation is an agent-based simulation of the whole process of acceptance, waiting, équipe intervention, and dismissal of patients. It considers the different patient conditions to reproduce triage choices both for 'vertical' patients (patients who are able to walk) and horizontal patients (patients who need a stretcher or a wheelchair). It uses one-year data of the ED, as stored in their information systems. It represents the different professionals moving from one activity to the other in different scenarios. A 'live' prototype was tested in the real setting, with real patients and professionals (no professionals' shifts were adjusted for this purpose) for five weeks. More information regarding the live prototype can be found in REFERENCE REMOVED FOR BLIND REVIEW PROCESS. See table 3 for more information on prototypes.

------Insert Table 3 about here-----

4.3 Different Sub-Group Identity Values Reflected in Solution Elements

When analyzing our data, we realized that subgroup identities were reflected in the solution elements and features, causing, in a few instances, conflicts throughout the prototyping process. For example, a privacy issue emerged while a new area was being designed. The new process considered the possibility of visiting patients at their chairs in an open environment. While the potential absence of privacy did not bother designers and nurses, this solution worried the medical subgroup who strongly disagreed with a "visit at the chair," pushing for a more intimate visit in that area. Doctors pushed to incorporate in the area architectural elements that could protect their visit. Interestingly, nurses supported the "visit at the chair" mode in the solution discussion. This dynamic fits with differences in the subgroups identities: in the analysis of the identity questionnaire results, the value of "privacy" was ranked by doctors among the first identity elements, while nurses ranked it in the very last position.

On the contrary, the value of 'work clarity' has a strong significance for nurses, while it is not that important for doctors. For instance, nurses were keen to provide clarifications on the positions of each medical trolley (i.e., an equipped cart with the essential medication and tools for nurses and doctors). Nurses inserted a blueprint of the position of the trolleys in the slides when sharing ideas of the new prototype in a meeting, as nurses are responsible for logistics in the ED. Some tensions emerged when doctors showed how bothered they were to invest their time in discussing those 'marginal' issues during team meetings ("*We cannot lose so much time about a trolley, come on!*"). The appendix shows how a different solution's elements are linked to different values and provides a few additional examples from our field notes.

4.4 Prototypes as Identity Markers: How the Characteristics of the Prototype Strengthen or Weaken the Impact of Subgroup Identities on Team Dynamics

Our evidence further suggests that the impact of identity us-vs-them dynamics changes depending on the characteristics of the prototype, i.e., tangibility, validity, and fidelity, that we classified following the definition and considerations reported in the data analysis (see also Table 4). Through the process, the team used both prototypes of low tangibility, fidelity, and validity (e.g., sketch) and high tangibility, fidelity, and validity (e.g., live prototype). In particular, some values of subgroup identities become more salient[1] - and thus affect the prototyping process more - for prototypes of high tangibility, fidelity, and validity than for prototypes of low tangibility, fidelity, and validity. To this regard, the prototype definition of the vertical patient's area represents an interesting example. After the definition of the final concept, the team was discussing how to set up the layout of the space and how to organize it in three phases. When the team discussed how to organize the areas and how big they should be through computer

[1] All the values that we listed in the top part of Table 2 are deemed important by members of subgroups. However, in different situations, some values may become salient, i.e. are activated and affect behaviors more significantly than other values.

simulation (prototype with low tangibility, fidelity, and validity), no one raised any objections. In contrast, when using sketches and the video as prototypes, the teams started discussing about the dividers between the areas. However, in the end, the team concluded the discussion with one doctor saying, "*a divider, or a tent, whatever.*"

Interestingly, when the team approached the live prototype definition (higher tangibility, fidelity, and validity), a heated conflictual debate started. When the nurses proposed a plastic divider on wheels, the technicians raised concerns regarding the fact that the solution had to be "*long-standing and possibly fixed*." The fact that doctors' offices already hosted several wheeled dividers was not significant to them, since "*in a waiting area, there are several security concerns*." Designers were actively pushing for a very rough and temporary solution. For instance, during a meeting, a designer asked: "*Why don't we simply stripe a tape line on the floor? That would show the two areas are divided but would not create any security concerns. This is a test, not a final solution.*" Healthcare professionals, specifically the doctors, answered that this was not acceptable, since temporary and '*not* stable' arrangements would affect the image of the ED. "*This is an unacceptable solution, and we are a healthcare provider; people come here to find a place of care and safety when they are in an unsafe condition. [... As doctors,] we have to represent how* solid [word stressed by speaker] *we are, and we cannot appear as a work-in-progress. We need to set up everything properly*." The team ended up by selecting a 12'000 Euro tent that was fixed on the ceiling at the intersection of phases 1 and 2, going up and down. Symbols of the two phases were printed on the tent, with additional costs. Values of subgroup identities became salient and 'visible' through the prototype, created more discussions and tensions during the live prototype definition than during the video-making definition, and for this reason, the same function of the prototype aiming at "dividing two areas of the space" was interpreted and defined differently by the same group of people.

Another example pertains to how the validity of the prototype interacted with subgroup identities. A lively debate around the validity of the prototyping activity emerged in a meeting. Designers pushed for testing an organizational prototyped solution in a fast and cheap way: they thus proposed to the team a prototyping tool, aimed at simulating the solution in a 'training ground,' with a role-game and "fake patients." They presented to the team an image of a gym in Canada, where professionals from an ED reproduced, with cardboard materials, the architectural structure of the possible new layout. By setting up processes and role-games, doctors and nurses would have had the chance to try out the new solution. The subgroup of technicians was surprised, but appreciated the low-cost and safety aspects of such a prototype, coherently with their subgroup values, since *"It will be fast and we will not have any problem with layout interventions and safety issues."*

In contrast, doctors and nurses started to question the validity of such a prototype, focusing on the fact that concentration under stress plays a central role for doctors and nurses in an ED. They explained to the team how stress *"needs to be considered if we want to test it for real." "Working under stress is what makes our work different, in front of real patients who need your help, who need it now, and others are queuing outside,"* a doctor told us. When the technicians and designers' subgroups pushed for the training environment, some nurses and doctors laughed at them, stating that *"I'll tell you, my colleagues won't be concentrated, I would not be in such a gym with fake patients,"* and a nurse added *"We can do that if you want, but it's not a valid experiment, it's a waste of time for everybody."* In the end, designers and technicians agreed to use the live prototype. Table 4 provides further examples of how different prototypes for the same solution element (i.e., triage and division of patients in 2 different areas) make different identity values salient.

------Insert Table 4 about here-----

4.5 Managing the Conflicts Between Subgroups Through Team Identity

The multi-disciplinary team in charge of redesigning the ED has an identity strongly oriented to innovation and experimentation. When the professionals of the team presented themselves to us, they first said, "*We are the ones who first brought triage practice in Italy,*" "*Our head doctor is the President of the National Association of Emergency Medicine*" and even during the project they continuously recalled their identity as an innovative-front line team, e.g., "*We have always been inspired by research, both clinical and organizational," "I am part of the internal group following the internal clinical studies, and I teach triage all around Italy,*" and "*We don't usually buy the extra furniture from our Supply Office, and that's why we often fight with them: we try to design the tool as we want it, and then we ask local artisans to build it.*" During the project, the subgroup of nurses of the team had created a new tool to support triage decision making and, while presenting it to the whole organization, they stated: "*This is a tool that does not exist in the literature, we [as a team] made it up, and we will measure its reliability.*" The head nurse reinforced this by saying: "*V. [nurse's name] says that* unfortunately, *we could not find this tool in the literature. I think this is not a problem. If the literature is not there yet, you create literature, and that is it. We will not be discouraged.*"

Given that the team was oriented towards innovation and experimentation, when sub-team identities conflicted, the team members were always willing to find a 'compromise' solution or to look for new ideas. For instance, in the example of the medical trolleys, the nurses agreed to be less accurate in the design of where to locate the cart because they knew that '*the experimentation must go on*.'

5 Discussion

5.1 A Grounded Theory on the Interplay between Work Identities and Prototypes in Multidisciplinary Teams

The objective of this study was to adopt a social identity perspective in the study of prototyping in teams (Elsbach, 2003; Hornsey & Hogg, 2000) and investigate how subgroup and team identities are represented in prototypes and with what implications for innovation processes. Our grounded theory (Figure 1) shows that different elements of a solution may reflect *important* identity values. During discussions around prototypes those values become *salient* and engender discussions and conflict. The importance of identity values is based on subjective self-ranking (see Table 1), while the salience of identity values reflects the likelihood of the enactment of those values (e.g., Morris, 2013). In particular, prototypes become identity markers, i.e. they make identity values salient, when they are characterized by higher tangibility, fidelity, and validity. In other words, the characteristics of the prototype act as an intervening condition (Strauss & Corbin, 1998) in the relationship between subgroup identities - reflected in the elements of a solution - and the emergence of prototypes as identity markers.

Furthermore, when prototypes act as identity makers, disagreements and conflicts emerge around what is seen in the prototype or what should be in the final solution. Our grounded theory also shows that the conflict around solutions, conveyed through the prototype itself, can be mitigated through a strong team identity. In other words, the superordinate team identity acts as an intervening condition that can move the team from discussing alternatives to alignment.

5.2 Theoretical Contributions

The main contribution of the study settles around the debate of prototypes as facilitators and inhibitors of innovation processes. Previous literature has started to unravel how the use of different prototypes can engender both positive and negative outcomes within multidisciplinary

teams, taking a processual view (e.g., BenMahmoud-Jouini & Midler, 2020; Fixson & Marion, 2012) or focusing on prototypes as objects of collaboration (e.g., Barley, 2015; Seidel & O'Mahony, 2014). The processual view identifies prototypes' archetypes to be activated in specific phases of the innovation process (BenMahmoud-Jouini & Midler, 2020; Täuscher & Abdelkafi, 2017), showing that if the "wrong" prototype is used for a specific phase, it can be not only needless, but also harmful to the process. Our study adds to this perspective by showing that a prototype can turn into an inhibitor of innovation because the team did not recognize the work identity dynamics associated with the prototyping process. Our results show that prototypes interact with how individuals define themselves as part of the team as a whole and of subgroups of the team, and how prototypes engender more or less conflict over the definition of a new course of action. In particular, prototypes catalyze the values of identities that are salient to professionals. Some of the identity values become visibly threatened (Petriglieri, 2011), and sub-groups feel the urge to raise awareness about their conflicting views. This result extends our understanding of the "dark side" of prototypes, adding identities as a relevant variable to consider.

This latter result also adds to the literature on prototypes as objects (e.g., Nicolini et al., 2011) and on how social identities are represented in artifacts (Elsbach, 2003; Pierce et al., 2016; Pratt & Rafaeli, 1997). The literature on prototypes as boundary objects and artifacts for collaboration has privileged a overly positive account of how prototypes can help innovation teams to work together in a better way. Although recent organizational research has started to problematize the role and nature of prototypes and artifacts (e.g., Barley, 2015; Seidel & O'Mahoney, 2014), it has not explicitly considered the role of work-related identities in favoring and inhibiting multidisciplinary collaboration. We contribute to this literature by detailing how the values of social identities may become salient thanks to fluid and temporary artifacts such as prototypes. Previous literature on identity markers has considered

stable and well-defined physical artifacts that an individual or a group of people uses to convey to other people the values of their identity such as a dress-code or an award over the desk (Elsbach, 2003, 2004). In our field study, instead we show that artifacts, i.e. prototypes, get created by different subgroups of a team and evolve over time, i.e. are fluid and temporary. On top of this, by making values salient, a prototype can sometimes positively reflect the values of one subgroup and, simultaneously, threaten the values of another. The literature on identity threat (Petriglieri, 2011; Ravasi & Schultz, 2006) proposes that individuals actively respond to threat in different ways (e.g., protecting the threatened identity and refusing to interact with or accepting ideas from other subgroups), often with negative consequences for teams and organizations. We further contribute to this debate by proposing that fluid and temporary prototypes act as identity markers both by incorporating values and threatening values.

The fact that the prototype as a *subgroup* identity marker can drive conflict in the multidisciplinary team does not have to be considered as an absolute negative condition. At the same time, the prototype as a *team* identity marker should not to be considered as an absolute positive force. Indeed, while conflicts between subgroups can harm a quick alignment effort of the multidisciplinary team, they may 'heat up' the conversation with different perspectives, leading to more creative outputs and early detection of potential issues. In fact, the disagreements that emerge through the design process could anticipate conflicts that would probably be otherwise latent during the design phase, becoming explicit only during the implementation phase.

In existing literature, prototypes facilitate interaction and communication within the design team and with product/service users and stakeholders (e.g., for needs identification, Bogers & Horst, 2014) and integrate different perspectives into a solution (BenMahmoud-Jouini & Midler, 2020; Liedtka, 2015). This study confirms the power of prototypes as discussion and

alignment tools, and adds to the prototype literature by identifying identity processes as an additional explanation of the facilitating role of prototypes.

It is important to highlight that prototypes that act as identity markers create tensions in the innovation process that - depending on how much the team can actively manage the prototyping strategy itself - can make the prototype both a facilitating tool and an inhibiting tool. As we elaborate in Figure 2, when the prototype is a subgroup identity marker, it can act both as a facilitator - because it anticipates certain team dynamics that otherwise would remain uncovered till the implementation phase - and as an inhibitor tool because it fuels conflicts among sub-groups of the team during the design phase. When the prototype is a team-identity maker, it can act both as a facilitator - because it helps the team overcome sub-groups identity conflicts – and, we further suggest, as an inhibitor tool - because it could prevent subgroup identities to emerge and thus block the anticipating power of prototypes as subgroups identity markers.

------Insert Figure 2 about here-----

5.3 Practical implications

We suggest that project managers, team members, designers, and top managers should learn how to actively manage the priming of subgroup and team identities to dynamically exploit the benefits and tensions of both. More specifically, our evidence brings to the fore the impact of prototype *characteristics* in the management of innovation projects. Since prototypes characterized by high tangibility, fidelity, and validity are associated with higher levels of identity-based conflicts across subgroups (and vice-versa), deciding on the characteristics of a prototype should be a joint decision between designers and project managers. In fact, two opportunities arise in terms of management of innovation projects. First, project managers could use prototypes as *diagnostic* tools and 'test' how the team works, by observing how conflicts unfold with the use of prototypes of different tangibility, fidelity, and validity. In fact, for a

project manager, it is vital to understand if the team can handle a certain degree of conflict and heated discussion.

Second, consistent with the *intentional* use of prototypes (Barley et al., 2012), team members could strategically focus on prototypes as tools that enable discussion or alignment between sub-groups. Professionals could thus use prototypes with the intended purpose of maximizing or minimizing the chance of emergence of salient values of subgroup identities (and the related conflict) as a significant variable affecting the final solution from the team. In this case, professionals should also decide when to introduce the characteristics that make the team align or discuss since these characteristics may foster frustrations and tensions not easily manageable by the team. In conflictual situations, professionals are likely to consider that the prototype itself was the issue (e.g., it was the wrong type of prototype for the process), without considering the underlying team dynamics associated with subgroup identities. A possible solution to avoid escalating conflicts among different professionals is to promote a higher-order identity, such as team identity.

Engineers and designers could plan whether to implement prototypes that incorporate individual solution elements or multiple ones and at which level of tangibility, fidelity and validity. For example, if the difference between subgroup values in the team is low, designers could implement a larger set of elements of the solution in a single prototype with high tangibility, fidelity, and validity (instead of creating multiple prototypes), potentially increasing the velocity of the project.

The use of prototypes as diagnostic or intentional tool that discloses team dynamics highlights the role of top management in the design of the prototyping strategy. The central role of managers during prototyping reinforces the vision expressed by Bogers and Horst (2014) who distinguish the prototyping effort that happens at the organizational level into two processes: the continuous prototyping happening at the level of the design team (where problems are iteratively

solved by the multidisciplinary team), and the discrete prototyping happening at the top managerial level (where managers are the stakeholders that formally and periodically need to be involved to assist and approve the solution development). We argue that our findings may set the stage for a more central role of top managers: Not only do they need to supervise and provide general support, but they also need to be involved in the strategic prototype development decisions. In particular they should be involved in the decisions related to which conflicts have to be diagnosed and which conflicts in the team should either be heated up or cooled in the phases of the process.

5.4 Limitations and future research directions

This work is not without limitations. First, it is based on one single case, and we cannot generalize our findings to different teams and contexts but can only aim at theoretical generalizability (Eisenhardt & Graebner, 2007; Lee & Baskerville, 2003). Although we believe that our grounded theory provides useful insights for many knowledge intensive contexts beyond hospitals, future studies could investigate how prototyping and identity dynamics unfold in different knowledge-intensive settings, such as R&D, engineering, or IT. In addition, future studies should explore how the size, degree of formalization, and centralization of organizational context may affect the dynamics we have portrayed. For example, previous studies (e.g., De Waal & Knot, 2019) have started to underline that professionals in smaller firms are more likely to improve performance of NPD by using fewer tools, but more thoroughly.

In this study, subgroup identities were related to professional affiliations (e.g., doctors, nurses, designers). However, as multidisciplinary teams often include clients, suppliers, and stakeholders, we recognize that in addition, organizational, supply chain, and customers' identities may play a significant role in the prototyping process. Future research could consider the role of other social affiliations and identities in the prototyping process.

Moreover, in the context under study, a strong team identity helped in overcoming professional differences among doctors, nurses, designers, and technicians. However, team identity is often difficult to build and sustain, especially in complex contexts such as knowledge-intensive teams and virtual teams (Mattarelli & Tagliaventi, 2010). We call for future research on what happens when different professionals conflict over prototypes without the support of an overarching team identity. We expect that, in such contexts, prototypes characterized by high fidelity, tangibility, and validity will engender conflicts that will not be solved by the team itself and may require an external intervention.

This study did not specifically look into the different innovation phases. Future studies could thus explicitly address how the role of prototypes as identity markers changes through the different phases of the innovation process. For example, we do not know whether a team would react differently in front of a prototype at different stages of the innovation process. Should we expect more identity dynamics to be activated when the prototype is used to take final decisions (i.e. because the team feels more pressure) or at the beginning of the process during the idea generation (i.e. because the team feels that if they are not able to influence possible design solutions, they will not succeed in obtaining what they value)?

To conclude, we invite scholars to get a deeper understanding of how prototyping strategies should be informed by identity dynamics and to further unravel how to make multidisciplinary teams more successful as their members engage with prototypes.

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Figure 1. Grounded Theory

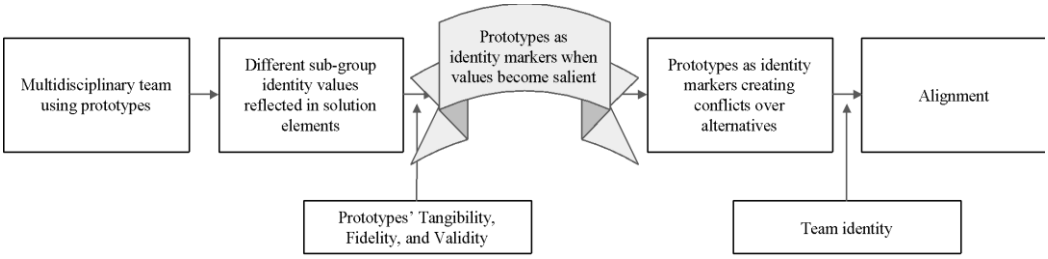


Figure 2. Prototypes and Identities

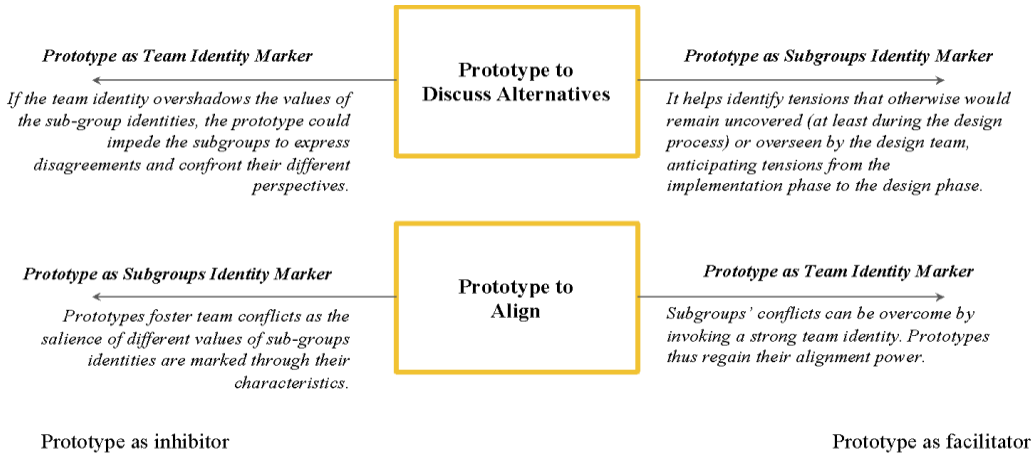


Table 1: Data Structure

Second Order Themes	**Definition**	**First order themes**	**Examples of field notes**
Sub-group identity	The values and beliefs characteristic and representative of the subgroups (Hornsey & Hogg, 2000; Mattarelli & Tagliaventi, 2010), i.e. doctors, nurses, technicians, designers	● Adaptability ● Concentration under stress ● Continuous learning and being updated ● Experimentation and innovation ● Privacy ● Safety ● Scientific research ● Speed ● Trust ● Work clarity	Speed - "*Working [as a doctor] in an ED is not like working in the wards. Here you are in the front line, you have to be fast, you have no time to complain, you cannot take your time to reflect at night about what would be better to do with that case. You act and that's it.*" (Doctor) Adaptability - "*I've been working with other nurses and in other hospitals...In here the nursing group is always pushing, always checking how you are performing and adapting to unexpected situations*." (Nurse)
Team identity	The values and beliefs representative and characteristic of the multidisciplinary team	● Adaptability ● Experimentation and innovation ● Safety ● Speed	Safety - "*As an ED we are always open, 24/7, always here for who is in trouble. We have to look ready, clean, organized, professional,... as people come here when they have no other places to go to. We are their safe place. We are a lighthouse in the night. [...] As a team we need to keep this in mind when we take decisions on the prototypes definition and on their testing.*" (doctor) Experimentation and innovation - "*Our group is called Futura Group. We are used to experimenting a lot. When we need something we search for solutions by ourselves. For small things, we have a reserved budget we deal with. For some furniture, in the past we have drawn what we expected and ask local artisans to produce them. Sometimes, we first test things, and then decide, this is not common for a public hospital.*" (nurse)
Prototype as identity marker	The prototype becomes an identity marker when it cues and/or affirms a person's social and/or personal identities (Elsbach, 2004). In particular, the prototype activates the salience of identity values and can	● Reflecting your subgroup identity in the prototype ● Prototype as identity threat	Reflecting the subgroup identity in the prototype - Among doctors' identity values, the preciseness of decisions is seen as a security issue. Doctors lamented the fact that ambulatories did not allow them to ask advice to colleagues and slow joint decision making. Thus the proposal of working in an open space reflected their identity value of safety. "*Working with no separation can help to*

	either reflect those values or threaten them (e.g., Ravasi & Schultz, 2006).		*understand if a colleague needs a hand on a difficult case, and makes it easier for you to ask for help or suggestions from a colleague. [...] You know, if you have to exit your door, knock to your colleague's door and interrupt him, you feel unqualified and unprepared...while if you are already shoulder to shoulder…[...] This is even safer for patients and for the organizations, as even young doctors find easier support in case of any doubt.*" (doctor) Prototype as identity threat - Nurses recognize themselves as being able to act in a flexible way upon the norms and procedures that they receive. The team proposes a solution that uses a new triage procedure to send the patients to different ED areas. Doctors want to fully codify the process by defining a list of symptoms that triage will use. *"Watch out! My nurses know what they are doing, the fact that a doctor comes and lists the symptoms of triage is not only wrong -as doctors cannot do triage- but it also reduces nurses' capacity of judgment. This is going to turn the solution into a less flexible system.[...] Do you know how many years and assessments and exams we do plan before we send a nurse in the triage area? [head nurse]*
Conflict	Conflict represents the arising of divergent views within the team. Disagreements include situations where individuals from different subgroups explain to each other their concerns about the solutions that a prototype represents (Mattarelli et al., 2013). Open conflict happens when team members have an open argument (Robbins, 1974), often characterized by emotional displays (raising voice, crossing arms, raising from a	• Disagreements about solutions • Open conflict on how to move the work forward	Disagreements - From a meeting discussion (N for nurse, Do for doctor, De for designer.) De1: *You think we can afford dividing patients by their relatives?* N2: *Oh my god, this is my dream* Do1: *Then who manages the relatives? You*? N1: Y*es, as we already do, but at least they are far away and not next to us* N2: *Relatives are there to complicate things, they interrupt you, they knock at the door…* Do2: *Well, if we manage to divide them [patients and relatives] the good thing is that we will be more concentrated, no relatives knocking at the doors, questioning, interrupting, …* N1: *Having someone next to the patients also means having someone who takes care and calls for your attention if something goes wrong. If the patient is alone we will have a major responsibility in assessing patients'*

	chair, leaving a room before a meeting is over).		*safety before the visit and during the waiting moments.* N1: *It's true, and that is upon us as nurses, and aid nurses* Do1: *But at least we would be faster with less interruption* Open Conflict - '*This is a hot theme and I don't want to confront my head physician in front of everybody and in front of my nurses - my boss knows that. But-again- I cannot avoid a heated discussion when I hear a doctor in a meeting explaining my senior nurses how to triage. And again, saying that triage needs a doctors' list to understand the symptoms of patients and decide what area to send them… this is quite a position. [Raise her voice] The same old discussions! The position of doctors who think to be above us. Triage is assessed by nurses, not by doctors, simply because they cannot do that!*" [head nurse]
Alignment	Alignment reflects convergence of different perspectives on a issue that the team is facing and takes the form of shared agreement and /or forced agreement. Shared agreement happens when the different subgroups identify, through a prototype, a solution that is satisfactory for all subgroups (win-win). Forced agreement happens when one or more subgroups are willing to put the interests of other subgroup/s above their own (win-lose).	• Shared Agreement • Forced agreement	Shared agreement - "*Ok, we all think this makes sense [for all of us]. So, it's decided, we start in 2 weeks and we need to set up everything.*" [head of physicians] Forced agreement - Discussion in a meeting, after the team decides to go on with the live prototype. Des for designer, T for Technicians. office professional, Doc doctor T1: *OK, if you really want to go on with this experiment... I've told you this is not how we work. We prefer to prepare everything in detail, blueprints, norms checking..., and then ask for support to external engineers to assess the proposed solution and launch the formal public tender for a detailed design of the layout. You give for granted the "civil engineering" part, but this is complicated*. Des1: *We know that, and we do not give it for granted, we trust you, but we want to do that only when we are sure of the main decisions behind those solutions.* Doc3: *We still have too many questions. Is 3 areas of the layout the right decisions? Or we just need 2? Can we really work without an ambulatory? Is the process really faster?* Des2: *And the numbers… we need numbers behind simulations to give you specifics*

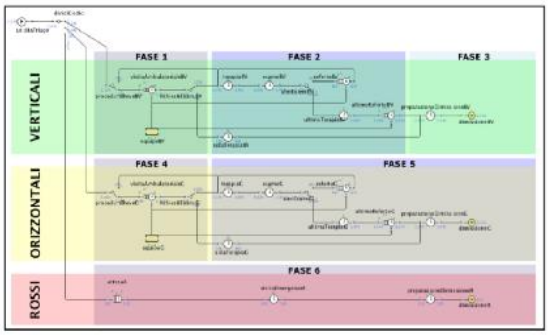
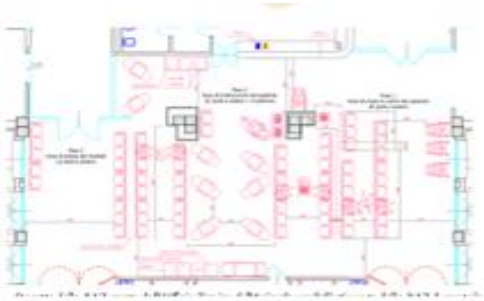
			regarding the number of chairs in each space. T1 : *OK, We won't say no. I understand that there is no other way, and you also want to invest money to run this experiment, with pre-works. I accept what we decide, otherwise we are stuck. And the hospital director says it's ok, then…If this is what everybody wants…."*

Table 2: Values of identities in the different subgroups

	Doctors	**Nurses**	**Technicians**	**Designers**
Most important values	Concentration under stress, Adaptability, Security, Privacy, Speed	Adaptability, Continuous learning and being updated, Concentration under stress, Speed, Experimentation and innovation, Work clarity	Security, Privacy, Adaptability, Speed	Experimentation and innovation, Scientific research, Adaptability, Trust, Speed
Least important values	Experimentation and innovation, Work clarity	Security, Privacy	Concentration, Experimentation, and innovation	Security, Privacy, Work clarity

Table 3: Description of prototypes

Type

Type	Description	Image
Simulation	The model is an agent-based computer simulation, developed with the software Anylogic. It represents the new process and actions that different actors should take for different logical choices. Key performance indexes are reported. The simulation is based on two months of historical data.	
Sketch	The sketch represents the new layout and furniture. Developed "on paper" by the team and in its final form by the designers and technical office. Extra information reports how the patient is thought to go through the new layout and where the different *equipes* should work, as well as a legend of colors and symbols representing furniture and tools to be used by the healthcare professionals in the different areas.	
Video	The video represents the story of a (fake) patient that arrives in the hospital and goes through the new process. Scenes were shot in the hospital in the real spaces prepared in ways that could recall the new layout. Actors are doctors and nurses from the hospital. Scenes and actions represent the process and the decisions that each professional is called to make. Actions of actors were discussed and agreed on in the design team. In different scenes, subtitles highlight the new working conditions.	

Live prototype	The whole waiting area was prepared (with new furniture, walls, doors, tools, …) to test a go-live working setting for the new solution, both in terms of space and process. The team prepared every detail of the live prototype, communicated the new procedures to the whole ED (without changing the personnel shifts) and ran a five weeks test. Each week the design team met to decide what to adapt for the following week.	  

Table 4: Characteristics of the prototypes and examples of field notes related to how prototypes activate the salience of identity values. The field notes below pertain to the same solution element, i.e. triage and division of patients in 2 different areas, that was discussed through different prototypes.

Prototype type	**Prototype characteristics***	**Examples of prototypes activating salience of identity values**
Simulation	Tangibility: 1 Fidelity: 1 Validity: 1	*From a non-participatory observation of a meeting where the simulation was introduced and discussed.* Deciding where to send each patient is a triage responsibility. Failing to address the right patient to the right area would cause problems to the service and impact the overcrowding situation of each area (e.g., too many patients in one area). While sharing the screen of the simulation development, a doctor asked what the symbols on the software stood for. A designer explained that those were counters of patients sent to each area. He also mentioned that this was an important point of discussion, and asked how the simulation could replicate the decision making of triage (e.g., how to split the patients among the vertical or horizontal area). A doctor answered this was not a problem; nurses agreed.
Sketch	Tangibility: 2 Fidelity: 1 Validity: 1	*From a non-participatory observation of a meeting where the sketch (that had previously been shared by email) was discussed.* Team members came with a printed copy of the lay out that they had sketched over with colors and pencils. During the meeting they showed each other their copies. One nurse hypothesized the number of chairs in the area and sketched the number on the layout. This started a conversation regarding the variables that could affect the decision of where to send the patients. While the team was discussing this, nurses got worried as they were not sure they could clearly distinguish among patients that needed to be sent to the vertical or horizontal area (value that becomes salient: work clarity). They decided to appoint a senior nurse to make a literature review to understand how to do that.
Video	Tangibility: 2 Fidelity: 2 Validity: 2	*From a non-participatory observation of a meeting where designers shared the video with the rest of the team* While watching the first version of the video, a debate started after the first scenes (showing triage activities) among nurses. “From the video it looks that it’s super easy and straightforward to understand where to send the patient. This cannot be true!”. It is not clear how to address the patients, there are too many variables to consider”, and a nurse stated pointing to a frozen image on the screen “literature does not help us”. Nurses realized they needed to create an appropriate tool to support the decision making of the triage to address the patients to the proper area (value that becomes salient: experimentation). A sub-team was appointed to develop a tool to support the triage in the decision.
Live prototype	Tangibility: 3 Fidelity: 3 Validity: 3	*From an interview with a nurse during the live prototype* Nurse: “This is crazy, we made a literature review and developed a tool, which everybody liked and approved. Now that we go live with it we feel like we are prepared and safe from that side. But it’s like we forgot to be flexible. We have always been flexible, we are trained to be adaptable and flexible [...] and now it’s like we are all “bananas”, they look at the tool and forget the basics of their everyday triage work(value that becomes salient: adaptability).

*__Tangibility__: low (1) with two-dimensions (e.g., hand sketches, storyboards, paper or digital interfaces, lines of code); medium (2) with three-dimensions (e.g., foam models, computer-aided design renderings, three-dimensional printed parts, breadboards); high (3) with four-dimensions (role-playing, virtual reality, desktop walkthrough, service staging, interactive processes, experience prototypes, behavioral prototype).
Fidelity: appearance fidelity (1) is how much the prototype appearance resembles the final solution; functionality fidelity (2) is how much the prototype functioning resembles the final solution, and production process fidelity (3) is how much the providing/production of the prototype resembles the one used for the final solution.
Validity: The more similar the evaluation environment is to the final environment, the higher the prototype validity. Lab environment without users (1); Lab environment with users (2); Final environment (2)

Appendix: Axial coding on the relationship between solution elements and identity values

The table lists the solutions elements in row and identities values in column. The solution elements are the concrete features of the solution that were discussed by the team during formal and informal meetings. 1 (-1) in the cell means that there is at least one field note showing the positive (negative) relationship between the solution element to the identity value.

	i) Concentration under stress	ii) Adaptability/ being flexible	iii) Security and Safety	iv) Privacy	v) Speed	vi) Work clarity	vii) Trust	viii) Continuous learning and being updated	ix) Experimentation and innovation	x) Scientific research
a) Service coding system as a variable					1		1		1	1
b) Decision-making: list of symptoms defining who enters the area		-1	1				1		1	1
c) Lay out divided into 2 different areas (vertical/easy treatment + horizontal/complex treatment)	-1	1							1	1
d) From ambulatories to open space	-1		1	-1	1	1	1	1		
e) Visit at the chair			1		1		1			
f) Architectural element to protect the visit	1		1	1	-1					
g) Patients and relatives are separated	1		-1		1		1			
h) Layout divided into 3 zones (process steps)			1		1	1			1	
i) New role: process nurse to report to the relatives			1	1		1	1			
l) Tablet for process nurse		1			1					
m) IT interface reporting patient-centered process info (for process nurse)						1				
n) IT interface reporting real time crowding measures for each process phase		1				1	1			
o) Kanban system to get a process overview		1				1				1
p) Each équipe picks the next patient (triage no longer pre-assigns the patient to the équipe)		1			1				1	
q) Mobile PC in the open space				-1						
r) Choice of space dividers			1	1		1			1	
s) Logistics (such as furniture, how many drawers, for what, ...)						1				
t) Choice of seats (color, number, comfort, ...)						1	1			

Examples of field notes for cells a-ix and c-i:

a-ix) The multi-disciplinary team and certain sub-groups recognized innovation as an important value of their identity. When the team decided to consider the type of service as a variable affecting the criteria for the triage assessment (and then as a criteria that drives the redesign of the ED layout), the identities that presented innovation as an important value were reflected into that solution.
"We are the first ED that introduced Triage in Italy, and this was done by our nursing staff. If there is any new idea [i.e. the service coding system] connected to an innovation in the triage practice, it can definitely be experimented here!" [nurse]

c-i) The new layout was intended to divide patients (and doctors) into two areas: one dedicated to the vertical patients (easy treatment) and another one dedicated to horizontal patients (complex treatments). Among doctors' values, concentration under stress was among the most important values. They discussed on how this layout could have impacted their routines, and how this affected the concentration capacity during their shifts in the different areas. The following quotes report a discussion among doctors at the coffee machine (from a non-participatory observation).
Do1: *The risk of working in this low complexity area is that -during the hours- the level of attention is lowered given the simplicity of the cases, and therefore errors can increase.*
Do2: *On the other hand, even when you work in the other area of greatest complication, errors arise, because you have complex cases without ever being able to relax*
Do1: *Yes, this is not positive at all, we have to report that during the team meeting.*