Usability and User Experience are not Enough: Gaps to Fill to Design for and Assess Well-Being and Engagement

Célia Martinie, Philippe Palanque, Marco Winckler

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Célia Martinie[1][0000-0001-7907-3170], Philippe Palanque [1][0000-0002-5381-971X] and Marco Winckler[2][0000-0002-0756-6934] [2]

[1] ICS-IRIT, Université Toulouse III – Paul Sabatier, Toulouse, France
[2] SPARKS-wimmics team, I3S, Université Côte d'Azur, France
martinie@irit.fr; palanque@irit.fr; winckler@inria.fr

Abstract. Well-being is a complex phenomenon that is deeply depends on the individuals themselves and includes subjective perception of the past, present and future experiences. Connecting with work adds a concrete dimension to that well-being that makes it possible to consider designing for well-being and assessing it. One key element related to well-being is engagement at work and gameful design is a mean to increase engagement. This position paper builds on the evolution of the field of HCI over the years to identify means of addressing well-being through engagement. We describe the concepts related to Usability and how they evolved towards User Experience to encompass more complex (related to self) elements. We show how previous work in the field has connected these two major properties (using tasks descriptions) and how it might be possible to extend further embracing human needs and motivation theory. A concrete example is given in the context of interaction with a digital clock. Even though this example is simple, it conveys the concerns and highlights possible directions towards solutions.

Keywords: Task models, usability, user experience, motivation, human needs, work, operator.

1 Introduction

The Human Factors community has been working on understanding the multiple internal states of operators (and more globally human beings) but also how to change this internal state to increase Subjective Well-Being (SBW) [3]. For instance, in [1], authors assess the connection between neurosis of adolescents and SWB. Foundations of human motivation and needs were made concrete with the seminal work of Maslow [10]. Even though its validity was (and still is) highly criticized in the literature [2] evidences are shown that self-actualization (the top-level need in the Maslow's hierarchy) is not questioned. Concomitantly, Human-Computer Interaction community has been extending its research focus from Usability-centered design of services, systems and products to hedonic aspects covered by the User Experience property. Beyond, one contributing factor to well-being is engagement that connects to the stimulation dimension of User Experience [14]. In this paper, we propose to use gameful design and automation as two design options to increase engagement of users/operators while performing their activities. We use a the task modelling notation HAMSTERS [18] to describe these activities and to assess their evolutions when automation and gameful design options are considered.

The paper is structured as follows. Next section introduces the contributions of Usability and User Experience on the design of interactive applications and interactions. This section also presents how task models can be used to represent usability and user experience related information. Section 3 extends section 2 by adding two additional concepts: hierarchy of needs and engagement. Section 4 introduces a simple illustrative example to show how targeting engagement (using gameful design and automation) can stimulate operators and reduce their workload. Section 5 concludes the paper and highlights potential directions for future work.

2 Usability and User Experience Contributions

2.1 Usability

HCI community historically focused on the usability of interactive systems, in order to ensure that operators will achieve their tasks with the interactive systems. Usability standard (as defined in [9]) has deeply changed the design of interactive systems by decomposing usability for ensuring careful consideration of three contributing factors. Assessing usability can be done in multiple manners and, as argued in [16], in some research contributions without careful consideration of the correlation between them. These contributing factors are:

- **Effectiveness**: corresponds to the coverage of users tasks offered by the system functions. It describes the capability of users to reach their goals with a given system.
- **Efficiency**: corresponds to the performance of users to reach their goals. It includes objective measurable elements such as number of errors or execution time.
- **Satisfaction**: corresponds to the users perceived satisfaction while performing their work with a given system.

Fig. 1 represents the schematic view of the field of HCI in terms of users performing a task. The Human Processor model proposed in [13] decomposes human activity into perceptive, cognitive and motor elementary tasks. This is close to the biological behavior of humans and remains far away from human affects and needs that is presented in models in the following sections.

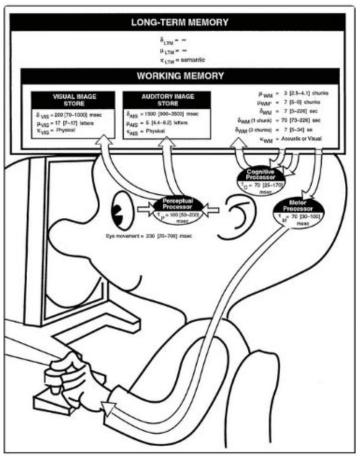


Fig. 1. The operator at work as depicted in the Human-Processor Model [13].

2.2 User Experience (UX)

User Experience property has been addressed more recently with methods supporting the design for User Experience [7] and with methods for the assessment of User Experience [6].

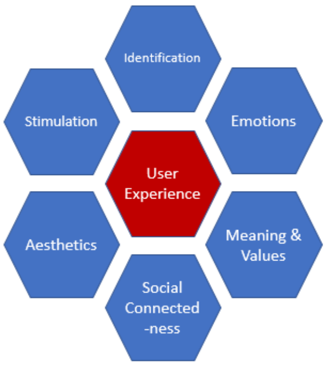


Fig. 2. The six contributing factors of User Experience as proposed in [6].

Various definitions have been proposed for User Experience including affects and emotions, aesthetics or values [7]. According to the work of [14] User Experience can be decomposed in:

- **Aesthetics**: The aesthetic level involves a product's capacity to delight one or more of our sensory modalities;
- **Emotion**: The emotional level involves those experiences that are typically considered in emotion psychology and in everyday language about emotions;

- **Identification**: a hedonic attribute group, which captures the product's ability to communicate important personal values to relevant others;
- **Stimulation**: The stimulation dimension describes to what extent a product can support the human need for innovative and interesting functions, interactions and contents
- **Meaning and Value**: The meaning level involves our ability to assign personality or other expressive characteristics and to assess the personal or symbolic significance of products;
- **Social-connectedness**: The social connectedness involves means to increase social pleasure offering means to interact and share information with others.

User experience goes beyond Usability and gets closer to feelings and emotions that are contributing to human motivation and human needs which are in return impacting well-being.

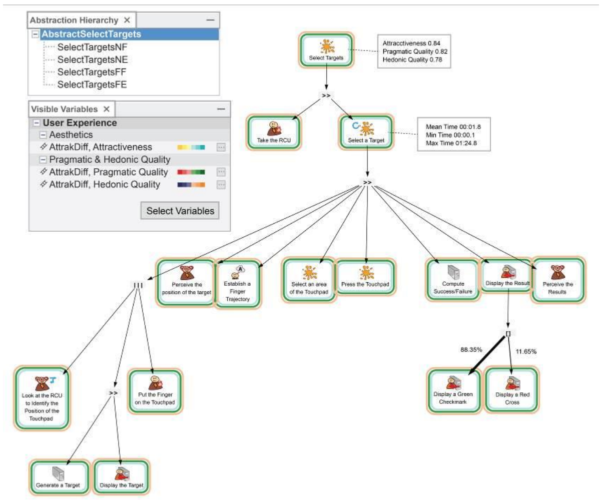


Fig. 3. Representation of user study result related to user experience in the task model indicating variations in the UX dimensions using color panels and representing frequencies of choice (%) on the connecting arrows to support usability analysis

2.3 Connecting Usability and UX Through Task Models

Operator work can be easily described using task models which decompose work in a set of goals each of them being refined by a set of tasks to reach the goal. HAMSTERS [18] is a tool-supported graphical task modeling notation for representing human activities and work in a hierarchical and ordered manner. At the higher abstraction level, goals can be decomposed into sub-goals, which can in turn be decomposed into activities. The output of this decomposition is a graphical tree of nodes. Nodes can be tasks or temporal operators. Tasks can be of several types (see Figure 3) and contain information such as a name, information details, and criticality level.

Only the single user high-level task types are presented here but HAMSTERS has a variety of further task types available and accounts for information, objects and knowledge involved in the performance of the work [19].
In [6], Bernhaupt et al. have proposed the integration of User Experience contributing factors including both hedonic and pragmatic qualities inside task models (addressing mainly the effectiveness factor of Usability).

The objective of that research work was to connect User Experience to the activity of operators in their daily work (in that case media consumption using a remote-control unit (RCU)).

3 Beyond Usability and UX

This section presents two additional conceptual frameworks: the pyramid of needs from Maslow and Gameful design for Engagement. These frameworks go beyond classical Usability and even the more recent concept underlying User Experience.

3.1 Motivation and Needs

The work of Maslow on the hierarchy of human needs was early introduced in [10] and refined in [11] which revisits the concepts introduced by Maslow which are decomposed in three core concepts:

- **Basic needs**: they encompass physiological and safety needs that correspond to the immediate and short-term survival of the individual. They ensure the sustainability of the biological machinery that compose human beings.
- **Psychological needs**: encompass relationship to others i.e. social aspects of human being as well as relationship with self, including prestige and subjective perception of accomplishment.
- **Self-fulfillment needs**: correspond to the definition of self-actualization aiming at deploying the full potential of the individual.

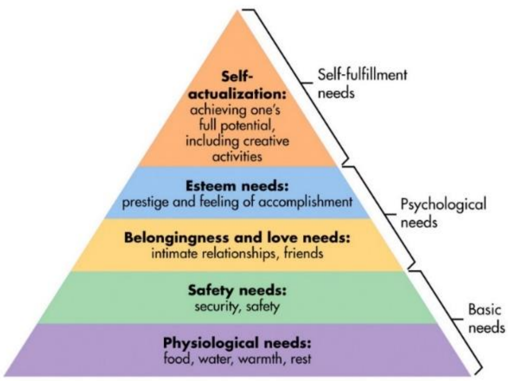


Fig. 4. The hierarchy of needs and motivation from [29] original work in [10]

Work is a transverse concept with respect to the hierarchy of needs presented in **Fig. 4**. Indeed, for each of the levels of the pyramid, work is:

- **Physiological needs**: e.g. work can contribute to provide food directly (farming) or indirectly (money);
- **Safety needs**: e.g. building fences or constructing protections may contribute to safety and security;
- **Belongingness and love needs**: e.g. earning resources via work might allow building a family;
- **Esteem needs**: e.g. building a career in a company might contribute to esteem via success;
- **Self-actualization need**: e.g. evolution in the work environment during the entire life might support the construction of the personality to become self-actualized.

3.2 Gameful design and Engagement

Although gameful design and gamification techniques have not been studied evenly across application domains (most of the contributions come from the application domains of education and health), Seaborn and Fels [21] surveyed the literature and established that the results of gamification are mostly positive. They highlight that gameful design, including gamification, raise engagement and user performance. Indeed, a study on the gamification of the tutorial of the AutoCAD 3D objects modelling application [22] reported higher subjective engagement levels with the gamified application, and that users performed a set of testing tasks from 20% to 76% faster after using the tutorial with the gamified components. Gameful design can also encourage participation and collaboration with other users as demonstrated in the context of online learning [23]. These examples (and many other ones) show that the range of potential benefits of gameful design is quite wide if design choices are carefully elicited.

Gameful design requires fine-tuning of the game mechanics that are integrated in the interactive system, and game elements have to match what the user is able to perform in the context of use. Wilson et al. [23] argue that some design choices may be counterproductive and that engagement and motivation may vary a lot depending on the type of game element. Adding artificial challenge to a system supporting functional needs engenders frustration [24]. Moreover, Korn et al [25] showed that in an industrial environment, some gamification elements may improve production speed but may also increase the error rate.

As stated above, adding game elements and challenges to motivate the user leads to add additional objectives and tasks to perform with the interactive system. These additional tasks interleave with work tasks, and have thus to integrate in a consistent manner with them in order to avoid frustration and errors (especially capture and interference ones). Moreover, the design of game elements also requires identifying automation opportunities (for these game elements), with the objective of increasing the overall usability of the system but also to make sure that proposed challenges are important and motivating experiences for the user [24].

Gameful design for interactive systems at work thus requires being able to describes exhaustively and systematically:

- User work tasks;
- User tasks while interacting with work automation;
- User tasks to reach game elements objectives;

Analyzing all these elements together is also critical in order to detect conflicting elements.

4 Illustrative example: The Mackworth clock

4.1 Introduction to the example

The Mackworth clock is an interactive system designed and developed to study the performance of operators monitoring information on airborne radars [26]. The system was developed to build experiments to assess vigilance capabilities of human being while monitoring autonomous systems. The Mackworth autonomous system (presented in **Fig. 5** a)) includes a green point, which moves in steps every second (like the second hand of a clock). In the experiment, at irregular time intervals, the green point moves the double of the usual distance (jumps one step). The operator has to detect this unexpected movement (representing a problem or a failure) and to press a button to prove that the malfunction has been detected.

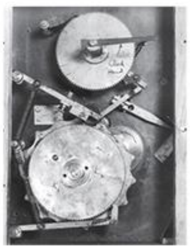
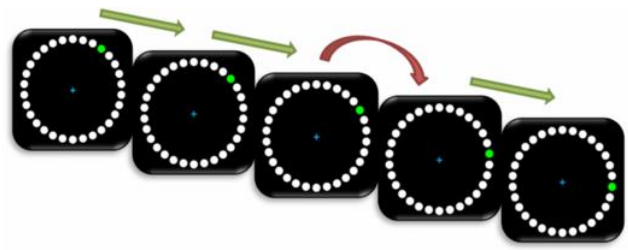
a)

b)


Fig. 5. a) original Mackworth Clock [26] and b) modified Mackworth Clock from [27].

Fig. 5 b) presents a modified and digitalized version of the Mackworth clock. We chose to present it because it makes more explicit (as a symbolic representation) how the Mackworth autonomous system was functioning.

The hypothesis behind this experiment was that human performance in detecting malfunctions would decrease over time. Indeed, the study of performance of operators monitoring this autonomous system confirmed the fact that attention and vigilance decrease over time. The main outcome of this study was to propose identify the best compromise between the duration of the monitoring period (the watch-time of the operator) and the errors. In the following sections, we discuss the opportunity to alter this experiment adding game elements to the monitoring task to assess the possible increase of attention and vigilance for longer monitoring tasks.

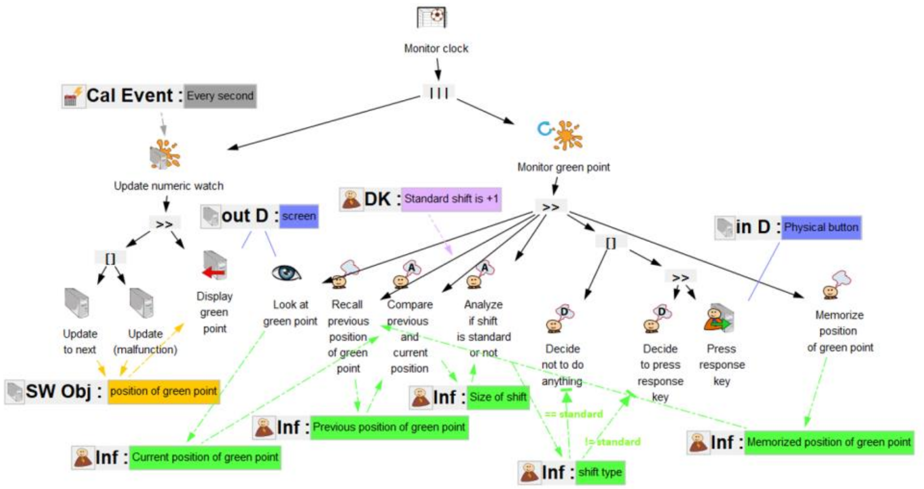


Fig. 6. Task model describing the tasks to "Monitor clock"

Fig. 6 presents the detailed description of the tasks the operator has to perform to monitor the clock. The main goal, represented at the top of the task model, is "Monitor clock". Under this main goal, the temporal ordering operator "|||" named concurrency has two branches that describe the tasks performing in parallel. On the left branch under the main goal, the system updates the clock every second (abstract system task "Update numeric watch" with an incoming arrow from the calendar event "Every second"). This task decomposes in a sequence (temporal ordering operator ">>") of a system task (a choice, indicated with the choice temporal ordering operator "[]", between the tasks "Update to next" and "Update (malfunction)") and the interactive output task "Display green point" which uses the output device "screen". The system tasks update the value of the software object "position of green point", which is required to perform the system output task "Display green point". In the right branch under the main goal "Monitor clock", the abstract iterative task "Monitor green point" decomposes in a sequence of user tasks. First, the user performs the perceptive task "Look at green point" using the output device "screen", which produces the information "current position of green point'. Then the user performs the cognitive task "Recall previous position of green point" using the information "Memorized position of green point" and producing the information "previous position of green point". Then the user performs the cognitive analysis task "Compare previous and current position" using both information "current position of green point" and "previous position of green point". This task produces the information "size of shift". Then, the user performs the cognitive analysis task "Analyze if shift is standard or not" using the information "size of shift" and the declarative knowledge "Standard shift is +1". Then from the result of this analysis task, the user makes a choice (described using the choice temporal ordering operator "[]" combined with the test arcs on the value of the information "shift type"). If the shift type is standard, the user decides not to do anything. If the shift type is different from standard, then the user decides to press the response key, and then presses the response key. At last, the user performs the cognitive task “Memorize position of green point” which produces the information “Memorized position of green point”.

4.2 Automation as a design option to reduce workload

The main goal of the user task is to monitor the clock and the challenge of being attentive and staring at the clock should remain (as migrating it to automation raise similar challenges such as monitoring automation instead of monitoring the clock – which is already an automation). However, other tasks such as “Recall previous position of green point” and “Memorize position of green point” may be difficult and error-prone and are articulatory with respect to the monitoring of the handle of the clock. For these reasons, we propose to migrate those tasks from the operator to the system. The automation of these work tasks decreases the number of tasks to perform for the operator. **Fig. 7** presents a screenshot of a new interface to present the information of these migrated tasks to the operator.

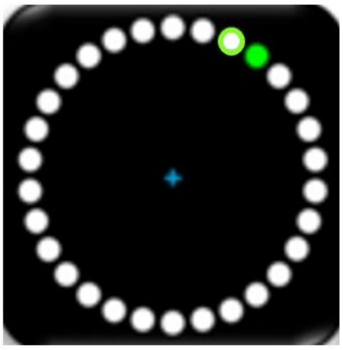


Fig. 7. Illustration of the design proposal for automating operator’s work

Fig. 8 presents the task model modified for this automation proposal. In the left main branch of the model, we added two system tasks: an output system task named “display previous position of green point”, as well as a storing system task. We also added a new software object “stored position of green point” to describe that the system will be storing the value of the previous position instead of the user doing it. In the abstract iterative task “Monitor green point”, we replaced the cognitive task “recall previous position of green point” with the perceptive task “Look at previous position of green point”, and removed the cognitive task “Memorize position of green point”, as well as the associated memorized information “Memorized position of green point”.

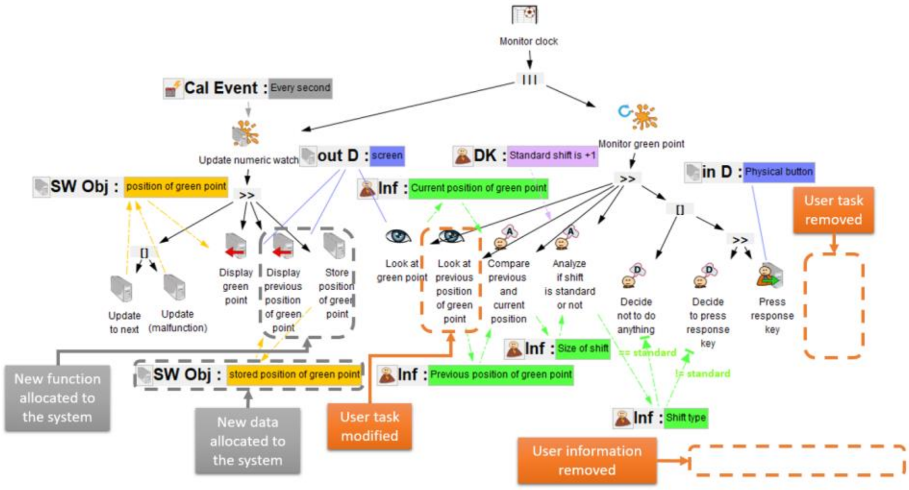


Fig. 8. Task model modified for the work automation

This proposal of work automation should decrease cognitive load but may lead operator to be less attentive. We thus propose to integrate a game element, focused on a continuous input from the operator, to increase immersion. The game element the continuous tracking of the green point using a mouse pointer. The operator has one hand on the mouse device and has to move the mouse pointer to the green point each time the green point shifts. Figure 6 presents three screenshots that illustrate this design proposal. At the bottom of the screens, a panel indicates the total time on the green point and the total time outside of the green point.

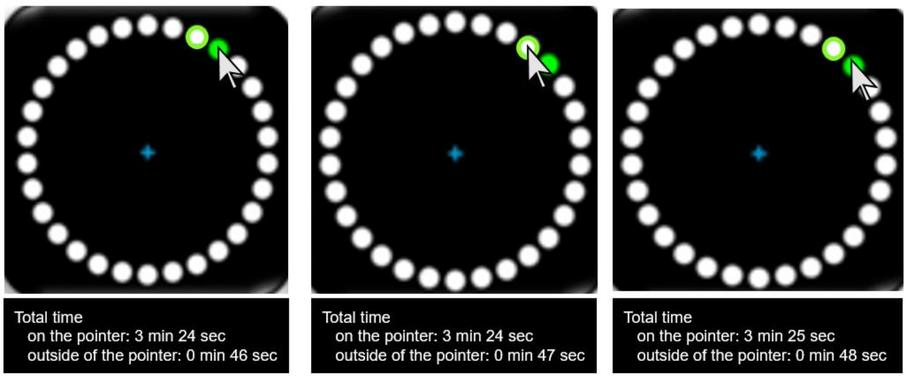


Fig. 9. Illustration of the game element added to the modified Mackworth Clock

Fig. 10 presents the task model modified to include the tasks related to the game element "mouse pointer tracking using a mouse device", as well as the automation of work (explained previously). In the left main branch, we added the system output task

"Display mouse pointer" which requires the software object "Mouse pointer position". In the right part of the model, we added a new branch which main task is "Monitor mouse pointer" and is iterative. This task interleaves with the two other sub-goals "Update numeric watch" and "Monitor green point". It decomposes using the same pattern as the green point monitoring task, but for the mouse pointer. The user first performs the perceptive task "Look at mouse pointer", which produces the information "mouse pointer position". The user then performs the cognitive analysis task "Compare mouse pointer position with green point position", using both the information "current position of green point" and "mouse pointer position". This task produces the information "mouse pointer position relative to green point". Depending on the value of this information, mouse pointer is on green point or mouse pointer is not on green point, either the user will perform the cognitive decision task "Decide not to do anything" or the cognitive decision task "Decide to move the mouse pointer" followed by the interactive input task "Move mouse pointer".

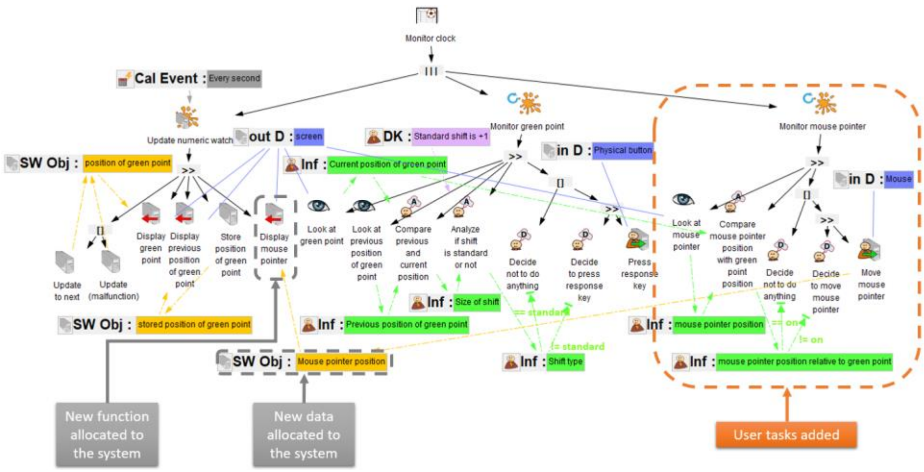


Fig. 10. Task model modified to integrate both automation and game element

This task model helps to figure out the impact of the game element on the operator's tasks. We see that the new set of tasks that we introduced represents as many tasks as the set of tasks to monitor the green point and that this set of tasks interleaves with the work task, and share a common information to process for the tasks (Information "current position of green point" at the bottom in **Fig. 10**). This confirms that the design proposal should increase the operator's workload while helping the operator to focus on the main goal.

By supporting the precise comparison of the original work tasks with the tasks altered by adding work automation and game elements, we argue that a task models based approach enables to identify relevant automation and gamification opportunities. The level of precision of task descriptions enables to filter out tasks that should be migrated to the system and tasks for which gamification will benefit to user performance and engagement. In that way, it supports reaching an optimum level of workload as exemplified in **Fig. 11**.

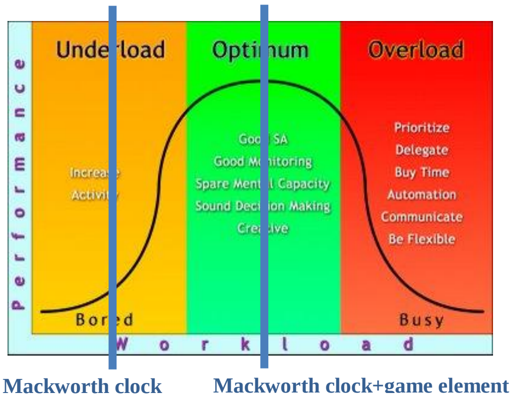


Fig. 11. Using Yerkes-Dodson [28] curve as a mean to represent evolution of user engagement and performance when integration game elements are added to work tasks.

5 Conclusions and Perspectives

This paper has presented the potential benefits of using game elements interleaved with operators' work in order to increase user experience and engagement of operators. We argue that describing how these game elements transform the operators' work is critical in order to be able to assess the impact (positive and negative) of the activities added by the game elements on operators' work.

We have revisited the Mackworth clock experiment which is centered on the monitoring (by an operator) of an autonomous system. We took the position that degradation of the monitoring performance of the operators was related to a loss of engagement, and an increase of boredom and was due to the lack of active participation of the operator on the system.

To improve performance, we decided to integrate in the work tasks additional tasks related to game elements added to the system. We used the HAMSTERS|XL notation to describe the original and the altered task models and used these models to demonstrate the higher engagement of operators when game elements are added.

Future work will consolidate these research results demonstrated on a very simple case study by applying them to more complex environments such as safety critical control rooms where engagement is critical to ensure that operators are constantly monitoring the evolutions of the system and able to react promptly in case of failures.

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