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Toward Discovering an Architectural Typology Based on the Theory of Affordance

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Abstract**—**This paper revolves around the concept of affordance. It aims to discover and develop an architectural typology based on the ecological concept of affordance. In order to achieve this aim, an analytical study is conducted and two sources were taken into account: 1- Gibson's definition of the concept of affordance and 2- The researches that are concerned on the affordance categorisation. As a result, this paper concluded 16 typologies of affordances, including the possibilities of mixing them based on both sources. To clarify these typologies and provide further understanding, a wide range of architectural examples are presented and proposed in the paper. To prove this vocabulary's capability to diagnose and evaluate the affordance of different environments, an experimental study with two processes have been adapted: 1. Diagnostic process: the interpretation of the environments with regards to its affordance by using the new vocabulary (the developed typologies). 2. Evaluating process: the evaluation of the environments that have been interpreted and classified with regards to their affordances. By using the measures of emotional experience (the positive affect 'PA' and the negative affect 'NA') and the architectural evaluation criteria (beauty, economy and function). The experimental study proves that the typologies are capable of reading the affordance within different environments. Additionally, it explains how these different typologies reflect different interactions based on the previous processes. The data which are concluded from the evaluation of measures explain how different typologies of affordance that have already reflected different environments had different evaluations. In fact, some of them are recommended while the others are not. In other words, the paper draws a roadmap for designers to diagnose, evaluate and analyse the affordance into different architectural environments. After that, it guides them through adapting the best interaction (affordance category), which they intend to adapt into their proposed designs.

Keywords**—**Affordance theory, affordance categories, architectural environments, architectural evaluation criteria, emotional experience.

I. First Part: The Analytical Study

A. Introduction

SINCE the beginning of any agent's life (animal-human), the interaction with the environment (terrain, shelter, water, gas, fire, tree, stones, object, tools, other animals and human display) begins. Agents perceive these surroundings by using their perceptual, cognitive, biological and physical systems. This leads to the occurrence of an interaction between these two characters (the agent and environment).

In order to succeed in creating environments for users with specific purposes, and to end up with the exact desired interaction, one has to analyse an agent's interaction along with the environment and to attempt to search for a scientific and analytic language for interpreting this relation. For this purpose, the main concern of this paper is to afford a theoretical framework for interpreting the architectural environment based on its affordance. Additionally, it intends to afford a clear road map for applying the notion of affordance to design.

″Note also that a glass wall affords seeing through but not walking through, whereas a cloth curtain affords going through but not seeing through. Architects and designers know such facts, but they lack a theory of affordances to encompass them in a system.″ [1, p.137].

The interaction between the environment and agent has been defined by Gibson by using the term 'affordance' [1], [2].

Reference [1] shows that Gibson formulated the word "affordance" in order to indicate to the actionable characteristics that are formed between the actor and the globe. Gibson defines the perception as an approach, which retrieves information that for coordinating with the agent's actions and the system provided by the environment. In fact, this made Gibson to enhance the notion of affordance, the objects' characteristics and the environment's arrangements that attempt to enhance their contributions to the interactive activity. Consequently, the environment's characteristics by which the agents need to perceive. Nonetheless, Gibson has not indicated that the ability relies on the environmental characteristics' context, or that the affordance relies on the agents' characteristics' context. In fact, this represents the cognitive science's role by disseminating the cognitive system into the internal and external representations (internal representations indicate to the structure and knowledge related to the minds of individuals, while external representations indicated to structure and knowledge related to the external environment) [3], [4].

The cross occurring between external and internal representations provides four kinds of an affordance (physical affordance, biological affordance, cognitive affordance and perceptual affordance) [5]. This assists in defining the analytical and scientific interpretation that are related to the relation between the environment and agent based on the capability of the agent and the usability of the involved environment.

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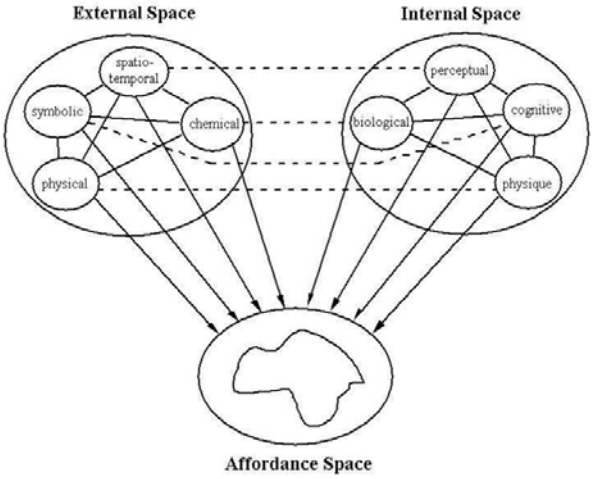

Fig. 1 The affordances' categorisation from the view of the distributed cognition

The affordances' categorisation from the view of the distributed cognition based on the cross occurring between external and internal representations is as follows:

- *Biological Affordance*: relies on biological processes. For instance:

a. Nutrition is afforded by a healthy mushroom; death is afforded by a toxic mushroom. These two examples are based on the biological levels.

- *Physical Affordance*: refers to the tasks, which are primarily controlled by physical structures. For instance:

a. The flat horizontal panel is only pushed towards a door.
b. Locomotion is afforded by an open environment towards spotting onto any direction on top of the ground. While locomotion is only afforded at openings by a cluttered environment.

- *Perceptual Affordance*: indicates that the affordances are importantly given by different spatial mappings. For instance:

a. If the switches that are related to the stovetop burners possess a similar spatial layout, affordances are accordingly provided by the switches in order to handle the burners.
b. The pictorial signs for men's and ladies' restrooms that are available in airports.

- *Cognitive Affordance*. The affordances pertaining to this type are given by different cultural conventions, such as:

a. The traffic lights; where red denotes the "stop" sign, yellow denotes the "prepare to stop" sign, and green denotes the "go" sign.

- *Mixed Affordance*: in this category, there are several affordances that are given when more than a single model is combined, such as:

a. Tying shoes is afforded by a Shoelace. This affordance indicates to a conjunction that is based on cognitive and physical affordances; the knowledge of fixing a tie and the physical property of a shoelace.
b. The "mailbox" example that has been illustrated by Gibson can as well refer to a mixed affordance. A mailbox cannot give the affordance pertaining to mailing letters along to a person who is not aware of postal systems. In this context, knowledge (cognitive affordance) and structure of a mailbox (physical affordance) are engaged in creating the affordance related to the recipient and mailing letters.

Gibson [1] also overlooked the importance of clarifying his notion of the system of information which supports the coordination of the agent's actions with the system provided by the environment.

Gaver produces a framework that aims to separate the affordances derived from the existing perceptual information by allowing a distinction through other four affordance categories (the correct rejections and perceived and the hidden and false affordances) [6].

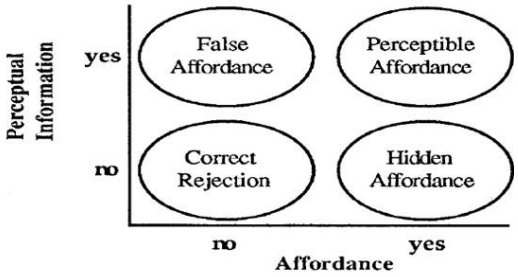

Fig. 2 Separating affordances from the available information about them which allows the distinction among the correct rejections and perceived and the hidden and false affordances

Gaver [6] and Gibson [1] agree that affordances represent possible actions that are afforded by an object or environment as existing, regardless of whether they are perceived or not. Gaver [6] separates the affordances from the available information, which allows him to generate the last four categories of affordance.

Gaver clarified these categories as follows [6, p.80]:

- Perceptible affordances exist where the afforded information on actions is perceptible to the user. These are very dependent on language, culture, context, experience, and etc., and can vary across multiple users.
- Hidden affordances are possible actions that may not be visible. They may infer to false affordances if users perceive an environment that affords not possible actions. Correct rejection happens when there is no affordance and no misperception of its presence.

The next stage will clearly indicate a new category of affordance (new vocabulary of design), which is the result of the discussion that is built on Gibson's definition of affordance and the contribution in categorising affordance defined by [6], [3], [4].

B. Developing an Architectural Typology Based on the Concept of Affordance

In this section, developing categories of affordance are achieved based on a scientific analysis belonging to the concept of affordance proposed by [1] and to the categories of affordance suggested by [6] and [5].

The developed categories are explained and clarified by a wide range of architectural examples.

1. Address Developing for a New Typology of Affordance

Gibson invents the word "affordance" to refer to the actionable properties between the world and actor (the agent and environment). According to Gibson's point of view [1], perception is the system that picks up an information, which supports the coordination of the agent's actions with the systems provided by the environment. He was clear in summarizing the concept of affordance in three points:

1- The properties of an agent,
2- the properties of an environment and
3- the system that picks up information, which supports the coordination between the agent and environment.

To discuss the first two points, it can be found that Gibson is limited in identifying the properties of the agent and environment while cognitive science was not limited, and defines it as internal and external representations (internal representations represent knowledge and structure within individuals' minds; and external representations represent knowledge and structure within the external environment) [3], [4]. The cross between the internal and external representation produces four types of affordances as previously mentioned. These types comprise; biological affordance, perceptual affordance, cognitive affordance and physical affordance [5]. Consequently, there are four types of affordances based on the agent's and environment's properties.

Fig 3 enlightens and summarises the categorisations of affordances from the perspective of a distributed cognition.

Discussion of the third point (the system that picks up information): To elaborate this point, it can be inferred that Gibson [1] separates affordances from the available information when he claims that ″affordances exist whether the agent perceives it or not″ [1]. Nonetheless, Gibson has not classified his notion any further.

Gaver [6] proposes a framework for separating affordances from the available perceptual information. This separation allows the distinction through correct rejections and perceived, hidden and false affordances (Table I).

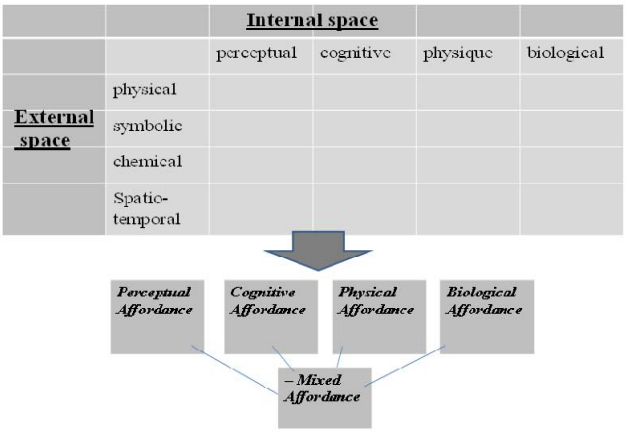

Fig. 3 The categorisation of affordances from the perspective of a distributed cognition (the author's introduction)

TABLE I
GAVER'S [6] TYPOLOGIES OF AFFORDANCES BASED ON SEPARATING AFFORDANCES FROM THE AVAILABLE INFORMATION

Perceptible affordance	Hidden affordance	False affordance	Correct rejection

2. Intersecting Distributed Cognition Category with Gaver's Category of Affordance

Intersecting of the distributed cognition categories with Gaver's categories of affordance delivers new typologies of affordances. These typologies are more comprehensive than the last two ones since they summarise possible actions between the agent and environment based on the environment's characteristic, the agent's characteristic and the available information about them (Table II) whereas distributed cognition's categories of affordance and Gaver's categories of affordance each alone were insufficient to encompass these three points together.

TABLE II
16 DEVELOPED TYPOLOGIES OF AFFORDANCE, FROM INTERSECTING GAVER'S TYPOLOGIES WITH DISTRIBUTED COGNITION'S TYPOLOGIES

	Perceptible affordance where information on the actions that are afforded are perceptible to the user	Hidden affordance actions that are possible but may not be visible	False Affordance if users perceive an environment that affords actions that are not possible	Correct rejection occurs when there is neither the affordance nor the misperception of its existence
Biological Affordance based on biological processes	1 Perceptible Biological Affordance	2 Hid den Biological Affordance	3 False Biological Affordance	4 Correct rejection Biological Affordance
Physical Affordance For tasks that are mainly constrained by physical structures.	5 Perceptible Physical Affordance	6 Hidden Physical Affordance	7 False Physical Affordance	8 Correct rejection Physical Affordance
Perceptual Affordance. Affordances are mainly provided by spatial mappings	9 Perceptible Perceptual Affordance	10 Hidden Perceptual Affordance	11 False Perceptual Affordance	12 Correct rejection Perceptual Affordance
Cognitive Affordance Affordances of this type are provided by cultural conventions.	13 Perceptible Cognitive Affordance	14 Hidden Cognitive Affordance	15 False Cognitive Affordance	16 Correct rejection Cognitive Affordance
Mixed Affordance Many affordances are provided by a combination of more than one module				

Table II represents 16 typologies of affordances, which can be combined together to form a wide range of mixed affordances. These affordances summarise the possible actions between the agent and environment based on the environment's characteristics, the agent's characteristic and the available information about them. The paper explains these typologies and provides examples according to the following sections.

C. Clarifications for the New Typologies

1. Perceptible Biological Affordance

The affordances here are based on biological process where information on the actions that are afforded is perceptible to the user. For instance, the nutrition visible banana affords the agent a perceptible biological affordance where nutrition is an affordance that is based on the biological process and the banana is visible, and hence, the affordance is perceptible.

2. Hidden Biological Affordance

The affordances here are based on the biological process, and they are possible but there is no information to perceive them. For example:

- Healthy banana unseen from the agent affords hidden biological affordances, the banana still affords biological affordance but it is hidden.
- Hidden digital curtain controls the light (see Fig. 4) by affording the agent an affordance based on the biological process, which represents the interaction with the light. Nonetheless, it is hidden. Accordingly, it affords hidden biological affordances**.**

Fig. 4 The presentation of Philip's daylight window concept [7]

Fig. 4 shows a window with a hidden digital curtain in different shapes, which is automated to control the day light.

3. False Biological Affordance

The user perceives an environment that affords a biological affordance (based on the biological processes), which is not possible. For example: plastic banana affords the infant a false biological affordance.

4. Correct Rejection Biological Affordance:

It occurs when there is neither the biological affordance (based on the biological processes) nor the misperception of its existence. For example: The case when a man feels he needs to drink a glass of water where in front of him, there is an apple. So, there is no glass of water, i.e., no biological affordance and the man has no misperception of its existence.

5. Perceptible Physical Affordance:

It defines the tasks that are mainly constrained by physical structures such that the information on actions that are afforded is perceptible to the user. For example:

a. The flat horizontal panel on the door, which is visible to the user can only be pushed.

Fig. 5 Flat horizontal panel on the door

b. The brick podium block at Montessori school affords the student a perceptible physical affordance where they can sit, and where the task sitting is constrained by a physical structure and by an information that is clear enough.

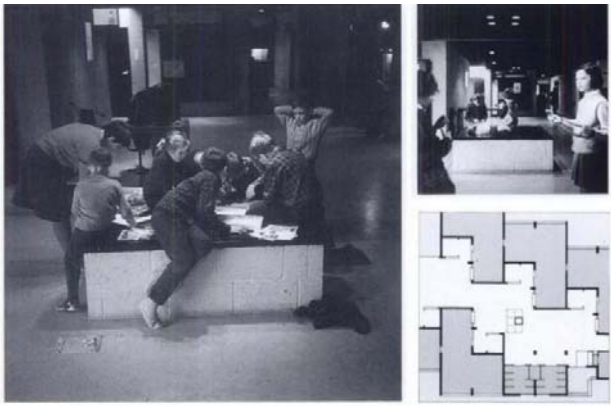

Fig. 6 Montessori school, Delft (395.417) [8]

6. Hidden Physical Affordance

It defines the tasks that are mainly constrained by physical structures and are possible, but with no information to perceive them. For example: The floor in the hall of the kindergarten section at the Montessori school possesses a square depression in the middle that is filled in with loose wood blocks, which can be taken out and placed around the square to form a self-contained seating arrangement (see Fig. 7). This design affords a physical affordance, but the information in which to perceive is hidden. Accordingly, the

design affords a hidden physical affordance.

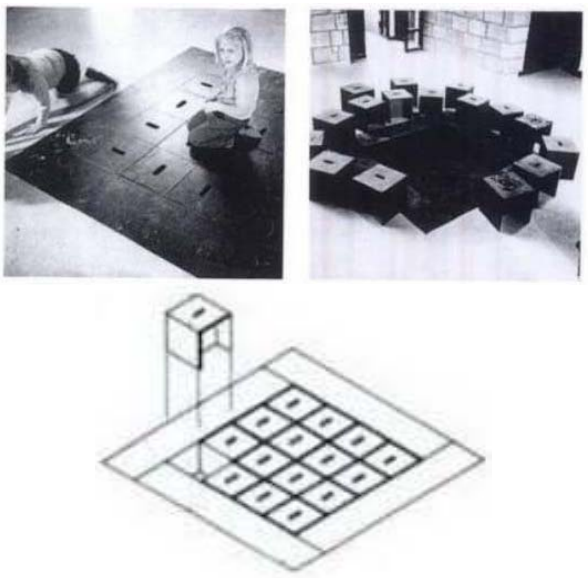

Fig. 7 Montessori school, Delft (395.417) [8]

As can be seen in the hidden swimming pool in Fig. 8, the swimming pool affords the task of swimming, which is constrained by the physical structure pertaining to the pool, its width, depth, and etc. Therefore, it affords physical affordance but it is hidden so that there is no information to perceive the affordance, and consequently, it affords a hidden physical affordance.

Fig. 8 Hidden water pools news 8 coverage [9]

7. False Physical Affordance

The user perceives an environment that attempts to afford physical affordance (i.e., tasks that are mainly constrained by physical structures), which is not possible. For example: If the last podium block at the Montessori school (Fig. 6) was made of carton instead of brick, the user will perceive a physical affordance that is not possible, but only a false physical affordance.

8. Correct Rejection Physical Affordance

It occurs when neither the physical affordance (the tasks that are mainly constrained by the physical structures) nor the misperception exists. For example: A small dimension chair that is designed for infants exists in front of an adult who wants to sit on it. Neither the small chair affords the adult physical affordance who is sitting on it nor can the adult have a misperception of that.

9. Perceptible Perceptual Affordance

In this category, affordances are mainly provided by spatial mappings where an information on the actions, which are afforded is perceptible to the user. For example:

a. If the switches of the stovetop burners have the same spatial layout as the burners themselves, the switches can accordingly provide affordances for controlling the burners.
b. The pictorial signs for women's and men's restrooms in an airport.

10. Hidden Perceptual Affordance:

In this category, affordances are mainly provided by spatial mappings, and are made possible, but there is no information to perceive them. For example: Hidden U-turn sign affords hidden perceptual affordance where the sign refers to an action that is provided by spatial mapping, which is possible, but when the information is hidden.

11. False Perceptual Affordance:

In this category, affordances are mainly provided by spatial mappings, but are meantime, not possible. For example: In Fig. 9, the Crooked House (Sopot, Poland) represents the spatial mapping, which affords a false perceptual affordance where it refers to an unbalance building (non-functional building) and this is not true as the building is functional.

12. Correct Rejection Perceptual Affordance

It occurs when there is neither affordance that is mainly provided by spatial mappings, nor the misperception of its existence. For example: A driver with a small car has seen obligated U-turn sign for big cars. In this case, we have correct rejection perceptual affordance where there is no affordance for the user since he(she) has a small car with no misperception in it.

13. Perceptible Cognitive Affordance

The affordances of this type are provided by cultural conventions, and the information on actions that are afforded is perceptible to the user. For Example: Visible Traffic lights afford three perceptible cognitive affordances (red means "stop", yellow means "prepare to stop" and green means "go") since these affordances are provided by different cultural conventions.

14. Hidden Cognitive Affordance

The affordances of this type are provided by cultural conventions where they are possible, but there is no

information for perceiving them. For example: The hidden traffic sign affords a hidden cognitive affordance.

Fig. 9 The crooked house (Sopot, Poland) [10]

Fig. 10 135 Degree Angle [11]: This is another example of the false perceptual affordance

15. False Cognitive Affordance

The affordances of this type are provided by different cultural conventions, but they are not possible. For example: An administration sign is labelled in front of the cashier office, which affords false cognitive affordance.

16. Correct Rejection Cognitive Affordance

It occurs when there is neither affordance provided by cultural conventions nor the misperception of its existence. For example: When you possess a car with a 4-meter length and you want to turn left, but you see the next sign as in Fig. 11. You can in return make a correct rejection to ignore this sign, because you know the length of your car.

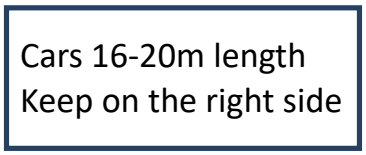

Fig. 11 Traffic sign

Here, we have the correct rejection cognitive affordance where there is neither affordances provided by a cultural convention that is concerned on your car, nor the misperception of its existence.

17. Mixed Affordance [5]

These affordances are provided by a combination of more than one module.

The previous paragraphs represent the 16 developed typologies of affordances, and if we count the possibility of its combination, we will have more than 120 cases of mixed affordances. Consequently, this research is insufficient to cover the whole cases. However, a few examples can be provided; for instance, the typology (9+13) which presents mixed affordance: (the Perceptible perceptual affordance + the perceptible cognitive affordance) as shown in Fig. 12.

Fig. 12 A manual transmission vehicle, (a car gear)

Fig. 12 clarifies mixed affordances category where it is a combination of the perceptible perceptual affordances that are provided by spatial mappings and the perceptible cognition affordance where the knowledge about driving is obtained from the culture. Consequently, the task of using the gear is constrained by the cultural convention and spatial mappings (mixed affordances).

Another example for the perceptible perceptual affordance + the perceptible cognitive affordance is shown in Fig. 13.

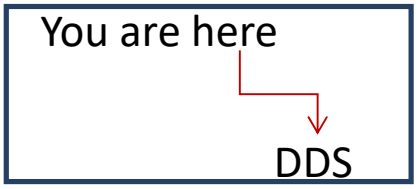

Fig. 13 Mixed affordances

The arrow affords the perceptible perceptual affordance, while the writing affords the perceptible cognitive affordance.

Another example is the category (5+6) which presents

Mixed affordances: (the perceptible physical affordance + the hidden physical affordance) as shown in Fig. 14.

Fig. 14 DB Fletcher Capstan Ilona expanding table (YouTube. 2006) [12]

The table affords the perceptible physical affordance and the hidden mechanism such that both allow the user to extend the table and afford the hidden physical affordance. Another example is the category (5+13) which presents the mixed affordance: (the perceptible physical affordance + the perceptible cognitive affordance) as shown in Fig. 15.

Fig. 15 Mixed affordances of the Grainger town project, Newcastle Award RTPI (2003)

The glass partition affords the physical affordance where the man can support his back (the task constrained by the physical structure). The writing on the glass partition (the cultural convention) has a cognitive affordance where it pushes people to use this place. Some of the last categories are discussed in Part II and are used in the experimental study in order to prove new capabilities of various vocabularies (the new categories of affordance) in reading and evaluating different environments.

II. Part II: The Experimental Study

A. Introduction

This part concerns on the use of developed typologies of affordances (the new vocabulary) and on proving their capabilities to diagnose and evaluate affordances across different environments through adapting two processes, namely:

1. Diagnostic process: interprets environments upon its affordance by using new categories (the new vocabulary).
2. Evaluating process: evaluates the environments, which have been interpreted and classified by its affordance by using the following measures:

i. The emotional experience measures (PA and NA).
ii. The architectural evaluation criteria (beauty, economy and function).

The diagnostic process proves the new category capability to interpret and read the affordances through different environments. On the other hand, evaluating the process proves that different categories of affordances can reflect different interactions. In particular, the emotional experience measures and architectural evaluation measures can provide answers to the following questions:

1. Why some environments (some categories of affordances) are friendlier than others?
2. Why some environments (some categories of affordances) are more successful than others?

Both processes have been discussed thoroughly in the following subsection.

1. Suggested Measures to Evaluate the Affordance of Architectural Environments

The affordance of architectural environments represents the action of capable properties between the user and the architectural environment in order to evaluate this interaction where researchers can use all related measures pertaining to the interaction.

This paper suggests some measures among those related ones to the user and to the architectural environments, which are comprised of:

1. Emotional experience measures: The Positive Affect (PA) and the Negative Affect (NA) are the dominant dimensions of the emotional experience. To measure these factors, Watson Clark and Tellegen [15] developed the Positive and the Negative Affect Schedule (PANAS) in order to assess these specific emotional states. In fact, they have created 60 items of feelings and emotions and

have expanded the version of the PANAS (the PANAS-X) [13]. PANAS-X is a scale that consists of a number of words and phrases that describes different feelings and emotions.

Negative Affect (10) comprises words such as afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset and distressed. While Positive Affect (10) comprises words such as active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud and strong.

Basic Negative Emotion Scales:

- Fear (6): (afraid, scared, frightened, nervous, jittery and shaky).
- Hostility (6): (angry, hostile, irritable, scornful, disgusted and loathing).
- Guilt (6): (guilty, ashamed, blameworthy, angry, disgusted with self and dissatisfied with self).
- Sadness (5): (sad, blue, downhearted, alone and lonely).

Basic Positive Emotion Scales:

- Joviality (8): (happy, joyful, delighted, cheerful, excited, enthusiastic, lively and energetic).
- Self-Assurance (6): (proud, strong, confident, bold, daring and fearless).
- Attentiveness (4): (alert, attentive, concentrating and determined) [13].

2. Architectural Evaluation Criteria of Beauty, Economy and Function that represents the three main challenges of the architectural design.

When judging any architectural building based on the beauty of its form, its functionality and its economic put constraints on the construction process. Burden [14] confirms this fact by declaring that ″a work of architecture is not just a structure built by and for certain people at a particular time and in a characteristic style, nor is it built only to fulfil a given utilitarian or symbolic function. It is also an art form the architect, which uses a variety of design tools for achieving the desired balance of functional concerns and beauty of form for designing the means of creation. Further, it involves associating and arranging different forms into new meanings. The invention and disposition of forms, elements and materials according to a plan, which represents a myriad of function and economic constraints, is based on designing a building″ [14, p.54].

We used some words of the PANAS-X scale that describes different feelings and emotions, as she used architectural evaluation measures in order to evaluate the interaction with different architectural environments as highlighted in Experiment 1.

2. Discussion of the Experiment

The experiment consists of two processes, which are applied as follows:

a- Diagnostic process: It is the process where the author stared by the vocabulary of the developed language (the developed typologies) based on selecting three architectural examples, which reflect three different typologies of affordances.

b- Evaluating process: It is the process that evaluates the three categories of affordances by using the first method, which consists of 60 participants, stimuli (projection screen), three independent variables and five dependent measures. After that, the process discusses the experimental results and draws the conclusion and recommendations.

To accomplish the experiment, the author selects three architectural examples from Table II, which summarise the 16 developed typologies of affordances.

The selected examples reflect three different typologies of affordances as follows:

- 2-Hidden biological affordance: The example, which is selected to represent this category refers to a hidden curtain (see Fig. 4).
- 6-Hidden physical affordance: The example, which is selected to represent this category refers to a hidden swimming pool (see Fig. 8).
- 5+6-Mixed affordance: The hidden physical affordance + The perceptible physical affordance: The example, which is selected to represent this category refers to a table that possesses a hidden mechanism for enabling a user to extend it (see Fig. 14).

In order to clarify the capability of these typologies, a set of questions as included in Appendices A, B and C are proposed to a set of participants in order to evaluate these environments (topologies) by expressing their positive or negative feelings, and their architectural judgment toward these environments, particularly, to evaluate its function, economy and beauty.

B. The Method of the Experiment

1. Participants

The respondents that have participated in the study consist of 60 students from the Jordan University of Science and Technology and from the German-Jordanian University. They are third-year and fifth-year students under the architecture major. We select architect students since their interests in the design subject made them the most relevant among others.

Replicating or even comparing this experiment to other groups is considered valuable.

2. Independent Variables

Independent variables are shown in Table III.

3. Dependent Measures

The dependent measures in this study comprise the followings:

1. The architectural evaluation criteria of beauty, economy and function can conventionally judge any architectural building based on the beauty of its form, its functionality and its economic constraints that face the construction process.
2. Emotional experience is another dependent measure of this study where the Positive Affect (PA) and Negative Affect (NA) represent the dominant dimensions of the emotional experience [15].

We use emotional experience measures and architectural evaluation measures for evaluating participants' interactions

among these different typologies.

Table IV represents the dependent measures for the independent variables and the questions, which are included in Appendices A, B and C.

TABLE III
INDEPENDENT VARIABLES

Independent variables	Examples
(2) Hidden biological Affordance	
(6) Hidden Physical Affordance	
(5+6) Mixed Hidden Physical Affordance + Perceptible Physical Affordance	

TABLE IV
THE DEPENDENT MEASURES FOR THE INDEPENDENT VARIABLES

ependent easures	Independent variable (2) Hidden biological Affordance	Independent variable (6) Hidden Physical Affordance	Independent variable (5+6) Mixed Hidden Physical Affordance + Perceptible Physical Affordance
1 Emotional experience			
-Positive eelings	Q2+6+4+11+13+14+21 Appendix-A-	Q2+6+4+11+13+14+21 Appendix-B-	Q2+6+4+11+13+14+21 Appendix-C-
B- egative eelings	Q8+10 Appendix-A-	Q8+10 Appendix- B -	Q8+10 Appendix- C -
2 Architectural evaluation criteria			
Beauty	Q5	Q5	Q8
unction	Appendix-A- Q16+17+24+27	Appendix- B - Q16+17+24+27	Appendix- C - Q16+17+24+27
conomy	Appendix-A- Q26	Appendix- B - Q26	Appendix- C - Q26
	Appendix-A-	Appendix- B -	Appendix- C -

4. Stimuli

Stimulated environments can be divided into a desktop system, an immersion system, and an intermediate solution between both of these systems [16]. Intermediate solutions use a projection screen or 3D-monitors [17]. In this study, an intermediate solution was used to enable research participants to investigate and interact with the proposed environments. We use a projection screen in order to present short videos that are enlightened to the three different environments (see Figs. 4, 8, 14).

5. Procedure

The experiment was conducted in several literature halls at the Jordan University of Science and Technology and at the German-Jordanian University in Amman by using a projection of a computer image for the three different environments, including the screen measures with 1.5 m long and 1.2 m wide. The author met the participants at their study halls where each 20 participants were first briefed on the experiment, and asked to watch the video carefully, which represents the considered environment that they were going to experience and imagine themselves being involved into it. At the end of the show, the subject was presented with a list of questions on a number of sheets of papers, which were included in Appendices A, B and C where the participants were asked to provide answers to them. The participants were informed that these questions are related to the environment they are watching.

C. Experimental Analysis and Results

The answer of each question as illustrated in Table IV (which represents the dependent measures) is based on a scale from 1 to 10 (1 means indeed no and 10 means indeed yes). This means that the qualitative measures (PA, NA, economy, beauty and function evaluation) were numerically described and the data are quantitative. To analyse the collected quantitative data, a simple descriptive statistic frequency and regression analysis is used and Tables V and VI represent the obtained results.

The obtained results are shown in percentages where the answers, which were listed according to a scale from 1 to 10, are split into two ranges (Range 1 is the lowest through Value 5 and Range 2 is the highest through Value 5). The scale was used to ensure that the participants have expressed their feelings properly and to split them into two ranges in order to have a simple and unfussy analysis.

TABLE V
THE RESULTS OF THE DESCRIPTIVE FREQUENCY ANALYSIS FOR THE DEPENDENT MEASURES (THE POSITIVE AND THE NEGATIVE FEELINGS) TOWARD THE INDEPENDENT VARIABLES (SEE TABLE III)

	(2) Hidden biological Affordance	(6) Hidden Physical Affordance	(5+6) Mixed Hidden Physical Affordance + Perceptible Physical Affordance
1-Emotional Experience A-Positive feelings	89.5% had positive feelings toward the design, 10.5% hadn't	90% had positive feelings toward the design, 10% hadn't	90% had positive feelings toward the design, 10% hadn't
1-Emotional Experience B-negative feelings	11.1% had positive feelings toward the design, 88.8 hadn't	25% had positive feelings toward the design, 75% hadn't	10% had positive feelings toward the design, 90 %hadn't

1. The Emotional Experience Result

The positive feelings toward the three different categories are almost the same where 90% of the participants had positive feeling toward the designs, while their negative feelings were different. Further, 10% of the participants had negative feelings toward the category (5+6), 11.1% toward Category 2 and 25% toward Category 6.

The results of positive and negative feelings indicate that the Categories (5+6) are recommended emotionally compared to Categories (2) and (6). following that, category (2) comes next, and finally, category (6). The analysis proves that different categories of affordance reflect different interactions,

including the answer of the question "Why some environments are friendlier than others?".

TABLE VI
THE RESULTS OF THE DESCRIPTIVE FREQUENCY ANALYSIS FOR DEPENDENT MEASURES (BEAUTY, FUNCTION AND ECONOMY) TOWARD THE INDEPENDENT VARIABLES (2), (6) AND (5+6)

	(2) Hidden biological Affordance	(6) Hidden Physical Affordance	(5+6) Mixed Hidden Physical Affordance + Perceptible Physical Affordance
Architectural evaluation criteria Beauty	79% said the design is beautiful, 21% said it is not	60% said the design is beautiful, 40% said it is not	89.5% said the design is beautiful, 10.5% said it is not
Function	70% said the design is functional, 30% said it is not	80% said the design is functional, 20% said it is not	87% said the design is functional, 13% said it is not
Economy	31.5% said the design is economy, 68.5% said it is not	55% said the design is economy, 45% said it is not	68.5% said the design is economy, 31.5% said it is not

2. The Architectural Evaluation Result

The architectural evaluation of Category (5+6) takes the best grades where 89.5% of the participants find it beautiful, 87% of them find it functional and 68.5% of them find it economical. Category 6 is more economic and functional than Category 2, but less beautiful. Further, 80% of the participants find it functional, 55% of them find it economical and 60% of them find it beautiful. 79% of the participant found the category 2 beautiful.

The obtained results confirm the last result, which indicates that different categories reflect different interactions where it is in percentages. Consequently, it provides the architect with a clue about selecting the friendliest and successful category, or just with the most successful one, or the friendliest one according to the intended conditions the architect needs to apply.

3. Regression analysis

By using this analysis, two questions could be answered:

- Q1: How well do the measures of the architectural evaluation predict positive feelings (in the three environments 2, 6 and 5+6)? How much variance(s) in perceived positive feelings can be explained by score on these scales?
- Q2: What is the best predictor of perceived positive feelings (in the three environments 2, 6 and 5+6), beauty of design, function or economy's evaluation?

Table VII illustrates the results and Table VIII illustrates the clarifications.

TABLE VII
REGRESSION'S ANALYTICAL RESULTS

	(2) Hidden Biological Affordance	(6) Hidden Physical Affordance	(5+6) mixed Hidden Physical Affordance + Perceptible Physical Affordance
Linear Regression Analysis	Dependent: positive feelings (Table IV illustrates the questions) Independents: Beauty, economy, function (Table IV illustrates the questions)	Dependent: positive feelings (Table IV illustrates the questions) Independents: Beauty, economy, function (Table IV illustrates the questions)	Dependent: positive feelings (Table IV illustrates the questions) Independents: Beauty, economy, function (Table IV illustrates the questions)
R square	0.56	0.40	0.57
Beta	Function -0.12 Beauty 0.55 Economy 0.37	Function -0.07 Beauty 0.65 Economy 0.44	Function -0.32 Beauty 0.71 Economy 0.55
Sig		Beauty 0.008	Beauty 0.006

TABLE VIII
CLARIFICATIONS OF REGRESSION'S ANALYTICAL RESULTS

	Positive feelings toward (2) Hidden Biological Affordance	Positive feelings toward (6) Hidden Physical Affordance	Positive feelings toward (5+6) mixed Hidden Physical Affordance + Perceptible Physical Affordance
Regression results Clarification	category (2) Architectural evaluation measures Explain 56% of perceived positive feelings And no variable makes a significant unique contribution in predicting the dependent measure (positive feelings)	category (6) Architectural evaluation measures Explain 40% of perceived positive feelings And the variable beauty makes a significant unique contribution in predicting the dependent measure (positive feelings)	category (5+6) Architectural evaluation measures Explain 57% of perceived positive feelings And the variable beauty makes a significant unique contribution in predicting the dependent measure (positive feelings)

D. Discussion

The numerical results of Tables V-VIII, which particularly, represent the evaluation results pertaining to the categories, {hidden biological affordance (2), hidden physical affordance (6), plus a mix of perceptible physical affordance with a hidden physical affordance (5+6)}, clarify the following points:

The participant's interaction with Categories 5+6 are recommended comparatively to Categories 2 and 6, which means that having a mixed perceptible with a hidden affordance is recommended than just having a hidden affordance. In particular, having this mix should be highlighted into further details (the positive feelings plus architectural evaluation criteria beauty, function and economy)

toward a mixed perceptible and a hidden affordance, which are recommended than just implying a hidden affordance. Consequently, designers can know how to succeed in the levels of PA, NA and the categories related to beauty, function, economy evaluation when adapting Categories 5+6 along into their designs.

1. Conclusion

This study aims to discover and develop a language (a typology), based on the ecological concept of affordance, and that what the analytical study has achieved. The analytical study concluded 16 typologies of affordances, including the possibilities of mixing them, and that based on Gibson's definition of the concept of affordance [1], and the researches that are concerned on the affordance categorisation [6], [3], [4]. Moreover, it aims to prove the affordance language's capability for diagnosing and evaluating different environments. This is what the experimental study came across through adapting diagnostic processes, evaluating them and applying them into various environments.

Through the diagnostic process, this study shows how each environment can be analysed upon its affordance, which means classifying it by its affordance (the sort of interaction, biological, cognitive, perceptual, physical, hidden, false, and perceptible and if there is no interaction (correct rejection) or mixing all these affordances with each other). Further, each environment can also be analysed by adapting the evaluating processes and their suggested measures of interaction (PA, NA, function evaluation, economy and beauty evaluation). The study explains how different typologies of affordances that already reflect different environments possess different evaluations. Some of these evaluations are recommended while the others are not based on the analysis of the evaluation measures. (Indeed, the future research can adapt other extra measures, where this study was limited in this part).

The application of the diagnostic process and the evaluating process cover three different environments (indeed, the future research must cover the rest, where this study was also limited in this part).

This paper draws a roadmap for the designer to diagnose, evaluate and afterwards analyse the affordance in different architectural environments, and to adapt the best interaction (the best affordance category), which is likely to be highlighted in future proposed designs.

APPENDICES A, B, C

The below sample presents the same questionnaire to the different typologies of (2), (6), (5+6).

.

Jordan University of Science and Technology
The Faculty of Architecture and Design
Questionnaire for M.Sc. in Architecture

The objective of the proposed questionnaire is to look into the architecture students' feelings and judgments towards the environment (presented earlier), by answering the following questions; The questions examine the architect's interaction on both the practical and emotional levels. Please place a (check mark) and continue:

Profession: third year student ☐ fourth year student ☐ fifth year student ☐

		Proposed design									
Q	**What feelings do you have once you can picture yourself using the proposed design?**	not at all				Some how					Yes very much
		1	2	3	4	5	6	7	8	9	10
1	Feelings of enthusiasm?										
2	Feelings of interest?										
3	Feelings of comfort?										
4	Feelings of pleasure?										
5	feelings of beauty?										
6	Feelings of uniqueness?										
7	Feelings of trust?										
8	Feelings of fears?										
9	Feelings of inspiration?										
10	Feelings of tenseness?										
Q	**What is your feeling once you imagine that you are inviting your friends to view the proposed design?**	not at all				Some how					Yes very much
		1	2	3	4	5	6	7	8	9	10
11	Feelings of pride										
12	Feelings of content										
13	Feelings of trust										
14	Feelings of uniqueness										
Q	**What is your functional evaluation towards the proposed design?**	not at all				Some how					Yes very much
		1	2	3	4	5	6	7	8	9	10
15	The design is new and effective and breaks the classic mold of design.										
16	The user would find the design difficult to use.										
17	The design functionality is appropriate and acceptable.										
Q	**Does the hidden mechanism in the proposed design:**	not at all				Some how					Yes very much
		1	2	3	4	5	6	7	8	9	10
18	Shock you?										
19	Surprise you?										
20	Entertain you?										
21	Excite you?										
Q	**As a designer do you think that using such hidden mechanisms in your designs will make them:**	not at all				Some how					Yes very much
		1	2	3	4	5	6	7	8	9	10
22	Unique?										
23	Bizarre?										
24	Practical?										
25	interested ?										
26	Economic?										
27	Useful?										
Q	**Do you think that you had a shift in feelings because of the:**	not at all				Some how					Yes very much
		1	2	3	4	5	6	7	8	9	10
28	Surprising element?										
29	The beauty of design and idea?										
30	Both 28+29?										

Fig. 15 Appendices A-B-C

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REFERENCES

[1] Gibson, J. J. (1979). The ecological approach to visual perception. Boston: Houghton, Mifflin.
[2] Gibson, J. J. (1977). The theory of affordances. In R. Shaw & J. Bransford (Eds.), *Perceiving, acting, and knowing: Toward an ecological psychology* (pp. 67-82). Hillsdale, NJ: Erlbaum.
[3] Zhang, J. (1997b). The nature of external representations in problem solving. Cognitive Science, 21, 179-217.
[4] Zhang, J., & Norman, D. A. (1994). Representations in distributed cognitive tasks. Cognitive Science, 18(1), 87-122.
[5] Zhang, Jiajie; Patel, Vimla L (2006), Distributed Cognition, Representation, and Affordance, In press: Cognition & Pragmatics, Volume 14, Number 2, 2006, pp. 333-341(9)
[6] Gaver, W.W. (1991). Technology affordances.CHI'91 Conference Proceedings. 79-84.
[7] YouTube. (2011), Philips Daylight Window Concept Presentation (updated 10/1/2008)
[8] Herman Hertzberg, (1995) Lessons for student in architecture, münchen Greeno James G. 1994. Gibson's Review 101(2): 336-342. Retrieved July 14, 2008.
[9] YouTube. (2009), Hidden Water Pools News 8 Coverage (updated 6/8/2009) (Accessed13/4/2011) http://www.youtube.com/watch?v=bqCt2M9VbIE
[10] Quazen. (2009), The Crooked House (Sopot, Poland) (updated 16/2/2009) http://quazen.com/arts/architecture/seven-strangest-and-most-bizarre-houses-around-the-world/#ixzz1JPkol3eQ (Accessed 13/4/2011)
[11] 2Loop.com (2006), 135 Degree Angle (updated 16/2/2006) http://www.2loop.com/strangebldg.html(Accessed 13/4/2011)
[12] YouTube. (2006), DB Fletcher Capstan Ilona expanding table (updated 9/12/2006) (Accessed13/4/2011) http://www.youtube.com/watch?v=Bh_qn62zny0
[13] David Watson and Lee Anna Clark (1994), THE PANAS-X Manual for the Positive and Negative Affect Schedule, The University of Iowa updated 8/99
[14] Ernest burden (1976), Elements of architectural design, New York, Watson Guptill Publications
[15] Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and Validation of Brief Measures of Positive and Negative Affect: The PANAS Scales. Journal of Personality and Social Psychology, 54, 1063-1070.
[16] Jansen-Osmann, P., & Wiedenbauer, G. (2004). The representation of landmarks and routes in children and adults: A study in a virtual environment. *Journal of Environmental Psychology, 24*(3), 347–357.
[17] Jansen-Osmann, P. (2002). Using desktop virtual environments to investigate the role of landmarks. *Computers in Human Behavior, 18*(4), 427–436.

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