Use cases of virtual reality to visualize a database how useful is VR for archaeology researchers?

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Abstract

We present here an original Virtual Reality (VR) application for navigating an archaeological database. The Activity Theory is drawn on to describe the use of the immersive tool, which was developed in the context of an archaeological research project. Based on the observation of researchers interacting with the tool and their verbal expression, we show that the efficiency of technology use and activities depends on the removal of technical obstacles but also on the interaction of three components: the subject, the objective and the tool. The activities, which seem the most relevant produce results that affect one or more of the three components. It seems that activity theory is a relevant tool to analyze the use of this kind of technology, VR, to visualize a database. Finally, we present lines of thought for digital humanities.

1 Introduction

In this communication, we present the analysis of the uses of a virtual reality tool created for viewing an archaeological database for academic purposes. The tool being studied was developed as part of the ANR Schopper project[1] which is drawing to a close [7]. We worked on this project since its beginning in a context of action research as both actor and observer. This project covers several aspects (AI, Immersion, Virtual Reality (VR), and Project Management) around the prehistoric site of Caune de l'Arago and its valley, but we only deal here with the use of VR, which is designed to view a database of more than 400,000 archaeological objects from excavations.

What is the real use of such a technical device, Virtual Reality, to visualize a database in the context of archaeological research? To answer this question, the authors of this communication carried out a cross analysis of the technological uses based on the observations of the archaeologists in charge of the project.

The Digital Humanities can be defined as the incorporation of information technologies into SSH (social sciences and humanities) research [1]. This incorporation goes beyond simple use to address the study of the impact of these technologies on SSH research methods. Digital humanities can also be presented as an interdisciplinary study of the use of socio-technical tools and social science methods [5]. Digital Humanities deal with the usage of technology to create new tools, which may affect the process of collaboration among scholars, and provide the functionality to visualize data across time and space [20]. The question that drives this research therefore seems to be in symbiosis with the rationale of the digital humanities.

Virtual Reality is used in archaeology on many projects, but it generally serves to immerse a researcher or the public in a reconstructed environment [3]. In the field of digital culture, technology like VR used to digitally reconstruct objects from the past; to give access to cultural resources and to digitally represent cultural artifacts [18]. In the Schopper project, the objective is quite different. It is to immerse the archaeologist in a database for research's purpose.

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[1]https://anr.fr/Projet-ANR-16-CE38-0007

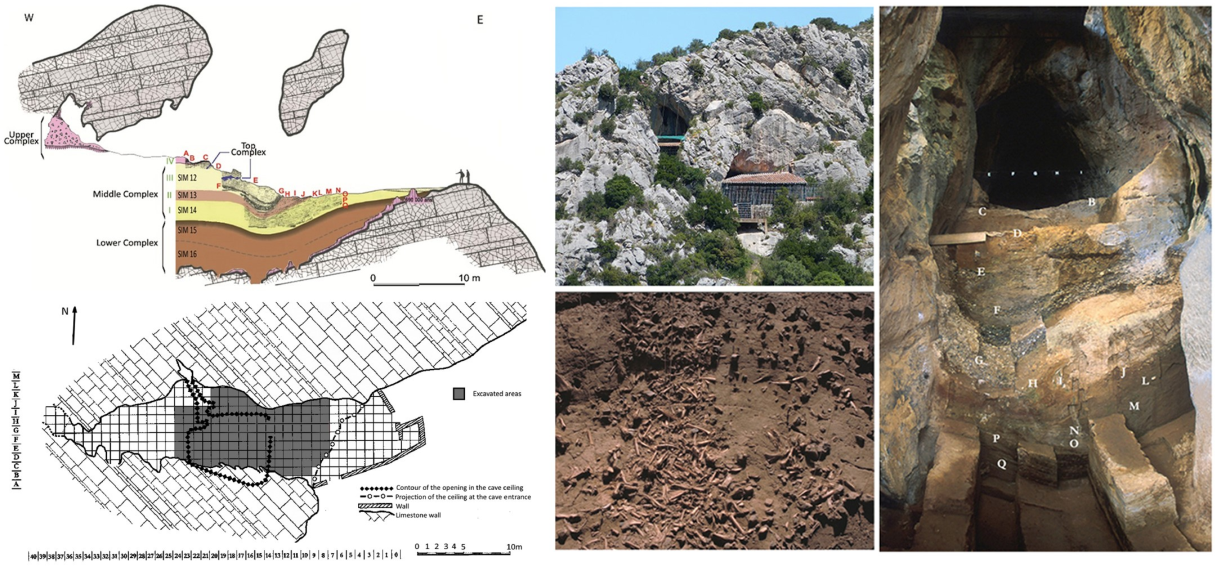

Figure 1: The Caune de l'Arago

By using an original approach based on the Activity Theory, already employed in several research projects, we reveal the first uses of VR and their developments. We try to identify the determinants of a relevant use of VR for the visualization of data and to analyze the impacts of the technology on the work of archaeologists at individual and collective level. We also make comparison with more classical tools of Digital Humanities. The communication is structured in the following way. We first present the Schopper project and describe the tool concerned. Then we briefly set out the Activity Theory and the principles of its use in the context of this research. Finally, we present the methodology employed and the results we obtained before discussing them in relation with digital humanities.

2 The Schopper project and the use of VR for the database

The ANR Schopper project brings together four partners whose expertise is pooled to develop innovative technological solutions. The aim of the project is to produce a simulator which will allow us to validate the behaviors of prehistoric man in a reconstructed immersive environment. The project initiator, CERP, is a prehistoric archaeology laboratory.

It brings its scientific expertise, and is in charge of the excavation of the Caune de l'Arago. One author of this paper is from the CERP. Craft-ai is a startup specializing in artificial intelligence.Immersion Tools contributes its expertise in virtual reality: they developed the virtual reality application which we present in this communication. The role of CEROS, of which three authors of this communication are members, was to analyze the interactions between the CERP researchers and the tool developed: AI simulation, the use of VR for the database and the use of 3D immersion in the valley. We only deal with the use of VR for the database here.

The Caune de l'Arago (South of France) located between the east of Pyrenees Mountains and the Mediterranean Sea is a major cave site from the Lower Paleolithic (figure 1). It owes its fame to the importance of its filling, covering 600,000 years of history and several climatic cycles, its archaeological richness and its numerous human remains including the famous skull of the "Man of Tautavel" [12] [15]. Since 1967, each archaeological object (animal bones, lithic remains or industries, stone ...) extracted from the site has been numbered, drawn to scale, and entered in an excavation book with the identity of the square (or "zone") and the layer where it was found, its nature, its spatial coordinates (XYZ), its orientation, its pendage (inclination) and its dimensions. It is then recorded in the laboratory in a SQL database "Palaeontological and Prehistoric Material" developed in the course of the 1980s [16]. From the first information entered, linked to the discovery in the field, CERP researchers complete the digital file of each object in their specialty according to a well-established codification (fauna and industry connected

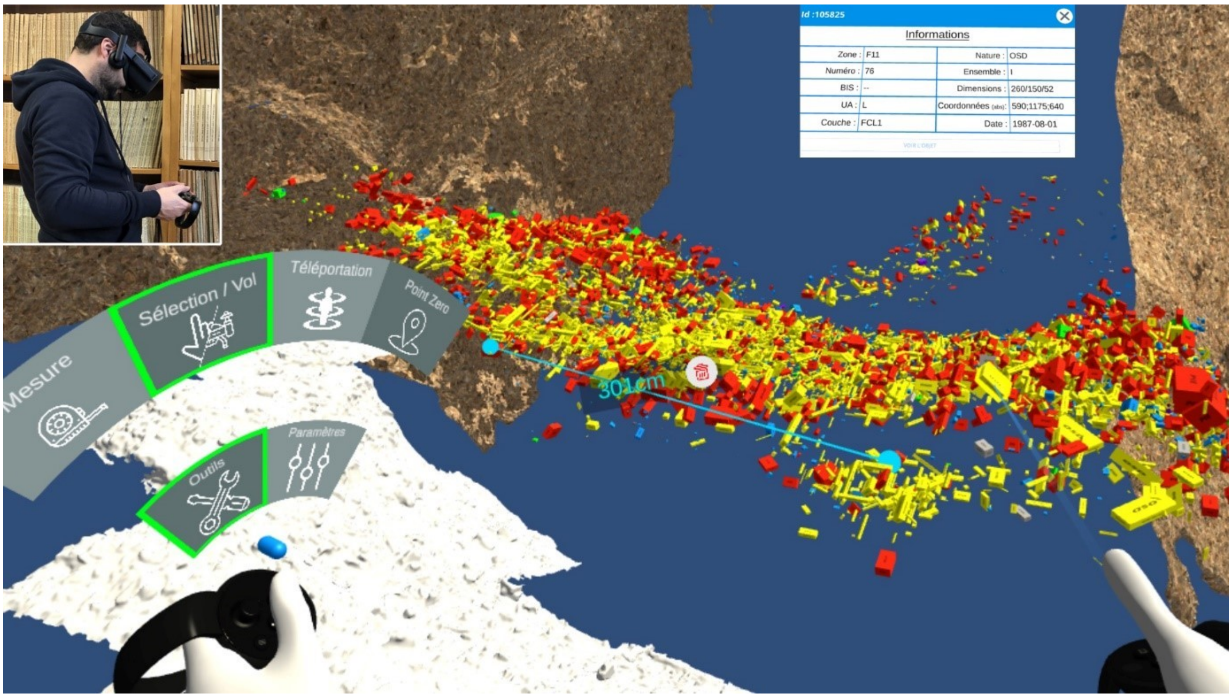

Figure 2: Example of visualisation of a level in VR

databases with numerous data fields). For example, the palaeontologist specifies if possible the anatomical determination of bone/teeth and the species to which it belongs, the age/sex of the animal; he codifies its fragmentation, the state of surface (alteration, color, presence of cut marks. . .).

In the figure 1, you can see on the left a longitudinal section of the cave showing the stratigraphical sequence with the main levels (red capital letters) and plan of the excavation (divided into 1 m squares) and on the right, one photography of the cave, the filling and detail of the level L, 540,000 years (photos © Denis Dainat, EPCC-CERP, Tautavel). To date, the Caune de l'Arago database contains more than 500,000 objects, including 400,000 coordinated objects corresponding to at least 55 archaeological levels [12] [15]. Prehistoric men frequented the Caune de l'Arago between 690,000 years and 70,000 years and an archaeological unit (or archaeological unit) corresponds to a level of occupation of the cave at a given time (Figure 1).

The archaeologists have queried this database since the 1980s with tools, which have evolved over time. These queries relate especially to the extraction of specific quantitative data, the study of the spatial distribution of objects, the refitting (finding the joints between elements extracted from the same lithic block or fragments from the same bone, like a puzzle) and defining the occupation levels of the cave. Before Schopper, the results obtained were only tables or figures and simple inert viewing modes in 2D or 3D of the different levels and the objects. With the Virtual Reality tool that has been developed, the researchers can now view the results of their requests through the VR headset and interact with these results; they are immersed in the information they need. Using its coordinates noted at the time of excavation, each object is replaced in the cave, which has been fully scanned for the project. The objects are represented by parallelepipeds whose dimensions, spatial position and orientation/pendage correspond exactly to the measurements made on the field. The color code used in the excavation identify the nature of the object (ex : blue for industries, yellow for bones, red for stones...). Equipped with a headset and two controllers, the researcher can select an object with the aid of a "laser". An "object" information sheet then appears, which contains its main features and indicates the availability (or not) of a 3D scan or a photo which can then be viewed. A small interface also gives access to various options (measurement tool, teleportation movement mode, grid of the squares, go back to initial point).

The display can be viewed horizontally by level, or vertically by square excavated. The principle is to launch a request via the Boolean operators in the main fields of the database by selecting the desired items with the laser and moving through the different menus visible in the headset (see Figure 2). The numerous data fields of the fauna and industry databases are also accessible. The results of the request are displayed, and the researcher can then move through the cloud of objects with the controllers or by moving physically. The different objects can be viewed essentially by turning the head with the headset then by selecting the desired object with the controller laser. It can also measure distances between objects. The display of levels in Figure 1 is not flat, as geological movement has distorted them between the observed time of their deposit and the excavation. The layers are defined at the excavation but the precise delimitation of a level and the allocation of a particular object to a level (archaeostratigraphic individualization) require precise analyses and comparisons between different archaeological disciplines [12]; these are two important research questions for the archaeologists.

At the beginning of the project, the researchers' needs were not well defined and focused on the representation of the cave. After some months of work, the project focused on viewing data in the cave. It is an ongoing project with frequent interactions between developers of VR and archaeologists. After each session of tests, all the bugs and the need for further functionality were sent to the developers.

3 The Activity Theory for studying the use of VR

The adoption and appropriation of digital technologies has been studied in numerous disciplines. In this communication, we have chosen to draw on the Activity Theory which has already been used in the study of digital technologies [2] [13]. The result of work by Soviet psychologists at the beginning of the 20th century, mainly Leontiev and Vykotski, the Activity Theory offers an alternative to the strictly behaviorist and cognitivist approaches. We refer the interested reader to reference [6]. The main elements of the Activity Theory have been represented in the form of schemas, with titles sometimes badly translated from Russian to English, and then from English to French. We represent activity under a form which seems to us on the one hand, more faithful to the initial conception and on the other hand more valuable for the analysis of activities. The activity must not be represented in the form of a triangle but in that of a triad, the central point of Figure 3 and the inseparable conjunction of three elements, the subject, the objective and the tool.

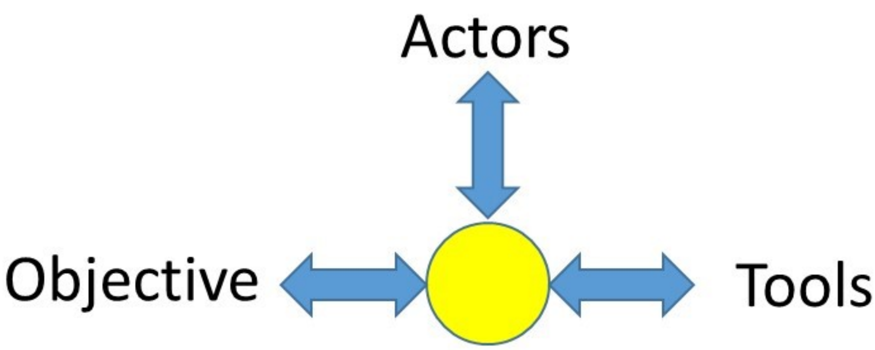

Figure 3: The activity triad

The Actors is the human subject considered in their environment. The Objective is the purpose, the raison d'être of the activity for the actor, the motivation which drives the actor, whatever the restrictions which may be placed on them and which they do or do not take account of. The objective is the element of the triad, which gives meaning and a mindset to the activity. In other words, an activity without objective becomes a simple operation. The tool, the most composite element of the three points of the triad, comprises first of all the technical part. But it is also composed of rules which are derived from the history of the actor and his community of belonging. These rules define what the actor can or must do with the tool.

An activity always has a result: a delivered statement, an object created or modified, a tool used or modified. This result can have an effect: on the actor, on the tool, on the objective, on another person and consequently, on other activities. Any representation, in the form of a schema, of a dynamic or even a continuous concept, as an activity is, is limiting, see figure 3. Therefore, in order to represent the effects of the result on the different elements of the activity, we place the result at the center of it, the double arrows signaling the dynamic, actions and effects, of the activity. There are as many triads as there are many actors concerned by an activity, even if each one carries out the same tasks, it is therefore essential to keep the actor as part of the study model. In organizations, numerous activities are complementary, they interact with each other, these activities are collective or joint [11] which can be represented in the form of a network. In this project we focus on individual use, but activities by the same actor can be linked to each other and form a network of individual activities. The network of activities, individual or collective, is in perpetual evolution, as the objectives changes, the tools change and become more complex and the actors learn. This evolution must be able to be traced by an analysis of the activity network. Finally, the Activity Theory approach underlines the importance of contradictions and tensions between and within activities [8]. These tensions are the main causes of developments and enrichment of activities. How should a relevant activity be defined in a digital field? Two avenues are proposed [17]. Firstly, an activity presents a potential for value if the triad is enriched by the effects of its result:

1. on the actor who acquires one or more new skills (which we call internalization);
2. on the tool which is enriched by a new technical functionality, a new content or a new formal or informal rule;
3. on the objective which evolves and allows other activities to be considered.

Secondly, the value created must be able, in one form or another, to be transferred or exported into the real world of work, in our case archaeological research. This is possible when the enrichment of the activity is implanted in the tool and can therefore subsequently be used or reused by the same or another subject or when the skill acquired by internalization is transferable via the researcher subject to another research activity.

4 The research methodology and the results obtained

4.1 Methodology

Two of the authors of this communication have been working on this project since it began in January 2017. The two others joined the project at the end of 2019. Eight archaeological researchers out of eleven on the CERP team tested the technical tool on two occasions: the first time in May and November 2019, the second in March 2020. Each use was fully filmed (duration between 30 and 60 minutes). As soon as the first session ended, the researcher concerned recorded his free impressions in an observation notebook. The recordings of each test were studied and discussed by the three researchers, then they were fully transcribed in text. In addition to these observations, we conducted individual interviews with each researcher after the second round of testing. These interviews were also fully transcribed.

We applied an inductive qualitative approach to the study of the materials collected [14]. We chose to code via NVIVO 12 all the VR tests on the database which all followed an identical protocol; this represents more than 150 pages of transcriptions and more than thirteen hours of video recordings. The other materials (interviews, observation notebook, emails and meeting reports) were used for triangulation purposes. A large coding grid of 48 codes was devised by three researchers using an inductive and iterative approach then cross-tested on several tests. The purpose of this grid was to capture all of the events occurring in the tests outside of a theoretical presupposition (see Appendix with the two sessions and the number of codes for each). In the end, the 16 tests (2 for each of the 8 researchers who carried out these tests) were coded and gave rise to around 1,500 codes which were analyzed.

The eight researchers who carried out the tests came from separate archaeological disciplines and have different characteristics (gender, wearing of glasses, familiarity or not with video game controllers, etc.) which could have an impact on the use of a VR headset. They have all been working on the site for several years and all know very well the cave, the excavation methods applied and the recording and entering of requests in the database.

During the first test session (Session 1 in the verbatim records), the version of the tool still presented several technical problems which made it difficult to use. On a second version of the tool (session 2), several months later and with a second version of the tool, the technical problems were still numerous but less blocking. In both sessions, the tests were supervised by one of the VR designers and/or two CERP researchers who were very familiar with the VR application; they were named Coaches 1 to 3 and their words are also recorded in the verbatim records. In the analyses below, we reproduce the verbatim records directly from the coding made in Nvivo.

4.2 The results obtained - verbatim are in italics

Activities depend on the actor; we must therefore observe the significant differences in use in accordance with the subjects with similar objectives and tools. In other words, without taking into account the characteristics of the actor you cannot understand the activity in depth. We have a small test group with heterogeneous characteristics, but we knew each researcher and this knowing seems to be necessary to understand the usage and the difficulties met by each of them. Researcher 1 is a woman specializing in the study of animals (palaeontologist). Like the majority of researchers, she knows the site well and has been partly trained on site. She is one of the first to try out the VR headset. She looks for one of the objects she knows and has a 3D scan. She is satisfied that she has found it and that she can observe the scan.

(Session 1) I'm going to look at that there. Hee hee [very proud of herself), I know where my stuff is, I do. [She stoops to identify the object she wishes to select. The object actually is one of the objects which has a scan].

The technical defects of the tool impede use in the sense that they break the triad by preventing interaction between actor / objective / tool and therefore the creation of a result. Researcher 5 is a geologist but above all he is the one who knows the cave the best and who is the current excavation manager. He observes the objects with their angles of inclination. He notices a large object which interests him a lot, but the tool does not allow him to find out what it is. The activity is stopped.

(Session 2) Researcher 5. That's pretty! [He closes the object window] The bear skull has an enormous slope. You get the impression that, especially towards the cave wall, there are objects which have a slope that ... it's as if the material had moved. That's definitely odd. When you move... And there on the surface, I'm trying to see... [He turns his head from left to right; spying an object] Oh wow, that thing! What is that monster! E8-465 [the information sheet appears - 465 is the number of the object founded in the square E8] What do I do to find out? I can't click on it. Coach 3. No, there's no fauna option, nothing. We just have that information there. Researcher 5. So, I can't find out what E8-465 is.

This need of jump between the ground level and the object is very similar to those between close and distant reading for text. "Close reading retains the ability to read the source text without dissolving its structure, distant reading does the exact opposite" [10].

The discontinuity problems prevent the smooth sequencing of activities. What we refer to as discontinuity is a change of interface or a step backwards which stops the sequencing of uses and is detrimental to enrichment.

An activity can provoke emotions in the actor and so have an impact on them. We observed several clearly expressed emotions. But it is not clear whether these emotions lead to or will lead later to other activities or a change in research practices. Researcher 11 studies man-made tools. Like all his colleagues, he is very familiar with the site which he has excavated for a long time. In the VR he sees a collection of objects which he is very familiar with and expresses his admiration through his words and his movements, but we do not see at this time the consequences of this admiration.

(Session 1) What I was saying, what I find extraordinary is that when I do that [he leans to get "underneath" the column, which he is looking upwards at], I am in the objects layer, wow!

The literature underlines the importance of tensions and frictions in activities (difficulties or surprising results) which are sources of activity enrichment. One example of what we call frictions is given below. For us friction means a discrepancy between what is seen in the VR and what the researcher knows. In this case we can clearly observe the beginning of a sequence of individual activities. Researcher 9 is perfectly familiar with the 151 human remains found on the site. He asks for them to be displayed and expresses his amazement at the relative positioning of one of these objects and this gives him the idea to dig at this point.

(Session 1) What is this [??] human remains which are on the wrong side? [Indicating an object] Ah, you see, I had already forgotten that there was one there, which is all on its own here; I'd really like to check what it is.

Enrichment of the tool is requested by the researchers who understand clearly that it is necessary in order to export the results of the activity into their research work. They ask for example to be able to save their researcher profile with the requests already made and also to have the option of taking the results from the tool and putting them into their publications. Researcher 4 is a woman specializing in the study of pollens (palynologist). She is very involved overall in the project as viewing vegetation in a reconstructed environment is essential. She considers uses linked to the publication of the article which she is currently working on. She took a measurement between two objects (coprolites that contain pollens) which she could use for a publication or a course.

(Session 2) Researcher 4. Can we save all the measurements like that, yes or no? Coach 2. I'm talking about requests. Saving measurements that would surprise me. Researcher 4. Because if I need that to illustrate an article, or a PowerPoint. Coach 2. There, you have to insert a screenshot, something like that. We had asked for that right at the beginning. Even to record it as well.

We go back to Researcher 9 who is thinking about his future publications and has clearly understood the value of saving requests in order to reuse them later.

(Session 2) Coach 2. After all, logically, when you have recorded your requests, you can access them directly. Researcher 9. Yes, so for the first time, I'll go and prepare all my stuff ... Coach2. That's it, because you'll have your personal account. Researcher 9. But could I name my requests? Coach 2. Of course. Researcher 9. So, I'll have my "fibula" request, my "femur" request, and my "femur plus fibula" request. Coach 2. Exactly. Researcher 9. That's very good.

We observed some activities which produced a result which really enriched the actors by internalization. In Session 2, Researcher 3 asked to use the VR tool to confirm one of her archaeological intuitions. It was the first direct request for use and was over quickly (20 minutes whereas the tests lasted for around one hour). Researcher 3 is an experienced palaeontologist and taphonomist. Here, the contribution of the tool was directly linked to its three-dimensional nature which allows you to see objects directly in order to check that they belong to the same level. As soon as she has her result, she wants to stop the test and go back to her researcher's work.

(Session 2) Researcher 3. Finally, the representation of the bison really is on one and the same level. You see, I thought that anyway they'd be spread over a greater depth, because seeing the size of the bones and what we dug up... there and there, we have already excavated at least three separate levels. My bisons are very much on the same level. That's very interesting. Well, that's good, that's what I wanted to see. What do I press now [in order to quit]?

5 Discussion

The studied virtual reality tool allows you to walk through a virtual cave, which is an archaeological site. We observe from the evolution between the two test sessions that the correction of technical problems is a pre-requisite for real uses and that mastering the tool is not obvious and requires time and repetition in handling. The tool is not finalized and many requests go back and forth between developers and archaeologists.

What can we learn from this case study for digital humanities? First, academics must be directly involved in the design and development processes, which will thus create powerful tools adapted to their needs, see digital humanities manifesto [9]. In our project, developers of VR cannot understand alone all the complexity of the archaeologists needs and their evolution.

Second, the activity theory seems to be a good way to study technology's use in Human Science especially for research work. This theory implies to take into account the characteristics of each actor (individual level) and to connect the activities between them (collective level). We think that these frequent jumps between these two classical views of technology's use are the best way to improve knowledge in this field. The activity theory also may deal with the rules, which must be integrated in the tools. For example, in archaeology, the positioning of found objects obeys strict rules that must be transferred inside the digital tool. In Schopper, when done badly, objects float in the air or become embedded in the walls of the cave. So VR is a good tool for data curation [4] and it hadn't been anticipated at all. Finally, activity theory offers a way of knowing whether a technological use can create value. This will be the case if the tool can be enriched by the actor or if the actor is enriched by the tool. For example, a researcher use the VR to check the spatial repartition and position of several new lithic refitting (reassembly of different parts of an object) discovered at the laboratory. This required several actions in the tools: selection, visualization and distance measurements, information of depth which made it possible to identify a problem on one reassembly, which had been done without the tool by a young researcher. With activity theory, we can follow these value-creating activities in and out of the technical tool and see their sequence.

Third, in our case even though the use of VR is an individual matter, some researchers begin to see the links between the use of VR and collective research work. We find Researcher 5 again; this begins here with a friction and is extended by ideas for collective action. He observes a group of objects whose pendage, (angle of inclination), seems to him to be to be totally illogical. He deduces from this that some information is incorrect and envisions reviewing the collective excavation procedures on the site. Usually he thinks that the tools can help the team to understand the "geometry" of a level.

(Session 2) Researcher 5: [Still crouching and immersed, he arrives at a zone with only blue and purple objects] Here we see that they are [the objects] in all directions. You can really see they have been scattered around, eh! That's incredible! When we say "it's in situ, it's in situ", perhaps we'll need to look again at them, eh, because with regard to the slopes, we perceive much more than it is in every way. Did we make mistakes with the excavation?

So we see in this example a clear link between individual usage of technology and collective work. We also have some verbatim about "the cave according to others" (see appendix) which show that researcher takes into account the interests of other team members. The collective face is present in an individual use of technology.

Fourth, the use of VR to visualize a database has points in common with more traditional tools used in digital humanities. We have presented above the comparison with text analysis tools: close reading and distant reading. The identification by the VR of the structure (distant reading) will allow comparisons with two other archaeological sites (one in Spain and the other in Korea) with the details of some particular object (close reading). We have also noticed a strong demand from archaeologists to be able to color the results of their queries. This need is clearly identified in history field [19] where a choropleth map can be considered as a data-rich visual primary source and different choropleth map layers can be considered a visual secondary source. Indeed, for archaeologist, the relative positioning of objects is linked to precise research questions (refitting, spatial repartition, individualization). And for this need, most users ask to have the possibility of "coloring" queries such as, for example, displaying with different colors the remains of deer and reindeer or two types of raw materials from the same level. It is indeed the basis of archaeostratigraphic distinction in addition to refitting to delimit a level. Researcher 10 is very concerned by this point and she clearly asks for this modification of the tools for studying two levels, K and L, which are very closed.

(Session 2) Researcher 10: Yes but what will interest me, is to know if K and L will have different colors. Coach 2. Not exactly. Researcher10: Otherwise, you cannot distinguish between the two. Coach3. This is exactly what we asked for. Exactly... have a small palette of colors to identify different requests.

Finally, with the use of VR we can mix factual information captured by tools (data) with the emotions of users. We feel that this mix may be interesting for the research work but we cannot prove it. Our work shows limitations (small number of tests in a very specific field) but we hope that the identified areas of reflection will be promising for research in digital humanities.

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Appendix : Codes and their definition

S1 is the first session of test and the number in the column measures the number of verbatim associated with the code of the line.

Name	Description	S1	S2
Actions		134	263
Measurement	The researcher takes a measurement between two objects or between the wall and the objects.	0	11
Request	The researcher makes a request to the database using the Boolean operators AND and OR.	18	81
Anticipation	The researcher predicts the result of an action before it happens.	1	1
Feedback +	The feedback is fast, and the researcher talks about it.	1	1
Feedback -	The feedback is slow, and the researcher talks about it.	14	18
Discontinuity	A maneuver stops the action underway.	9	6
Object selection	Specific and/or critical selections.	9	26
Movement	Specific and/or critical movements.	5	10
Control +	The researcher speaks about his mastery of the action and its result, feels in control.	14	14
Control -	Difficulty in interacting with the tool.	63	95
Physicality		87	84
Crouching	The researcher crouches in order to see below through the headset.	7	7
Grasping	The researcher tries or talks about grasping with his hands physically.	5	4
Head movement	A significant or exaggerated movement of the head.	17	13
Arm movement	A significant or exaggerated movement of the arms.	6	3
Discomfort	An unpleasant feeling, dizziness.	4	9
“Swimming”	Being amongst the objects, and moving amongst them (verbalized).	6	11
Physical difficulty	A problem with glasses, hair or something else.	36	28
Walking	The researcher walks and moves IRL (In Real life).	6	9
Space-time		42	33
Lost with VR	The researcher can no longer find his way in the virtual environment.	15	9
VR collision	The researcher goes into the walls or leaves the virtual cave.	5	12
Temporal distortion	The researcher no longer knows how much time he has spent.	4	0
Lost IRL	The researcher loses his direction amongst the objects/material which surround he physically.	11	7
RAZ	The researcher is lost and returns or requests to return to the starting point.	7	5
Realism		95	172
Friction	Discrepancies/frictions between the cave in the VR and the cave as known up to now by the researcher.	79	148
The cave according to others	Remarks about the cave as the researcher imagines that other researchers think about it.	5	3
Real cave	Remarks about the cave as it was at the time of the level being studied.	11	21
Emotions		67	96
Frustration	The researcher expresses his frustration.	14	10
Surprise	The researcher expresses his surprise.	3	5
Amusement	The researcher is amused.	7	12
Admiration	The researcher is amazed by the tool (wow).	31	56
Personification	The researcher speaks about/to the tool as if it was a person.	5	6
Disgust	The researcher expresses disgust (It’s ugly, my God,. . .).	7	7
Uses		33	56
Autonomy	The researcher thinks that he is using this tool more autonomously.	1	0
Speed	The researcher thinks that he is faster at using this tool.	0	2
Need+	The researcher thinks that the tool meets one of his needs which pre-existed the VR.	11	27
Need -	The researcher finds that the tool does not meet his needs.	3	18
Collective innovation	The tool provides new ideas for collective research or action.	1	3
Variety	The researcher praises the variety of uses allowed by the VR.	4	0
Waiting to see	The researcher doesn’t know what to do.	2	1
Fun	The researcher compares the VR to a video game.	11	5
Appropriation		98	95
Improvements	The researcher suggests proposed improvements of the tool.	55	30
Idea	The researcher himself has an idea for a request or for an exploration of the database.	7	32
Supervision	The researcher is encouraged or dissuaded by the session coach to perform a certain action.	36	33
Project		33	49
Defect	Problem or defect reported with the tool.	33	33
Version	Comparison of versions.	0	16