



Archaeology, neuroscience, and robotics join to investigate robots that invent tools

The METATOOL project received 4 million euros from the European Innovation Council (EIC) and the 'Awareness Inside' Pathfinder Challenge to investigate how robots can invent new tools as ancient humans did.

A consortium of seven institutions, led by Ricardo Sanz (Universidad Politécnica de Madrid) and Pablo Lanillos (Donders Institute, Radboud University) has been funded by the European Innovation Council with four million euros to investigate how robots can develop cognitive abilities for inventing tools as ancient humans did around three million years ago. Archaeology, neuroscience, and robotics join forces to shed light on this technological leap that our ancestors achieved, and to develop novel technology inspired by human metacognition and awareness.



The METATOOL Project consortium at the kick-off meeting at the Universidad Politecnica de Madrid (UPM) in Spain on October 2022. Archaeology, neuroscience, and robotics join forces to provide disruptive technology inspired by human awareness: *robots that use and invent tools*. In the picture some of the researchers of the project (from left to right): Ricardo Sanz (UPM), Christian Buckley (University of Sussex), Esther Aguado (UPM), Ernesto Gambao (UPM), Verena Hafner (Humboldt University of Berlin), Carlos Vivas and Sarah Terreri (PAL Robotics), Desiree Struijk (Senta International B.V.), Geeske Langejans (TU Delft), Khalil Kahlaoui (UPM), David Alvarez (UPM), Pablo Lanillos (Donders Institute), Alberto Brunete (UPM), Martin Molina (UPM), Casper Hesp (Senta International B.V.), and Miguel Hernando (UPM). Not in the picture but also involved in the project: Carlos Hernandez and Pierre Mercuriali (TU Delft), Luke Miller (Donders Institute) and Anil Seth (Sussex University).

Using the past to create the future

There is no consensus about when our specific modern human cognitive and metacognitive abilities evolved, and what drove the origins of tool invention and creation. We know, through archaeological records of ancient technologies, that **there was a critical transition from using tools**, a widespread animal behaviour, **to making tools**. Around 3.3 million years ago, our hominin ancestors made the first tools, creating simple stones with sharp edges. This must have required advanced technological imagination and reasoning. The METATOOL project aims to understand how cognition evolved to allow for tool invention and creation to serve as the basis for developing future technologies. "*Using the past to create the future*"—comments the archaeologist Geeske Langejans. Particularly, the project seeks the development of robots with awareness capabilities that are able to invent new tools.

Robots that invent tools

Current artificial intelligence systems and robots cannot monitor and evaluate the consequence of their actions as well as humans do; let alone develop new tools to address environmental challenges. Tool invention is an outstanding technological milestone in human history. If we understand these processes, a similar breakthrough can be envisioned in engineering. *“We already have algorithms to enable machines to use tools and now it is time to develop robots that invent tools”*—says Pablo Lanillos, scientific leader of METATOOL. To achieve it METATOOL will investigate computational models of synthetic awareness based on human metacognition and validate them in robotic experiments.

Ethics of conscious machines

Inevitably, awareness technologies are seen as closely related to consciousness and therefore raise relevant ethical concerns for our society. Our research does not pursue the development of artificial consciousness per se but uses system-architectural insights from human awareness to develop improved technology. However, METATOOL acknowledges that it is crucial to have a professional debate about the ethical dimensions of awareness technology to appropriately inform society.

The ‘Awareness Inside’ Pathfinder Challenge

Eight projects have been funded by the European Innovation Council (EIC) to develop technologies based on awareness principles that will feed novel engineered complex systems, that are more resilient, self-developing and human-centric. This challenge places awareness as a prerequisite for real and contextualised problem-solving and action adaptation (and their consequences) to specific circumstances. Awareness and self-awareness may serve to provide a human-aligned, coherent and purposeful behaviour, learning, adaptation, and self-development of intelligent systems over longer periods. As Ricardo Sanz emphasizes, the project leader of METATOOL, *“Autonomous machines shall have a better perception of their environment and capabilities, and awareness technologies will be a step forward”*.

