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THE EFFECT OF UNCERTAINTY PERCEPTION ON ACTIVITY SELECTION IN PRODUCT DEVELOPMENT TEAMS

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Uncertainty perception plays a key part in innovative product development projects since they have high levels of uncertainty. Consequently, understanding the strategies that teams use to deal with uncertainty can point to key insights for improving project performance. Therefore, it is relevant to investigate this area of uncertainty perception and subsequent activity in product development project teams. In spite of the existing literature on product development and uncertainty, gaps remain in mapping the types of perceived uncertainty in different projects and also understanding of the influence of uncertainty on individual´s activities. We present evidence from a case study of two interconnected projects in a high technology company. The key results were the mapping of several uncertainties that are perceived by the team members in both projects and the activities triggered by different uncertainty types. Key insights from this study are the interconnections between uncertainties, affecting product development activities across projects. Despite taking specific counter actions in the first project, major uncertainties were still inherited by the subsequent project, significantly impacting the project´s early phases activities.This research generates three main contributions in terms of mapping uncertainties and triggered activities. The first is the existing of multiple perceived uncertainties interacting in both project types, which increases the challenges of the projects. The second is the uncertainty sets situations, which have a major role in the project in contrast to the single uncertainties situations, and has significant impact in the product development projects and their performance, echoing also in the triggered activities. The third is the triggered activities which are different for single uncertainty types situations and uncertainty sets situations.

Keywords: uncertainty, uncertainty perception, activity, new product development projects

INTRODUCTION

New product development (NPD) projects are critical for the businesses success and they can vary in terms of content and nature. Two examples are the NPD project that focuses on the development of one product (McDermott & O'Connor, 2002; Verworn, Herstatt, & Nagahira, 2008) and the Platform based project which focuses on the development of a family of products (Muffatto & Roveda, 2000; Postema & Obbink, 2002; Robertson & Ulrich, 1998). Nevertheless they are all extremely uncertain (Hjalmarson, Cardella, & Adams, 2006; Stockstrom & Herstatt, 2008; Tatikonda & Rosenthal, 2000a). Uncertainty is inherent to the NPD processes and it is present all

aspects and stages, because of their nature and the unknown tasks outcome (Huang, Liu, & Ho, 2015; Rode, Cosmides, Hell, & Tooby, 1999; Stockstrom & Herstatt, 2008).

Uncertainty can have many definitions, but for this paper uncertainty is defined as a "potential deficiency in any phase or activity of the process which can be characterized as not definite, not known or not reliable" (Kreye, Goh, & Newnes, 2011) and is perceived within the project as well as in relation to the project´s environment (Huang et al., 2015). There is a wide range of uncertainty types which can be attribute to complexity, to the unknown outcome of the task and it can be related to the internal or to the external world of the individual being connected to Technology, Schedule, Environment, among others (de Weck, Eckert, & Clarkson, 2007; Liberatore, 2002; Ragatz, Handfield, & Petersen, 2002), which can be perceived differently and affect projects outcome.

Individuals in the product development team react to the uncertainty by carrying out different actions aiming to reduce or control their uncertainties in the NPD process, such as information seeking, knowledge sharing and simulation (Hult, Ketchen, & Slater, 2004; Stockstrom & Herstatt, 2008). In the NPD process there is a wide range of activities that individuals can engage in NPD to progress the process (Bessant & Francis, 1997), each of these are driven by how people experience uncertainty in this various ways. It is possible to highlight for example the decision making process, individually or in a team. In the case of decision making in a team, there is also greater scope for uncertainty, since personality and cognitive style can influence it (Dewberry, Juanchich, & Narendran, 2013). Another example is when people deal with information, by seeking it or sharing it, which can be related to the project performance (Daft & Lengel, 1986; Hult et al., 2004; Stockstrom & Herstatt, 2008).

However, the relationship of how the uncertainty is perceived and the activity is executed and the overall project performance is little understood. How the individual and the team involved in the project deal with uncertainty perception can improve or not the performance of the project, therefore the individual's action and reaction during the NPD´s processes are essential for its success (Kim & Wilemon, 2002). Consequently, understanding the strategies that teams use to deal with uncertainty can point to key insights for improving project performance, since the perceived uncertainty can negatively affect it by making activities more challenging (Song & Montoya-Weiss, 2001; Zhang & Doll, 2001). In spite of the existing literature on uncertainty, uncertainty perception and product development, the gap remains in understanding the influence of uncertainty perception type on individual´s activities, and its effect, directly or indirectly, on project´s performance considering the complexity of the project (Olausson & Berggren, 2010; Sicotte & Bourgault, 2008). Therefore, it is relevant to investigate this area of uncertainty perception and subsequent activity in product development project teams.

As such, this research addresses this gap by exploring the uncertainty types the project members perceive and how they act in response to this and aims to answer: which are the uncertainty types the project development team perceives in the project and how these different types influence the activities that are triggered when dealing with the uncertainties? In order to answer this research question we adopted a case study where we interviewed 23 individuals in two projects, where the first focus on the creation of possibilities and explore insights from customers and from the involved team. The second type is the NPD project, where the project has a specific product to develop. The NPD project followed the first project. This research generates three main contributions in terms of mapping uncertainties and triggered activities. The first is the existing of multiple perceived uncertainties interacting in both project types, which increases the challenges of the projects. The second is the uncertainty sets situations, which have a major role in the project in contrast to the single uncertainties situations, and has significant impact in the product development projects and their performance, echoing also in the triggered activities. The third is the triggered

activities which are different for single uncertainty type situations and uncertainty sets situations. This project is structured as follows: the literature on product development projects, uncertainty perception on NPD projects and activity selection on uncertainty perception. The next section is the research design with the methodological approach, followed by the findings, discussion and conclusions. It closes with the limitations and outlooks.

LITERATURE REVIEW

Uncertainty is present in several types of projects and for this research we focused at it in respect to New Product Developed projects and Platform based projects. New product development projects can be seen as one of the most important parts of a business (Stockstrom & Herstatt, 2008), are risky, uncertain of its success, require resources, research for development and structure (Huang et al., 2015) and are focused on the development of a specific product. Platform based projects are known for degreasing the cost of production and increasing the product quality by focusing on the creation of a diversity with less technical diversity for a specific domain (Postema & Obbink, 2002).

Uncertainty plays a key role in both projects types since they both deal with innovation and have a complex nature, but in each of them different uncertainty types can be perceived by the teams, triggering activities that can be crucial for the projects performances. Uncertainty perception in NPD projects and in Platform based projects affects activities like information seeking, knowledge sharing, simulation, testing and planning (Daft & Lengel, 1986; Hult et al., 2004; Koufteros, Vonderembse, & Doll, 2002; Postema & Obbink, 2002; Sciences & Texas, 2005; Stockstrom & Herstatt, 2008).

Product development projects

An extensive range of projects can be established in order to develop a new product. For this paper we will explore two different types of projects: the NPD project and the Platform based projects. These types were chosen since in all of them uncertainty is intrinsic to their nature and in all the steps of all projects, it is possible to find uncertainties from the project itself and also from outside it (Huang et al., 2015).

The new product development projects are as its name state, characterized by the development of a new product; it can be due to radical or implemental innovation (McDermott & O'Connor, 2002; Verworn et al., 2008). In the new product development project different process can be used to actually develop the product and also to help reduce the uncertainties inherit in the project´s nature. One example is the "stage gate" process, which has five steps: the identification of the opportunity, the idea generation, screening and evaluation of the idea, the design, development and testing, and the launch of the product (Cooper, 1990, 2008).

On the Platform base project focus on the development of a platform that will generate a family of product and are known for degreasing the cost of production and increasing the product quality by focusing on the creation of a diversity with less technical diversity for a specific domain (Muffatto & Roveda, 2000; Postema & Obbink, 2002; Robertson & Ulrich, 1998). The process for this project have four steps, being conception, definition, deployment and evolution (Postema & Obbink, 2002).

Similarly, in both projects, in all the steps uncertainty is perceived and it can suffer influence from the complexity of the project itself but also from the product that it is being developed (Kim & Wilemon, 2003). On the other hand the projects' types differ in their focus. The NPD project is focused on the development of one specific product while the Platform based product is focused on the development of a family of products, and in practice each of them have their own challenges. In the NPD project the challenges faced by the development team can be

related to the use and development of unproven technology, the need to remain competitive in the market, insufficient information (Huang et al., 2015; Kim & Wilemon, 2003; Tatikonda & Rosenthal, 2000a, 2000b), besides all these challenges, the Platform based product as focused on the development of a family of product, still have the challenge to develop more than one product.

For companies implementing product development project, knowledge acquisition and learning processes are relevant for an organization once this knowledge helps the improvement of the next projects development (Bessant & Francis, 1997). Learning with previous projects is crucial and it is possible that some challenges from the NPD project can come from their early phases or even from the previous projects, and these can be the Platform based projects, among others. For that reason it is important to understand how their perceived uncertainties and activities can influence the subsequent NPD project. Therefore there is a need to understand the perceived uncertainties in these projects and how they affect the projects' activities

Uncertainty perception in NPD projects

Uncertainty is a wide-ranging theme, which has brought interest from researchers being explored by several frameworks, by for example in engineering (Muhanna, Zhang, & Mullen, 2007), in design (Blacud et al., 2009), in psychology (Cosmides & Tooby, 1996; Tversky & Kahneman, 1974), among others. Uncertainty literature in general has been described in terms sources (de Weck et al., 2007; Liberatore, 2002; Ragatz et al., 2002; Ullman, 2009), dimensions (Walker et al., 2003), layers (Kreye, Goh, Newnes, & Goodwin, 2012) and levels (Walker et al., 2003) . Given this diversity of terminology in the literature we adopted the general understanding that uncertainty is defined as a "potential deficiency in any phase or activity of the process which can be characterized as not definite, not known or not reliable" (Kreye et al., 2012).

In spite all the characterization, uncertainty is still a mysterious variable (Sicotte & Bourgault, 2008) with a crucial importance for projects, however, people only act on perception, therefore for this paper, the uncertainty is only relevant when perceived by an individual in a development project and it triggers an activity aiming to deal, solve or better understand it. Perceived uncertainty is the project development when an individual is not able to fully understand some aspect of the project or the product being developed (Milliken, 1987; Song & Montoya-Weiss, 2001).

There is a wide range of uncertainty types that can be perceived by an individual in a product development team. The major types can be clustered into four cluster groups: product development, technology development, project, data, environmental and market.

The product development cluster is related to perceived uncertainties in product, design, requirements, parameters, and quality. These uncertainties are related to the actual product development and can be perceived by individuals from several departments involved in the project´s team, especially on the early phases of the project (Akerlof, 1970; Blacud et al., 2009; Lee, 2003; Liu, Chen, Chen, & Shin, 2011; Milanovic & Hiskens, 1998). This uncertainty is also related to the product development but it can be crucial when dealing with innovative technological products, as is related to the new technology development and technical development activities, therefore being more perceived by individuals in the technical part of the development team (Fox, Gann, Shur, Von Glahn, & Zaas, 1998; Milliken, 1987; Song & Montoya-Weiss, 2001).

The project cluster is related to the perceived uncertainties in the processes, schedule, roles and budged of the project. They can be perceived by individuals when any of the project´s process, as engineering for example, are new or evolving, which can affect the hierarchy, finance and the speed to market (Boynton, Gales, & Blackburn, 1993; Fox et al., 1998; Liberatore, 2002).

Data uncertainty cluster is related to information and communication. It can be related to data incompleteness or inaccuracy and to the communication in the project team, which can affect the project´s flow once communication is not align (Kreye et al., 2011; Souder & Moenaert, 1992).

The last two clusters are related to uncertainties outside the company's scope, which is environmental and market uncertainty. Environmental perceived uncertainty is connected to supplier, and market uncertainty is associated to consumer, culture and competition, both clusters can be perceived more by managers when they do not fully understand the nature or the changes of those (Fox et al., 1998; June, Beckman, Haunschild, & Phillips, 2004; Milliken, 1987; Parlar & Perry, 1996; Souder, Sherman, & Davies-Cooper, 1998)

The uncertainty perception can also be influenced by the complexity of the product being developed or the project and more than one uncertainty can be perceived together or be connected (Olausson & Berggren, 2010; Sicotte & Bourgault, 2008; Tatikonda & Rosenthal, 2000a). Current literature focus on specific types of uncertainties like technology and market, for example, and in a few studies several uncertainties are treated connected or together, which highlights the importance of a broader understanding of the multiple uncertainties faced by the development team and how each type or source of uncertainty perceived by the individual can trigger different activities in the project, influencing its success (Olausson & Berggren, 2010; Sicotte & Bourgault, 2008) . Overall, uncertainty perception is crucial for the development of new products once it triggers activities that will influence the projects performance (Salomo, Weise, & Gemünden, 2007).

Activity selection based on uncertainty perception

To deal with uncertainties, the individual in the project team engages in activities. Activities can be described as being an object oriented system (Bedny & Karwowski, 2004).This activity can be related to information seeking, knowledge sharing, representation or simulation, among others. The activities types can be clustered into three clusters: information, product and project.

Information seeking and knowledge sharing activities are both related to the cluster of information. The first is seeking information in sources like files, books, internet, documents, journals, among others, on this type of activity the individual interacts only with non-human sources (Daft & Lengel, 1986; Huang et al., 2015; Muffatto & Roveda, 2000; Robertson & Ulrich, 1998; Stockstrom & Herstatt, 2008). The second activity from this cluster is associated to acquire or share knowledge with others from the same or different departments in the company or even from suppliers or customers, as example meetings and trainings (Daft & Lengel, 1986; Hult et al., 2004; Stockstrom & Herstatt, 2008).

Representation and simulation are related to the product cluster. The first is representing the concept like prototyping or doing a mock-up, the second is simulating how it would work. They are both is described in product development as a practice by which the individual brings certain elements to life, in order to be able to evaluate its value in relation to the goal. With simulation, the individual can bring to reality his/her ideas and see their interactions and connections, which allows him/her to have a better understanding of it and help dealing with the perceived uncertainty (Poon and Maher, 1997; Dorst and Cross, 2001).

Activities related to the process itself are the ones related to the project cluster, as for example contingency planning. The uncertainty perception can be a wonder for the project´s strategic planning made on the early phase or even before the project started and to deal with it managers can develop a contingency plan (Milliken, 1987 ; De Meyer, Loch & Pich, 2002) .

The activity outcome is processed by the individual and it can result into a new uncertainty and a new activity or set of activities, or the individual can be satisfied by the outcome of the activity in relation to the initial uncertainty. It is possible that different perceived uncertainties can trigger a different type of activity or even a set of activities sequence until the individual or the team is satisfied with its outcome. The activity can also be connected to the individual expertise or department in the project team and the activity selection is determinant in the product development outcome (Song & Montoya-Weiss, 1998).

Conceptual framework

A conceptual framework was build based on the uncertainty types and clusters already mentioned. The definition used for the uncertainties was based on (Kreye et al., 2012): "potential deficiency in any phase or activity of the process which can be characterized as not definite, not known or not reliable", and it is summarized in Table 1.

Table 1: Mapping of the uncertainty types in projects

Product & Technology development cluster		
Uncertainty Type	Uncertainty Definition associated to the data	Related Reference
Product	When the product or its characteristics are not known /clear / certain	Lee (2003)
Design	When the design of the product or any of its part is not known/clear/certain	Blacud et al.(2009)
Requirements	When the requirements for the product is not known/ clear/ certain	Liu et al. (2011)
Parameters	When the parameters for the product is not known/ clear/certain	Milanovi & Hiskens (1998)
Quality	When the quality of the product or any of its parts is not /certain; can also be related to the quality of the tests and simulations	Akerlof (1970)
Technology	When the technology is not known/reliable/exist/tested	Song & Montoya-Weiss (2001)
Project cluster		
Uncertainty Type	Uncertainty Definition linked to the data	Related Reference
Process	When the project´s processes are not known/clear/define	Gupta & Brennan (1995)
Schedule	When the schedule is not clear/feasible	Liberatore (2002)
Roles	When the individuals roles are not known/clear/ define	Boyton et al. (1993)
Budget	When finance or financial status is not known/defined	Yang (2005)
Data cluster		
Uncertainty Type	Uncertainty Definition linked to the data	Related Reference
Information	When the information for the project /product development is not known/ clear/ reliable	Kreye et al. (2012)
Communication	When communication between individuals in the project team is not clear/open	Boholm (2016)
Environmental & Market cluster		
Uncertainty Type	Uncertainty Definition linked to the data	Related Reference
Supplier	When the supplier or its relationship is not reliable/ trustable	Parlar & Perry (1996)
Consumer	When the consumer is not known/ defined	Fox et al. (1998) ; June et al. (2004)
Competition	When competition is not defined / known	June et al (2004)

Culture	When culture is not known/	Milliken (1987)

It is possible that several uncertainties that can be perceived by an individual in a product development team, but other uncertainties were not considered for this research. This framework was used as a base for the data analysis.

In this framework the activities already mentioned were also included was basis for the analysis, as being the clusters: activities related to information, as information seeking and knowledge sharing; activities related to the product as representation and simulation; and activities related to the project as contingency planning.

RESEARCH DESIGN

To understand the perceived uncertainties of individuals in the project teams and their influence on the activities, a case study with two interconnected projects was performed. We were aiming to see different types of uncertainties and how they different influence the activities in two contexts therefore we are using in-depth case with a projects comparison (Eisenhardt & Graebner, 2007). The projects comparison enables a broader exploration of the research´s objective and also creates more robust theory, since it is grounded in diverse empirical evidence.

The case study was based in a high technology sector company dealing with consumer electronic products. A qualitative approach was used with semi-structured in-depth face-to-face interviews with individuals from two projects' team. Project 1 was a Platform based project that had as a characteristic only the early phases, the core team had 15 people and 8 were interviewed. Project 2 was a New Product Development project that developed one of the possibilities explored on the Project 1 and had a core team of 30 people, where 20 were interviewed. Follow up interviews were made to achieve data saturation.

On the interviews the individuals were asked about the uncertainties encountered in the projects and their response to it, asking for examples of the activities taken to mitigate those uncertainties. The interviews were about 30 minutes each, individual, confidential, and aimed at mapping the different uncertainties across the projects and map the activities.

This approach is related to prior works in R&D journal (Schneckenberg, Velamuri, Comberg, & Spieth, 2016), where similar works exploring uncertainty used a similar design and as we are still on the stage of exploring, this approach is the appropriate.

In addition to the interviews, secondary data was gathered from field notes of the researcher being in the company for 4 months, together with the analysis of formal documentation on process structure and activities in the company as projects reports.

The interviews were recorder, transcribed using Atlas ti. Software, we them applied grounded analysis in order to identify the uncertainty types (Yin, 2004) and after they were contrasted with literature in order to organize the final framework. In order to final access data validity and reliability the results were presented back to the company where they also agree with the interpretations and results.

FINDINGS

For a better understanding of the analysis, the projects were analysed together. The overall map of the perceived uncertainties is presented on the first section followed by the overall map of the activities.

Case context

The case focused on two product development projects. The first project was a NPD project aiming on developing a high technology consumer product and the second project was a Platform based project which aimed at developing a family of high technology consumer products based on a platform base.

Uncertainty perception

A major finding was the overall mapping of the uncertainties, which made possible to visualize the wide range of uncertainty types that were perceived in both projects by individuals in the development team. This map demonstrates how the innovative product development projects´ reality is extremely uncertain, complex, and challenging for the development team to deal with all those different perceived uncertainty types in a satisfactory way for the project. The individual can perceive uncertainties related to his own expertise but also related to other factors as environmental uncertainties and market uncertainties are inherit in these projects.

The key findings were that for Project 1 the mapping of the perceived uncertainties were related to product, technology, process, schedule, information, communication, consumer, roles and finance and for Project 2 the overall mapping of the perceived uncertainties were related to all the uncertainties presented on Table 1. Since the projects are related to technology development and innovation, the quotes were anonymized as they mention key features of the product.

In Project 1, as the nature of the project was a platform based but only with the early phases, the communication uncertainties echoed on the product development as it can be illustrated on the quote: "*yeah it should be doing this and that but how it should look like, what should the variants must be…oh no one know because hey guys come up with your suggestions and discuss with your counter partner on the other side of the wall doing some other stuff, how can your feature, how can your functionality combine with what the other guys are doing or what are the boundaries around you and what you are doing .So, say what you do, what kind of requirements does that put to other, we may team to do a product...*" (Manager, project 1). The communication between the departments is crucial in a project and this difficulty in communication can have negative effects since what one department does can directly affects another department, making the project development more complex and stressful for the individuals in the team. The difficulties of alignment and communication from the beginning of the project affected the whole project development and also its result in overall by leaving individuals from the team with a feeling that they did not completely fulfilled the projects potential, since the communication uncertainties affected the flow of the project by making the team spend more time in tasks and aligning communication late in the process. The perceived uncertainties in this project made it more complex and difficulty to mature the technologies that were being researched by the team, making the project advanced for some departments that were able to better deal with them, but not enough for other departments that needed more time, resources and better communication to deal with them. It also made the team leave incomplete tasks when the project finished, giving a frustration feeling, and making Project 2 inherit uncertainties that could have been dealt in a satisfactory way by the team.

In Project 2 the majority of the uncertainties were related to the product and to technology. When developing the product, the features were a key concern of the team and it involved both, the product uncertainty as being related to the product´s characteristics and also the technology since it was a technology innovation product. This can be illustrated by a quote by an engineer in project 2: "*we have been lacking a little bit the foundation to really understand from the very beginning if we, you know, will the [key feature] survive, or will we have enough [key feature] power, will we have..*

you know whatever, what will the [feature characteristic] levels be, will it be enough if we have this much, you know, we really didn´t know for sure, for course we did have some references on some of the parameters…" (engineer, project 2). This uncertainty was inherited from the previous project and it affected the project schedule, once the individuals has to take time to better understand, study and test the features, and the technology uncertainty had an impact on the team's confidence into developing the product, since they could not affirm that the features would be able to be developed in the schedule of the project. This uncertainty also affected the departments involved in the project, as more than one department can be affected by a specific feature, and one feature can affect the other, which made the departments better align their communication and work closely to each other. This uncertainty also had an impacted on the development of the products parts, as they ended up being out of synchronization: *"…we have 3 different units, actually, the [key feature], left and right parts, and they are not synchronized at this point, regarding alfa and prototyping and so one. The [key feature] we haven't had a prototype one yet, even though we have alfa 2 on the left and alfa 1 on the right so, they are in different stages and all we don't have a combined unit at this point..." (User experience designer, project 2).* This quote shows that the team had to deal with the uncertainty affected the product that was not being developed as a whole but as separated parts and that these parts may not work with each other, which affected not only the schedule of the product development but also the confidence of the team in finishing the project on time. The technology and product uncertainties had impact through the whole development team in different departments driving a lack of confidence in the project´s result, which made individuals to feel frustrated with the development and the product, feeling that they could have done more features and in a better way. Also, it result into a schedule tightness, once that for dealing with these uncertainties, several activities were triggered and they took a longer time than expected, together with communication issues that resulted in delay in the project and the product launch.

Contrasting both projects it's possible to recognize that individuals in the projects´ team perceive several types of uncertainties in the project development, which can make their activities more complex and challenging. Project 1 perceived less uncertainty types that Project 2 related to the product, which can be due to the nature of the project, once Project 1 only had the early phases of the Platform based project. Although being different project types, with different focus and results, they share similar types of perceived uncertainties. This can be due to the fact that both are related to the development of technological products and as being in the same company, the team can perceive similar uncertainties even being in different projects' types. Furthermore, even though Project 2 followed Project 1 the several uncertainties from the same type were perceived in both projects, even if being related to specific things to the project itself. This could have been influenced by the activities that were triggered by the uncertainties that drove new uncertainties from the same cluster or from different clusters or even those uncertainties that were not dealt with satisfaction by the individuals can be inherited by the next project. This shows the importance of the individuals dealing with the perceived uncertainty until they are satisfied with the outcome, so they do not have a domino effect later in the project or even on a next project, especially when the first project is a Platform based project that will develop a family of products where all of them can be affected by these uncertainties.

An additional key finding was the uncertainties sets, which happen when more than one uncertainty is perceived together by the individual. A wide range of uncertainties sets can be perceived in a same cluster or between clusters. Uncertainties sets were perceived in both projects in challenging situations, when the individual feel lost and out of focus. A quote by a manager from Project 1 illustrate this situation: "*…what was…should the focus be in the project, the scope, focusing on what...uncertainty around the method, if it was actually something that ended up in anything doable, what were the work that we were doing, were there customer for it…uncertainty*

around who we had on board, what the roles were in the project...." (Manager, project 1). These uncertainties were perceived in the beginning of the project and influenced the whole project´s flow, since in the beginning of the project the focus was not clear for the individuals, the team had a feeling of confusion throughout the project. This difficulty into understanding and making the project focus clear led to communication uncertainties, lack of alignment and frustration. This uncertainty set illustrated by the quote is basically the parts of the description of the project and its basic characteristics as: focus, method, costumer and roles, and being perceived together it shows that the project basics are not well established and understood by the team or managers. This affected the team´s work, communication, collaboration between departments and its overall result, once the individuals could not see the final objective of the project or their roles in it. The projects´ nature were significant for the uncertainties sets to be perceived by individuals, once they are both projects dealing with development of innovative products it is expected to have uncertainties perceived by the team in routine activities as single uncertainties.

Single uncertainties can affect the product or the project by making it more challenging for the individuals in the team and can even have a domino effect later in the project, which makes them key to deal with, but the uncertainties sets are a "make or break" situation, which makes them vital to deal for the project´s survival. They escalate once they are perceived, by making the individual feel discourage, frustrated, lost in the project and can lack the motivation for the project development, which can influence a project´s failure, once the project is not well understood by the team, developing and achieving its result becomes truly challenging. This shows the importance of dealing as soon as the sets are perceived especially if they are related to basic aspects of the project and by dealing early with them it is possible to mitigate their "make or break" effect into the individuals and the project. Dealing with them early and in a satisfying manner can also make the individuals develop and improve new skills, gather more information and be more active in the project development, making the project stronger and the individuals more driven into make the project a success once they understand the project´s outcome and know clearly their role in it.

Activity selection based on uncertainty perception

The data and the analysis made possible to see that for each uncertainty type or cluster a different activity or activities sets were triggered by the individual. These activities can be related to three key aspects: information, product and project. The activities related to information can be characterized as information seeking and knowledge sharing, the ones that can be related to the product are representation, testing, and the last ones are associated to the project as for example contingency planning. The mapped activities from both projects are synthesized in Table 2 with the uncertainty types and clusters. It is relevant to notice that there are uncertainties types that were not mapped in both projects, therefore there are no activities mapped for them.

Table 2: Mapping of triggered activities related to the perceived uncertainties

Uncertainty Type	Platform based project activities	New product development project activities
Product	Qualitative and quantitative research of opportunities from different customers segments; studying the features; reading; searching;	Build the simplified model, simulate; answering to a lot of questions; verify the concept; tests; user interaction , ask question; sent to the second review; presented in a meeting to stakeholders;
Design	Not applied / mapped in this	Different iterations of the design and

	project	modifying it; to conduct workshops; to simplify as much as possible in the images;
Requirements	Not applied / mapped in this project	Check own earlier products, what's on the market, what have was done earlier, what challenges did have earlier;
Parameters	Not applied / mapped in this project	Prototype; research
Quality	Not applied / mapped in this project	Simulations
Technology	Feasibility studies	Simulations; present it to project leader, team and manager; verified and check;; testing
Process	To move targets; prompting, measuring, talking, listening;	Feedback;
Schedule	Book further in the calendar	Violating the means of the process model; contingency planning
Information	Context mapping; street interviews, ideation and concepting ; evaluation :gather the data in house; quantitative insights, online surveys	Review meeting; bringing some stakeholders from different departments; waiting for information;
Communication	Talk to people to make sure the communication lines are open;	Check with other departments; research with people from other departments; talking with the people on a daily basis
Consumer	User case looking at the end user; personas build; studying the market	Use of information from Project 1
Culture	Not applied / mapped in this project	Regional launching
Competition	Not applied / mapped in this project	Check competitors' products;
Supplier	Not applied / mapped in this project	Trying to fix it, and sharing information with the company; email and visiting ; cooperation together with the supplier
Roles	Discussions; meetings	Discussions; meetings
Budget	Waiting for the project to finish	Phase shift

Analyzing the results, it is possible to see that the activities triggered by the perceived uncertainties in Project 1 were more related to information like information seeking as research, studying, reading and feasibility studies, also related to knowledge sharing as meetings and discussions. This can be related to the specific nature of the project and the aim of it, since it was focused only on the early phases of the Platform building project, which is linked with research possibilities. On Project 2, the activities triggered by the perceived uncertainties are more related to the product, like simulation and testing, which can also be connected to the project´s nature and objective which as an NPD aiming to launch an innovative product.

The mapping made it possible to see that many departments deal with the same uncertainty type but have different focus areas, therefore the activities have different objectives. It is interesting to notice how the same uncertainty type can trigger different activities and different activity types, which makes impossible to have a recipe for dealing with each uncertainty type with a specific activity. One example of this case is when dealing with product uncertainty in project 2, the activities are related to the product itself as representation and simulation but also related to information as knowledge sharing. This demonstrates show activities related to different aspects can be complimentary to each other in order for the individual to deal with the perceived uncertainty. It is relevant to consider that the activities can be influenced by the individual expertise and department as well as by other perceived uncertainties that were not mapped and also by several other variables that were not considered in this research.

By contrasting the projects, it is possible to notice two trends: the first is the different activities types, which can be seen when also focusing on the product uncertainty, on Project 1 the activities are related to information as information seeking, exemplified by the qualitative and quantitative research and reading, and in Project 2 there is this mix of activities related to information and related to the product. This can be due to the nature of the projects, since project 1 has as objective to have platform base products, it is on its nature to be more related to research, on the other hand, project 2 is a NPD project, being focused on developing the product, therefore it is expected to have more activities related to the product as simulation, testing and representation than in project 1. The second is the same activities types, focusing on the perceived uncertainty related to roles in the projects, it is possible to see that they were dealt with the same activities types in both projects, showing that in spite having a specific roles and designations in the project, individuals still do not have confidence in the role assignment and definition. This demonstrates how it is not possible to affirm that a specific uncertainty will trigger only a specific activity type in the project.

When focusing on the perceived uncertainty sets, in Project 2, there was a set of design and roles uncertainty, that can be illustrated by this quote: This product uncertainty drove a role uncertainty in the project "*the [key feature] was pretty difficult to close in way because we had to figure out who was in charge of for all that thing and take decision and so on, so that was a big talk about, or debate about the whole design of the [key feature] as some departments had opinions, and it was not easy to close that one." (*User experience designer, project 2). In this case, a design uncertainty that when perceived by itself in project 2 was dealt with representation, but when it is perceived as a set together with roles uncertainty is dealt with meetings and discussions, shifting the activity type from product to information. This specific uncertainty set and triggered activities set were vital to the project and influenced in the project scheduling causing a delay on the final product delivery. Also, it generated a discussion in the project team on roles and decision making when a feature can have influence on several different departments, causing difficulties in alignment. This illustrates that an uncertainty set can have a different activity type triggered than when the uncertainty is perceived by itself, and the activities triggered by the set can have key importance in the project once they can mitigate the effect of the set or not, bringing more challenges to the project.

The overall activities mapping made possible to see that even though activities were triggered by the perceived uncertainties in project 1, and these uncertainties were dealt by the individuals, the same uncertainty types came back in project 2, minding that project 2 followed project 1. It is possible that as being projects with different nature, the uncertainties came back with a different sphere of the uncertainty, and were in different departments, but also these uncertainties were inherited by project 2, showing that even when an individual deals with the perceived uncertainty in a manner that he can find satisfactory, this uncertainty can still be perceived by the same individual or by a different individual in the project team or across projects.

DISCUSSION AND CONCLUSIONS

This research generates three main contributions in terms of mapping uncertainties and triggered activities. The first is the existence of multiple perceived uncertainties interacting in both project types and their impact on activities. The second is the uncertainty sets situations, which have a major role in the project in contrast to the single uncertainties situations, and has significant impact in the product development projects and their performance, echoing also in the triggered activities. The third is the triggered activities which are different for single uncertainty type situations and uncertainty sets situations.

Analyzing the results, it is interesting to see that in spite most literature focus on one type of uncertainty, in this study the individual perceived several types in both projects occurring during the whole project. This result agrees with the literature by showing the uncertainties perceived within the project (Muffatto & Roveda, 2000; Robertson & Ulrich, 1998; Stockstrom & Herstatt, 2008) and also from outside it, as environmental uncertainty (Huang et al., 2015; June et al., 2004; Kreye et al., 2011; Parlar & Perry, 1996). These uncertainty types can be affect the product development and the project´s flow, by making it more challenging for the individuals. These results contributes to the literature by showing a broader view of the multiple perceived uncertainties that are perceived by the individuals in the development teams and how they can influence the project performance, also by demonstrating how the several uncertainties enhance the challenges in the project when perceived single, but they can also be perceived in sets. To practice, it demonstrates that managers should be aware that the uncertainties perceived by individuals in one project team and the level of success in dealing with them can be reflected not only in the current project performance but also in the following projects.

Uncertainties have been previously seem in literature as sets of two, as for example market and technology, market and customer, market and competitors (Fox et al., 1998; Huang et al., 2015; Olausson & Berggren, 2010). However, it was possible to see that these sets are more complex and can have multiple uncertainties combinations in a situation, associated with new product development and high technology companies (Huang et al., 2015; Olausson & Berggren, 2010; Sicotte & Bourgault, 2008).These sets are different from a single uncertainty. Single uncertainties can have major effects in the project, but the uncertainty sets are “make or break” situations in the project, being vital to be perceived early in the project and be dealt satisfactorily. They affect the individual´s confidence in the project development by making they feel frustrated and lost. It also affects the projects performance since the uncertainty set drives a paralyzing situation in the project requiring extra meetings and discussions to be dealt with and involved several departments and managers (Olausson & Berggren, 2010). These sets still affected the triggered activities once they were shift from being more practical activities as simulations for being more information activities as for meetings, discussions and decision making in the team, which increase the uncertainty once each individual perceive uncertainty differently (Daft & Lengel, 1986; Dewberry et al., 2013; Hult et al., 2004; Olausson & Berggren, 2010; Sicotte & Bourgault, 2008; Stockstrom & Herstatt, 2008).These results contributes to the literature by showing that the uncertainty sets incorporate several uncertainty types and can have a wide range of combinations with numerous uncertainties interacting in critical situations. For practice, it shows to managers that when an uncertainty set is perceived by an individual in the development team, it demonstrates a critical situation in the project and major actions should be taken in order to strengthen the project´s focus and secure its performance.

Previously literature have described uncertainty and activity in a one to one relationship where, for example technological uncertainty triggers development activities (Song & Montoya-Weiss,

2001), however the results show that this relationship is varied and it varies in terms of where its occurring in the project and also in terms of the others uncertainties involved in that moment. Activities related to information, product and project were triggered to deal with the perceived uncertainties by acquiring, sharing, simulating and testing the knowledge (Daft & Lengel, 1986; Hult et al., 2004; Stockstrom & Herstatt, 2008). The results made possible to see two trends: the first is the different activities types triggered by the same uncertainty type across projects, particularly when focusing on product uncertainty that was inherited over time in the first instance it triggers activities related to information and then a different activity type, related to product, on the second round. On the other hand the second is the same activities type triggered by the same uncertainty type across project, as for example roles uncertainty triggered information related activities in both projects. These results contribute to the literature by showing how the uncertainty and activity relationship is varied and is related to other variables in the project. For practice, it shows that the companies can not focus on a certain strategy when perceiving an uncertainty, they have to consider other factors as for example where it is the process.

LIMITATIONS AND OUTLOOK

This research was qualitative based and has the intrinsic limitations of the chosen method and similarly by the project types that were researched. It is also limited by having a retrospective approach. It is interesting to notice that it is possible that the uncertainties can trigger different activities depending to when in the project they are perceived. This research focused on the Platform base project, as not having specific phases and the early phases of the NPD project, since they are the ones with most perceived uncertainties. Additional limitation is that activities are impacted by a range of different uncertainty types and other variables, which makes it is not possible to map all of them in the research.

Uncertainty is still a mysterious variable (Sicotte & Bourgault, 2008) and future studies suggestions would include the study on the uncertainties and triggered activities on different difficulty levels of project and product development. It would also be interesting to understand how the perceived uncertainty types and triggered activities change during the project and team role (managers and technical team).

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