Chapter 1
Flow for Presence Questionnaire

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Abstract This chapter discusses the development of a new questionnaire for measuring Presence and Flow state of the users of technological devices. The human factors are the fundamentals of the EC-funded project DiFac and the Presence measurement is one of those. Presence is the sense to be immerses in a synthetic environment any nature it has. The questionnaire is an innovative instrument to detect the level of Presence sensation and the quality of the experience whenever it approaches the Optimal state. This chapter presents the methodology and the possible approach of the Flow for Presence questionnaire in an industrial environment explaining how this methodology can evaluate the well-being of humans in the factory. The application on the Factory Constructor underlines the industrial benefits of this project result.

1.1 Introduction

The industrial world is managed in a precise way by using measurable factors and indicators. An enterprise looks for precise markers as numbers indicate, for example, the production rate or the increasing factor for coping with market needs or others exact ratings. This chapter presents the definition of Presence, one of the human factors base of the European DiFac project and its application in industrial field. Being Presence a psychological concept, there are various definitions of this concept and no one is better than the others, but all of them are good depending of the point of analysis. During the project, a questionnaire was developed for

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measuring the Presence level of a virtual environment (VE) and in addition the Flow state. *Flow* is a subjective state that people report when they are completely involved in something to the point of forgetting time, fatigue, and everything else but the activity itself.

The questionnaire itself is an innovative step forward in the Presence measurement linked with Flow, and this chapter shows how the results could be immediately useful for people who do not have specific knowledge in psychological fields.

The text finally presents an application with the VE called Factory Constructor (FC) one of the results from European DiFac presented in details in Chap. 10 of this book.

1.2 Presence

1.2.1 Presence: A First Definition

The term "*Presence*" entered the general scientific debate in 1992 when Sheridan and Furness used it in the title of a new journal dedicated to the study of virtual reality (VR) systems and teleoperations: *Presence, Teleoperators and Virtual Environments.* In the first issue, Sheridan clearly refers to Presence as an experience elicited by technology use (Sheridan 1992, pp 123–124): the effect felt when controlling real-world objects remotely as well as the effect people feel when they interact with and immerse themselves in VEs.

A first definition of "Presence" is introduced by the International Society of Presence Research (ISPR). ISPR researchers define "Presence" (a shortened version of the term "telePresence") as:

> A psychological state in which even though part or all of an individual's current experience is generated by and/or filtered through human-made technology, part or all of the individual's perception fails to accurately acknowledge the role of the technology in the experience. (International Society for Presence Research 2000)

Nevertheless, the above definition has two limitations. First, what is Presence for? Why do we experience Presence? As underlined by Lee (2004):

> Presence scholars, may find it surprising and even disturbing that there have been limited attempts to explain the fundamental reason why human beings can feel Presence when they use media and/or simulation technologies. (p 496)

Second, is Presence related to media only? As commented by Biocca (1997) and agreed by most researchers in the area:

> While the design of virtual reality technology has brought the theoretical issue of Presence to the fore, few theorists argue that the experience of Presence suddenly emerged with the arrival of virtual reality. (http://jcmc.indiana.edu/vol3/issue2/biocca2.html)

Recent insights from cognitive sciences suggest that Presence is a neuropsychological process that results in a sense of agency and control (Riva 2006, 2007; Riva et al. 2008). For instance, Slater suggested that Presence is a selection mechanism that organizes the stream of sensory data into an environmental gestalt or perceptual hypothesis about current environment (Sanchez-Vives and Slater 2005; Slater 2002).

Within this framework, supported by ecological/ethnographic studies (Gamberini and Spagnolli 2003; Gibson 1979; Mantovani and Riva 1999, 2001; Riva et al. 2004; Spagnolli and Gamberini 2005; Spagnolli et al. 2003; Waterworth and Waterworth 2006), any technology, virtual or real, does not provide undifferentiated information or ready-made objects in the same way for everyone. It offers different opportunities and creates different levels of Presence according to its ability in supporting the users' intentions.

1.2.2 Presence: A Second Definition

Recent findings in cognitive science suggest that Presence is a neuropsychological phenomenon, evolved from the interplay of our biological and cultural inheritance, whose goal is the enaction of volition: Presence is the *perception of successfully transforming intentions into action (enaction)*.

Recent research by Haggard and Clark (Haggard and Clark 2003; Haggard et al. 2002) on voluntary and involuntary movements provides direct support for the existence of a specific cognitive process–binding intentions with actions. In their words:

> Taken as a whole, these results suggest that the brain contains a specific cognitive module that binds intentional actions to their effects to construct a coherent conscious experience of our own agency. (Haggard et al. 2002, p 385)

Varela et al. (1991) define "*enaction*" in terms of two intertwined and reciprocal factors: First, the historical transformations that generate emergent regularities in the actor's embodiment; second, the influence of an actor's embodiment in determining the trajectory of behaviors. As suggested by Whitaker (1995), these two aspects reflect two different usages of the English verb "enact." On one hand is "to enact" in the sense of "to specify, to legislate, to bring forth something new and determining of the future," as in a government enacting a new law. On the other hand is "to enact" in the sense of "to portray, to bring forth something already given and determinant of the present," as in a stage actor enacting a role. In line with these two meanings, Presence has a dual role:

- First, *Presence "locates" the self in an external physical and/or cultural space:* the Self is "present" in a space if he/she can act in it
- Second, *Presence provides feedback to the Self about the status of its activity*: the Self perceives the variations in Presence and tunes its activity accordingly.

First, we suggest that the ability to feel "present" in the interaction with a technology—an artifact—basically does not differ from the ability to feel

"present" in our body. Within this view, "being present" during agency means that (1) the individual is able to successfully enact his/her intentions (2) the individual is able to locate himself/herself in the physical and cultural space in which the action occurs. When the subject is present during a mediated action (that is, an action supported by a tool), he/she incorporates the tool in his/her peripersonal space, extending the action potential of the body into virtual space (Clark 2003). In other words, through the successful enaction of the actor's intentions using the tool, the subject becomes "present" in the tool.

The process of Presence can be described as a sophisticated but covert form of monitoring action and experience, transparent to the self but critical for its existence. The result of this process is a sense of agency: The feeling of being both the author and the owner of one's own actions. The more intense the feeling of Presence, the higher the quality of experience perceived during the action (Zahoric and Jenison 1998). However, the agent directly perceives only *the variations* in the level of Presence: *breakdowns* and *optimal experiences* (Riva 2006).

Why do we monitor the level of Presence? The hypothesis on which the questionnaire is created is that this high-level process has evolved to control the quality of action and behaviors.

According to Csikszentmihalyi (1975, 1990), individuals preferentially engage in opportunities for action associated with a positive, complex, and rewarding state of consciousness, defined by him as "optimal experience" or "Flow." The key feature of this experience is the perceived balance between great environmental opportunities for action (challenges) and adequate personal resources in facing them (skills). Additional characteristics are deep concentration, clear rules and unambiguous feedback from the task at hand, loss of self-consciousness, control of one's actions and environment, positive effect, and intrinsic motivation. Displays of optimal experience can be associated with various daily activities, provided that individuals perceive them as complex opportunities for action and involvement (the concept is further explained in the following dedicated paragraph). An example of Flow is the case where a professional athlete is playing exceptionally well (positive emotion) and achieves a state of mind where nothing else is important to but the game (high level of Presence). From the phenomenological viewpoint, both Presence and Flow are described as absorbing states, characterized by a merging of action and awareness, loss of self-consciousness, a feeling of being transported into another reality, and an altered perception of time. Furthermore, both Presence and optimal experience are associated with high involvement, focused attention, and high concentration on the ongoing activity.

1.2.3 The Presence Levels

How can we achieve a high level of Presence during interaction with a technology? The answer to this question requires a better understanding of what intentions are.

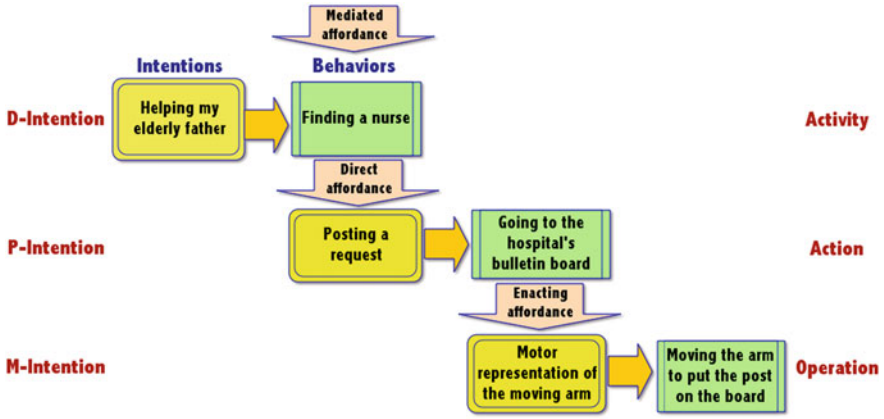

Fig. 1.1 The intentional cascade

According to folk psychology (Folk psychology is interpreted as a theory when the "common sense" perceptions of one's daily life, such as those of pain, pleasure, excitement, anxiety, etc., are interpreted as principles used to explain mental states), the intention of an agent performing an action is his/her specific purpose in doing so. However, the latest cognitive studies clearly show that any action is the result of a complex intentional chain that cannot be analysed at a single level (Pacherie 2006, 2008; Searle 1983).

Pacherie (2006, 2008) identifies three different "levels" or "forms" of intentions, characterized by different roles and contents: distal intentions (D-intentions), proximal intentions (P-intentions), and motor intentions (M-intentions):

- *D-intentions (future-directed intentions)*: These high-level intentions act as both intrapersonal and interpersonal coordinators and as prompters of practical reasoning about means and plans: "Helping my elderly father" is a D-intention, the object that drives the activity "finding a nurse" of the subject (see Fig. 1.1).
- *P-intentions(present-directed intentions)*: These intentions are responsible for high-level (conscious) forms of guidance and monitoring. They have to ensure that the imagined actions become current through situational control of their unfolding: "Posting a request for a nurse" is a P-intention driving the action "going to the hospital's bulletin board (see Fig. 1.1).
- *M-intentions (motor intentions)*: These intentions are responsible for low-level (covert) forms of guidance and monitoring: We may not be aware of them and have only partial access to their content. Furthermore, their contents are not propositional: In the operation "putting the post on the board" (see Fig. 1.1), the motor representations required to move the arm are M-intentions.

Any intentional level has its own role: *The rational (D-intentions), situational (P-intention) and motor (M-intention) guidance and control of action.* They form an intentional cascade (Pacherie 2006, 2008) in which *higher intentions generate lower intentions.*

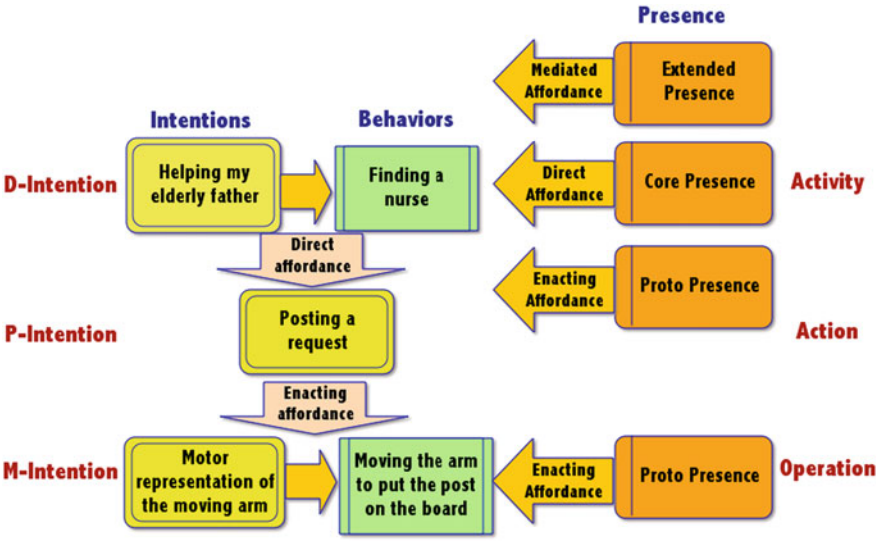

Fig. 1.2 Activity and Presence

We previously defined Presence as *the perception of successfully transforming intentions into action (enaction)*. However, even if we experience a single feeling of Presence during the enaction of our intentions, the three-level structure of the intentional cascade suggests that Presence, on the process side, can be divided into three different layers or sub-processes (for a broader and more in-depth description, see Riva 2008; Riva et al. 2004), described in Fig. 1.2:

- *Extended presence(D-intentions/activities)*: The role of "Extended Presence" is to *verify the relevance to the Self of possible/future events in the external world (Self vs. possible/future external world)*. The more the Self is able to identify mediated affordances (that cannot be enacted directly) in the external world, the higher the level of extended Presence will be.
- *Core presence (P-intentions/actions)*: This can be described as *the activity of selective attention made by the Self on perceptions (Self vs. present external world)*. The more the Self is able to identify direct affordances (that can be enacted directly with a movement of the body) in the external world, the higher the level of core Presence will be.
- *Proto presence (M-intentions/operations)*: This is the process of internal/external separation *related to the level of perception–action coupling (Self vs. non-Self)*. The more the Self is able to use the body for enacting direct affordances in the external world, the higher the level of proto Presence will be.

As underlined by Dillon et al. (2003), converging lines of evidence from diverse perspectives and methodologies support this three-layered view of Presence. In their analysis, they identify three dimensions common to all the different perspectives, relating to a "spatial" dimension (M-intentions), a dimension

relating to how consistent the media experience is with the real world, "naturalness" (P-intentions), and an "engagement" dimension (D-intentions).

The role of the different layers will be related to the complexity of the activity done: The more complex the activity, the more layers will be needed to produce a high level of Presence (Fig. 1.2).

At the lower level, operations, proto Presence is enough to induce a satisfying feeling of Presence. At the higher level, activity, the media experience has to support all three layers.

As suggested by Juarrero (1999), high-level intentions (future intentions/objects) channel future deliberation by narrowing the scope of alternatives to be subsequently considered (cognitive reparsing). In practice, once the subject forms an intention, not every logical or physically possible alternative remains open. Once I decide to do "A," "non-A" is no longer an alternative and I will consider "non-A" as a breakdown (Bratman 1992).

1.2.4 Presence Measurements

Sheridan (1996) presents the concept of Presence as "natural (expected) responses of human and environment to each other." This concept merges into the idea of assessing physical responses by movement or sound into a measure of presence, for example, would the human react to a loud noise or swift movement in a VE as they would in the real world? The measure of reflexive responses as an indicator of presence is studying the response of the subject in comparison with a real-life reflex response, for example, avoiding an object which is coming towards the face (explored in Nichols et al. 2000). It has been suggested that this indicates a feeling of presence as the participant reacts to the situation as he or she would in the real world suggesting he or she feels to some extent that he or she is "there" in the virtual world.

Barfield and Weghorst and Billinghurst (1993) acknowledged the need for a set of metrics that can be used to measure performance within VEs and to quantify the level of presence experience by participants of virtual worlds. They suggested as potential indicators of presence virtual world task performance, subjective assessment and degree of disorientation to be considered conclusive. Within this chapter, it is noted that subjective rating of Presence is not entirely dependable but is used in lieu of a suitable and more reliable alternative because it provides a good initial indicator for initial exploration. Alternative "more robust" metrics that are being developed and researched are commented on, for example, physiological indicators, such as posture, muscle tension, and cardiovascular responses to virtual events, such as heart rate evoked by looming of virtual objects. It was also noted that speed and accuracy on tasks performed solely within the VE might also be influenced by the sense of virtual presence. The possibility of using a secondary task method for measuring Presence similar to that used to measure mental workload is considered, where the quality of performance of the secondary task is an indication of the Presence experienced by the subject (i.e., poor performance

indicates high Presence as resources are concentrated on the environment not the secondary task).

Bystrom et al. (1999) present the Immersion, Presence, Performance model for the measurement of Presence. It provides a guide determining the factors that influence Presence, aid research into the relationship between immersion, presence, and performance in VEs, and help designers of virtual worlds select appropriate display features when they design VEs. *Immersion* in this case is defined as: The quantifiable aspect of display technology, primarily determined by the extent to which displays are

- Inclusive, stimuli from the real world is excluded from the user
- Extensive, the number of sensory modalities accommodated by the system
- Surrounding, how panoramic the displays are, and
- Vivid, the resolution of the displays

Slater and Wilbur (1995) argue that a sense of presence in a VE will contribute to user behavior that closer matches real-world behavior, such as reflex responses to suitable stimuli. For example, when an object looming towards the user's head and he or she moves his or her head avoiding obstacles even though intellectually he or she knows the object do not actually exist.

Freeman (1999) assesses Presence by using a hand-held slider, and participants were asked to continually rate their feelings of Presence with continually changing display stimulus.

In Kalawsky et al. (1999), it is suggested that the evaluation of Presence involves the following measures:

- *Objective measures*: task demands, task results, correlated measures (e.g., error numbers, achieved task levels, etc.)
- *Subjective measures*: on-line evaluations, post-test evaluation, questionnaires, explanation of high stress
- *Physiological measures*: heart rate, blood pressure, respiration rate, ECG
- Task performance evaluation
- Learning efficiency

Although a combination of all these measures may provide the most comprehensive measure of the concept of presence that can be achieved, realistically it is not possible to measure all these variables with respect to every system. Being one of the DiFac objectives to have a methodology easy to be used, the selected measurement was a questionnaire. The Flow for Presence Questionnaire (FPQ) is presented in the following paragraph.

1.3 Flow

Why do people perform time-consuming, difficult, and often dangerous activities for which they receive no discernible extrinsic rewards? This was the question that originally prompted Csikszentmihalyi and his companions into a program of research

that involved extensive interviews with hundreds of rock climbers, chess players, athletes, and artists (Csikszentmihalyi 1975; Nakamura and Csikszentmihalyi 2002). The conclusion was that in all the studied groups, the interviewees reported a very similar subjective experience: They enjoyed it so much that they would like to repeat it further times. This was denominated the *flow experience*, because in describing their feelings when the activity was going well, several respondents used the metaphor of a current that carried them along effortlessly.

Flow is a subjective state that people report when they are completely involved in something to the point of forgetting time, fatigue, and everything else but the activity itself. It is what we feel when we read a fascinating novel or play a good game of your favorite sport or take part in a stimulating conversation. The defining feature of flow is intense experiential involvement in moment-to-moment activity. Attention is fully invested in the task at hand, and the person functions at his or her fullest capacity.

1.3.1 Flow Characteristics

The intense experiential involvement of flow is responsible for three subjective characteristics commonly reported:

The merging of action and awareness

During the flow state, the attention resources are fully invested in the task, so that objects beyond the immediate interaction generally fail to enter awareness.

One of these objects is the self. Respondents frequently describe a loss of self-consciousness during flow. Without the required attention resources, the usual dualism between actor and action disappears. As Mead (1934) proposed, the "me" disappears during flow, and the "I" takes over.

A sense of control

During flow, the typical experience is a great sense of control or, more precisely, a lack of anxiety about losing control. This sense of control is also reported in activities that involve serious risks, such as hang gliding, rock climbing, and race car driving. The described sense of control is in fact the possibility, rather than the actuality, of control.

Worrying about whether we can succeed at what we are doing (any activity we are performing) is one of the major sources of psychic entropy in everyday life, and its reduction during optimal experience is one of the reasons why the experience becomes enjoyable and rewarding.

An altered sense of time

During flow, attention is so fully invested in moment-to-moment activity that there is little left over to devote towards the mental processes that contribute to the

experience of duration (Friedman 1990). As a result, persons deeply immersed in an activity typically report time passing quickly (Conti 2001).

1.3.2 Flow Measurement

Conventional Flow research has adopted two main methodologies: The flow questionnaire, which explains the concept and asks respondents to describe similar previous experiences, and the Experience-Sampling Method (Larson and Csikszentmihalyi 1983), which interrupts respondents at random time intervals.

The flow questionnaire (Csikszentmihalyi 1982; Delle Fave and Massimini 1988) contains three standard descriptions of Flow derived from Csikszentmihalyi's earlier research. The three quotations, which are also used in this research, are:

1. My mind isn't wandering. I am not thinking of something else. I am totally involved in what I am doing. My body feels good. I don't seem to hear anything. The world seems to be cut off from me. I am less aware of my problems and myself.
2. My concentration is like breathing. I never think of it. I am really oblivious to my surroundings after I really get going. I think that the phone could ring, and the doorbell could ring, or the house burn down or something like that. When I start, I really do shut out the whole world. Once I stop, I can let it back in again.
3. I am so involved in what I am doing, I don't see myself as separate from what I am doing.

In the Flow questionnaire, respondents were presented (in a self-completion questionnaire) with the three descriptions and asked whether they could recall similar experiences. They were then asked to describe these experiences and to rate associated feelings, e.g., level of involvement, effort, anxiety, etc. This methodology depends on respondents recognizing the flow descriptions and relating them to their own previous experiences.

1.4 How to Design Technologies that Foster Presence and Flow

This perspective allows us to predict under which mediated situations the feeling of Presence can be enhanced or reduced.

First, minimal Presence results from an almost complete lack of integration of the three layers discussed in paragraph 4.2.3, such as is the case when attention is mostly directed towards contents of extended consciousness that are unrelated to the present external environment (e.g., I'm in the office trying to write a letter but I'm thinking about how to find a nurse for my father). By the same reasoning, maximal Presence arises when proto Presence, core Presence, and extended

Presence are focused on the same external situation or activity (Waterworth and Waterworth 2006). Maximal Presence thus results from the combination of all three layers with a tight focus on the same content. The concepts described above are summarized by the following points:

1. *The lower the level of activity, the easier it is to induce maximal Presence*: The object of an activity is wider and less targeted than the goal of an action. So, its identification and support are more difficult for the designer of an advanced technology. Furthermore, the easiest level to support is the operation. In fact, its conditions are more "objective" and predictable, being related to the characteristics (constraints and affordances) of the artifact used: It is easier to automatically open a door in a VE than to help the user in finding the right path for the exit. At the lower level, operations, proto Presence is enough to induce a satisfying feeling of Presence. At the higher level, activity, the media experience has to support all the three levels.
2. *We have maximal Presence when the environment is able to support the full intentional chain of the user*: This can explain (i) the success of the Nintendo Wii over competing consoles (it is the only one to fully support M-intentions) and (ii) the need for a long-term goal to induce a high level of Presence after many experiences of the same rehabilitation technology.
3. *Subjects with different intentions will not experience the same level of Presence, even when using the same technology*: This means that understanding and supporting the intentions of the user will improve his/her Presence during the interaction with the technology.
4. *Action is more important than perception*: I'm more present in a perceptually poor VE (e.g., a textual MUD) where I can act in many different ways than in a real-like VE where I cannot do anything.

1.5 The FPQ

The FPQ is the Presence measurement tool developed in DiFac project. It is structured in three parts.

The *first part* contains three descriptions of the optimal experience. The subjects judge, with a Likert point scale (0–8), the VR ambient, verifying in which moment they "feel" an optimal experience, being in Flow condition.

The personal variables are explored focusing items on the following subjects:

- Cognitive
- Affective
- Motivation
- Skills and challenge

The *second part* of the questionnaire is created to obtain a general picture of the psychological individual selection in his or her daily optimal experience. The point

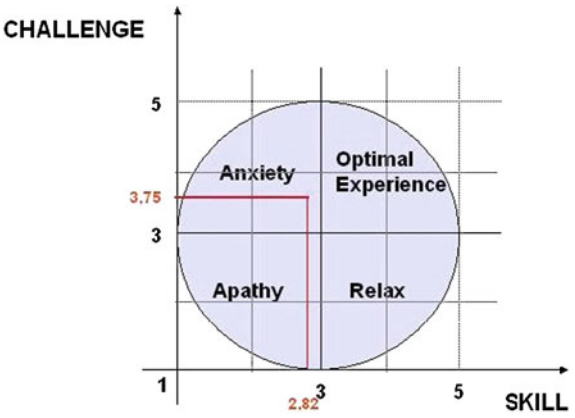

Fig. 1.3 Testers' state_skill and challenge balance

rating in the other experiences (daily life experience) is necessary because of the term of comparison to know the critical level that distinguishes a "normal" experience from an "optimal" one. In sum, each subject is a "himself control," there is no comparison with another subject.

The *third part* of FPQ has been taken from a version of the Flow Questionnaire in which an Italian research group measures the state called anti-flow (Massimini et al. 1987; Delle Fave and Massimini 1990, 1992). It is the antithetic or opposite condition with respect to the optimal experience. Investigating the anti-flow state is important to build a correct rating point in terms of measurement structural validity.

The questionnaire passed through three validation phases. The following paragraphs show the tests phased of the questionnaire. At the time the project was in its evaluation phase, the questionnaire was not definitive, it passed the first and second phases, and it was composed by 40 items. The foreseen third step, which will be soon applied, reduces the items around 35.

1.5.1 First Study

Sample: 500 subjects (250 male; 250 female)
Nationality: Italian
Age: 18–35
Time: 1 h for each subject (40-min trials + 20 min to complete the questionnaires within 5 min after the end of each experience)

The test was made on a set of daily experiences for each participant evaluating Presence and Flow. At the end of each "trial," the subject filled in the questionnaire.

This is the battery of the trial:

- Read a narrative description of a tennis match (10 min).
- Watch the television a registration of a tennis match (10 min).
- Play a tennis game using a static system console (10 min).
- Play a tennis game using a dynamic system console: Nintendo Wii Tm (10 min).

At the end, we analyse the data with SPSS software (www.spss.com) and a program to analyse the structural relation among the constructs. The more peculiar questions will be saved: 50/80 items.

1.5.2 Second Study

Sample: 100 subjects (50 male; 50 female).
Nationality: Italian
Age: 18–35
Time: 15 min to navigate and 5 min to fill in the questionnaire

For each subject, we have a session in an immersive VE. The environment is a model of an imaginary city. Azione s.r.l. (www.azionefilm.it) is the software house that developed the environment.

After the test, each subject, fill in the Presence–Flow questionnaire (the remaining items from the first version after the validation).

The sense of the second phase of the study is to verify the FPQ in an immersive VE context.

1.5.3 Third Study

Sample: 90 subjects (45 male; 45 female).
Nationality: Italian
Age: 18–35
Time: Each subject will navigate for around 15 min and 5 min to fill in the questionnaire.

The sample is divided in three group (30 for each group), a different environment is presented to each group.

Azione s.r.l. built a VR environment (an imaginary city) in three different version: (1) low-media quality and interaction, (2) middle-media quality and interaction, and (3) high-media quality and interaction. During the trial, for each subject, it was also measured an objective data using a non-invasive encephalogram (EEG) helmet.

For data analysis in the third study, we use SPSS software.

We expect to have an overall score of Presence and Flow in the group with higher-media quality and interaction mode, according to the theories.

The sense of this third phase of the study is on one hand verify the Presence–Flow questionnaire in different immersive levels; on the other hand, verify the strength of the subjective measurement (the questionnaire) through the correlation with the objective measurement (EEG helmet).

1.6 The Application: The FC

The FC allows the users to design a new production line or reorganize a preexistent one. The FC is composed of different modules, such as the planning table, the Web-based simulation, and the VE visualized by GIOVE. The FC is described in Part 3 of the book. The questionnaire was applied to the VE of the factory through which the user can design the production line.

The environment permits to add machines for designing the line and to select and link a product and a worker to the selected machine.

1.6.1 The Test

The FPQ was administered during different evaluation session of the FC environment. The expert presented DiFac result, its characteristics, and functioning. The data presented here collected information from Italy, Korea, and Estonia.

The following participants (38 total) provided feedback on FC environment by filling in the FPQ:

1. At ITIA, ten people who were not aware of the software.
2. Among academics and industrial people, 12 participating the CAD-CAM conference in Korea. It was the final public event for the Korean project.
3. Among academics and industrial people, nine participating in a lecture about Digital Factory and DiFac presentation at Tallinn University.
4. Eight people, mainly IT workers from Ropardo but not aware about the project.

1.6.2 Data Analysis

This section presents the analysis of the data collected from the FPQ. The participants rated their opinions against a series of statements using a Likert scale from 1 to 5 (Table 1.1):

Table 1.1 Likert scale for the Flow for Presence Questionnaire

1	2	3	4	5
Highly disagree	Quite disagree	Neutral	Quite agree	Highly agree

For each question, a mean score of 1–2 was perceived as bad, 2–3 as insufficient, 3–4 as sufficient, and 4–5 as good. The only exception is the value for the Flow General Index, which is analysed differently and should be around 0 to be good. All data from the questionnaires were collected in an Excel file and the means were calculated. The results are discussed as follows.

1.6.2.1 General Index Evaluation Experience: 4.72

The General Index Evaluation value is linked to both Flow and Presence evaluation. The index indicates the wish to repeat the experience. When the rate for the repetitiveness is higher than 3, generally the environment is good. The value higher than 4.5 indicates that the people enjoyed themselves in using the environment and would repeat the experience.

1.6.2.2 Presence General Index: 3.77

The Presence General is good being the value higher than 3. The FC appears in this version a general good presence level but some aspects can be improved. The participants felt a good emotional state: well balanced between personal internal state as influenced by the external environment. The question number 4 that is about the sense involvement has a low score (2.33) because the use of the FC through the PC modality involved mainly sight. The possibility to listen to something is limited to the collaboration section using the Skype modality for discussing the design with somebody else. Very positive is that the testers feel a very low level of boredom in using the environment (question 5 with 2.13 rate): This means that the test at a first test is interesting and imply a good attention level, actually the challenge level is good.

Symptom that the design of the environment is good is the answer to the question number 39: "The images blocked my activity." The mean of this specific question is extremely low: 1.74. The quality of the design is one of the factors that help Presence level, as the paragraph 4.4 has already shown.

1.6.2.3 Flow General Index: 0.9318

The mean of these data is calculated in a different way and its value should be between −1 and +1, closer to 0 is better.

The index appears scarce, the people using the FC is not really experiment the flow state. In fact, as you can see from Fig. 1.3, the testers experiment anxiety even if not in high level.

This value appears with negative score because some related questions are negative and measure the so-called anti-flow (Massimini et al. 1987; Delle Fave and Massimini 1990, 1992). The anti-flow state is the antithetic or opposite condition with reference to the optimal experience. Investigating the anti-flow state is important to build a correct rating point in terms of measurement structural validity. For statistical rules, the flow general index is included between − and + 1.

"The flow is the state in which people are so involved in an activity that nothing else seems to matter" (Csikszentmihalyi 1990). Attention is fully invested in the task at hand, and the person functions at their fullest capacity. The subjective experiments the following characteristics:

- The merging of action and awareness
- A sense of control
- An altered sense of time

Reaching the optimal experience of Flow has the following characteristics:

- Flow tends to occur when the activity one engages in contains a clear set of goals.
- Flow causes a balance between perceived challenges and perceived skills.
- When perceived challenges and skills are well matched, attention is completely absorbed.
- Flow is dependent on the presence of clear and immediate feedback.

1.6.2.4 Skill Index: 2.82; Challenge Index: 3.757

Reaching the optimal experience requires a balance between the challenges perceived in the specific situation and the skills the person brings in it. Challenges are potential factors inside the environment that can facilitate or obstacle the quality of the experience. Skills are potential abilities that the subject can bring in the environment. A good balance between these two states the flow indicators here above listed are assured. When the challenges are high and skills low, the experience produces anxiety rather than flow.

The items related with challenge index have a score nearly on 4 (agree with the sentence), only one has a lower rate: "The activity I was carrying out was encouraging me and it represented an opportunity and an effort to express myself and act." The environment does not appear as an opportunity for a self expression. On the other hand, the FC has specific rules for designing the production line; it is not something that can be used for expressing personal creativity.

The lower rate for skill question is for: "During the experience, response to my actions blocked the progress." According to Csikszentmihalyi, an equilibrium of

challenges and skills often occurs in the activity when the goals appear relatively clear and providing rather quick and unambiguous feedbacks.

1.6.2.5 Disorientation Index: 1.44

Disorientation level changes depending on the type of VE, the hardware (HMD, gloves, glasses, etc.), and personal sensitivity of the vestibule system. Here is really low, because all tests were made using PC/mouse. The disorientation level of the FC is really low proof of that is the "malaise" questions (number 16) that have a rate of 1.28.

We test people after using the environment on a PC (both desk and lap top) because the results presentation was given at users' premises and none of them has a cave system or a virtual room at their sites. In any case, one of the main objectives was to demonstrate how DiFac technology could be portable and the FC on a laptop results to be user oriented. For the future, will be interesting to have same questionnaires after the interaction with FC through the CAVE, using a 3D mouse and glasses this will check the disorientation level using different hardware.

1.6.2.6 Coping Index: 3.47

Coping rate is strictly linked with the ability to manage unforeseen situations, find the solution to unexpected situation or problem. Human beings react to the unexpected situation in different ways: denying the situation, rationally facing the different aspects of the problem, and rebalancing the sense of the experience. Many people passing through the three states before arriving the third one that is the more positive one.

The coping level is good, in particular, the testers were strongly agree with the proposition "During the experience, I was able to solve the majority of the issues if I applied the necessary effort," it means the skills level/quality of the people is something really important for reacting and learning how to face problems.

1.6.3 Results and Future Development

In summary, the environment has a good rate for Presence, and the testers will be happy in repeating the experience. The absence of sounds compromises the natural use of the environment; the suggestion is to add some sounds natural for the factory to have the single user more engaged in a non-mediated word, the industrial "clang" could be cut whenever a collaborative session started for allowing the users to use the Skype conference tool. The repetition will make the users' skills higher, and the experience can reach characteristics nearer to the Flow. Suggestions for developers are:

- Clear set of goals in the environment
- Merging of action and awareness
- Increasing subject's sense of control
- Clear and immediate feedback, step-by-step completing different duties

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