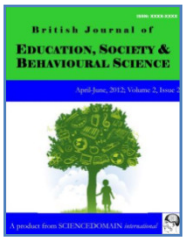

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Intellectual Style Inventory (ISI): Learning Style Assessment after Cortical Functional Specialization

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Authors' contributions

This work was carried out in collaboration between all authors. Author MSS invented the tool, shared in the study design, did the practical work, and wrote the manuscript. Author ZMM shared in the study design supervised the practical work and reviewed the written manuscript. Author SSM did the proof reading and the English editing. Author ASH performed the statistical analysis and shared in writing the statistical methods used and data description in the results section. All authors read and approved the final manuscript.

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ABSTRACT

Background: Many criticisms face theoretical bases and measurement tools used for identifying learning styles. The Intellectual Style Inventory (ISI) introduced in this work provides a new approach for learning style assessment based on cortical functional specialization. The ISI emphasizes the distinct characteristic processes of thinking and perception in each cortical lobe. It adds that the lobe indicating an individual's first preference in thinking may differ from his lobe of first preference in perception. Knowing an individual's preferred cortical lobe in thinking and in perception could help identify his learning style according to his predominant intellectual processes.
Aims: The aim of the present study was to investigate the theoretical assumption after the

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ISI, and the appropriateness of the tool.
Methodology: Study sample was composed of 203 volunteers of both sexes with mean age of 33.2 years. The subjects completed the ISI and demographic data were also collected. One month later, 19 of the study sample retook the ISI.
Results: Content validity coefficient (V) and homogeneity reliability coefficient (H) for all items and sets of items of the inventory exceeded 0.71. Likelihood ratio comparing first preferences in thinking and perception showed non-significant results. No significant difference was found between test and retest.
Conclusion: In conclusion, it could be suggested that for the same individual; there is no relationship between the first preference concerning each of the two intellectual functions; thinking and perception: two distinct faculties describing learning. ISI is a potential reliable tool for learning style assessment under the concept of cortical function specialization.

Keywords: learning styles; thinking; perception; cortical functional specialization; law of preference; assessment tool.

1. INTRODUCTION

Learning styles are characteristic cognitive, affective, and psychosocial behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment [1]. Different approaches describing learning tendencies and preferences are highly overlapping and interconnected. At the same time they are still controversial with a lot of criticism to both their theoretical bases and tools of assessment.

1.1 Background

1.1.1 Criticism for underlying learning styles' Theories and Instruments

A number of educational psychologists believe there is little evidence for the efficacy of most learning style models since such models often rest on doubtful theoretical grounds [2]. Moreover, according to Susan Greenfield the practice is nonsense from a neuro-scientific point of view [3]. A non-peer-reviewed literature by Coffield and his colleagues identified 71 different theories of learning style and criticized most of the main instruments introduced as assessment tools [4]. An example is; Dunn, et al. [5] Visual, Auditory, Kinesthetic (VAK) model based on Fleming's learning style theory [6] which is widely used in United States schools, and used in 177 peer reviewed articles [4]. The Coffield team suggested that the idea of a learning cycle, the consistency of visual, auditory and kinesthetic preferences and the value of matching teaching and learning styles were all highly questionable.

Kolb's model [7] is another highly popular learning style tool based on the theory of Experiential Learning (ELT). It defines learning to be the process whereby knowledge is created through the transformation of experience. The ELT model portrays two dialectically related modes of grasping experience; Concrete Experience (CE) and Abstract Conceptualization (AC) and two dialectically related modes of transforming experience; Reflective Observation (RO) and Active Experimentation (AE). The combination of one way of grasping information with one way of transforming knowledge results in four different learning styles; the Converger, the Diverge, the Accommodator and the Assimilator. According to Smith [8], there are six points of criticism regarding Kolb's model. One of which

targets the weak empirical evidence and others are more concerned with the theoretical justification describing the process of experiential learning.

Myers-Briggs Type Indicator (MBTI) [9] as a personality based learning model was designed to measure Jungian psychological types [10]. MBTI is also criticized for describing learning styles in non-specific fashions [11] which makes the use of these personality based markers to measure learning styles not recommended [11-12]. Moreover, it is after Coffield's team that the analytical and empirical work done with the MBTI is sought to be uncritical and unreflective.

From the previous review of some of the most popular learning style models in use, it is clear that so far no solid bases -theoretical or empirical- support the underlying theories and modalities describing learning styles. Hence, it is of crucial importance to introduce a more substantial approach for human learning exploration. The concept of functional specialization of the human cortical lobes introduced by Katherine Benziger [13] and based on Jung typology [10] in our speculation- could be able to perform such a task. We hypothesize that cortical functional specialization is able to describe learning in a more specified manner from more than one perspective and with respect to different intellectual abilities. Such intellects include; perception and brain filters at one side, as well as thinking and decision making at the other.

1.2 Theoretical Framework

Functional specialization states that the cortex is clearly divided into four almost equal areas. Each hemisphere of the brain is divided by a central fissure that separates the frontal lobe on each side from the posterior portion of the hemisphere (the posterior cortical convexity). Each of these four areas functions differently based on its unique specialized capabilities. Concerning perception, each area has its own specialized screens or filters to perceive selectively what it needs to perceive to perform its function. At the same time regarding thinking each area has highly specialized processing modes that use the information it perceives to accomplish tasks in its specific way [13]. Therefore, with respect to their specialized functions, these four cortical areas upon acting in union comprise primary tools for appropriate thinking and deciding at one side, and perceiving both the detailed and the long view of reality in a holistic manner at the other side [13]. Moreover, the four different cortical lobes are not utilized equally by each individual, rather they are subject to the law of preference. Preference according to Benziger is the functionally specialized area of a person's cortex which is highly efficient and therefore more energizing for the person to use.

According to the neurophysiological model introduced by Benziger, Jung's four functions describe thinking, and are rooted in the four distinct areas of the cortex. Thinking type is housed in the left frontal lobe (FL) and Intuition type in the right frontal lobe (FR), and both are abstract and conceptual. While the Sensing type is housed in the left posterior convexity (BL) and the Feeling type is housed in the right posterior convexity (BR) and both deal with concrete data in a different manner. This model could be emphasized by what modern neuroscience call "functional module" which denotes for a continuous and circumscribed portion of cortex dedicated to one particular function and not others [14].

Carl Jung described Sensing as preference to focus on concrete aspects of a situation by using one or more of the five senses. Alternatively, Intuition describes the focus on abstract ideas made through possibilities, meanings, and relationships associated with a concrete situation. Thinking as one category of judgment is a function which links ideas together

through logical connections and leads to an impersonal finding. Feeling, on the other hand, describes a rational act of evaluation using subjective values and relative merits of the issues for judgment and decision making [15].

Similarly, Herrmann [16-17] quantifies a person's relative preference for thinking in four different modes that are based on the task specialized functioning of the physical brain in his Four Quadrant Whole Brain Model or Herrmann Brain Dominance Model (HBDM). According to Herrmann, the four quadrants of distinct groups of thinking activities are Quadrant A: the Theorist (left cerebral) characterized to be problem solving, mathematical, technical, analytic and logic. Quadrant B: the Organizer (left limbic) which includes planning, controlled, conservative, administrative, organizational individuals. Quadrant C: the Humanitarian (right limbic) described as talker, musical, spiritual, emotional, interpersonal individuals. Finally Quadrant D: Innovators (right cerebral) who are conceptualizing, synthesizing, imaginative, holistic, and artistic. Such descriptions of the Theorist, Innovator, Humanitarian and Organizer within HBDM are nearly congruent to the Jungian Thinking, Intuition, Feeling and Sensing respectively, with respect to the individual's approach to assimilate and adapt information as a faculty of thinking [18]. Moreover, and as described, both the Theorist and the Thinking processes are specific for the front left cortical lobe functions (FLt), the Innovator and the Intuitive describe thinking processes of the front right cortical lobe (FRt), the Feeling together with the Humanitarian are represented by the base right cortical lobe (BRt), while the Organizer and the Sensing have thinking abilities characteristic for the base left cortical lobe (BLt) (Fig. 1). Based on the aforementioned, it can be postulated that these four cortical lobes could represent four different thinking styles that describe human learning characteristics in terms of Jung typological functions and Hermann Whole Brain Model descriptions.

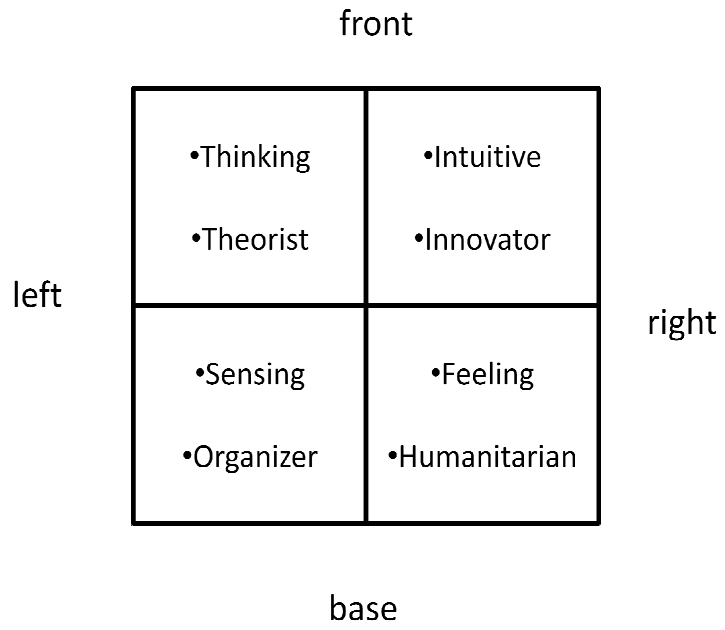

Fig. 1. The four thinking styles rooted in the four cortical lobes

Complementary to Herrmann's model, Lumsdaine and Lumsdaine [19] described four different modes of how students learn, and matched them to the Herrmann's four quadrant

thinkers. In their approach; they seemed to be more concerned with specific learning processes such as how to capture, organize, shape, and retrieve perceived information [20]. The introduced modes were external learning (quadrant A learning); where subjects prefer to learn from an authority through lectures and text books, internal learning (quadrant D learning); where individuals learn through visualization, insight, understanding of concepts holistically and intuitively, the interactive learning (quadrant C learning); according to which learning takes place by means of discussions and hands-on sensory-based experiments where the learners try and fail and try again through encouragement and verbal feedback, and finally the procedural learning (quadrant B learning); which is accomplished by methodological step-by-step testing of what is being taught, as well as through practice and repetition to improve skills. In our speculation, these four different ways of learning as described by Lumsdaine and Lumsdaine could possibly be denoting the process of perception specific for each cortical lobe.

In addition, the visual versus the auditory –as described by Fleming [6]- could also describe the perception faculty of the frontal right lobe versus the frontal left lobe respectively, noticing they appear to be more specific to perception of abstract data. As reported, the former or visual learners have a preference for seeing and like to think in pictures and use visual aids, while the later or auditory learners best learn through listening [6]. Hence, we can match between auditory and visual learners and external and internal learners according to Lumsdaine and Lumsdaine in describing the perception faculties of the front left and front right cortical lobes respectively.

Similarly, Benziger research [13], introduced a description of the perceptive faculties of the left and right cortical lobes of the posterior convexity which can be matched to the procedural learning and interactive learning after Lumsdaine and Lumsdaine. The base left cortical lobe has been shown to be very concrete with filters which direct its attention towards bounded shapes and predominant words. For the base right cortical lobe, attention is directed towards faces, facial expressions, non-verbal patterns of communications, spatial and color relatedness, things which can be touched or felt or connected with.

Therefore, we can speculate that the faculty of perception for each of the distinct cortical areas could be assessed –in addition to Lumsdaine and Lumsdaine learning modes- in terms of Fleming's description of the auditory and the visual learners to describe the front left and front right lobes. While, the base left and the base right could be assessed after descriptions introduced by Benziger for their predominant brain filters.

In conclusion; we can postulate that; there are four different perception styles characteristic for the four cortical lobes. Cognitive processes regarding target of attention and brain filters could be described in terms of reported descriptions of Lumsdaine and Lumsdaine external learner and Fleming's auditory learner for the front left lobe perception (FLp) style and Lumsdaine and Lumsdaine internal learner and Fleming's visual learner for the front right lobe perception (FRp) style. As for the base right and base left perception (BRp and BLp, respectively) styles; they could be described in terms of Lumsdaine and Lumsdaine interactive and procedural learners, respectively together with characteristic brain filters as described by Benziger & Holmes [13] (Fig. 2).

Consequently, the aim of the present study was to examine preferential cortical dominance - for the same individual- concerning each of perception and thinking as two distinct faculties of learning. Another objective was to introduce the Intellectual Style Inventory (ISI) as a convenient tool for learning style assessment. Content validity, statistical conclusion validity

and test-retest reliability were constructed to evaluate both the theoretical base and the psychometric properties of the invented tool.

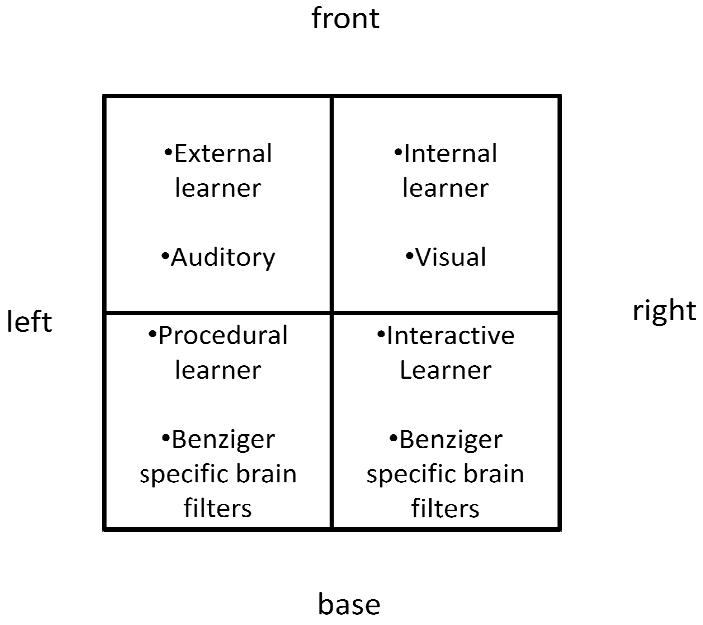

Fig. 2. The four perception styles rooted in the four cortical lobes

2. METHODOLOGY

2.1 Participants

A convenient sample of 203 highly educated male and female volunteers age 25 or more constituted the population of this study. The eligibility criteria included evidence of absence of cognitive impairment or psychiatric chief complaint. Demographic data were collected from the sample and included age, sex and highest level of education. The approval of Ethics committee was obtained.

2.2 Instrument

For the ISI; two separate questionnaires, 24 statements each were created. One questionnaire was used for the assessment of the faculty of perception and the other for thinking. In the former; the four sets of sentences were concerned with describing the brain filters and focus of attention distinct for the four different cortical lobes (Table 1). In the later four sets _six statements each_ described the characteristic features of the process of thinking and decision making manifested by each of the four cortical lobes of the brain (Table 2). Arabic translation, was tested by retranslating into English, then introducing to the volunteers. Each questionnaire was designed as a forced-choice format. Participants had to rank their relative preference choices among the four modes of perception in the first questionnaire and the four modes of thinking in the second one. The format allowed individuals to order their preferences by ranking them in a descending order starting with the first preference and ending with the last one.

Table 1. ISI items describing characteristic features of perception in the different cortical lobes

Intellectual function	Item
Perception of the front left cortical lobe	• Upon using a device for the first time, I prefer more to read the leaflet. • I tend to repeat a word loudly to learn how to write it correctly. • I do the work best if it is related to what is read or written. • When I try to remember something I hear its description as if someone is speaking in my mind. • Upon memorizing I prefer to read to myself in a loud voice. • I am interested in knowing the function of things.
Perception of the front right cortical lobe	• Upon using a device for the first time, I prefer more to look at illustrations and drawings. • I am better at the work which deals with diagrams and pictures. • I like novels which describe the seen as if I am watching it. • I cannot concentrate with visual distractions. • I always summarize learning materials into diagrams. • To explain something I prefer to draw it for illustration.
Perception of the base right cortical lobe	• I am good at reading body language and facial expressions. • In a conversation I search for hidden meanings and observe people while speaking. • Peacefulness and harmony increase my productivity at work. • Prevalent bad feelings in the working environment distract my concentration. • Colors are the first to attract my attention in a picture. • The sound of a baby cry irritates me very much.
Perception of the base left cortical lobe	• I prefer prominent words which direct my mind. • I am better at the work which is well defined. • I remember the order of memories precisely. • Bounded shapes attract my attention in a picture. • I like to order and organize things. • I prefer to use clear and confirmative words.

Table 2. ISI items describing characteristic features of thinking in the different cortical lobes

Intellectual function	Item
Thinking of the front left cortical lobe	• My beliefs are built on logic. • My mind is always busy with tasks. • I take my decisions in an objective and systematic way. • I always make comparisons. • I judge with my mind not my feelings. • I am clever at analysis and choosing between alternatives upon making a decision.
Thinking of the front right cortical lobe	• People see me innovative in creating new ideas. • I have a lot of dreams for the future. • I prefer to work in theoretical fields. • I always find unusual solutions to problems. • Others always say that I have a philosophy in life. • I always have a holistic vision.
Thinking of the base right cortical lobe	• I always consider the feelings of others when taking decisions. • I search for harmony in everything. • People like to share their happiness or sadness with me. • I feel too much sympathy with people in trouble. • I listen a lot to my feelings. • It is important to show your feelings.
Thinking of the base left cortical lobe	• I prefer clear and factious data upon taking decisions. • People see me clever at accomplishing routine work and solving daily problems. • I consider practical experimentation the best way for learning. • While doing something new, I never give up till succeed. • I don't pay a lot of attention to drawing future plans. • I take my decisions based on the concrete reality.

2.3 Content Validity

According to the American Psychological Association, content validity refers to the degree to which the content of items reflects the content domain of interest. As mentioned by Yang [21], content validity represents a reputable, objective strategy for validating the questionnaire with respect to its relevance to the theoretical back ground introduced. Methodology used for the content validity was performed after Crocker & Algina [22] standard procedure. Seven researchers and experts were asked to evaluate the extent to which each item was able to describe the content domain according to the theoretical description introduced through a three points likert scale (Tables 3-6). The scale included the score +1 for the choice "essential", 0 for "useful but non-essential", and the score -1 for the "non-essential" choice. The content validity coefficient (V) and homogeneity reliability coefficient (H) proposed by Aiken [23-24] were calculated –by substitution in specific equations- to quantify the validity rating of each item and the experts' degree of consistency

for the item evaluations respectively. Similarly, the V and H coefficients were calculated for the different sets of items with statistical investigation for their significance.

Table 3. Content validity sheet for items describing perception of the frontal cortical lobes

Content domain	Item for validation	Theoretical base
Front left cortical lobe (Perception*)	Upon using a device for the first time, I prefer more to read the leaflet.	Learn from text books [19].
	I tend to repeat a word loudly to learn how to write it correctly.	More influenced by the phonological aspect of written words [32].
	I do the work best if it is related to what is read or written.	Learn from lectures and text books [19]. Learn from an authority [19].
	When I try to remember something I hear its description as if someone is speaking in my mind.	Responsible to manage speech and structure of language (Broca's area) [34].
	Upon memorizing I prefer to read to myself in a loud voice.	Like to read to self loud [6].
	I am interested in knowing the function of things.	Filters recognize goal directed behavior [33]. Perceive function and functional relationships [13].
Front right cortical lobe (Perception)	Upon using a device for the first time, I prefer more to look at illustrations and drawings.	Prefer to learn through visualization [19].
	I am better at the work which deals with diagrams and pictures.	Play internally with noticed patterns [33].
	I like novels which describe the seen as if I am watching it.	Manage the non-verbal dance of gestures which can accompany speech [33].
	I cannot concentrate with visual distractions.	They avoid visual distractions [35].
	I always summarize learning materials into diagrams.	Lexical processing is more sensitive to visual form [32].
	To explain something I prefer to draw it for illustration.	Use its imagination to rotate or transform the pattern [33].

**Perception is defined as specialized screens or filters to perceive selectively what it needs to perceive to do its job [13]*

2.4 Statistical Conclusion Validity

In the present study the null hypothesis asserts that there is no relationship -for the same individual- between the cortical lobe acquiring first preference in thinking and that acquiring first preference in perception, where thinking and perception represent two distinct faculties of learning. This means that for an individual with FL lobe as first preference in thinking –for example- there are equal chances for the four cortical lobes to acquire his first preference in perception. In other words, the order of preference of a cortical lobe in thinking has no influence on the order of preference of the same cortical lobe in perception and vice versa.

Results were arranged in a scale where 1 was given to FL lobe with first preference in perception (FLp=1), 2 was given to FR lobe with first preference in perception (FRp=2), 3 for the BR lobe with first preference in perception (BRp=3) and 4 for BL lobe with first preference in perception (BLp=4). Same was the scale for thinking; 1 for FL lobe with first preference in thinking (FLt=1), 2 for FR lobe with first preference in thinking (FRt=2), 3 for BR lobe with first preference in thinking (BRt=3) and 4 for BL lobe with first preference in thinking (BLt=4). Likelihood ratio was used for the analysis of qualitative data if more than 25% of the cells have expected count of less than 5.

Table 4. Content validity sheet for items describing perception of the basal cortical lobes

Content domain	Item for validation	Theoretical base
	I am good at reading body language and facial expressions.	Direct its attention to gestalts, faces & facial expressions [33].
	In a conversation I search for hidden meanings and observe people while speaking.	It sees primarily non-verbal patterns of communications [33].
Base right cortical lobe (Perception*)	Peacefulness and harmony increase my productivity at work.	Designed specifically to harmonize or establish comfort [33].
	Prevalent bad feelings in the working environment distract my concentration.	Internally evaluates in-coming data which indicate harmony from those in which harmony is lacking [33].
	Colors are the first to attract my attention in a picture.	Attentive to color relatedness [33].
	The sound of a baby cry irritates me very much.	More sensitive to the meaning of a baby's cry [33].
	I prefer prominent words which direct my mind.	Hears words which will direct it towards specific objects [33].
	I am better at the work which is well defined.	Filters direct its attention towards specific words that instruct it to accomplish some task [33].
Base left cortical lobe (Perception)	I remember the order of memories precisely.	Internally orders incoming data so as to generate ordered data and procedures [33].
	Bounded shapes attract my attention in a picture.	Sees primarily bounded shapes [33].
	I like to order and organize things.	Specialized in sequencing [13].
	I prefer to use clear and confirmative words.	Hears predominantly words [33].

**Perception is defined as specialized screens or filters to perceive selectively what it needs to perceive to do its job [13]*

Table 5. Content validity sheet for items describing thinking of the frontal cortical lobes

Content domain	Item for validation	Theoretical base
Front left cortical lobe (Thinking*)	My beliefs are built on logic.	Logic [16]. Adapted at linking ideas together by means of their logical connections [36].
	My mind is always busy with tasks.	Most interested in general operational principles, problem solving and decision making [36]. Calculate, evaluate, diagnose and prescribe very effectively [13].
	I take my decisions in an objective and systematic way.	More conceptual than visceral and interested in technical aspects [36].
	I always make comparisons.	Weigh the variables [36]. Excels at prioritizing [36].
	I judge with my mind not my feelings.	Create rational order and make sound plans and decisions based on logical analysis [36].
	I am clever at analysis and choosing between alternatives upon making a decision.	Analytic [16]. Separating entire systems into their component parts [36].
	People see me innovative in creating new ideas.	Novelty (especially, new ideas and concepts) is highly appealing to this brain [36].
	I have a lot of dreams for the future.	So focused on future possibilities [36].
Front right cortical lobe (Thinking)	I prefer to work in theoretical fields.	More interested in concepts than in actual events [36].
	I always find unusual solutions to problems.	Excel in the perception of possibilities, patterns and relationships which are not obviously visible [36].
	Others always say that I have a philosophy in life.	Yield metaphysical or philosophical systems [37].
	I always have a holistic vision.	Holistic [16].

**Thinking is defined as highly specialized processing modes that use the information it perceives to accomplish tasks in its specific way [13]*

2.5 Test-Retest Reliability

Test retest reliability is a measure of the consistency of a measure over time [25]. One month later, 19 of the study sample (10% of the sample) were asked to retake the ISI for evaluation of test retest reliability. Wilcoxon Signed Ranks test was used as a nonparametric test to detect the statistical changes in the data after retest of the questionnaire.

Statistical analysis was done using SPSS version 18 software (SPSS Inc., Chicago, IL, USA). A p value of .05 or less was considered significant.

Table 6. Content validity sheet for items describing thinking of the basal cortical lobes

Content domain	Item for validation	Theoretical base
Base right cortical lobe (Thinking*)	I always consider the feelings of others when taking decisions.	Their interests are in the “human” rather than the technical aspects of any problem [36].
	I search for harmony in everything.	They put a premium on facilitating harmonious interactions [36].
	People like to share their happiness or sadness with me.	They are highly attuned to what is “going on” with others [36].
	I feel too much sympathy with people in trouble.	Emotional and interpersonal [16].
	I listen a lot to my feelings.	Intrapersonal Individuals [16].
	It is important to show your feelings.	Easily pass their own mood to others [10].
	I prefer clear and factious data upon taking decisions.	Focuses on what is "real" and "concrete" in the moment [36].
	People see me clever at accomplishing routine work and solving daily problems.	Process by following a pre-established or pre-programmed order which has been loaded earlier and can simply be run [36].
Base left cortical lobe (Thinking)	I consider practical experimentation the best way for learning.	Highly motivated to learn procedural applications [36].
	While doing something new, I never give up till succeed.	Learn through practice and repetition to improve skills [16].
	I don't pay a lot of attention to drawing future plans.	Focuses on the immediate experience [36].
	I take my decisions based on the concrete reality.	Preferring to work with tangible objects, rather than either people or ideas [36].

**Thinking is defined as highly specialized processing modes that use the information it perceives to accomplish tasks in its specific way [13]*

3. RESULTS

Study subjects had a mean age of 33.2 (12.5) years, 38% were males and 62% females. The level of education was Bachelor degree for 64% of the sample and the rest had higher levels of education, namely Master, PhD or MD.

As shown in Table 7, content validity coefficients V and H for items describing perception of the FL cortical lobe ranged between .71 and 1.00, with .92 and .89 representing V and H of the set of items respectively. Items describing perception of the FR cortical lobe V ranged between .79 and .93, while H was .88 for four items and .96 for two items. V and H for the set of items describing perception of the FR lobe were .87 and .96, respectively.

Table 7. Content validity coefficient (V) and homogeneity reliability coefficient (H) for items and sets representing perception of the frontal cortical lobes

Domain	Front left cortical lobe						Front right cortical lobe					
Item	1	2	3	4	5	6	1	2	3	4	5	6
V for item	.93	1.00	.93	.71	.9	1.00	.92	.86	.86	.93	.79	.86
V for set	.92						.87					
H for item	.92	1.00	.83	.71	.96	1.00	.96	.88	.88	.96	.88	.88
H for set	.89						.96					

In Table 8, items describing perception of the BR lobe showed all values of V and H to exceed .86. Values for V and H for the set of items in this domain were .93 and .96, respectively. As for items describing perception of the BL cortical lobe V was .93 for 2 items and 1.00 for 4 items, while the values of H were .92 for one item, .96 for another item and 1.00 for the rest of items. The set of items describing perception of the BL lobe showed the values of V and H to be .98 and .97, respectively.

Table 8. Content validity coefficient (V) and homogeneity reliability coefficient (H) for items and sets representing perception of the basal cortical lobes

Domain	Base right cortical lobe						Base left cortical lobe					
Item	1	2	3	4	5	6	1	2	3	4	5	6
V for item	1.00	.86	.93	.86	.93	1.00	1.00	1.00	.93	1.00	1.00	.93
V for set	.93						.98					
H for item	1.00	.92	.92	.88	.96	1.00	1.00	1.00	.96	1.00	1.00	.92
H for set	.96						.97					

All values of V and H for items and sets describing thinking of the front cortical lobes (FL & FR) ranged between .80 and 1.00 (Table 9).

Table 9. Content validity coefficient (V) and homogeneity reliability coefficient (H) for items and sets representing thinking of the frontal cortical lobes

Domain	Front left cortical lobe						Front right cortical lobe					
Item	1	2	3	4	5	6	1	2	3	4	5	6
V for item	1.00	.93	.93	.86	.93	.93	1.00	.86	.93	.86	.93	1.00
V for set	.93						.93					
H for item	1.00	.8	.92	.96	.92	.92	1.00	.88	.96	.88	.96	1.00
H for set	.93						.93					

Individual items describing thinking of the BR lobe showed V and H values of at least .92, with .95 and .96 for V and H for the set of items respectively (Table 10). Finally, Table 10 shows V and H values for items and set of items describing thinking of the BL cortical lobe to range between .71 and 1.00.

Table 10. Content validity coefficient (V) and homogeneity reliability coefficient (H) for items and sets representing thinking of the basal cortical lobes

Domain	Base right cortical lobe						Base left cortical lobe					
Item	1	2	3	4	5	6	1	2	3	4	5	6
V for item	.93	1.00	.93	1.00	.93	.93	1.00	.71	.86	.86	.93	.93
V for set	.95						.88					
H for item	.92	1.00	.96	1.00	.96	.92	1.00	.88	.96	.88	.96	.92
H for set	.96						.93					

As for the statistical conclusion validity; the relationship between the first cortical preference in perception and the first cortical preference in thinking for the same individual has shown to be non-significant i.e. there is no relationship. As shown in Table 11, 82 individuals have chosen FL cortical lobe as their first cortical preference in thinking (FLt) with 21 of them (who represent 40% of FLp group) having the same cortical lobe (FL) as their first preference in perception. Out of the 82 with FL lobe as first preference in thinking, 10 (33% of FRp group) have chosen FR lobe as their first preference in perception, 15 (45% of BRp group) have chosen BR lobe as first preference in perception and 36 (41% of BLp group) have chosen BL lobe as their dominant lobe in perception. Illustrated data indicate that nearly the same percentages (40%, 33%, 45%, 41%) within the four groups representing the four cortical lobes with first preference in perception (FLp, FRp, BRp, BLp respectively) showed to have the FL cortical lobe as the predominant lobe in thinking. Accordingly, we can say that for an individual with FL lobe as first preference in thinking there are equal chances for the four cortical lobes to acquire his first preference in perception. Similarly, very close percentages; 2%, 7%, 3%, 7% within the four groups showing first preference in perception; FLp, FRp, BRp, BLp, respectively, had the FR cortical lobe as the predominant lobe in thinking. Within the FLp, FRp, BRp and BLp groups, 47%, 53%, 39% & 39%, respectively had the BR cortical lobe as the predominant lobe in thinking. Finally, almost equal percentages; 11%, 7%, 12% & 13% within FLp, FRp, BRp and BLp groups, respectively had the BL cortical lobe as the predominant lobe in thinking, which emphasizes the same idea.

Table 11. Likelihood ration for first preferences in thinking and perception for the study sample

			Perception				Likelihood ratio	P-value
			FLp (53)	FRp (30)	BRp (33)	BLp (87)		
Thinking	FLt (82)	Count	21	10	15	36	5.119	NS*
		% within P	40%	33%	45%	41%		
	FRt (10)	Count	1	2	1	6		
		% within P	2%	7%	3%	7%		
	BRt (88)	Count	25	16	13	34		
		% within P	47%	53%	39%	39%		
	BLt (23)	Count	6	2	4	11		
		% within P	11%	7%	12%	13%		

**Non significant*

Concerning test-retest reliability; 80% of the studied sample had the same first preference choice for perception and 90% of them showed the same preference in thinking, with non-significant difference between the test (base line) and the retest (Fig. 3).

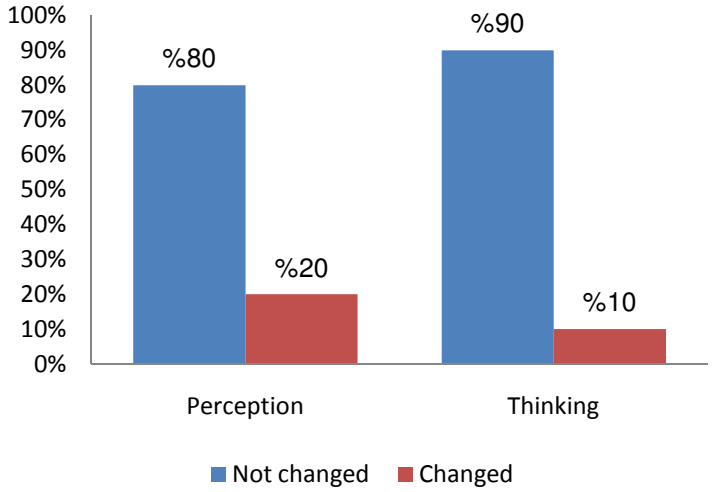

Fig. 3. The difference between the baseline and the retest of the ISI for perception and thinking

4. DISCUSSION AND CONCLUSION

The present study was constructed to target a main issue; learning style assessment. Most popular models addressing such issue were individually criticized either for the theoretical base or the assessment tool or both together [4]. Moreover, the presence of high number of learning style models -from different perspectives- which show some kinds of similarities and are even sometimes overlapping, made it a serious challenge to develop a holistic model that integrates most sounding perspectives in a meaningful unity to investigate learning styles [26].

The ISI introduced in this work aimed to determine the predominant learning style for an individual in terms of his natural cognitive lead or intellectual ability which represents his learning identity. As a tool for learning style assessment; the ISI followed more than one of the well-established approaches and reframed them. The ISI assesses individual learning as an "information processing style" defined as an individual's intellectual approach for information processing [27]. The approach of the ISI could also be described in terms of "personality cognitive styles" since its characteristic descriptions are permanent personality dimensions instinct for each individual [28]. Moreover, it follows the new trend which regards brain as a four-chambered organ with motor and sensory compartments distinguished at both the left and right sides [29].

For the conceptual framework of the ISI, it benefited from both historical and recent theories. The ISI was inspired by Jung Typology and the progressive work of Myers-Briggs and Katherine Benziger on it, together with Fleming's learning style theory, HBDM and finally, Lumsdaine and Lumsdaine as complementary to Hermann's model. Moreover, the ISI integrated all the previously mentioned theories and models and incorporated them in the neurophysiologic model for Jung's four functions introduced by Katherine Benziger [30].

The corner stone in the rationale of the ISI is the belief of Jung that in order for individuals to function well they must have a way to perceive a stimulus represented by the Sensing or the

Intuition types, and a way to make an adequate response to that perception by making a decision or judgment which is represented by the Thinking or the Feeling types. Benziger in her Benziger Thinking Styles Assessment Model (BTSA) dealt with the Jungian four types as types for thinking and rooted them in the four distinct areas of the brain cortex. Moreover, she was able to provide specific descriptions of the brain filters and locus of attention for the four cortical lobes which describe how they can process perception.

Accordingly, and in light of cortical functional specialization -introduced earlier- the ISI postulated that the four cortical lobes offer four different types of thinking and four different types of perception, where the functions of either of thinking or perception differ from each other in the same lobe i.e. distinct, and at the same time such functions differ from one lobe to another i.e. discriminative. The ISI also assumed that each individual after the law of preference (see the theoretical framework) has a certain cortical lobe which represents his first preference in thinking and a certain lobe that represents his first preference in perception. Besides, the ISI postulated that it is not a must to have the same cortical lobe as the predominant in both thinking and perception, rather, one may have one cortical lobe as the predominant one in thinking and another different lobe as the predominant in perception. Alternatively, a different subject may have the same lobe to predominate in both functions (who I call: the True Jungian Type).

Consequently, the ISI depended on Jung descriptions for the four types in the construction of the tool. Sentences more related to judgment and decision making were used to describe functions of thinking of the four cortical lobes, together with the description introduced by Benziger through her BTSA model as well as Hermann's types which are rooted in the same four cortical lobes or quadrants according to his model; the HBDM. As for functions of perception, the ISI depended more on brain filters of the four cortical lobes described by Katherine Benziger, Fleming's theory which is based on sensory preferences and the work of Lumsdaine and Lumsdaine [19] who concentrated on learning processes much related to the tasks of perception in the HBDM (see the theoretical framework).

Hence, the ISI had three hypothetical assumptions to prove; the first is that there are four different styles of thinking and four different styles of perception. Second; that each individual has a cortical preference in thinking and a cortical preference in perception. The third assumption of the ISI postulates that; the cortical lobe representing first preference in thinking and the one representing first preference in perception may or may not be the same for the same individual.

In favor of the first two assumptions, statistical analysis for the relationship between the cortical lobe of first preference in thinking and that of first preference in perception for the same individual resulted in non-significant results. Moreover, results showed that for an individual with any of the four cortical lobes representing his first preference in thinking there are equal chances for the four cortical lobes to acquire his first preference in perception which agrees with the third assumption.

However, in order to increase the degree of confidence in the statistical outcomes, the ISI as a tool was tested for its ability to reflect precisely the functions of the different styles of thinking and perception -after the theoretical background- successfully. Also, it was investigated for some of its psychometric properties.

Construct validity, predictive validity, internal consistency reliability, and test-retest reliability are suggested as the four criteria which have to be fulfilled as a minimum standard for any

instrument [31]. For the ISI, construct validity was replaced by content validity coefficient V to measure the relevance of the ISI to the theoretical background. When V was calculated it showed that the ISI was an effective assessment tool since its value for all items and sets of items included in the tool exceeded .71 and reached the significant standard (α=.05). Internal consistency reliability for the ISI was indicated by the homogeneity reliability coefficient H. Values for H in all items and sets of items also ranged between .71 and 1.00 and effectively reached the significant standard (α=.05). Test-retest reliability showed non-significant change between the study sample first preference choices in thinking and in perception in the test (base line) and the retest (one month later) which indicates good test reliability. As for predictive validity for the ISI, it was replaced by the statistical conclusion validity which we found more beneficial for the study objectives.

In conclusion, the present work introduced the ISI as a new tool for learning style assessment after the concept of cortical functional specialization. The ISI was tested for its relevance to the theoretical base and for its psychometric properties and showed to be a potentially useful tool. Moreover, after the hypothetical assumptions introduced by the ISI we can suggest that; for each individual, learning style could be assessed in terms of his predominant lobe (cortical preference) in each of thinking and perception as two distinct intellectual functions describing learning.

Further studies for feasibility, validity and reliability testing of the psychometric tool are needed with larger sample size. Applying the tool on individuals that differ in gender, age, education, social and economic standards, occupations and even nationalities would help in drawing features of the different combinations of thinking and perception styles and discover their characteristics and nature. Review articles illustrating profoundly cognitive tasks of the four cortical lobes after findings of neuroscience with respect to thinking and perception process are also suggested with urge.

CONSENT

All authors declare that written informed consent was obtained from the patient (or other approved parties) for publication of this case report and accompanying images.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Curry L. Learning preferences in continuing medical education. Canadian Med Assoc J. 1981;124:535–536.
2. Curry L. One critique of the research on learning styles. Educational Leadership. 1990;48:50–56.
3. Henry J. Professor pans 'learning style' teaching method. The Telegraph; 2007. Retrieved from Available:http://www.telegraph.co.uk/news/uknews/1558822/Professor-ans-learning-style-teaching-method.html.
4. Coffield F, Moseley D, Hall E, Ecclestone K. Learning styles and pedagogy in post-16 learning: A systematic and critical review. London: Learning and Skills Research Centre/ University of Newcastle upon Tyne. London; 2004.
5. Dunn R, Dunn K, Price GE. Learning style inventory. Lawrence, KS, USA: Price Systems; 1984.
6. Fleming ND. Teaching and Learning Styles: VARK Strategies. Honolulu Community College; 2001.
7. Kolb A, Kolb D. The Kolb Learning Style Inventory—Version 3.1 2005 Technical Specifications. Hay Group; 2005.
8. Smith MK. David A. Kolb on experiential learning. Encyclopedia of informal education. 2001;1-15. Retrieved from. Available: http://www.infed.org/b-explrn.htm.
9. Myers IB, Briggs K. The Myers-Briggs type indicator (Form G). Palo Alto, CA: Consulting Psychologists Press; 1975.
10. Jung C. Psychological Types. London: Pantheon Books; 1923.
11. De Vita GD. Learning styles, culture and inclusive instruction in the multicultural classroom: a business and management perspective. Innovations Educ Teaching Int. 2001;38,165–174.
12. Norman G. When will learning style go out of style? Adv in Health Sci Educ. 2009;14,1–4.
13. Benziger K, Holmes S (Eds.). The Human Brain, A Reservoir of Diverse Flexible Strength or Chaotic Raging Violence. Proceedings from : International Conference on Human Efficiency. Berlin; 1995.
    Available: http://www.benziger.org/articlesIng/?p=26.
14. Fuster JM. Cortex and memory: Emergence of a new paradigm. Journal of Cognitive Neuroscience. 2009;21:2047-2072.
15. Lawrence GD. People types and tiger stripes: A practical guide to learning styles (2nd ed.). Gainesville FL: Center for Application of Psychological Type; 1982.
16. Herrmann N. The creative brain (2nd ed). Kingsport: Quebecor Printing Book Group; 1995.
17. Herrmann N. The whole brain business book. New York: McGraw-Hill; 1996. Available:http://core.ecu.edu/psyc/wuenschk/docs2210/Research-10-StatConclValid.doc
18. Eagleton S, Muller A. Development of a model for whole brain learning of physiology. Adv Physiol Educ. 2011;35(4),421-426.
19. Lumsdaine M, Lumsdaine E. Thinking preferences of engineering students: implications for curriculum restructuring. Journal of Engineering Education. 1995;84(2):193-204.
20. Leaver BL. Teaching the Whole Class (4th Ed). Thousand Oaks, CA: Corwin; 1997.
21. Yang WC. Applying Content Validity Coefficient and Homogeneity Reliability Coefficient to Investigate the Experiential Marketing Scale for Leisure Farms. Retrieved from http://www.jgbm.org/page/8%20Wan-hi%20Yang.pdf.

22. Crocker L, Algina J. Introduction to Classical and Modern Test Theory. New York: CBS College Publishing; 1986.
23. Aiken LR. Content Validity and Reliability of Single Items or Questionnaires. Educational and Psychological Measurement. 1980;40,955-959.
24. Aiken LR. Three Coefficients for Analyzing the Reliability, and Validity of Ratings. Educational and Psychological Measurement. 1985;45:131-142.
25. Raat H, Botterweck AM, Landgraf JM, Hoogeveen WC, Essink-Bot M. Reliability and validity of the short form of the child health questionnaire for parents (CHQ-PF28) in large random school based and general population samples. J Epidemiol Community Health. 2005;59:75–82. doi: 10.1136/jech.2003.012914
26. Graf S. Adaptivity in Learning Management Systems Focusing on Learning Styles; 2007. Available: http://www.big.tuwien.ac.at/system/theses/77/papers.pdf?1298561821
27. Cassidy S. Learning Styles: An overview of theories, models, and measures. Educational Psychology. 2004;24(4):420-444.
28. Riding RJ, Cheema I. Cognitive styles: An overview and integration. Educational Psychology. 1991;11:193-215.
29. Crow TJ. Auditory hallucinations as primary disorders of syntax: An evolutionary theory of the origins of language. Cognitive Neuropsychiatry. 2004;9(1/2):125-145.
30. Saleh MS, Monir ZM, Eltahlawy E. Learning Style Preferences and Academic Achievement among Researchers. Asian Journal of Education and e-Learning. 2013;01(4):191-197.
31. Coffield F, Moseley D, Hall E, Ecclestone K. Should We Be Using Learning Styles? What Research Has to Say to Practice. Learning and Skills Research Centre / University of Newcastle upon Tyne, London; 2004.
32. Lavidor M, Walsh V. A magnetic stimulation examination of orthographic neighborhood effects in visual word recognition. Journal of Cognitive Neuroscience. 2003;15(3),354-363.
33. Available: http://www.benziger.org/the-btsa-Physiological-Foundations.html.
34. Benziger K. The physiology of type: Jung's four functions. Retrieved from Available: http://www.benziger.org/articlesIng/?p=34.
35. Available: http://www.studygs.net/visual.htm.
36. Available: http://www.benziger.org/the-btsa-The-four-modes.html.
37. Available: http://samvak.tripod.com/intuition.html.

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