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## From the instrumental to the organizational genesis of a new imaging system in radiotherapy: a meeting point between French-speaking ergonomics and macroergonomics

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**Abstract:** This communication forms part of the articulation of two research programs carried out within the Social Human Sciences Research Laboratory of the Institute for Radiation Protection and Nuclear Safety (IRSN). The first is concerned with transversal organizations (processes, supply chains, etc.) and the complex nature of performance (safety, security, quality, etc.) in these organizations which are characterized by a fragmentation of the activity. The second analyzes the way in which technologies are integrated into the activity of actors and to what extent they allow this activity to develop. These two research programs come together in particular around the concept of “organizational genesis” (Folcher & Bationo Tillon, 2018, 2019; Bationo-Tillon, Poret & Folcher, 2020; Folcher, Bationo-Tillon, Poret & Couillaud, 2021). This concept is presented here from a research carried out in the field of radiotherapy. In this area, advances related to the development of computing and imaging have played and continue to play an essential role in the evolution of treatments. At the same time, these advances, which are experiencing a sustained rate of development, raise the question of their appropriation by radiotherapy professionals, directly linked to that of patient safety. Indeed, if these advances contribute to the quality of treatments, they can also bring out new risks for patients.

Understanding the process of appropriation of a technical novelty is at the heart of the research presented here. Starting from this focus on the relationship between the actors and the technique, our results show that the introduction of the technical novelty has effects not only on the individual level, but also on the radiotherapy treatment process as a whole. In other words, from an analysis of the appropriation which could be similar to an analysis of the Human-Machine interaction, our research has highlighted the way in which a modification of the technical system leads to modifications at the level of the cross-functional collective activities (Poret, Folcher, Motté, Haradji, 2016) founding the organization. With the concept of organizational genesis, which allows this passage between different levels of understanding, our research conceptually anchored in French-speaking ergonomics meets the objectives of macroergonomics (Carayon, Karsh, Gurses, Holden, Hoonakker, Hundt, Montague, Rodriguez, Wetterneck, 2013; Kleiner, 2008).

We hope that this communication, and the concept of organizational genesis presented therein, will open up discussions between two ergonomic traditions - French speaking ergonomics and macroergonomics, which present numerous complementarities for the analysis and design of organizations.

### **Keywords**

Macroergonomics, French-speaking ergonomics, multi-scale and multi-level analyses, organization.

# From the instrumental genesis to the organizational genesis of a new imaging system in external radiation therapy: a meeting point between French-speaking ergonomics and macroergonomics

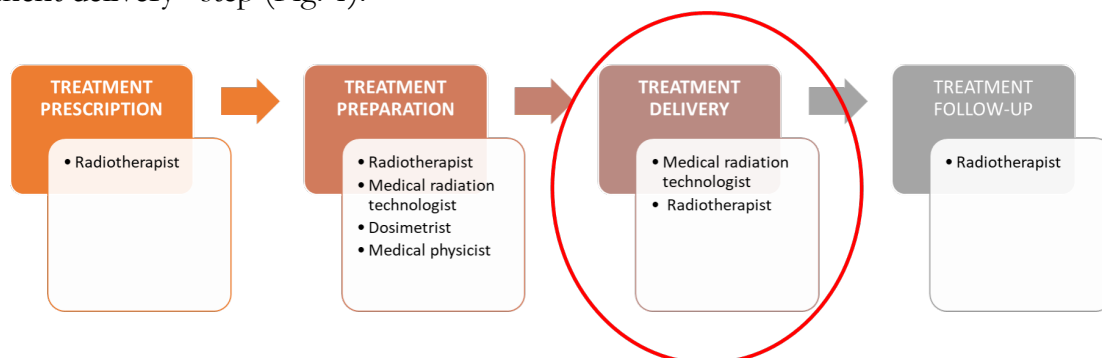
## Context

The research presented in this paper (Poret, Caminati, Thellier, 2021) is in the medical field of radiotherapy, which is a method of local cancer treatment that uses ionizing radiation to destroy cancer cells while preserving the surrounding healthy tissue as much as possible. This field of radiotherapy is experiencing an intense rhythm of technical innovations. Progress linked to the development of information technology and imaging has played and continues to play an essential role in the evolution of treatments. At the same time, these advances, which are developing at a sustained rate, raise the question of their appropriation by radiotherapy professionals, which is directly linked to patient safety. Indeed, if these advances contribute to the quality of treatments, they can also lead to new risks for patients.

The research took place in a radiotherapy department that is part of the National Federation of Cancer Centers (UNICANCER). This service treated between five to six thousand patients per year between 2014 and 2017, mostly for breast cancer, prostate cancer or ENT (ear, nose and throat) cancer. At the time of the research, this department was in the process of replacing an aging treatment machine with a new machine that allows better conformation of treatment to tumor volume than conventional radiotherapy. This change also entailed a change in the medical imaging system, which the medical radiation technologists use in particular to control the positioning of the patient at each treatment session.

## Objectives

The objective of the research was to better understand what happens during the appropriation of these technical innovations, as well as the risks that may emerge for patient safety. More specifically, we sought to understand and characterize the appropriation process of the new medical imaging system by the medical radiation technologists, who use these systems during the “treatment delivery” step (Fig. 1).



**Figure 1** - The radiotherapy treatment process: several steps involving different professionals

As illustrated in figure 1, the treatment of the patient, from its prescription to its delivery, is realized in a process that involves several professions (radiotherapist, medical radiation technologist, etc.) in different steps. In this process, the activities of each are interdependent, within the framework of a distributed collective activity (space, time, medical disciplines) that collectively constructs different dimensions of performance (quality of care, patient safety, etc.). It is an organizational configuration where the actors have to work together across various boundaries (Engeström, 2000; Carayon, 2006; Bationo-Tillon, Poret, Folcher, 2020), testifying to the complexity of healthcare organizations that must ensure patient safety (Carayon, 2006).

# From the instrumental genesis to the organizational genesis of a new imaging system in external radiation therapy: a meeting point between French-speaking ergonomics and macroergonomics

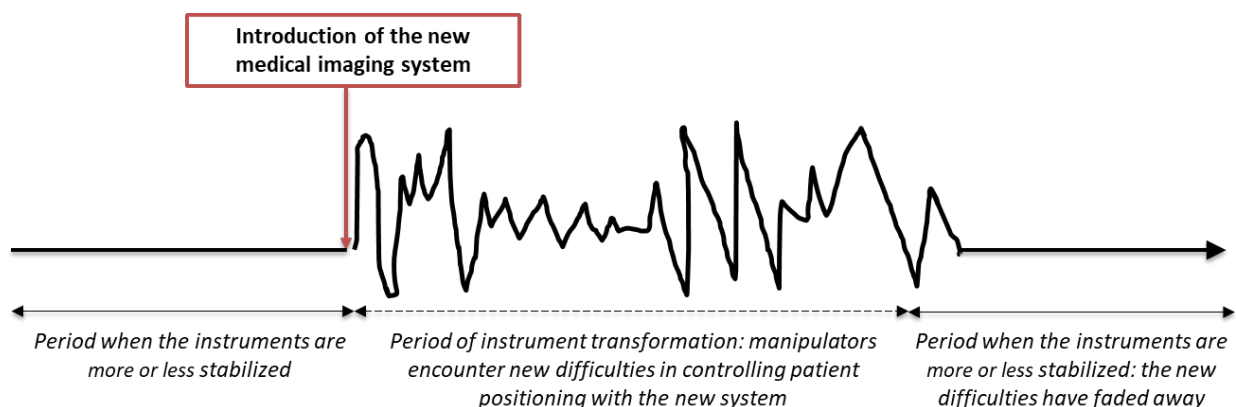
## Methods

We have understood the appropriation process from a conceptual anchoring in French-speaking ergonomics (Daniellou & Rabardel, 2005; Rabardel & Béguin, 2005), more precisely in the instrumental approach (Rabardel, 1995). This approach allows to understand how technical systems are arranged and transformed by people in the context of carrying out their activity and its various objectives. Appropriation is defined as a development process during which these arrangements emerge from the encounter and joint transformation between people and technical systems. It is this development process, called “instrumental genesis” in this theoretical approach, that we have studied in the framework of the research presented.

A methodology which crossed observations of the activity, interviews<sup>1</sup> and analyses of traces<sup>2</sup> of the activity was implemented at different times: before, during and after the deployment of the new medical imaging system in the service. This diversity of methods was developed in order to approach the activity 1) intrinsically - i.e. as it is really experienced by the medical radiation technologists - 2) diachronically - i.e. as it takes place over time and 3) in its instrumented dimensions. The analysis involved tracing the developmental history of the instruments that medical radiation technologists developed with previous medical imaging systems, as well as how they transform from the introduction of the new system.

## Main results

Our results allow us to define appropriation as a relative re-stabilization of their instruments after a period of destabilization that was initiated by the introduction of the new medical imaging system (fig. 2). We will detail some of these results during the oral presentation.



**Figure 2** - A period of relative destabilization/re-stabilization following the introduction of the new medical imaging system

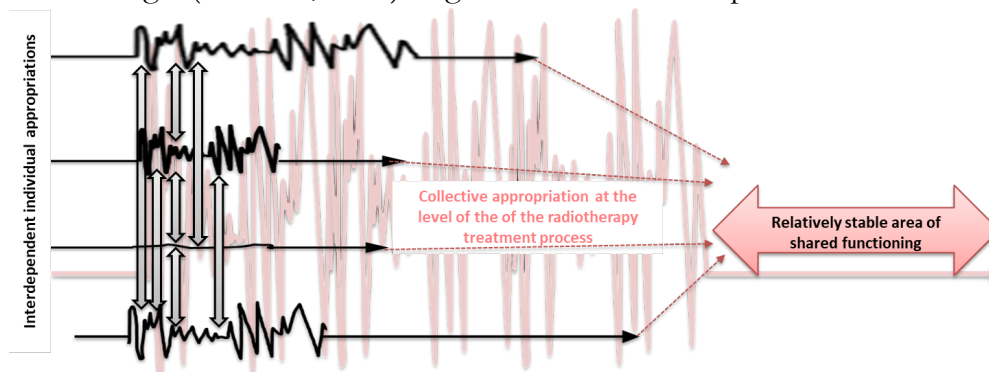
Beyond these individual characteristics of appropriation, our results show that the introduction of the new medical imaging system has effects on the radiotherapy treatment process as a whole. Since the activities of the various actors in the radiotherapy process are interdependent, the introduction of a novelty at one step of the process initiates a period of destabilization-

<sup>1</sup> More exactly, we conducted different types of interviews (exploratory, semi-directive, post-activity debriefings, interviews based on the card sorting technique).

<sup>2</sup> We collected at different times the schedules of the treatments - on the old treatment device then, on the new device - in order to perceive the evolution of the type of treatment, the locations and the number of patients treated. We also collected breakdowns, recorded in the breakdown log, to identify their frequency, their nature and their consequence(s) on the schedule, on the postponement of treatments, etc. We have sometimes questioned, a posteriori and when the opportunity arose, members of the healthcare team to shed light on certain elements.

## From the instrumental genesis to the organizational genesis of a new imaging system in external radiation therapy: a meeting point between French-speaking ergonomics and macroergonomics

restabilization of instruments and practices at this step, but also at the other upstream steps of the radiotherapy treatment process. The effects of the introduction of the novelty therefore go beyond the level of the actors who are in direct daily contact with it: the new medical imaging system destabilizes not only the instruments and practices of the medical radiation technologists who use it on a daily basis during the treatment delivery session, but it also destabilizes the overall process in which delivery is the final stage. Indeed, it is all the actors in the process who will have to progressively evolve their instruments and their practices until, ideally, a "relatively stable zone of shared functioning"<sup>3</sup> (Cuvelier, 2014). Figure 3 illustrates this phenomenon.



**Figure 3** - A dynamic of convergence towards a relatively stable zone of shared functioning at the level of the treatment process

In other words, the instrumental geneses of each actor of the treatment process are interdependent and give rise to higher-level geneses: the organizational geneses. The latter are characterized by taking into account, in the instruments in the course of genesis of each, of needs for the realization of the activity of the other actors of the process. Thus:

- at the level of each step of the treatment process, organizational geneses correspond to the integration - in the instruments being genesized - of elements that enable the other actors in the process to carry out their activity. This is the phenomenon by which the instruments being generated integrate elements relevant to the realization of activities at the level of the other steps of the process;
- at the global level of the process, organizational geneses correspond to the phenomenon by which the boundaries of the different steps of the process are crossed and linked together by collective activities that allow for the transition between activities that take place in different places at different times (Poret, 2015; Bationo-Tillon, Poret, Folcher, 2020).

Finally, our results also allow us to characterize the relationship between these different levels of geneses. Indeed, several months after the introduction of the new medical imaging system in the department, the medical radiation technologists have not completely appropriated the new medical imaging system, and still encounter some difficulties to control the patient positioning. The examination of the origin of these difficulties shows that the medical radiation technologists know how to use the new system, but that the difficulties they encounter originate in the upstream steps of the treatment process. Therefore, the activity of the other actors in the upstream steps must evolve so that the medical radiation technologists can effectively use the new imaging system during the downstream step of delivering the treatment to the patient. More specifically, the quality of the images taken during the treatment preparation step must evolve so that the medical radiation technologists can compare them with those they take during each treatment session to check the positioning. These results thus allow us to characterize the

<sup>3</sup> This is our translation of the French concept of "zone relativement stable de fonctionnement partagé"

# From the instrumental genesis to the organizational genesis of a new imaging system in external radiation therapy: a meeting point between French-speaking ergonomics and macroergonomics

relationship between instrumental and organizational geneses as a “star \* statement” (Theureau, 2009, 2015; Poizat & San Martin, 2020): instrumental geneses in interdependence at the process level give rise to organizational geneses that can constrain instrumental geneses in turn. In other words, the organizational geneses include and constrain the instrumental geneses that made them emerge.

From a design point of view, we have integrated these results in the proposal of a change management approach that considers these different levels, while ensuring that patient safety is maintained during this period.

## *Discussion/perspectives*

The research presented in this paper has allowed us to understand and characterize the effects of the introduction of a technical innovation at different levels, not only at the individual level but also at the collective and organizational level. The introduction of a technical innovation at one point in a process characterized by interdependence between the activities necessarily has effects at other points in the process, which must be anticipated and accompanied.

In other words, from an analysis of the appropriation which could be similar to an analysis of the Human-Machine interaction, our research has highlighted the way in which a modification of the technical system leads to modifications at the level of the cross-functional collective activities (Poret, Folcher, Motté, Haradji, 2016) founding the organization. With the concept of organizational genesis, which allows this passage between different levels of understanding, our research conceptually anchored in French-speaking ergonomics meets the objectives of macroergonomics (Carayon, Karsh, Gurses, Holden, Hoonakker, Hundt, Montague, Rodriguez, Wetterneck, 2013; Kleiner, 2008) which “[...] aims to understand various work system elements and their interactions as well as the linkages between multiple system levels” (Carayon, Kianfar, Li & Wooldridge, 2015, p. 579). It seems to us that this meeting point could initiate more sustained exchanges between these ergonomic traditions that are conceptually rooted differently, but that seek to apprehend global organizational phenomena from an understanding of human activities that gives centrality to the individual.

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# From the instrumental genesis to the organizational genesis of a new imaging system in external radiation therapy: a meeting point between French-speaking ergonomics and macroergonomics

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