Review Article GU J Sci, Part B, 11(1): 105-119 (2023)

Gazi University

Journal of Science

PART B: ART, HUMANITIES, DESIGN AND PLANNING

http://dergipark.gov.tr/gujsb

A Conceptual Process Model Proposal for Visual Perception (VP) and Cognition in User-Product Interaction

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Article Info

Received: 14/02/2023
Accepted: 12/03/2023

Keywords

User-product interaction,
Interaction design,
Interaction process model,
Visual perception (VP) and cognition in design,
Behavior and cognition in interaction design

Abstract

Interaction design is defined in general as the creation of physical and emotional conversations with a product, system, or service as a result of the experiences of actions and reactions between form, function, and new technology [1]. User-product interaction refers to the behavioral connections between the user and the product that are examined to comprehend the concrete actions and use that understanding in product design. The designers are expected to have a versatile, dynamic and interdisciplinary knowledge as well as interpreting professional requirements with their subjective notions to address better product designs yet better user-product interactions. This versatile design knowledge is ultimately appeal to a visual world that reveals cognitive, structural and functional interactions of the users with products. Visual perception (VP) is one of the key but the most important prerequisites of the user-product interaction since it directs cognitive and behavioral actions of the users. Current studies explore various dimensions on the user-product interaction design process but it is needed to further explore its inclusive context, VP and cognition. to generate new perspectives within a holistic approach. In this study, we discussed the visual perceptive and cognitive dynamics of the user-product interaction process and proposed a conceptual process model that can give product designers more thorough and trustworthy interaction data while ultimately assisting them in redesigning and enhancing user-product interaction.

1. INTRODUCTION

Interaction design is “the art of facilitating interactions between humans through products and services” [2]. It is about “designing spaces for human communication and interaction” [3]. It entails creating user experiences (UX) that improve and expand on the ways in which people interact, communicate, and work [4]. Several terms including UX, user interface design (UI), user-centered design, product design, web design and interactive system design have been used to highlight various facets of the design but the term "interaction design" is frequently used to refer to the entire field, including its theories, methodologies, and approaches [4]. Recent studies such as the role of affect in user-product communication [5], relationship between affect and usability [6], the role of pleasure in product usage [7], a framework for understanding and generating interactions and experiences in new products [8], the role of actions in user-product interaction [9] examine a wide range of techniques and procedures that a designer can employ when developing a product.

The foundation of interaction design is the “dialog between a person, product, system or service” [10]. Directed by designers, *the shapers of behavior*; form, function, and technology all exhibit this dialogue's physical and emotional characteristics. This definition entails the behavioral dimension of the user-product interaction process in which vision and cognition are the most prominent brokers. Defined as perceptual organization, the process by which the visual system quickly and imperceptibly transforms individual feature estimates into the perception of coherent regions, structures, and objects [11]. This cognitive and perceptual context of user-product interaction refers to the process of transforming the images of physical

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products into visual representations stored in visual memory as experience outputs. This process represents the success of the product when the expected perception and value coincide with the user experience.

Interaction design also combines various disciplines. Cognitive psychology, which deals with understanding, memory, and perception, is one of the most significant of these. Art, where aesthetics and emotions are at its core, is another significant field. Good designs take advantage of the brain's built-in capacity for perceptual processing, and interpretations of such designs are quick, cross-cultural, and resistant to instruction [12]. In order to achieve this, designers must have the ability to understand and synthesize the dynamics of user-product interaction process. In this context, this study aims to discuss the dynamics of VP and cognition in both design and user-product interaction processes. For this purpose, similarities between new product development (NPD) processes and user-product interaction processes are analogically discussed in the context of VP and cognition. To this end, a conceptual process model for VP and cognition in the context of user-product interaction is proposed.

2. VISUAL PERCEPTION AND COGNITON IN USER-PRODUCT INTERACTION PROCESS

2.1. Visual Cognition and Visual Perception

The interaction stems from the users' understanding of the phenomenon of the product. *Understanding* depends on the subject having certain abilities to perform complex mental transformations. Among these abilities, cognition, visual perception, visual intelligence, knowledge, learning, reasoning and recognition should be defined as the basic cognitive and psychological domains of the user-product interaction process [see 13].

The term “cognitive” (from the Latin word cognition-knowledge, cognition) means “informative”, “related to cognition” [14]. *Learning* and *cognition* are based on available knowledge. To develop usable *knowledge*, people need to understand the human challenges in which they can raise questions, make predictions about the problem/situation/event encountered, and explain relevant phenomena using reliable repeatable evidence [15]. Special attention is paid to traditional cognitive processes such as perception, attention, memory, imagination and thinking [16] which are considered as the components of the general process of information exchange between man and the environment. The eye-mind connection is at the center of many cognitive activities, including one's navigation and perception of the environment [17]. The essence of cognition is characterized by *concepts* to distinguish a particular object from others. The subjectivity of user-product interaction stems from the concepts that represent the knowledge of the users interacting with products.

Learning involves making cognitive connections, embodies and includes changing actions and perceptions, and consists of social and emotional participation in communities. It is developmental, influenced by participation levels, historical and takes place in context and cannot be separated from contexts [18]. In the context of user-product interaction process, users can actually be considered to have entered a cognitive process from the moment they interact with any product in any sensory way. In this case, users begin to assume the role of *learners*. According to Moulding, Songer [18], a cognitive perspective considers the individual learner as the primary unit of analysis, and emphasizes the processes and structures that are supposed to work mentally at the moments when the individual physically interacts with others, objects and events or mentally imagines these interactions.

Learning process consists of four main processes related to the understanding process: concept formation, ordering experiences according to the relevant feature, problem solving and perceptual learning (effects of past experience on sensory perceptions) [19]. In this learning process, it is constantly tried to establish connections between the past cognitive, sensory, psychological and physiological experiences and the product. This establishment process is the object of user-product interaction where VP and memory feed and shape cognitive processes about problems such as what the product is, how it is used, what it is produced for and what it does.

Metacognition refers to information about our cognitive state and is often associated with the choice of behavioral control and control procedures to achieve a goal. It is used to describe theory of mind, beliefs, monitoring of cognitive performance, and choice of strategy. Visual metadata and metacognition are not only important for guiding real memory processes, but also form the basis of judgments about the psychological experiences of ourselves and others [20, 21].

The role of metacognition is to provide a feedback loop in which strategy selection (e.g. reasoning an answer versus memory exploration; statistical learning) can be carried out [22]. Research in cognition and perception highlights the possibility that visual metadata can affect visual performance. Although it is often assumed that metacognitive functioning in these areas involves conscious awareness of activities within the mind, there is evidence that strategy selection and monitoring of cognitive performance are not always conscious [22]. If people believe that some tasks are easy, they may not put enough effort into it. This is especially important for understanding visual tasks that leverage executive functions and deliberate, strategic processes. In the context of user-product interaction, this situation may occur in unexpected behaviors of the users in regards to their experiences conveying their habits and connotations about the product interfaces.

Environmental cognition refers to the awareness, impressions, information, images, and beliefs that people have about their environment. It does not merely mean that individuals and groups have knowledge and images of these environments and the existence of their constituent elements, but also that they have impressions of their character, function, dynamics and structural reciprocity and assimilate them with meaning, significance, and mythical-symbolic properties [23].

A *cognitive map* is a type of mental to enable analyzing of tasks requiring mental operations [24]. Cognitive maps are *internally represented schemas* or mental models for specific problem-solving areas that are learned and coded as a result of the individual's interaction with his/her environment [25]. Siau and Tan [26] defines cognitive mapping within three categories:

- *Causal mapping;* representations of a set of causal relationships between structures in the belief system,
- *Conceptual mapping;* graphical representation where nodes represent concepts and links represent relationships between concepts,
- *Semantic mapping;* It is used to explore an idea without the constraints of a super-imposing structure.

Cognitive mapping consists of a series of psychological transformations for an individual to acquire, store, remember and decode information about the relative locations and qualities of things [27]. If an experienced user is unable to decipher the systematic logic behind a particular product's UI, it may be a result of users not drawing cognitive maps about the desired tasks. Hence, the success of the user-product interaction depends on the fact that the usage scenario maps offered by the product to its users are presented directly, plainly and in a visual context that can be easily perceived and understood.

Visual perception encompasses the neural transmission process triggered by the stimulation of sensory receptors sensitive to photon energy emitted from light sources. In this process, what seems pure turns into what is perceived as a result of cognitive audits that define individual differences such as sense, emotion, experience, intelligence, culture, and gender. The exchange of information between these two creates VP which also corresponds to visual thinking data classified by visual metacognition filter, expressed by representations and stored in visual memory.

VP opens up crucial areas where we can learn about the myriad possible connections between other mental and behavioral phenomena, what might happen in people's minds and behaviors [28]. Perception can abstract objects from their context because instead of registering shape as a mosaic of elements, it grasps it as organized structure. According to Les and Les [19], typically, it is not a matter of extracting common features from particular samples; refers to a different concept of abstraction, a much more complex cognitive operation. This abstraction is an element that determines the psychological aspects of the user-product interaction as well as the operational aspects. For this reason, it can control our behavior [29] and may lead to both the development of new use models that would be translated into mimetic behaviors and cultural and social transformations. Since seeing consists of grasping structural features rather than indiscriminate detail recording [19], the foundation of user-product interaction is based on VP.

At the first moment of perceptual contact with the interacting object, information begins to be produced, and calibration based on this information is determined by the visual properties of the products rather than their somatosensory feedback [29]. An example of this is that large objects are perceived as heavier and smaller ones as lighter [30, 31]. Then, visual information has the ability to influence 'normal' information, including the physical properties of objects such as weight and size, and trigger manipulative actions in interaction with foreign objects [32]. This emphasizes both the inclusiveness and directivity of visual perceptual process in user-product interaction.

The ability to comprehend structural features by spontaneous, stimulating chemical arrangement according to the simplest general pattern suitable for it is called *visual intelligence* [19]. Visual intelligence leads the formation of VP and visual thinking. *Visual thinking* is "the representation of knowledge in the form of structures in motion; it is the flow of images as pictures, diagrams, explanatory models, orchestrated paintings of immense ideas, and simple gestures" [33]. It is an interaction between seeing, imagining and drawing and calls for perception, interpretation and creation of visual messages in an active and analytical way [34]. Visual thinking relies on "accessing one's visual imagination in mental imagery or through drawing" [35, see also 36, 37] but it is more than visualization of the messages [38]. Les and Les [19] define the mental processes associated with visual understanding as visual thinking in the context of understanding visual forms.

Visual thinking is an intuitive and intellectual process of generating visual ideas and of active problem-solving [34, 36, 38, 39] on visual contexts [40]. The process begins with perception [41, 42] and counts on visual—images, shapes, patterns, textures, symbols, colors— rather than verbal language [38]. VP process relies on visual language on reasoning and making sense of the things. *Reasoning* is generally modeled as a process that draws conclusions by combining generalized rules starting from scratch [19]. In the VP process, the rules are generated by concepts that are reasonably interrelated with other concepts driven by other objects, situations or environments since the size, location, shape, and orientation of an object are all calculated by the perceptual system primarily in relation to other objects and surfaces in the scene [29]. *Recognition* presupposes the existence of something to be acknowledged. The most beneficial and common interaction between perception and memory occurs in the recognition and validation of what is seen [19]. Visual recognition brings addressing and memory search to the fore.

2.2. Visual Perception Process

According to Kaufman-Scarborough [43], perception involves a selective retrieval process in which information processing capacity is selectively allocated or not allocated to incoming information. He examines the information process in three phases. First, the perceivers have to be in the *exposure* of the information source. Second, to have meaning, language must be recognizable, images must evoke appropriate mental images, symbols must have meaning, and music must be accepted and appropriate, that is, there must be *sufficient perception* for its context. *Coding* is the process of converting a message into an efficient combination of signs, colors, words, pictures, sounds and other cues for delivery to the intended recipient of the message while the third, *decoding*, simply is the opposite of encoding. For a message to be recognized, processed, and understood effectively, the sender's encoding process must be translatable by the receiver's decoding process.

The simplified version of the neural network model [see 44] in form perception is handled by Ware [12] in 7 sensing layers. First layer represents perception of the edges while at the second layer people perceives vertices, axes and biobs. The third layer stands for geon attributes such as aspect ratio, horizontal/vertical position and size of the object. At the fourth and fifth layers of the process, object's relative properties such as orientation, attached/detached and larger/smaller to other objects are perceived. The sixth layer represents geon feature assemblies that contain information about how parts are interconnected. The final layer is for defining the objects. The perception of an object is mostly based on information in memory triggered by visual information and is fed from outside environment resources in relatively small proportions [12]. Addressing the perception at the level of different layers and under the user-product interaction variables may also be useful in revealing the causality of this visual information.

2.3. Individual Cognitive and Perceptive Differences in User-Product Interactions

Individual visual abilities account for VP process and entail cognition to address image descriptions. An assessment of visual abilities includes baseline data on visual acuity, contrast sensitivity, field of view, light and color reception [45], and motility and brain functions [see 46]. Visual acuity refers to a person's ability to resolve spatial detail [47]. Contrast sensitivity tests a person's ability to perceive pattern stimuli at low to moderate contrast levels. The contrast sensitivity function provides a comprehensive representation of the spatial discrimination capabilities of the visual channels [48]. The useful field of view is the total area where effective vision is maintained relative to the fixed straight edge fixation point [47]. The ability to distinguish and identify color within useful field of vision is called color vision [49]. In addition, Dini, Ferlino [50] discuss visual function under the following different, specific perceptual abilities:

- *Visual acuity*, the capacity to focus on details both far and close;
- *Visual field size*, the size of the space that can be embraced at a glance;
- *Color sensitivity*, perceptual capacity to allow color discrimination;
- *Contrast sensitivity*, the capacity to detect the difference between two adjacent elements;
- *Light sensitivity*, eye reaction to light and light changes;
- *Stereopsis and binocularity*, the possibility or capacity of perceiving depth based on the difference in the viewing angles of the two eyes.

3. CONCEPTUAL PROCESS MODEL FOR VISUAL PERCEPTION AND COGNITION IN USER-PRODUCT INTERACTION

3.1. Modeling Criteria

Even the cognitive and perceptual processes of the users in terms of user-product interaction represent tacit knowledge and intuitive behavioral dimensions that draw a complex structure, systems thinking approaches should merge down the dynamics of the process into categories within a holistic perspective. In its simple form, systems functioning is a complex total that depends on its parts and the interactions between these parts [51]. Systems approaches are holistic and use 'collaborative' thinking and therefore address issues in depth. Holism sees systems as more than the sum of their parts and considers the research primarily in terms of how they emerge and survive in the new whole. While systems language supports practical thinking, it is the causal context between the background problem and the solution that drives system design [52]. Hence the criteria for the model is to define the main domains of VP and cognition process within the context of user-product interaction in a systemic way of causality, relatedness and sequencing. To this end, the model is generated to ensure a sequential-iterative processing [see 53] in which the process dynamics can operate interconnected to other dynamics and within independent sequences.

The cognitive and psychological dimensions of the design thinking is represented as *emergence* [see 54] on the basis of process model of “seeing-moving-seeing cycles” [see 55, 56, 57]. Here "moving" refers to the "moves" made by the designer as a result of his or her "seeing" and *reflection* [see 57] on the visual representations. The design emergence is supported by external symbolic visual representations in this model in which the designers have a “reflective conversation with his or her ideas” as depicted in sketches and the “back-talk” of information [54]. The information here is originated from *perception, visual cognition* and *mental imagery*. The act of vision relies on *perception* in *low-level* as to perceive the initial image in regards to the definition of objects and *visual cognition* stems from *high-level vision* which is about defining the relevance of objects to their existences [58]. Perception is based on stimuli information of specific or distinctive part–whole characteristics via identification of shapes [54] that are guided by *visual prototypes* [see 41]. On the contrary, visual cognition corresponds to stored information [59] and knowledge wherein classes of shapes, visual objects and patterns are reasoned from visual prototypes [54].

The third information dimension in the model, *mental imagery*, represents the seeing through experiences in case the physical objects are not seen actually. One of the cognitive bases for the emergence of design is the reformulation, or re-representation, of visual images in drawing [60], that is, the designers retrieve their mental imagery to create new visual images from which are stored in their visual memory as visual prototypes and precedents [see also 61].

Theoretically, similarities can be established between the visual thinking process of the designers and the VP and cognitive functioning process of the users in product interaction. Although these two processes have behavioral, functional and purposeful differences in terms of the methods used by designers in NPD process and the interaction of users with products, they have structurally similar characteristics. Here, designers synthesize the visual prototypes that are the sources of their expertise in visual thinking and cognition. Users, on the other hand, make a synthesis with their perceptual and cognitive abilities to perceive, understand and use the physical products. The process implemented by designers in the context of seeing-moving-seeing can be developed as seeing-understanding-[action]-experience for the users. These analogical similarities constitute the general structure of the process model proposed in this research as shown in ***Figure 1***.

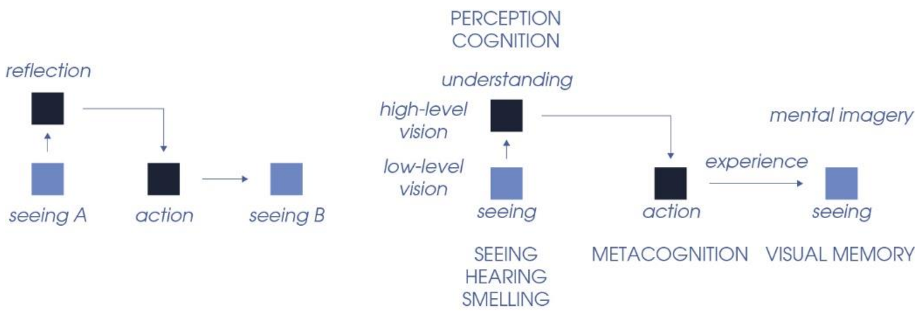

Figure 1. *Analogical representation of VP process in the context of user-product interaction. Left: A model of seeing-moving-seeing [57], Right: An analogical representation of the user-product interaction*

Even the design research literature serves several models on the process of NPD, Howard, Culley [62] identifies the following set of typical creative design stages by comparing 19 creative process models from various disciplines: (1) analysis phase, (2) generation phase, (3) evaluation phase and (4) communication/implementation phase. In this study, the general operating substructure of the proposed model is based on the analogies of these main phases of the NPD process upon the ground of visual thinking processes discussed above. To this end, analysis phase of NPD process is extracted as the users' (1') *knowledge needs* so that the users should interpret the perceived product. The generation phase is processed into the (2') *cognitive stage* where the users get interacted with products to generate further assessments on features and functions of the products and evaluate them in terms usability, affordance and accessibility. The evaluation phase of the NPD process is regarded as the (3') *adaptation and application phase* of VP process in which the users evaluate the user experiences and develop adaptations in regards to the visual representations. Finally, the implementation phase of the NPD process is reflected as the phase of users having developed (4') *object files* to categorize the overall process in terms of visual constructs, concepts or prototypes.

3.2. Conceptual Process Model

The proposed conceptual process model (see ***Figure 2***) is a representative figure, indicative of the predominant cognitive and visual perceptive dynamics of user-product interaction. The process dynamics can operate independently of each other in terms of personal and situational conditions, as well as revealing different contexts within the same sequence. In addition, the processes presented in the model may cover different flows. For instance, while the seven-layered visual thinking process proposed in the model actually covers the whole process, it is presented aiming for a simpler expression here as the first stage triggered by the effects of different cognitive processes following the act of seeing. As a matter of fact, visual thinking is a complex and versatile system, and it is a cyclical process. In this respect, the proposed model represents a general understanding and may differ in domain-specific applications.

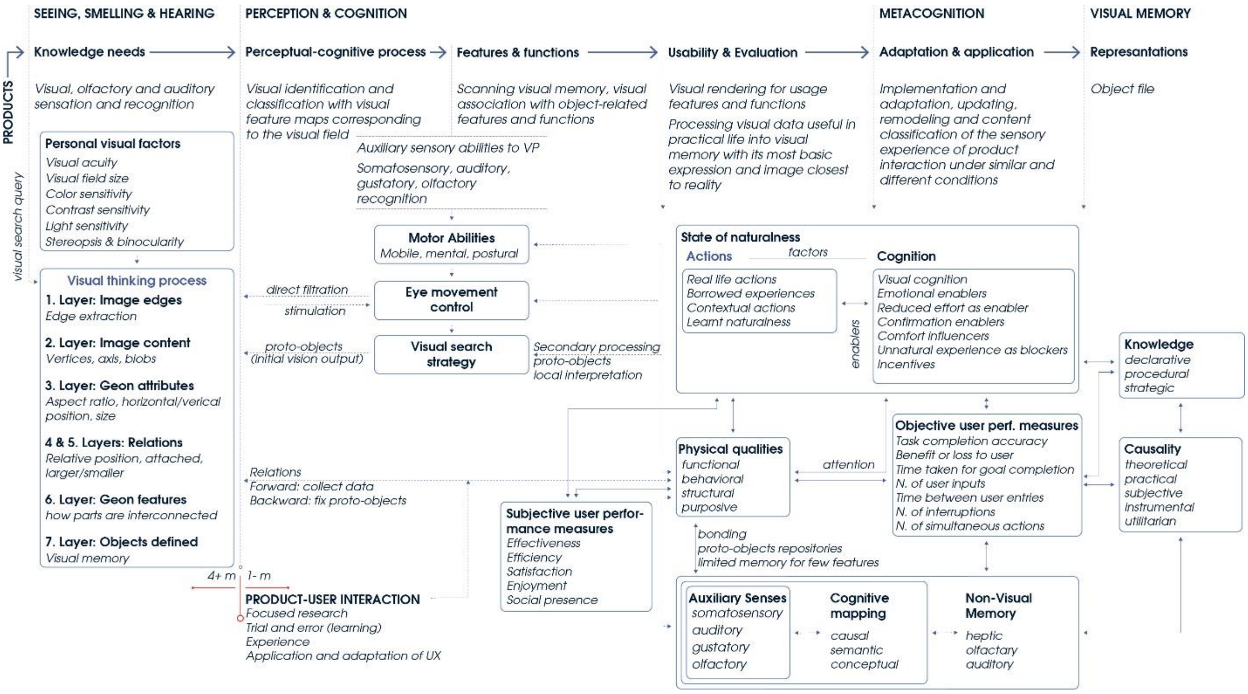

Figure 2. *Conceptual framework for visual perception and cognition process in the context of user-product interaction*

The analysis phase of NPD process represents the stage of thorough examination of the task, need, or product idea's initial descriptions [63]. At this initiative stage, designers establish a need, a problem or a product idea [64]. For the proposition of VP process in user-product interaction, this stage is represented as the basic level of recognition in which the users notice the product with low-level vision and/or hearing and smelling. The main characteristics regarding the functionality [task, need] and/or the basic shape of the products [product idea] are established at this stage by the users. At this stage, the users *need knowledge* about the product to *analyze* and identify what they have noticed.

According to the general understanding, although the user-product interaction is reciprocated as long as the users physically interact with the products, the interaction process has already started in the first stage when products are noticed by perceivers. This stage reveals the characteristics of sensory interactions depending on the distance between the product and the user. According to the range of spatial sensory modalities, an individual's environmental perception occurs in the far environment for environments more than four meters away, the near environment for an area of 1-4 meters, and the personal space for distances less than 1 meter [65]. As a matter of fact, the interaction in far environments is considered as the first stage in which the user-product interaction starts, and it is assumed that this interaction includes the first *analysis* stage. In this first phase, in which VP begins, users enter the period of making sense of the products they notice sensory. The users analyze their first impressions of the key features of the products they interact with, and low-level VP takes place at this stage. For further visual thinking processes, they may need to interpret the physical attributes of the product in question, supported by vision and/or other auxiliary senses.

The proposed model represents the product journey from its low-level visual perception to the process where product's visual prototypes are coded as object files in visual memory. While the user-product interaction is dependent on seeing, smelling and hearing for the near and far environments, other auxiliary senses feed VP in the personal space. In terms of interaction, the perception distance where the most intense sensory experiences are practiced therefore corresponds to the personal space. Consequently, proposed framework for the VP process regarding the user-product interaction is conceptualized with a focus of distance that defines the sensory attributes of interaction.

At this stage, the seven-layer visual thinking process based on the neural network model discussed above is considered as a model in which the functioning can be expressed in the broadest way. Because this model can also be useful in detecting traces of variability in the structure of visual-perceptual differences in the act of seeing. Personal perceptual differences such as visual acuity, contrast sensitivity, effective visual field, sync sensitivity, light sensitivity, stereopsis and binocularity reveal the individual differences of these VP layers. The whole process proceeds with the variables of individual cognitive and perceptual abilities according to the qualities of the perceived at this stage.

The generation phase of the NPD process corresponds to the stages of *concept generation* in which the designers develop abstract solutions to the problems and *embodiment design* wherein the conceptual solutions are detailed [63]. The functional state of the product concepts is evaluated through task analysis and the behavioral dimension is generated with conceptual design ideas and the embodiment design is detailed by structural design activities at this NPD process [66]. This stage is represented as the stage of users' having physical interactions with the products in their personal spaces. The users' VP is supported with auxiliary senses such as somatosensory, auditory, gustatory and olfactory [see 67]. At this stage, the users generate concepts of the products regarding detailed functions and features.

Vision is a process of producing shape descriptions from external world images [40]. Ware [12] states that in the model he presented regarding the VP process, the antecedents for planning are finalized by being controlled throughout feature maps in a series of strategic and cognitive processes. In this model, visual search queries trigger the visual thinking process to define to which feature maps the search queries correspond. Visual thinking process manages the eye control movement and visual search strategy to match the conceptual visual outcomes [prototypes] that are represented as proto-objects with the feature maps. While the initial stimulation is filtered directly at the initial stage of VP, proto-objects triggers the secondary level filtration of local visual search in regards to functional, behavioral, structural and purposive qualities of the products. The usability and evaluation of the products are carried out to create *visual concepts* that would benefit the user in her/his practical life.

The evaluation phase of the NPD process refers to the reinterpretation stage [68] in which the integration of sub-solutions, refinement and finalization of the solutions are examined. This phase is represented as the metacognition phase in the proposed conceptual process model of VP, that is, the implementation and adaptation, updating, remodeling and content classification of the sensory experience of product interaction under similar and different conditions.

Defined by the quality of experience, the success of product experience in regards to "the way the users feel the product in their hands, how well the users understand how it is used, how they feel about it while they're using it, how well it serves their purposes, and how well it fits into the entire context" [69] is one of the dynamics of this phase. Users evaluate their interactions with the products in the context of experience quality and visually encode their product experience in this context into their visual memories.

One context of experience quality is the naturalness of the experience. Naturalness is evaluated instinctively and individually as the result of a series of interacting operational and cognitive processes. Actions such as real life experiences, borrowed experiences, contextual actions and learnt naturalness are the enablers of operational drivers while visual cognition, sensory enablers, reduced effort as an enabler, confirmation enablers, comfort influencers, unnatural experience as blockers and incentives are the cognitive enablers of the states of naturalness [70].

Real life experiences represent the actions of muscles memorized by former product interactions, e.g. turning a dial-button to the right to operate a product interface. Borrowed experiences stem from borrowed attributes of real life skills such as being detail oriented, goal oriented, efficient decision making etc. that are utilized into similar parts of other activities. Contextual actions are the actions that are relevant to be associated with the needs and the use context of the products. Learnt naturalness represents the naturalness of actions that become behaviors first, then the habits and finally a part of personality [70].

Visual cognition as a cognition enabler for the naturalness of experience is derived from the semiotic analysis [70] in which Chandler [71] specifies four sequential steps. The first step defines the identification of visual elements like color, form, material, object, composition etc., the second step represents the identification of the signifiers as they are physical or direct representations of visual items, the third step is the identification of signified as they are metaphorical or conceptual representations of the signifiers, and the final step is thermalizing of the common themes of the signified. Within these steps, the users' VP *re-cognizes* the interaction process while emotional enablers take the emotional state of the naturalness to encode the visual memory with emotional shortcomings. The interest but the expertise in interaction process feed the naturalness of the experience by reducing efforts which directs users to make direct connotations between the perceived and the actions. Confirmation in naturalness of experience is regarded to the users having confirmed with feedbacks about the process of use, that is, information flows enable the segregation of the VP process into segments to better address the actions to the visual memory. While the comfort enablers enforce the cognitive processes to get action in a natural way, the unnatural experiences in regards to the product in interaction reduces motivation and blocks the VP process of prototyping visual images. Incentives force the users to develop new routines and throughout the repetition of them creates the habits that makes the interaction process more natural so that the users may more consistently correlate visual imageries with the products in the VP process [70].

Quantitative user performance measures of the process such as task completion accuracy, benefit or loss, time to target, amount of user input, time between user entries, number of turns for communication, number of interruptions and number of simultaneous actions [72] represent the objective way how users interact with the products. However, their effects on the subjective behaviors of users have a more critical role in terms of experience quality and psychological and cognitive processes of related dynamics. As a matter of fact, users' personal inferences about the interaction process, that is, subjective performance measures such as effectiveness, efficiency, satisfaction, enjoyment and social presence [72] etc., have a structure that reveals the perceptual context of the user-product interaction and instinctively creates the VP of the products. Physical attributes of products such as purpose, behavior, function and structure [e. g. 66] also constitute the objects of these performance criteria. Cognitive mapping, as discussed above, represents the products' feature maps of usage, semiotics and semantics.

The final phase of the NPD process refers to the processes of integration, manufacturing, installation, test, approval and launch of the product [63]. In the proposed conceptual model of VP process this stage reveals the visual representations or the prototypes. The users define the *object files* within the categories of knowledge as declarative, procedural and strategic [i. e. 73] fed by the entire experience process. The causality regarding theoretical, practical, subjective, instrumental and utilitarian domains behind the object files codes the visual cognition process as useful and simplified knowledge patterns to be decoded for the following life experiences.

Defined as "object file", visual memory handles many features of the objects together with visual and non-visual features [12]. Here, the attributes of the feature maps corresponding to the visual field have a critical role in determining the quality of experience in user-product interaction. As a matter of fact, this area includes metacognition and visual memory, in which the implicit knowledge of the user's essence is coded at the sub/conscious level, as well as visual intelligence and visual thinking. In other words, visual memory maps that define visual areas are special areas where real product interaction experiences are stored, evaluated and directed in the most realistic (utilitarian) way.

4. DISCUSSION AND CONCLUSIONS

In order for a model to be useful, it must satisfy a number of requirements: it must address a crucial managerial issue; the decision-making process must be based on accurate and readily available information; the model's assumptions and simplifications must be reasonable; and the model must be computationally tractable [53]. The fact that VP and cognition processes remain parallel structures for both the designers and the users interacting with products entails the shift between these two processes. That is, designers do design from a top-down process of the VP while the users perceive the products from a bottom-up process. Hence the first issue is addressed in this study through an analogical approach to the managerial process of NPD and the holistic process of VP and cognition that are the prerequisites of the user-product interaction process as briefly discussed above.

Even the VP and cognition processes reveal dynamic and cyclic structures, the information and their interrelated connections with other domains are conceptualized within an iterative perspective to better and simply address the causalities, relatedness and sequencing in a systemic way. That is to say for the addressing of the second issue of model requirements, one trying to address a product's perception by a user can interpret dynamic-specific analysis of the user-product interaction through the proposed model's simplified but not limited definitions.

One feature of the proposed model to compensate the third issue of model requirements is the analogical assumptions stated above which strengthens the validity of the process sequences and dynamics. Furthermore, the model represents gigantic literature of the process of cognition, metacognition, learning, understanding, reasoning, perception, vision, visual thinking, visual intelligence and their contexts with subjective and objective personal measures as well as individual differences in user-product interaction process with reasonable simplifications.

The proposed model in general may not respond to be computationally tractable due to its multifaceted perspective but in terms of dynamic-specific analysis it may provide tractable conjunctions between behavioral and perceptual actions of the users. For instance, the way how a user visually perceives a product's physical features should be traced in objective and subjective performance measures as well as in the quality of experience or state of naturalness. Hence the proposed model directs the dynamics within an iterative sequence of perceptual and cognitive behaviors that would be traced by further analysis in partial sequences.

The conceptual model proposed in this study reveals the basic and inclusive VP and cognition dynamics of user-product interaction process. It represents a conceptual figure of interchangeable sequences that may or may not follow each other in regards to the context variables. Even the model needs to be further explorations and testing, the theoretical background information leads the way how the dynamics proposed here interact with each other within a dynamic sequential flow of actions and behaviors. The model proposed in this study may be used as a framework in visual perceptive and cognitive analysis of the user-product interaction processes to better address the conjunctions between aforementioned dynamics, to develop new use scenarios and behaviors, to explore the relations of VP, quality of experience and the state of naturalness.

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