Acronyme	**MATCHING**		
Titre du projet en français	*Collaboration avec des systèmes intelligents*		
Titre du projet en anglais	*Collaboration with Intelligent Systems*		
Mots-clefs	Intelligent Systems; Creative Process; Group; Conflict; Leadership; Collaborative Interactions; Emergency of Collective Agency; Complexity; Control; Explainability; User's state; Trust; Privacy; Agency; Diversity, Authority; Ethics; Long-Term Interaction; Co-Adaptation; Learning; Deskilling; Vulnerability		
Établissement porteur	**Université de Grenoble-Alpes (UGA)**		
Responsable du projet	**Prénom, Nom, Qualité**		
	Responsable: Agnès Helme-Guizon, Co-responsables: Catherine Pelachaud (CNRS-SU), Gilles Coppin (IMT)		
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Durée du projet	84 Mois		
Aide totale demandée	**5 160 000 €**	**Coût complet**	**34 644 010 €**

Liste des établissements du consortium :

Établissements d'enseignement supérieur et de recherche	***Secteur(s) d'activité***
Université Grenoble Alpes (UGA)	***Computer Science, HCI, Social Sciences, Human sciences***
Université Paris-Saclay (UPS)	***Computer Science, HCI***

Institut Mines Télécom (IMT)	*Computer Science, HCI, Social Sciences*
Université de Lille	*Computer Science, HCI, Social Sciences*
Sorbonne Université	*Computer Sciences, HCI, Social Sciences*
Grenoble INP	*Computer Science, HCI, Social Sciences*
Université Gustave Eiffel	*Psychology, Ergonomics*
Université de Toulouse	*Computer Sciences, Robotics*
Université Claude Bernard Lyon 1	*Computer Science, Social Sciences*
ENAC	*Computer Science, HCI, Ergonomics, Avionics*
Université de Lorraine	*Computer Science, HCI*
CESI	*Engineering science*
ENSAM	*Engineering science*
Université de Technologie de Troyes	*Computer Science, Social Sciences*

Organismes de recherche	***Secteur(s) d'activité***
CNRS	*Computer Science, HCI, Social Sciences*
INRIA	*Computer Science, HCI*

Autres partenaires	***Secteur(s) d'activité***

Résumé du projet en français (Non Confidentiel – 4000 caractères maximum, espaces inclus)

Les systèmes intelligents (ou agents) font de plus en plus partie intégrante de presque tous les domaines de notre vie quotidienne (personnelle et professionnelle) et les façonnent. Malgré les efforts déployés dans les domaines de l'interaction humain-machine et des sciences humaines et sociales, de nombreux défis demeurent sur la manière de concevoir, de modéliser et d'évaluer une collaboration satisfaisante entre l'humain et les systèmes intelligents. Cela nécessite de renouveler les modèles théoriques, les modèles d'interactions, et de s'interroger sur leurs conséquences sociales et sociétales.

Le projet MATCHING vise à créer des formes renouvelées d'interactions entre les utilisateurs humains et les systèmes intelligents afin de tirer un meilleur parti des compétences respectives des humains et du système. Le but est de créer un partenariat global dans lequel la combinaison de l'humain et du système est meilleure que l'un ou l'autre seul. Le projet abordera différentes configurations d'interactions en mettant l'accent sur les groupes hybrides comportant plusieurs humains et plusieurs agents. Mais il examinera également la question de l'augmentation de l'interaction d'un utilisateur avec des outils basés sur l'IA, tels que des systèmes de recommandations, d'aides à la décision ou des compagnons artificiels dédiés. L'explicabilité, la transparence et l'équité de ce type d'interaction hybride seront prises en considération, ainsi que la diversité et les capacités des utilisateurs, leurs états affectifs et/ou cognitifs et leur volonté d'exercer leur agence et leur autorité en ce qui concerne les questions éthiques et le bien-être de l'utilisateur. Le projet MATCHING aborde également l'évolution des compétences dans les sphères privées et professionnelles, le sens du travail et de l'activité, la gestion de la responsabilité, de l'éthique et de l'autorité dans les futures organisations intégrant des agents intelligents.

Résumé du projet en anglais (Non Confidentiel – 4000 caractères maximum, espaces inclus)

Intelligent systems (or agents) are becoming an integral part of nearly all areas of our daily lives and shape them. Despite efforts in HCI (Human Computer Interaction) and HSS (Human and Social Sciences) to address these questions, how to design, model and evaluate effective and beneficial collaboration between human and intelligent systems is still understudied. This requires renewed theoretical and empirical models of interactions and questioning around the associated ethical issues.

The project MATCHING aims at creating new forms of interactions between human users and intelligent systems that take advantage of differences in human's and system's skills, while reducing reliance on their respective weaknesses, to create an overall partnership where the combination of the human and the system is better than either one alone. The project will address different configurations while putting the emphasis on groups (multiple humans, multiple agents) but will also go through the question of augmenting one user with proper interaction with AI-based tools such as recommenders, decision aids or dedicated artificial companions. Explainability, privacy, and fairness of this type of hybrid interaction will be taken into consideration as well as the users' diversity and abilities, affective and/or cognitive states and willingness to exert their agency and authority with regards to ethical issues and user's well-being. The MATCHING project also addresses the evolution of skills in private and professional spheres, meaning of work and activity, management of responsibility, ethics and authority in the future organizations embedding intelligent agents.

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1. Context, objectives and previous achievements

1.1. Context, objectives and innovative features of the project

Intelligent systems (or agents) are becoming an integral part of nearly all areas of our daily lives and shape them. They can be a recommendation system on our smartphone, a conversational agent (e.g., Siri) or a robotic system at home or in industry. Their introduction raises new questions about how humans and machines collaborate and their impact on human activities, placing humans at the heart of a complex ecosystem. These systems can empower users' ability to make decisions but can also reduce their agency and autonomy. They can provide services tailored to each individual… at the expense of privacy. They can create new forms of human activity or make some jobs redundant creating a risk of replacing the human by the machine. Intelligent systems impact habits, abilities, and social behaviors of individuals and groups but also of organizations.

If AI-based entities are designed to be at the service of humans, it appears that they produce unexpected and sometimes deleterious effects. However, the issues of user acceptance of these AI-based devices and human-AI collaboration remains understudied from a users' behavior perspective given the importance of these issues, both from an academic and a managerial point of view.

In this project, we go beyond the traditional approach that views AI-based entities as objects. We consider that they could be social actors with whom humans can interact using a wide range of communication means. We contend that the characteristics (design) of these AI-based entities as well as the qualities projected on them that are anchored in stereotypes (humanness, gender, authority, etc.) as well as the anticipated interactions will modulate the acceptability, the nature and the quality of the collaboration with them as well as the individual and collective well-being.

Despite efforts in HCI (Human Computer Interaction) and HSS (Human and Social Sciences) to address these questions, how to design, model and evaluate effective collaboration between human and intelligent systems is still understudied. In the near future, this will be even more challenging as these systems will be more diffuse in the environment. This requires novel theoretical and empirical models of interaction to support collaboration between human users and intelligent systems. This also requires developing new AI approaches: better integrated in a cooperative collaboration with humans, with better knowledge on the user's emotional, psychological, physiological and physical states, more explainable, more adaptable along time with a more and more experienced user.

The expected breakthrough of this project is to create new forms of interactions between human users and intelligent systems that take advantage of differences between human's and system's skills, while reducing reliance on their respective weaknesses, to create an overall partnership where the combination of the human and the system is better than either one alone. The project will address different configurations (depicted in Figure 1) while putting the emphasis on group ones (multiple humans, multiple agents) but will also go through the question of augmenting one user with proper interaction with AI-based tools such as recommenders, decision aids or dedicated artificial companions. Explainability, privacy, and fairness of this type of hybrid interaction will be taken into consideration as well as the users' diversity and abilities, affective and/or cognitive states and willingness to exert their agency and authority with regards to ethical issues and user's well-being. Addressing these challenges requires collaboration with specialists in HCI, AI, ethics, sociology, psychology, anthropology and management sciences.

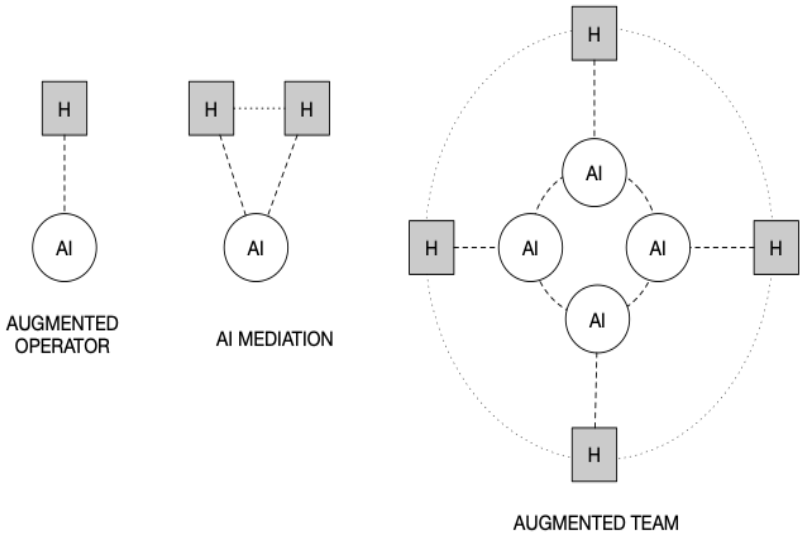


Figure 1: Different types of cooperation between humans (H) and intelligent systems (AI)

1.2. Main previous achievements

The project MATCHING addresses scientific and technical challenges that have been worked out and developed at the national and international levels and already have reached some relevant achievements:

Human-AI teaming: as stated by the US National Academies of Sciences Engineering and Medicine, "although AI has many potential benefits, it has also been shown to suffer from a number of challenges for successful performance in complex, real-world environments such as military operations, including brittleness, perceptual limitations, hidden biases, and lack of a model of causation important for understanding and predicting future events. These limitations mean that, for the foreseeable future, AI will remain inadequate for operating on its own in many complex and novel situations for the foreseeable future, and that humans will need to carefully manage AI systems to achieve their desired utility." Beyond applications to advanced military and critical systems (e.g. NATO HFM 247, 300, etc.), recent advances in Digital Twinning of industrial systems and cobotics have highlighted the need to think about AI possibly symbiotic with humans instead of remaining a simple tool. Most worldwide major academic research centers, companies and governments (e.g. Japan Society 5.0 based on fair and inclusive AI within society) have promoted the idea of Controllable AI, which means humans should cooperate and not be simple users or simply used by an artificial authority.

Human and Social Sciences: Research in SHS on human-machine interaction has highlighted a set of contrasting cognitive, affective and behavioral reactions (positive, negative or neutral) depending on the intelligent systems, the individuals or (social) situations. For example, an intelligent system (e.g. robot / chatbot anthropomorphized or not, voice assistant, autonomous vehicle) can lead to positive reactions (trust, attachment) and approach behaviors (use, appropriation, adoption). Conversely, this same intelligent system can create a feeling of discomfort, eariness (cf. Uncanny valley) and induce unexpected reactions or behaviors, even contrary to what was expected (reactance, lies, avoidance, etc.), generate coping strategies (in order to protect oneself from a self-threat and to regain control). The work remains fragmentary. A large number of mechanisms underlying and factors varying these reactions remain to be explored in order to contribute to an optimal human-AI interaction.

Socially interactive agents - SIAs (a term for both physical robots and virtual agents) have been endowed with the ability to communicate verbally and non-verbally. But unlike avatars, they are autonomous. That is, they have the ability to perceive their human interlocutors, to interpret their multimodal signals in terms of mental state, affective state, belief..., to plan what to say and how to say it, to manage speaking turns, etc. To engage their human interlocutors in an interaction, computational models have been developed to detect

and model a representation of their mental and affective state. Lately, various machine learning approaches have been proposed: for example, deep-learning approaches are used to develop multimodal behaviors generation models; reinforce-learning approaches allow agents to adapt to their human interlocutors. Most of the existing research has focused on dyadic interaction and short-term interaction. There remain challenges to manage multi-party interaction (be with multi-users and/or multi-agents), to allow agents to sustain long-term interaction, to apply the agents in a vast range of applications (e.g., creative task, conflict management).

Animation and movement control: Interaction between humans and AI-driven entities requires measuring, understanding and modeling the internal and external states of the users, based on multimodal signals. Plenty of sensors exist to monitor the user's state, including physiological signals and movements, which helps to build models of the users and predict their intentions. Two main approaches exist to design these models: rule-based (AI rules are manually written by the designers and then optimized) and data-driven approaches (AI rules are automatically deduced by a set of examples). Recent works proposed to use deep reinforcement learning to make a model imitate the behavior of a human based on some observations. Extending these models to multiple-agents interaction, while taking into account diversity, cognitive and affective state of the user, raises the challenge of designing AI-entities capable of facilitating collaborative tasks involving a group of hybrid (real and simulated) agents.

The project will benefit from the previous experience and contributions of the different research groups of the consortium along the set of projects they have respectively participated in:

EU Project H2020 Council of Coaches (2017-2020) ; EU Project ITN Animatas (2017-2020); French-Japanese Project TAPAS (2019-2024); French-Japanese Project PANORAMA (2020-2025); National project ANR Social Touch (2017-2019); National project ANR MATCH (2022-2025); National project ANR ENHANCER (2022-2025) ; PRECOGS (Man-Machine Teaming PEA 2018); EU HORIZON-CL4-2022-HUMAN-01-14 ShareSpace (2023-2025); EU H2020 JPICH Digital Heritage SCHEDAR (2017-2020); National project INRIA Défi AVATAR (2017-2022); National project INRIA Défi Ys.AI (2022-2026); National project ANR EUR DigiSport (2020-2028); National project ANR PPR Sport REVEA (2020-2024); National project ANR Equipex+ CONTINUUM (2020-2028).

2. Detailed project description

2.1. Project outline, scientific strategy

Within the PEPR eNSEMBLE, the present project mainly addresses the key challenge #2 i.e., the role of AI and computer agency in collaborative systems. Combining human and artificial intelligence in collaborative set-ups requires the creation of renewed human-computer partnerships where the whole is more than the sum of the parts. Human-Centered AI should promote upskilling rather than deskilling, should empower rather than create vulnerabilities, as well as intelligibility, fairness and control by human actors.

We address the question of cooperation between intelligent systems and human agents especially through the interaction with an autonomous AI, with AI-based agents that are embedded in the system, the adaptive interactions (to the tasks and the user’s characteristics: goals, age, gender, competencies, etc.) relatively to leadership, authority, trust, control, empowerment and vulnerability.

This list should not be considered as exhaustive, rather it highlights our focus on system level issues and indicates that the generic use of AI as an optimization paradigm will not be addressed in so far, no interaction is concerned. A multidisciplinary approach is needed to address the challenges of understanding and modeling adaptive interactions between humans and intelligent agents while taking into account social and societal consequences.

2.2. Scientific and technical description of the project

The project MATCHING is organized around 3 axes that focus respectively on groups, control in complexity, and long-term interactions, each comprising 2 WPs. They are detailed below.

Axis1 – Collaboration between groups of people and intelligent systems

Leading team: Catherine Pelachaud & Gilles Coppin

Interaction in everyday life or work situations happens often in groups. In this axis, a group may be composed of up to twenty people and include one or several intelligent systems. Group interactions involve complex human behaviors with turn-taking, embodied synchronization, imitation, etc. However, they cannot be viewed as a dyad or even as a set of dyads. Moreover, interactions in groups involve dynamics that tend to accentuate polarization among group members. Introducing intelligent systems for supporting group interaction should consider these complex configurations and capture these group dynamics to enhance cohesion, ensure collaboration on a joint action and manage conflicts. The challenge of axis 1 is to ensure that the introduction of intelligent systems in a group of human users serves the purpose of the collaboration. We will develop measures and metrics to understand how collaboration happens and evolves in a group of human users and intelligent systems, taking into account the complexity of individual behavior in the context of collaboration (WP1.1). We will also define mechanisms so that a group of intelligent systems do not manipulate the leadership at the expense of the human users (WP1.2). This requires complex moderation principles to de-escalate conflicts, enhance the creativity process and drive the group to a common performance/goal as well as ethical considerations regarding the role and limits of the actions of an intelligent system and to which extent it should report its action to a human expert.

WP1.1 - Modeling and understanding group of agents with social capabilities in intelligent systems

Interaction in everyday life or work situations happens often in groups. The project aims to go beyond dyadic interaction. This WP will develop models to understand and explore the implications of collaborative interactions between groups of humans and of agents. Several topics will be addressed regarding the sociability of agents, the participation and adaptation of agents to group and collective activities, as well as the use of AI to enhance the role of artificial agents in creative tasks.

WP1.2 - Mitigating users' control and authority in collaborative interactions with intelligent systems

This WP will address the control of fairness of AI and the implications on authority within the system. The concept of authority sharing is initially derived from the notion of "Mixed Initiative Systems". Authority sharing is a strategy for using the resources of the agents of a simple or complex system (or system of systems), giving this system the capacity to allocate at each moment, and according to the context of the situation, a precise task to an agent (human or automaton) which will be the most able to carry out this task under the optimal conditions of effectiveness (achievement of the objective of the task) and safety (integrity of the material, the people and the environment). From this definition, new challenges now address the acceptability and fairness of such approaches, including human-centered and sociological aspects, far beyond simple efficiency seeking. This work package will therefore be concerned with understanding, measuring and managing leadership, acceptability and conflict within group members of an interaction.

Deliverables of Axis 1:

- D1.1: Conceptual models and tools to support group interaction within intelligent systems
- D1.2: Principles of management of control and authority in intelligent systems

Axis 2 – Maintaining understanding and control with complex intelligent systems

Leading team: Agnès Helme-Guizon & Franck Multon

With the increasing complexity of intelligent systems comes the complexity of understanding them. Indeed, a common observation when interacting with intelligent systems is the lack of understanding of the human users upon the elements that drive the system's decisions which are necessary to empower individuals and maintain a sense of control. The goal of Explainable AI (XAI) is generally couched in terms of explaining to users how the algorithm works (e.g., criteria). However, users also seek to understand what aspects of their own behavior the intelligent system understands. More importantly, they want to know what the system will allow them to do next and what are the consequences on the different stakeholders. Reversely, the AI entity should estimate the state and intentions of the users, to compute the required behavior to assist them. Moreover, human users need to stay in control of these intelligent systems. But as a system achieves more and more complex tasks, it also becomes more and more difficult to control, whether through off-line configuration (e.g., recommender systems) or online interactions (e.g., conversational agents or achieving collaborative tasks), especially when the control depends on proprietary applications. To this end, we will conceive models and frameworks to design interactions with AI-driven entities (WP2.1) that deal with users' diversity, affective and/or cognitive states and willingness to control. We will also consider ethical, explainability, privacy, and fairness questions of this type of hybrid interaction (WP2.2).

WP2.1 - Modeling & understanding of collaborative or competitive interactions between humans and AI-driven entities

Interaction between humans and AI-driven entities requires measuring, understanding and modeling the internal and external states of the users, based on multimodal signals. This will enable the AI system to adapt the interaction while dealing with user's diversity, representations and experience. A promising approach consists in modeling human-AI interactions from the observation of human-human interactions. A key challenge is to encompass and integrate the range of cognitive and emotional states of the user's resulting from anticipated or current interaction with the system as well as his/her own agency. In addition, the project will explore new avenues to enhance the cooperation within hybrid teams using dialog, verbal communication or action adaptation between virtual and real entities.

WP2.2 - Integrating and mitigating users' diversity and agency

Interaction between human and intelligent systems should be conceived and modeled bearing in mind explainability and fairness of AI mechanisms, management of trust and privacy, users' diversity (including gender, age, abilities, culture), variety of degrees of control, user's free will and agency as well as user's well-being when cooperating with artificial agents. Also possible unintended negative consequences of the interaction for every stakeholders should be anticipated. These issues, though challenging and so far understudied, are all the more essential in complex systems involving human and intelligent agents.

Deliverables for Axis 2:

- D2.1: Models and tools to support efficiency and trust in collaborative systems
- D2.2: Principles of system adaptation to users' diversity
- D2.3: Best (ethical) practices for cooperation between humans and intelligent systems

Axis 3 – Long-term collaboration with intelligent systems

Leading team: Mohamed Daoudi & Gilles Coppin

Intelligent systems can engage in long-term interactions with human users for their services. By adapting to the users, intelligent systems may change the behaviors of human users. For example, humans who search for recommendations (e.g., movies, diagnosis) may get used to following them rather than exploring alternatives or questioning them; they may also decide to systematically go against them due to new algorithm aversion; finally, they may try to develop intuitions on how the system works (such intuitions are rarely "correct", since humans and machine learning algorithms reason in completely different ways). These long-term interaction mechanisms can lead to incorrect assumptions, expectations and potentially deception. Collaboration between humans and intelligent systems can also modify users' behavior outside of the interaction, potentially at a much longer time scale. Indeed, users, especially expert users, come to rely on these systems, and begin to lose expertise. This form of deskilling may be benign or devastating in safety critical systems (e.g., assistive robotic surgery) when users no longer fully recall how to utilize their skills in an emergency. While some railings are available in specific contexts (e.g., continuous training of airline pilots), many users and institutions do not consider this form of deskilling which can lead to the reduction in the quality of users' work. The challenge is to adapt collaboration with intelligent systems to augment users' capabilities over the long-term (WP3.1). To achieve this, we will develop effective measures of the quality of collaboration during interactions to understand how users' behavior evolves over time. We will also create measures to evaluate the quality of collaboration outside of interactions. Furthermore, we will develop intelligent systems that can continuously and effectively develop users' expertise while preventing deskilling (WP3.2).

WP 3.1: Co-adaptation of complex systems and humans on a long-term perspective

The embedding of smart agents within hybrid collective activities will raise the question of mutual adaptation as a human group would generate when including a new partner. The questions of dynamic task allocation as well of tuning the respective know-how and roles has to be renewed because of agents' specificities in terms of learning and cooperating. Humans and agents should learn how to interdependently interact on shared tasks and shared objectives, by replacing or complementing each other. This work package will thus be focused on mutual and long-term learning from humans and artificial agents associated within an "hybrid" system. Especially, long-term should be understood here as not being limited to a mission or simple joint work session, but rather as repeated situations of cooperation or even sequences of dialog and exchange without any focused and operational actions. This addresses the construction and the maintenance of a common ground (or common knowledge spaces) along a long period of time and joint activities.

WP 3.2: Impact of intelligent systems on expertise and deskilling

Fully or even partially delegating tasks to intelligent agents has an obvious impact on companies and more generally work organizations. Human resources management aspects, such as building operators' careers on competences or continuous increase of abilities, are to be seriously tuned to the insertion of new kinds of intelligent automata. The same statement can be applied to the experiences states of workers, and to the genuine meaning and value of work when facing this potential new taylorism (splitting tasks and re attributing a large part of the machines). This work package will tackle these questions from the various contributions of Human and Social Sciences, but also from a technical point of view that could better define standards, limits and conditions of use of AI techniques when applied to collective work places. The notion of authority sharing could also be addressed and formalized here.

Deliverables for Axis 3:

- D3.1: Conceptual models and tools to support co-adaptation between human and agents
- D3.2: Findings from user studies on long term collaboration and deskilling

2.3. Planning, KPI and milestones

The Project MATCHING is structured along three priority thematic, each of them being divided into two WPs (see 2.1 Project outline). There is no time dependency or sequential constraint between the thematic; they are equally important and do not necessarily build on each other. Moreover, as we expect the future system design approach to be human centered, the research actions should address the topics while combining and entangling human modeling, study of new interaction techniques as well as the social aspects of embedding intelligent agents in collective actions. As such, there is no need for a Gantt chart.

Hence, over the project duration we will issue calls to finance research actions that can correspond to one PhD or more; associating several PhDs or post-docs so as to treat a topic from different points of view and obtain richer and broader outcomes can also be financed. Most of these research actions will be based on multidisciplinary approaches, associating disciplines such as Cognitive Sciences, Psychology, Management Sciences, Human-Machine Interaction, Artificial Intelligence, Ethics, etc. This multidisciplinary aspect will be part of the criteria we propose to evaluate the quality of research actions.

The Project will be organized in successive calls for research actions. In the first year, the research actions will correspond to 3-5 PhDs. The following yearly ones will be managed through internal scientific calls issued at the PEPR level and selected by a Scientific Committee.

Key Indicators

The project MATCHING will address the general KPIs defined in the National Program FRANCE 2030 as defined in the project of governance of the PEPR eNSEMBLE.

Risk Management and mitigation

Risk Type	Risk	Corrective measure
Human Resources	PhD recruitment: we don't get enough candidates for all positions	Flexibility in the number of PhDs per year and possibility to postpone a topic
Coordination	Works of different partners are not connected or integrated	Organization of yearly consortium seminar. Facilitation of interdisciplinary projects.
Technical risk	Quick evolution of Artificial Intelligence technologies and challenges and relevance of solutions	Flexibility of research priorities (yearly analysis and potential tuning). Regular survey of the evolution of international communities.
Technical risk	Interdisciplinary nature of some of the research projects (difficulties in cooperation, recruitment, publication, etc.)	Organization of dedicated workshops, summer schools. Elicitation of epistemological strategy associated to PhD and post-docs workplan.

3. Project organisation and management

The management Committee of the project MATCHING shows a strong interdisciplinarity and complementarity. It encompasses three leaders and two main contributors. The three leaders respectively represent Human Sciences, Affective Computing and Cognitive Sciences expertise and have all been involved in many previous and current interdisciplinary projects, involving humans and AI. The two additional contributors bring a strong expertise in behavior analysis and simulation, as well as in adaptive systems that

enlarge and consolidate the scientific spectrum of the management. It is interesting to mention that the five members of the committee largely cover the regions in France (Grenoble, Lille, Paris, Rennes & Brest) so that the relays towards local research would be facilitated. The responsibilities of Work Packages in the project have been allocated to binoms while trying to balance the fields of expertise, but beyond this formal allocation, there will be continuous exchanges within the Management Committee to keep benefits from the wide spectrum of its members.

3.1. Project managers

Agnès Helme-Guizon is currently a Full Professor in social marketing at University Grenoble Alpes. She got her PhD in 1997 from Paris Dauphine Université. After three years as an assistant professor in Angers she moved to Grenoble. For several years, she has been responsible at CERAG for a research team (+40 researchers and PhD students) centered around Responsible Behaviors and Societal Challenges. Since 2020 she is a member of the Scientific Board and the Comex of MIAI@Grenoble Alpes, one of the four AI institutes granted by ANR in 2019. She is also a member of the Scientific Research Committee of the chair Ethics & AI of MIAI@Grenoble Alpes. As such, she contributes to the vividness of the ethical and societal issues related to AI and in peculiar AI usage in the AI community.

Her areas of research uncover technologies used as a lever for individual behavioral change (related to food and physical activities) and their impacts on empowerment and vulnerabilities for a variety of powerless groups including women, older consumers, overweight or over-skinny individuals, low economic status population, etc. Precisely, she is interested in whether and how agency / authority both from the human and the AI shapes their interactions as well as the resulting coping strategies to recover control, with a permanent concern for the associated ethical issues.

Agnès Helme-Guizon has been project or WP leader of French and European projects funded by UGA, Région Auvergne Rhône-Alpes, Ademe, AFM-AMS, EIT Food4Health, etc. involving multi-disciplinary teams. She has authored more than 100 articles, book chapters and peer-reviewed communications.

Gilles Coppin is a professor of computer science at IMT Atlantique, the first major school in the West of France combining digital, energy and environment. He has been for several years the Director of the Lab-STICC Research Unit of the CNRS (UMR 6285), which hosts more than 500 researchers in a wide range of disciplines in Information and Communication Technologies. He obtained his engineering degree from Télécom Bretagne in 1984, his PhD in mathematics and computer science from EHESS in Paris in 1999 and his habilitation in computer science from Paris 6 University in 2007.

After a first career in the defense industry where he developed airborne systems and worked on new approaches to artificial intelligence applied to classification, he led from 2000 to 2004 the Department of Artificial Intelligence and Cognitive Sciences of Telecom Bretagne then the interdisciplinary LUSSI department from 2004 to 2006. In 2006-2007, he was visiting professor at the Aero Astro department of the MIT (Massachusetts Institute of Technology) within the laboratory. HAL (Humans and Automation Lab). Since 2007, Gilles Coppin has been involved in the governance of the Lab-STICC laboratory that he has been heading from 2014 to 2020.

His areas of interest include human control of complex systems as well as human-machine interactions and cooperation, including cognitive decision models, group and team modeling, dialogue management. His recent projects have focused on controlling drone swarms through intuitive human-machine interactions, Human-AI interaction and digital transformation of industry. For the past ten years, he has represented France in several NATO HFM groups dedicated to human factors and drone control. He has published more than 80 articles and book chapters and has directed and participated in more than 30 research projects at the national and international levels.

Catherine Pelachaud received the Ph.D. degree in computer science from University of Pennsylvania, Philadelphia, PA, USA, in 1991. She is currently a CNRS director of research in the laboratory ISIR, Sorbonne

University, where her research encompasses socially interactive agents, modeling of nonverbal communication and expressive behaviors. She has authored more than 200 articles. She is and was associate editors of several journals among which IEEE Transactions on Affective Computing, ACM Transactions on Interactive Intelligent Systems and International Journal of Human-Computer Studies. She has co-edited several books on virtual agents and emotion-oriented systems. She participated in the organization of international conferences such as IVA, ACII and AAMAS, virtual agent track. She was the recipient of 4 best papers award of IVA. She is recipient of the ACM – SIGAI Autonomous Agents Research Award 2015 and was honored with the title Doctor Honoris Causa of University of Geneva in 2016. Her Siggraph'94 paper received the Influential paper Award of IFAAMAS (the International Foundation for Autonomous Agents and Multiagent Systems).

Franck Multon is Senior Researcher in Inria, leader of the MimeTIC team. He received his PhD in computer Sciences in 1998 in University Rennes1. He has been hired as full Professor in University Rennes2 in the sports sciences department in 2007, where he created the biomechanics team of the M2S Lab. He ran pioneer research in using Virtual Reality for Sports analysis and training, with international leadership in this domain. He created the joint Inria team MimeTIC in 2012, a multidisciplinary team working on human analysis and synthesis. In 2018 he was detached to Inria to lead a national initiative about digital science applied to sports. Since 2021, he is leading a joint laboratory with InterDigital Nemo.AI about "artificial intelligence for media and associated experiences in a digital and responsible society", with a national Inria initiative Défi "Metaverse Challenges – next generation of avatars". He authored more than 100 papers in various domains such as computer graphics, virtual reality, sports sciences, biomechanics, and sensors. He received 4 Paper Awards in ACM VRST, IEEE ICRA, Eurographics, and IEEE IMET conferences. He was associate editor in several international journals, including MIT Press Presence, Wiley Computer Animation & Virtual Worlds, guest editor in MDPI Sensors, and participated in several program committees, such as CASA, MIG, IEEE VR, ACM SIGGRAPH, VRST, Eurographics… In 2018, he was co-founder of the Moovency start-up company reselling motion capture and software solutions to monitor discomfort at work, in ergonomics.

Mohamed Daoudi is Professor of Computer Science at IMT Nord Europe and the lead of Image group at CRIStAL Laboratory (UMR CNRS 9189). His research focuses on several areas, including human behavior understanding, facial expression recognition, pattern recognition, and computer vision. He has published over 150 papers in some of the most distinguished scientific journals and international conferences. He was/is Associate Editor of several leading journals including Image and Vision Computing Journal, IEEE Trans. on Multimedia, Computer Vision and Image Understanding, IEEE Trans. on Affective Computing and Journal of Imaging. He has served as General Chair of IEEE International Conference on Automatic Face and Gesture Recognition, 2019. He is a fellow of the International Association for Pattern Recognition.

3.2. Organization of the partnership

To date, the following **15 partners (representing 35 teams)** have been identified to contribute to the project MATCHING: The partners that compose the project consortium cover a large spectrum of disciplines and approaches related to collaboration with intelligent systems. They show strong expertise in specific domains and clear complementarities between disciplines as exemplified in the following table

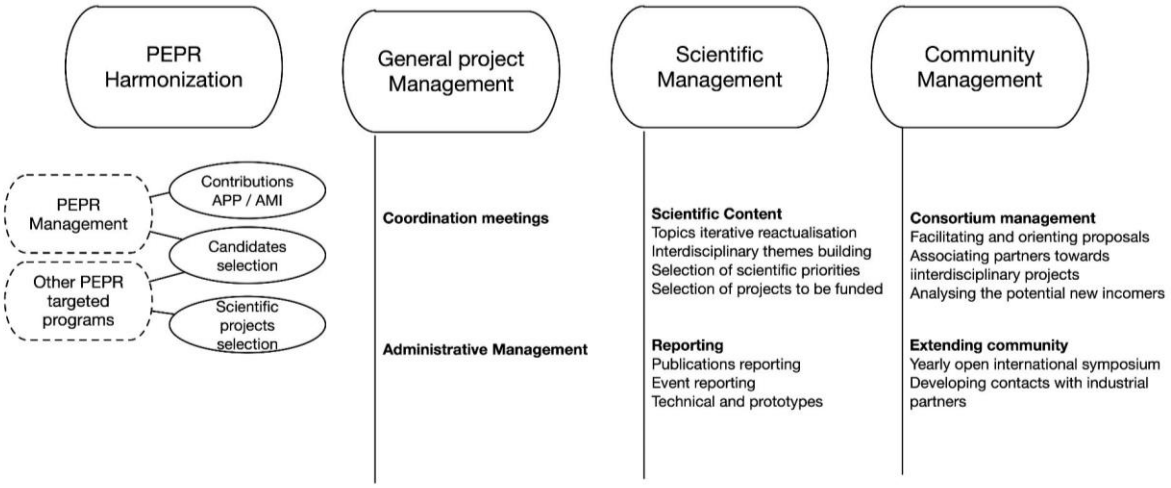
Partner	Expertise	Example of highlights
CNRS	HCI; Robotics; Haptics, AI	- 5+ HCI teams - Leader of the Continuum project - ISIR is a prestigious lab in robotics and AI - Platform CoVR - Platform Greta - Platform Jean Zay (supercomputer) - Platform immerStar

		- 1 researcher is part of the executive committee of the PEPR eNSEMBLE
Sorbonne Université	HCI; VR; AR; XR; virtual agent; AI	- ISIR is a prestigious lab in robotics and AI - SCAI
Inria	HCI; VR; AR; XR; Avatar; AI	- 5+ HCI teams - 2 ERCs in HCI - Leader of the Continuum project - Leader of the PEPR IA - 3 Platforms: immerStar, Kinovis, IGRIDA (cloud)
UPSaclay	HCI; VR; AR; XR; Avatar; AI	- 5+ HCI teams - 2 ERCs in HCI - Leader of the Continuum project - 1 researcher is part of the executive committee of the PEPR eNSEMBLE
UGA & INP	Management sciences Philosophy HCI; Robotics; Intelligent environments; Knowledge	- 1 researcher is part of the executive committee of the PEPR eNSEMBLE - 1 researcher is part of the Scientific Board and executive committee of MIAI@Grenoble Alpes - 1 researcher is head of the chair Ethics & AI of MIAI@Grenoble Alpes - 3 Platforms: VISIO-R, Kinovis and Playground
IMT	Affective Computing, HCI, AI, SHS	- 1 researcher is part of the executive committee of the PEPR eNSEMBLE - Interdisciplinary approaches - ANR Program AI@IMT - Platforms PIXL, ATOL (Continuum), IRIS (Continuum)
Univ. Lille	Perception action, behavior cognitive and brain mechanism	- Platform IrDIVE - Federation Sciences et Cultures du Visuel - Platform: PsyCLE
Univ. Lorraine	Computer Science, HCI	- Several research teams are working on different aspects of HCI, including natural language processing, computer vision, and virtual reality. - Platform: Multimodal voice assistant
ENAC	Computer Science, HCI, Ergonomics, Avionics	- User-centered design for aviation systems - Augmented Reality for air traffic control - Eye-tracking for aviation research - Human factors in aviation safety
Univ. Gustave Eiffel	Psychology, Ergonomics	- AI research group: develop intelligent systems - HCI research team: design, develop, and evaluate interactive systems
Univ. Lyon 1	Computer Science, Social Sciences	- LIRIS-UX: user experience research, user-centered design, and UX evaluation methods. - Labex IMU (Intelligence des Mondes Urbains)
Univ. Toulouse	Computer graphics, animation, XR	- Founding member of ANITI, a multidisciplinary research institute - Open-source software for 3D graphics engine - XR platform
ENSAM	Computer Science	- VR platform simulator
UTT	Computer Science, Social Sciences	- Platform hypertopic
CESI	Virtual Reality, HCI, Interdisciplinary research	- VR Lab

3.3. Management framework

The project will be piloted by a management committee composed by the three project leaders (respectively from UGA, CNRS, IMT) assisted by two main contributors (from INRIA & IMT).

The management of the project MATCHING is aligned with the overall governance of the PEPR Ensemble. To handle the specificities of the project MATCHING, it will be structured along 3 main themes (general, scientific and community) as indicated in the following diagram and described here below.



Community management

- **Consortium management**: while organizing a yearly seminar with the project consortium, there will be a broad diffusion of on-going work progress. The management committee will also handle the tuning of the emergent research themes. Regularly sharing these elements with the whole consortium will reinforce the community identity and strength. A special effort will be put on the association of human sciences and computer sciences to motivate interdisciplinary projects and proposals.

- **Extending the community and promoting MATCHING**: Around two international open symposiums will also be organized on the program duration to internationalize the community. Two networking actions towards industrial actors and organizations will also be handled - in complement of the generic action at the level of PEPR - along the period of the project.

- **Scientific animation:** 1-3 summer schools will be organized along the project (planning for the second and fifth year of the project so that all PhD students could be participating even if at different stages of their work). Two interdisciplinary hackathons, associating HSS and HCI, will also be organized during the project.

Scientific management

- **Definition of scientific content**: the management committee will iteratively work on the definition of research priorities of the project to adapt them to intermediary achievements and to the main achievements observed in the community and the evolution and emergence of technology and societal issues along the program duration. Specific attention will be paid to the cooperation between Human Sciences and Computer Sciences. The actions will result in a continuous update of scientific programs and priorities managed by the project.

- **Reporting**: the management committee will provide yearly reports on publications, conferences, communication events or technical results produced through the project activities.

General project management

- **Coordination meetings**: coordination meetings of the Management committee will be organized monthly for the current managers of the project. Face-to-face meetings will be planned twice a year for a better consolidation of the management team.
- **Administrative management**: a quarter-time project manager will be attached to the project MATCHING. His/her role will be to assist the co-coordinators in the animation of the network and the exchanges between partners, the preparation, the follow-up and the update of the tools necessary to the management of the projects, the implementation of the internal and external communication actions, the organization of the annual meetings of the teams, the colloquiums and/or workshops, the preparation of the agendas and the reports, the collection of the indicators and the assistance in the drafting of the activity reports, the follow-up of the administrative documents, etc.

Harmonization at PEPR level

The three project leaders of the project MATCHING are part of the executive committee of the PEPR eNSEMBLE. The Executive Committee includes the four Program Directors, the program manager and the Project Leaders of each Targeted Project. The Executive Committee ensures the implementation, management and monitoring of the program. Together, they ensure the supervision of the program phases in each of the Targeted Projects, as detailed in the project of governance.

The Executive Committee meets regularly and at least once a year in order to prepare the report to the Steering Committee on the progress of the program and to propose a possible revision of the roadmap for each Targeted Project. During these progress points, it will present the call for expressions of intent ("Appel à Manifestation d'Intérêt"; AMI) and the call for projects ("Appel à Projet"; AAP) for validation by the Steering Committee.

Also, the MATCHING project leaders will contribute to the general processes of the PEPR: communication (e.g., feeding the websites with targeted communication elements), harmonization of scientific priorities with other targeted projects (as there could be some joint interests and good synergies to find along the PEPR duration), participation to the PhD and post-doctoral candidates selection committees.

3.4. Institutional strategy

Fourteen universities or institutions are implied in project MATCHING. How it fits in their strategies is detailed below.

University of Paris Saclay: The University of Paris-Saclay is committed to developing a strategy in artificial intelligence (AI) and human-computer interaction (HCI) aimed at strengthening research, training and economic development in these fields. In the field of AI, the University of Paris-Saclay is developing interdisciplinary research covering areas such as machine learning, computer vision, automatic natural language processing and robotics. Researchers at the university are also working on AI applications in areas such as health, the environment and energy. Université Paris-Saclay focuses on developing technologies that enable natural and intuitive interaction between humans and machines.

Université Grenoble Alpes & Grenoble INP: UGA and Grenoble INP strongly support the development of research projects involving interdisciplinary projects involving SHS and STS teams since they ensure the production of knowledge, innovations and expertise that society can expect from scientific research, in order to respond to the innovation, social and societal challenges it is facing. Moreover AI (and intelligent systems) is a major and recognized expertise of the UGA as evidenced by the creation of MIAI - one of the 4 French national AI institutes - in 2019 and its confirmation in 2022 by the ANR. The project MATCHING corresponds to several UGA teams' research areas in computer sciences, human-machine interaction and social sciences such as management and philosophy. UGA has SILECS / Grid'5000, users' experimental labs and observational platforms.

Sorbonne Université: Interaction with intelligent systems is an important research field at SU with for instance the Institute of Intelligent Systems and Robotics (ISIR) or the institute of Artificial Intelligence (SCAI). SU is conducting multidisciplinary research on various themes in human-intelligent system interaction, including human-artificial intelligent agents interaction, human-centered approaches to machine learning, decision making, AI and robotics to name a few.

IMT: The Institut Mines Telecom has defined its 2023-2027 strategy which has identified an overall thematic positioning that includes, among other things, the responsible industry of the future and digital sovereignty. Efforts will be focused on the co-evolution and the emergence of human 5.0, aiming to consider the reciprocal actions and interactions of Man and technological environment by addressing the issues of augmented skills and knowledge, sensory systems and the contribution of the human in terms of intelligence, meaning and creativity for efficient complex systems. Digital sovereignty also involves AI and responsible data which will rely on solid mechanisms of cooperation between humans and complex systems.

CNRS: CNRS has been involved in various aspects of AI and HCI (human-computer interaction) research. In the field of AI, CNRS researchers have contributed to the development of machine learning algorithms, natural language processing, and computer vision, among other areas. They have applied these AI techniques to various domains such as robotics, healthcare, and transportation. Regarding the association of AI and HCI, CNRS researchers have explored how AI can enhance the user experience and usability of computer systems. They have also studied the ethical implications of AI in HCI, such as privacy concerns and algorithmic bias.

INRIA: “sustainable artificial intelligence” is one of the research priorities identified by Inria in its strategic research plan (Contract of Objectives and Performance). Inria already invested resources in ambitious projects related to PC3, such as the PEPR IA, the Défi project Ys.AI with Interdigital, or several Horizon European projects. Interaction with AI-driven entities is addressed by several Inria teams, and by platforms such as the immerStar VR platform (part of the Equipex+ CONTINUUM), OpenViBE and BioPyc software.

Université de Lille: Université de Lille has been actively involved in the association of AI (Artificial Intelligence) and HCI (Human-Computer Interaction) and affective computing. The Université de Lille focuses also on exploring a functional approach of vision, the relations between perception and action, and the role of reinforcement in behavioral changes. Research topics encompass behavioral, cognitive and brain mechanisms. The Université de Lille is a multidisciplinary research institute that brings together experts in AI, computer vision, human-computer interaction, and cognitive science to advance research, innovation, and education in these fields.

Université Toulouse: Université Toulouse is involved in the association of AI (Artificial Intelligence) and HCI (Human-Computer Interaction) through its participation in ANITI (Artificial and Natural Intelligence Toulouse Institute). ANITI is a multidisciplinary research institute that brings together experts in machine learning, natural language processing, robotics, and human-computer interaction to advance research, innovation, and education in these fields. They are working to develop new AI technologies that are more transparent, trustworthy, and understandable to end-users.

Université Gustave Eiffel: Université Gustave Eiffel combines expertise in the fields of AI, HCI, and psycho ergonomics to understand how users interact with AI-based systems, how to optimize user experience and satisfaction, and how to improve system performance. The ultimate goal of their research is to create AI systems that are intuitive, easy to use, and provide value to users. Through collaboration with industry partners and other academic institutions, Université Gustave Eiffel is at the forefront of research in AI and HCI along with psycho ergonomics, and is contributing to the development of innovative technologies that improve human-computer interaction.

Université Lyon 1: Université Lyon 1 has been actively involved in the association of Artificial Intelligence (AI) and Human-Computer Interaction (HCI). It has also explored the ethical implications of AI in HCI and worked on designing interfaces that promote transparency and user control. Université Lyon 1's involvement in the association of AI and HCI has helped advance the state of the art in this field and has contributed to making AI-powered technologies more user-friendly, transparent, and ethical.

ENAC: ENAC, the French Civil Aviation University, has been involved in the association of AI (Artificial Intelligence) and HCI (Human-Computer Interaction) for avionics in several ways. ENAC has developed virtual reality training environments for pilots, which use HCI to enhance the training experience. ENAC is a member of the SESAR Joint Undertaking, which is a public-private partnership focused on modernizing European air traffic management. Through this collaboration, ENAC is involved in developing and testing new technologies for air traffic management that use AI and HCI.

Université de Lorraine: Université Lorraine has been involved in the association of Artificial Intelligence (AI), spoken dialogue and Human-Computer Interaction (HCI) through various research activities and collaborations. Their research includes the use of machine learning and natural language processing to enable more intuitive and personalized interactions, as well as the development of interfaces that can adapt to the user's needs and preferences.

ENSAM: To advance research in AI and HCI, ENSAM Arts et Métiers has established dedicated research centers and laboratories. These centers focus on developing new AI algorithms, tools, and techniques that can enhance human-computer interaction and applying AI to solve complex engineering problems. For instance, the school has launched research projects aimed at developing intelligent robots that can assist humans in performing complex tasks, such as manufacturing, healthcare, and transportation.The school has partnered with companies like Dassault Systèmes and Renault to develop advanced simulation tools that can enhance human-robot collaboration in manufacturing.

Université Technologique de Troyes: The university conducts research in AI, machine learning, natural language processing, and HCI. The research projects include developing intelligent systems for personalized e-commerce, analyzing social media data to identify trends, and designing natural language interfaces for chatbots.

CESI: The CESI's Laboratoire d'Innovation Numérique pour les Entreprises et les Apprentissages au service de la Compétitivité des Territoires, LINEACT conducts research in AI, data science, and HCI. LINEACT's research projects include developing AI algorithms for predictive maintenance in industrial settings, analyzing user behavior in virtual environments, and designing human-centric interfaces for smart home systems.

All partners of the project MATCHING are thus actively involved in the cooperation between humans and intelligent systems. We indicate below, for all partners identified to date, a rough and minimal evaluation of the resources available for the conduct of scientific projects on human intelligent systems interactions. This global effort should naturally be increased on the total duration of the project. Also as it may be considered at the general level of the PEPR, the research activities of the project will be able to rely on the significant CONTINUUM network of Human Machine Interaction platforms

The estimation of the internal efforts from the partners of MATCHING project is expected to reach **more than 150 man-years** on the total duration of the project and is summarized in the following table:

Partner	Involved staff	Estimated effort in m.month
CNRS	40	650,00
INRIA	12	240,00
UGA	12	120,00
UPS	12	100,00
Sorbonne University	12	100,00
Grenoble INP	8	59,00
IMT	16	164,00
Univ Lyon 1	3	34,00
Univ. Lille	5	34,00
Univ Toulouse	3	76,00
Université de Lorraine	6	59,00
Univ Gustave Eiffel	4	80,00
ENAC	3	63,00
ENSAM	9	65,00
UTT	5	34,00
CESI	5	58,00
Involved perm.	155	
	Person.months	1936,00

4. Expected outcomes of the project

4.1. Addressing societal challenges

Artificial Intelligence and Intelligent Agents have become pervasive in our society and industry shaping our behaviors and raising societal concerns. The cutting-edge interdisciplinary research conducted in the project MATCHING collaborative work between (groups of) humans and intelligent systems echoes these society changes and concerns. From their advances and knowledge created, we expect large socio-economic and societal benefits in the long-term in a variety of domains that imply human-AI collaboration in the workplace and in the society. Hence, we will provide some recommendations to best address user's diversity and inclusion as well as (dis)abilities so as to build adaptive intelligent systems that preserve user' autonomy and well-being. Also, we will provide a review of the best practices for cooperation between humans and intelligent systems; we will provide an understanding of users' skilling (vs deskilling) and proposals to enhance (vs reduce) it. The user-centered perspective of the development of models, guidelines and interoperable components in the domain, as well as (ethical) recommendations will foster their appropriation by companies, industries, organizations and by the citizens.

This ambitious objective can be achieved thanks to the strongly interdisciplinary dimension of the partners involved in the project, as well as a clear management of the scientific directions along the program, insisting on the creation of multidisciplinary initiatives.

4.2. Cross-fertilizing the PEPR projects

The results of the project MATCHING are obviously to be associated to the developments of the other projects of the PEPR eNSEMBLE, as even if techniques and features addressed by these different projects seem initially addressed separately, they will all converge in new collective hybrid systems for a better cooperative work and digital life.

Thanks to its close links to the MIAI initiative in Grenoble, as well as to the ANITI, 3IA Côte d'Azur, PRAIRIE 3IA, or SCAI of Sorbonne université, the project MATCHING will contribute to the general and national effort to renew and better shape the use of human-centered AI in science, industry and daily life.

Also, as trust in automated and intelligent assistants and agents is one of the main topics that will be addressed by MATCHING, we plan to contribute to the confiance.ai national initiative while adding more "human in the loop" considerations in this program, with a strong impact on the industrial domain.

4.3. Dissemination strategy

From a scientific point of view, we will ensure the publication and dissemination of results in major journals and conferences in the relevant fields (e.g., by supporting the organization of workshops associated with the main conferences in the fields).
We will follow ANR's Open Science policy by requiring all funded research projects within the program to publish their data and outputs on national platforms: HAL open archive for publications, TGIR Huma-Num's Nakala for data. All the produced code will be released and maintained under open-source licenses and referenced in the Software Heritage database, with the support of the program's research engineers who will be specifically trained in these practices.
To ensure the visibility of the community beyond its scientific results, we will establish connections with national (AFIHM, AFIA, AFXR, ARPEGE) and international (ACM, EUSSET) learned societies, taking advantage of the fact that several Program Directors and members of the Executive Committee are strongly involved in them. Also we will build upon the 4AI institutes (MIAI, PrAIrie, ANITI and 3IA Côte d'Azur) network and SCAI to disseminate our results in their research and industrial communities.

Regarding the general public, civil society and institutions, the Executive Committee will encourage the participation and presentation of the program's activities in annual national events such as Fête de la Science, or in outreach initiatives in high schools such as Chiche! or Declics. It will pay specific attention to events and actions targeting young women (such as the one by Femmes de Sciences for example). It will also work closely with local initiatives of pilot and partner institutions to bring the academic world closer to society, such as contributing to funding programs for artists' or designers' residencies in research laboratories (e.g. AIRlab at University of Lille). This will feed our research, but also produce artifacts adapted to communication towards the general public (interactive artworks, serious games, performances) that will be showcased e.g., during public sessions of the eNSEMBLE days or other events.