

Beyond the Relationship between Cognitive Structures and Opportunity Recognition Capability: What about Engineers' Thinking Style?

1

Abstract— This mixed study explores the relationship between thinking styles (TS) and opportunity recognition capability (OR). We sampled engineers and technicians currently studying engineering as a second profession and engineering post-degree. Respondents have a predominant rational TS. Age and work experience have a positive relationship with rational TS. There is a difference in OR level between technical and post-degree respondents. Age, work experience, entrepreneurial experiences, and tenure have a positive correlation with OR level. We found clues to that respondents' rational thinking style, could have a positive effect on OR. We triangulated the quantitative results by a semantic analysis of the item statements. This work contributed to entrepreneurial cognition research questioning the theory of OR as the result of a simple structural alignment between structural knowledge and market events. Also, for engineering education we explore the relationship between engineering students' cognitive processes and entrepreneurial skills

Index Terms— Thinking Style; Cognitive-Experiential Self-Theory; Opportunity Recognition; Entrepreneurial Cognition.

I. INTRODUCTION

Innovation and entrepreneurship have become a priority in engineering education but there is no consensus about what content must be included in courses [1]. State policies and industrial associations have challenged engineering educators to expand engineering students' training by developing an entrepreneurial mindset as a strategic tool [2]. So, higher education institutions should play a role in developing an entrepreneurial mindset among engineering students [3]. An engineers' entrepreneurial mindset encompasses a deep expertise in technology combined with creativity, innovation, problem solving and building business [4].

Entrepreneurial activities achieve higher levels of economic growth, employment, and innovation [5; 6; 7; 8; 9; 10; 11]. Every entrepreneurial process starts with a business opportunity [12; 13]. Opportunity can be defined as a perceived means to generate an economic value that has not been exploited until now [14].

Opportunity recognition is the core of entrepreneurship [15]. Opportunity recognition has been defined as the cognitive process through which individuals conclude that they get an opportunity [14]. So, cognitive mechanisms have a central role in individuals' business opportunity recognition [16; 17; 18].

People acquire and process information from situations in a specific manner or thinking style [19; 20; 21].

According to cognitive-experiential self-theory (CEST) two different information-processing systems (rational and experiential) may operate independently and interactively influencing each other and contributing to individuals' experience and behavior [22; 23; 24; 25; 26]. So, the research question in this work is: how do engineers' thinking styles influence their opportunity recognition capabilities?

This mixed study explores the relationship between thinking styles and opportunity recognition capability in a sample of professionals and technicians currently studying engineering as second profession or engineering post-degrees. First, we used a self-applied questionnaire to measure the respondents' thinking styles and opportunity recognition level with two scales [27; 25] also we measure respondents' tenure, work experiences, and functional specialization, among other attributes such as demographics and education. But we know that cross-sectional data could lead to common method bias, risk for spurious results, and potential reverse causality. So, we made a semantic analysis between statements, triangulating the quantitative results to reduce those problems enhancing our understanding of the results.

This study makes two theoretical contributions. First, for engineering education research, we explore the relationship between engineering students' cognitive process (i.e., thinking style) and entrepreneurial skills (i.e., opportunity recognition capability). Second, we make an epistemological contribution to entrepreneurial cognitive literature by using a semantic perspective to explain research results through item statements relationship [28].

This study makes two practical contributions. First, we highlight the importance of engineering students' opportunity recognition capability. Second, we show that engineers' rational thinking style is not an obstacle to recognizing business opportunities despite researchers that promote a more intuitive type [29; 30].

II. BACKGROUND

A. Opportunity recognition Capability

The ability to sense or recognize business opportunities depends on individuals' experiences and observations, their cognitive and creative capabilities, and their knowledge and learning capacity [31; 32; 33; 34] they trigger the formation of beliefs about, among others, the opportunities that might be pursued [35]. Education and prior knowledge may positively influence the opportunity recognition in entrepreneurs and undergraduate students [28; 36; 37].

There are at least three factors associated with opportunity recognition (OR): alertness, engagement in active search, and prior knowledge of a market, industry, or customer

[14]. Traditionally, it has been argued that some individuals can identify the connections or patterns between events because they may possess cognitive structures such as prototypes (idealized representations of events) or exemplars (specific examples of concepts) that they can use to match those events [14]. So, recognizing opportunities may entail the resemblance between outside world events and mental models of situations and contexts [38].

The knowledge gained from prior experiences could shape new perceptions affecting the sensing opportunities [39; 40; 41]. For instance, an engineering professional with a logistic career possibly has a mental model of market competition quite different than another with a finances career because they focus on distinct market changes [40; 41]. Focus on different changes may imply different dots to link and perceive as a business opportunity [42; 41].

An effective engineering entrepreneurial education should provide theoretical knowledge and should enable students to engage with practical entrepreneurial skills. The years of formal education may contribute to entrepreneurs' versatility to use linear and nonlinear thinking style [43].

B. Thinking Style: experiential vs rational

Thinking style has been defined as one's preferred manner of using mental skills to rule daily activities such as understanding and solving problems [44]. Training could be used to reinforce individuals' cognitive style preferences or to develop a less preferred style [45]. According to cognitive-experiential self-theory the rational and experiential systems may operate in an independent, interactive, inter-operative, and synchronous manner [22; 23; 24; 25; 26].

The experiential system is associated with affection and encoding information as concrete images, examples, and narratives. It operates automatically and preconsciously, is intuitive, rapid, associative, and related to more heuristic judgment. Meanwhile, the rational system is slower, relatively affect-free, deliberative, analytic, and conscious, encoding information as abstract symbols, words, and numbers, and is associated with more normatively acceptable judgment by use of logic rules [22; 24; 25; 46; 26]. Neurophysiological evidence suggests that the two processing types relied on distinct neurological systems [47].

The experiential-rational distinction is reasonable from an evolutionary perspective. For instance, we can say that the earlier experiential system replaced the animals' instinct to learn from past experiences (i.e., associative learning) being capable of reacting automatically by mental shortcuts to solve adaptation problems, after that, a later rational system was developed to solve problems by abstract symbols and logical inferences facilitating interpersonal argumentation [48; 22; 49; 23; 25; 50; 46].

Intuition could be more relevant in the opportunity recognition and evaluation stages of business venturing [29; 30]. However, rational thinking is routinely employed in the entrepreneurial process [43]. Successful entrepreneurs could have a greater balance between linear (rational-analytic) and nonlinear (intuitive-emotional) thinking styles than other business actors supporting the opportunity recognition by cognitive processing of linear and nonlinear inputs [43].

C. Hypothesis development

Entrepreneurs and senior managers could be more intuitive than middle and lower-level managers [51]. Novices tend to use rational thinking (analytical) to construct a solution whereas experts rely on experiential thinking (intuitive) [52; 24]. Intuition could be more relevant in the opportunity recognition and evaluation stages of business venturing [29; 30]. However, rational thinking is routinely employed in the entrepreneurial process [43].

H1a. Engineering students and professionals with a higher level of experiential thinking style may show more opportunity recognition than respondents with a higher level of rational thinking style.

H1b. Engineering students and professionals with a higher level of rational thinking style may show more opportunity recognition than respondents with a higher level of experiential thinking style.

H1c. Engineering students and professionals with more work experience (experts) will show a more experiential thinking style.

H1d. Engineering students and professionals with more tenure (experts) will show a more experiential thinking style.

H1e. Engineering students and professionals with entrepreneurship experience (experts) will show a more experiential thinking style.

Entrepreneurial education and prior knowledge may have a positive influence on opportunity recognition [36; 37]. Prior entrepreneurs' knowledge of a market, industry, or customer is associated with opportunity recognition capability [14]. The ability to sense or recognize business opportunities depends on entrepreneurs' experiences and knowledge [31; 32; 33; 34]. Individuals with different careers should focus on diverse changes which imply different dots to link or an unlike change pattern to perceive as a business opportunity [40; 42; 41].

H2a. Engineering students and professionals with entrepreneurship experience will show higher levels of opportunity recognition than individuals without that experience.

H2b. Engineering students and professionals with more tenure will show higher levels of opportunity recognition.

H2c. Engineering students and professionals with more work experience will show higher levels of opportunity recognition.

H2d. Engineering students and professionals with different specializations will show different levels of opportunity recognition.

H2e. Engineering students and professionals with different educational levels will show different levels of opportunity recognition.

III. METHOD

This study adopted a mixed design. First, we made a cross-sectional design to gather data from Engineering students and professionals with work experiences via a self-applied questionnaire on the Qualtrics™ platform. The response options collected were quantitatively analyzed using SPSS. Second, we triangulated the results by semantic analysis of the item statements.

A. Sample

The sample encompasses professionals and technicians currently studying engineering as a second profession and engineering post-degree students in a Chilean university. The sample is obtained randomly. They were invited to answer the survey through university formal authorities in 2023. There is no incentive.

We obtained 454 total responses. We delete all incomplete responses, except if they have a maximum of two numerical items without responses that we replaced with the variable average value. After that clean process, 363 responses remained. Respondents were 260 (71.6%) males, with an average age of 36.5 years. Their education level included 83 (22.9%) technical, 232 (63.9%) university, and 48 (13.2%) post-degree. They have an average tenure of 5.8 years and 14.6 years of work experience. 47.7% have a functional specialization in operations, 19.8% in administration, 14% in IT, 4.4% in logistics, 3.9% in R&D, 3.9% in finances, 2.5% in accounting, 2.2% in human resources, and 1.7% in marketing.

B. Survey

The survey contained demographic (age, gender), educational level (technical, university, post-degree), tenure (years), work experience (years), entrepreneurship experience (Yes/No), and functional specialization (marketing, finance, operations, human resources, logistics, research and development, accounting, IT, and administration) questions.

C. Variables

Questions of opportunity recognition (OR) are obtained from [53], also in [37], and [27]. Those scales are aligned with the definition of opportunity recognition competency as the ability to find new ideas. We decided to delete one of the [53] items because it was built in negative form, and research shows that an unbalanced scale design (very few negatively worded items) can introduce ambiguity in results by non-attendance to the negative item content [54]. We used a Likert scale with five points (strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree). So, in this work opportunity recognition is operationally defined as self-perceived capabilities to recognize opportunities.

Questions of rational-experiential thinking style are obtained from [25]. That scale encompasses 40 items of rational and experiential ability and engagement. We decided to use only ten items of rational ability (RA), and ten items of experiential ability (EA). We based our decision on [45] given that they have not found strong support for the ability and engagement distinction. We used the original Likert scale with five points that ranged from 1 (definitely not true of myself) to 5 (definitely true of myself).

The questions are translated into Spanish using [55] method i.e., one author translates from the source (English) to the target (Spanish), and another author blindly translates back from the target to the source. The originals, target, and back-translated versions were examined by independent raters for meaning errors. Errors were corrected and the new versions were examined for new independent raters. Finally, we obtained a Spanish version. The scales are shown in Table I.

TABLE I

Rational-Experiential Thinking Style and Opportunity Recognition

Rational-Experiential Thinking Style [25]

Rational

- rac_1- I'm not that good at figuring out complicated problems (ra—)
- rac_2- I am not very good at solving problems that require careful logical analysis (ra—)
- rac_3- I am not a very analytical thinker (ra—)
- rac_4- Reasoning things out carefully is not one of my strong points, (ra—)
- rac_5- I don't reason well under pressure, (ra—)
- rac_6- I am much better at figuring things out logically than most people, (ra)
- rac_7- I have a logical mind, (ra)
- rac_8- I have no problem thinking things through carefully, (ra)
- rac_9- Using logic usually works well for me in figuring out problems in my life, (ra)
- rac_10- I usually have clear, explainable reasons for my decisions, (ra)

Experiential

- exp_1- I don't have a very good sense of intuition, (ea—)
- exp_2- Using my gut feelings usually works well for me in figuring out problems in my life, (ea)
- exp_3- I believe in trusting my hunches, (ea)
- exp_4- I trust my initial feelings about people, (ea)
- exp_5- When it comes to trusting people, I can usually rely on my gut feelings, (ea)
- exp_6- If I were to rely on my gut feelings, I would often make mistakes, (ea—)
- exp_7- I hardly ever go wrong when I listen to my deepest gut feelings to find an answer. (ea)
- exp_8- My snap judgments are probably not as good as most people's, (ea-)
- exp_9- I can usually feel when a person is right or wrong, even if I can't explain how I know, (ea)
- exp_10- I suspect my hunches are inaccurate as often as they are accurate, (ea—)

Opportunity Recognition [53]

- OR_1 - While going about routine day-to-day activities, I see potential new venture ideas all around me.
- OR_2 - Recognizing a good opportunity usually requires experience in a specific industry or marketplace.
- OR_3 - Discussions with my family or friends can help me to recognize business opportunities.
- OR_4 - I am alert or sensitive toward new venture opportunities. (6)

D. Data analysis

First, we make a quantitative analysis of response options. To reduce common method bias we used reverse-scoring items in RA and EA scales and an anonymous questionnaire assessment. We conducted an exploratory factor analysis to validate OR, RA, and EA constructs. Maximum Likelihood analysis was utilized for factor extraction, and the Varimax rotation method was used to transform the final factor solution into a simple solution.

We know that cross-sectional data does not allow us to describe a causal-effect relationship between variables but, instead we can obtain some clues of those relationships. So, we made regressions between OR, RA, and EA constructs. We

made a T-students test for the dichotomic entrepreneurship experience and gender variable, and ANOVA for educational level, and specialization.

Finally, to triangulate the results we use statements with significant correlations between them to make a semantic logical analysis to support our inferences

IV. RESULTS

A. Quantitative analysis of response options

In the next lines, we describe the results. The complete analysis is in the Appendix. Descriptive statistics are in Table II.

TABLE II
Descriptive Statistical

	N	Minimum	Maximum	Media	Desv. tip.
gender	363	0	1	,72	,451
educat	363	1	3	1,90	,594
tenure	363	0	34	5,80	5,585
work	363	0	40	14,16	8,132
experience					
specialization	363	1	9	5,15	2,667
entrep_exp	363	0	1	,51	,501
rac_1	363	1	5	4,27	1,124
rac_2	363	1	5	4,37	,984
exp_1	363	1	5	4,10	1,037
rac_3	363	1	5	4,52	,835
exp_2	363	1	5	3,38	1,287
exp_3	363	1	5	3,29	1,247
rac_4	363	1	5	4,29	1,106
exp_4	363	1	5	3,11	1,278
exp_5	363	1	5	2,74	1,283
rac_5	363	1	5	4,37	,930
rac_6	363	1	5	3,45	1,085
exp_6	363	1	5	3,37	1,093
exp_7	363	1	5	2,92	1,175
rac_7	363	1	5	4,22	,970
rac_8	363	1	5	4,31	,951
exp_8	363	1	5	3,51	1,113
exp_9	363	1	5	3,02	1,244
rac_9	363	1	5	4,27	,869
rac_10	363	1	5	4,16	,929
exp_10	363	1	5	3,39	1,060
OR_1	362	1	5	3,78	1,075
OR_2	363	1	5	3,64	1,080
OR_3	363	1	5	4,03	,837
OR_4	363	1	5	3,65	,970
age	363	22,29	62,21	36,5250	7,40366
N válid	362				

Regarding the factorial analysis, we obtained three unidimensional constructs (table III). The Cronbach's alpha in OR is .717, in RA is .669, and in EA is .759.

TABLE III

Rotated factor Matrix^a

	Factor		
	1	2	3
exp_3	,869		
exp_2	,750		
exp_5	,527		
exp_7	,481		
exp_4	,441		
exp_6			
exp_8			
OR_2			
rac_9		,598	
rac_7		,583	
rac_8		,581	
rac_10		,443	
rac_2			
rac_3			
rac_4			
rac_5			
exp_10			
OR_4			,765
OR_1			,755
OR_3			,462

Extraction method: Maximum likelihood.

Rotation method: Varimax with Kaiser.

a. Rotation has converged in 5 iterations.

We validated each construct using some recommendations [56]. So, the convergent validity is accepted when inter-item correlations are significant. Also, the discriminant validity is accepted when the inter-item partial correlations controlled by the mean value of the construct are not significant.

Correlations between mean constructs, demographics, education level, specialization, and entrepreneurial experience are shown in Appendix. We highlight the significant positive correlation between OR and rational thinking style and entrepreneurship experience, also, the positive correlation between work experience and entrepreneurship experience. Entrepreneurship experience has a significant positive correlation with OR and does not have significant correlation with RA and EA. Additionally, there is a positive correlation (< .05) between age, work experience and rational thinking style level. Finally, a positive but no significant correlation between rational and experiential thinking styles confirms that they are different constructs.

In the sample the mean level of the rational thinking style is higher than the mean level of experiential (Table IV). The Wilcoxon test shows that the difference between rational and experiential mean values is significant (Table V).

TABLE IV
Statistical of constructs

		exp_mean	rac_mean	OR_mean
N	Valid	363	363	363
	Lost	0	0	0
	Media	3,0882	4,2390	3,8228
	Desv. típ.	,89575	,65925	,77094
	Minimum	1,00	1,00	1,00
	Maximum	5,00	5,00	5,00

TABLE V

Wilcoxon test	
	rac_mean - exp_mean
Z	-14,420 ^b
Sig. asintot. (bilateral)	,000

a. Wilcoxon Test

b. Based on negative ranks

Regarding the hypotheses. Hypothesis 1a is about the relationship between experiential thinking style and OR level. Regression shows no significant relationship between both variables. On the other hand, Hypothesis 1b is confirmed because regression shows clues of a significant positive effect of rational thinking style on the OR level (Table VI). That positive effect may remain at any educational level, in respondents with or without entrepreneurship experience, and in both genders.

TABLE VI

Rational Thinking Style and Opportunity Recognition							
Model	Coef. no estándar		Coe f. t	Sig.	Confidence interval at level 95,0% for B		
	B	Error típ.	Beta		Inferior	Superior	
1 (Constant)	2,571	,255		10,064	,000	2,069	3,073
rac_mean	,295	,060	,253	4,958	,000	,178	,412

a. Dependent Variable: OR_mean

Hypothesis 1c and 1d are about the differences in experiential thinking levels related to work experience and tenure. Results in Table 4 show no significant correlation between those variables. Hypothesis 1e proposes that respondents with entrepreneurship experience show a more experiential thinking style than students with non-experience. The T-test did not show any significant results.

Hypothesis 2a is about the relationship between respondents' entrepreneurship experiences and their OR level. Table 4 shows a significant and positive correlation between both variables. T-students test shows a significant difference in

OR mean level between respondents with or without entrepreneurship experience (Table VII).

TABLE VII

Test of independent samples									
Levene test					T-test				
	F	Sig.	t	gl	Sig. (bilateral)	Means differences	Difference error tip.	Confidence interval 95% for the difference	
entrep exp								Inferior	Superior
OR_mean assuming equal variance	2,386	,123	-4,637	361	,000	-,36510	,07874	-,51995	-,21024
No assuming equal variance			-4,626	351,853	,000	-,36510	,07893	-,52033	-,20986

Hypothesis 2b is about the relationship between tenure and OR. Table 4 shows a positive correlation significant at level $< .05$. Hypothesis 2c is about the relationship between work experience and OR, the result is not significant.

Hypothesis 2d is about the relationship between working specialization and OR. An ANOVA test shows no difference in OR mean level. Hypothesis 2e is about the relationship between different educational levels and OR. An ANOVA test shows only a difference in OR mean level between technical and post-degree educational levels ($p < .05$) (Table VIII).

TABLE VIII

Dependent Variable:	OR_mean								
(I) educat			Mean difference (I-J)	Error tip.	Sig.	Confidence interval at level 95%			
						Inferior	Superior		
HSD de Tukey	technical	university	-,11070	,09805	,497	-,3415	,1201		
		post degree	-,34178*	,13902	,038	-,6690	-,0146		
		university	,11070	,09805	,497	-,1201	,3415		
	post degree	post degree	-,23108	,12156	,140	-,5172	,0550		
		technical	,34178*	,13902	,038	,0146	,6690		
		university	,23108	,12156	,140	-,0550	,5172		
Games-Howell	technical	university	-,11070	,09852	,501	-,3440	,1226		
		post degree	-,34178*	,13243	,030	-,6566	-,0269		
		university	,11070	,09852	,501	-,1226	,3440		
	post degree	post degree	-,23108	,11423	,114	-,5044	,0422		
		technical	,34178*	,13243	,030	,0269	,6566		
		university	,23108	,11423	,114	-,0422	,5044		

*. Mean differences are significant at level 0.05.

In summary, the quantitative analysis of the response options confirms that respondents have a predominant rational thinking style. Also, age and work experience have a positive correlation with rational thinking style. We found that age, work experience, entrepreneurship experiences, and tenure have a positive correlation with OR level. There are clues to that respondents' rational thinking style, could have a positive

effect on OR. Finally, there is a difference in OR level between technical and post-degree respondents.

B. Semantic analysis of the item statements

We know that questionnaires are not only devices that elicit information from respondents but also a source of information that respondents use to make decisions about the strength of agreement with the statements [57; 58]. So, we analyzed the statements and their semantic relationship to confirm by triangulation the quantitative results obtained.

First, we describe the item statements composition of OR, EA and RA constructs. Second, we selected statements with significant correlations ($p < .01$) between them (see Appendix). Each author reads iteratively the statements looking for semantic logical links between them. After that we discuss each semantic logical links until reach a consensus, the final results are described next.

In this work OR encompasses: OR_1 (*While going about routine day-to-day activities, I see potential new venture ideas all around me*); OR_3 (*Discussions with my family or friends can help me to recognize business opportunities*); and OR_4 (*I am alert or sensitive toward new venture opportunities*).

RA construct encompasses: rac_7 (*I have a logical mind*); rac_8 (*I have no problem thinking things through carefully*); rac_9 (*Using logic usually works well for me in figuring out problems in my life*); and rac_10 (*I usually have clear, explainable reasons for my decisions*).

EA construct encompasses exp_2 (*Using my gut feelings usually works well for me in figuring out problems in my life*), exp_3 (*I believe in trusting my hunches*), exp_4 (*I trust my initial feelings about people*), exp_5 (*When it comes to trusting people, I can usually rely on my gut feelings*), and exp_7 (*I hardly ever go wrong when I listen to my deepest gut feelings to find an answer*).

Quantitative results show that in this sample experiential style may have no effect on OR (hypothesis 1a). The EA statements refer to using gut feeling or hunches for figuring out problems, (exp_2) judging people (exp_4, exp_5), and find an answer (exp_7). The OR statements refer to imagining new ventures (OR_1), dialoging with family and friends (OR_3), and staying alert to new ventures (OR_4). There is not an evident logical link between those statements except maybe the word “sensitive” in OR_4 but there is no significant correlation between OR_4 and any EA items. So, semantic analysis supports the quantitative results.

Regarding hypothesis 1b, quantitative results show that rational thinking style could have a significant positive effect on OR. The items rac_7 and rac_10 have significant ($p < .01$) and positive correlations with OR_1, OR_3, and OR_4. Semantically we can see the association between rac_7 (I have logical mind) and rac_10 (explainable reasons for my decisions) with OR_3 (discussion with family and friends). If a rational system evolved to facilitate interpersonal argumentation using abstract symbols and logical inferences [22] then, reasonably, we can find a positive relationship between those rational statements and the opportunity recognition statement about discussion with family and friends.

Regarding the relations between rac_7 and rac_10 with OR_1 (I see potential new venture ideas) and OR_4 (I am alert

to new ventures), we must remember that the rational thinking style encodes information in abstract symbols [22]. So, processing those abstract cognitive structures that float over the concrete routine day-to-day activities may increase the alertness to market change and potential venture opportunities [40; 41].

On the other hand, rac_8 (thinking things carefully) has a significant ($p < .01$) and positive correlation with OR_4 (I am alert to new ventures). According to the above, the rational style uses abstract encoding to think things carefully and the cognitive processing of the abstract cognitive structures (mental models) may increase the entrepreneurs' alertness [40; 41].

V. DISCUSSION

The respondents' thinking style is predominantly rational, which is not a surprise because they were engineering professionals and students who are educated predominantly in analytical tools with an ideology focused on system optimization and organizational efficiency [59]. The curricula, teaching methods, and institutional culture influence the educational experience [1], and professional novices are indoctrinated in engineering culture (values, norms, rites, and jargon) by engineering schools and professional societies [60]. So, engineering students favor a linear and analytical approach [61; 44].

The respondents' rational thinking style may have a positive effect on opportunity recognition capability because the rational system operates primarily in the medium of language and is capable of high levels of abstraction [22]. The role of abstractions and language is highlighted in the semantic analysis through the relationship between rac_7 and rac_10 with OR_3 that involved rational statements and discussion with families and friends.

The research proposes that successful entrepreneurs employ analytical, rational, and evidence-based thinking to discover opportunities [62; 63]. Also, entrepreneurs with a rational thinking style prefer more tangible data, information, facts, and analytical tools perceiving higher levels of business environment uncertainty [64]. However, those data are encoded as abstract symbols. The semantic analysis reaffirms that the processing of abstract cognitive structures enhances the alertness of business opportunity (i.e., relationship between rac_7, rac_10, and rac_8 with OR_4).

Respondents' tenure can promote opportunity recognition capabilities because individuals' prior knowledge and experience with a market can allow them to combine information in new ways and discover opportunities [65]. Research suggests that entrepreneurs discover opportunities because they have idiosyncratic previous knowledge of economic sectors that they know well [66]. The semantic analysis shows that more tenure can be associated with more imaginative capability (OR_1).

Prior respondents' entrepreneurship experience promotes business opportunity recognition because competencies and skills for entrepreneurship may only be acquired through experiences in real-world ventures [1]. Traditionally it has been argued that entrepreneurs may recognize business opportunities by structural alignment between events in the outside world and their mental models to make sense and identify a course of action [38]. In this work the

entrepreneurship experience as a proxy of entrepreneurial mental models shows a positive correlation with OR reaffirming the traditional view, however it does not show any correlation with EA and RA. So, how do the entrepreneurs process their entrepreneurial mental model to recognize opportunities? How do they make a match between environment information and their knowledge structures? [67].

Respondents with different educational levels (technicians vs post-degree) can show different levels of opportunity recognition capabilities because the process of developing opportunity recognition capability takes time involving a variety of activities and resources [12]. Both regulative and normative dimensions of the university context could increase students' opportunity recognition and entrepreneurial intention [68]. So, human capital (individuals' skills and knowledge acquired through education or job training) may increase the capabilities of discovering and exploiting business opportunities [9; 69].

Evidence suggests that entrepreneurs use linear and nonlinear thinking styles in their cognitive processes and recognize opportunities depending on linear and nonlinear inputs [43]. However, research shows that the relationship between intuition and opportunity recognition could be strong [29] and that intuitive subjects may be more driven to entrepreneurial behavior than analytics [70]. But in this work, engineering students and professionals' rational thinking style could positively affect their opportunity recognition capability while the experiential (i.e., intuitive) style does not. The semantic analysis shows that experiential statements have not logical relationship with OR statements, but rational statements do. So, is it possible that the role of intuition in entrepreneurial mindset could be simply contingent to sample's characteristics?

VI. CONCLUSION

The purpose of this study is to explore the relationship between engineering students and professionals' thinking styles and opportunity recognition capability (OR) expanding the entrepreneurial cognition research literature. We sampled professionals and technicians currently studying engineering as a second profession and engineering post-degree at a Chilean university. We measured the respondents' thinking styles and opportunity recognition via a self-applied questionnaire. The results are triangulated by semantic analysis of the statements.

The analysis shows that respondents have a predominant rational thinking style. Also, we found that age and work experience could have a positive effect on rational thinking style. The respondents' rational thinking style, entrepreneurship experiences, and tenure have a positive correlation with OR. There is no correlation between entrepreneurship experience and thinking style. Also, there is a difference in OR level between technical and post-degree respondents. Finally, respondents' rational thinking style may have a positive influence on OR level.

This work makes two theoretical contributions to entrepreneurial cognition research. First, we highlight the role of rational versus intuitive thinking style on the professionals' opportunity recognition capabilities linking semantically the statements used showing a more transparent and dynamic cognitive explanation. Second, we question the traditional

theory of the structural alignment between structural knowledge and market events as a mechanism associated with opportunity recognition because entrepreneurship experience as proxy of knowledge and both dimensions of thinking style does not show any relationship, so how do entrepreneurs make that structural alignment?

The practical implications highlight the role of prior entrepreneurship experiences in improving the engineering students' entrepreneurial mindset. Also, we show that the rational thinking style is not an obstacle to recognizing business opportunities therefore, the teaching and training practices to enhance engineering students' intuitive thinking style may not be necessary. Regarding engineering entrepreneurial education students should be encouraged to recognize their own strength and weakness to enhance their OR skills by specific training in their rational thinking style.

This work has limitations. First, items used allow only an initial exploration, future research requires new items specifically associated with entrepreneurial processes. Second, the sample encompasses a mix of engineering students and professionals, given that the engineers' formation may promote a rational thinking style, we cannot rule out a bias in the sample so, the generalization to other professions is limited. Third, the sample only belongs to the Chilean country, future research requires a cross-cultural perspective.

COMPLIANCE WITH ETHICAL STANDARDS

The authors declare that no funding was received.

Authors declare that they have no conflict of interest.

The participants received and accepted informed consent.

REFERENCES

- [1]. Schuelke-Leech, B.A. "Engineering Entrepreneurship Teaching and Practice in the United States and Canada." *IEEE Transactions on Engineering Management*, 2021: 68 (6): 1570-1589. DOI: 10.1109/TEM.2020.2985350
- [2]. Primario, S, P Rippa, and G. Secundo. "Rethinking Entrepreneurial Education: The Role of Digital Technologies to Assess Entrepreneurial Self-Efficacy and Intention of STEM Students." *IEEE Transactions on Engineering Management*, 2024: 71. 2829-2842. DOI: 10.1109/TEM.2022.3199709.
- [3]. Joao, I.M, and J.M. Silva. "Developing an Entrepreneurial Mindset Among Engineering Students: Encouraging Entrepreneurship Into Engineering Education." *IEEE Revista Iberoamericana del Aprendizaje-IEEE RITA*, 2020: 15 (3). 138-147. DOI: 10.1109/RITA.2020.3008105
- [4]. Korte, R. "Identifying as an Entrepreneur: A Social Identity Perspective of the Entrepreneurial Mindset." *Advances in Engineering Education*, 2018: 7(1) ISSN: EISSN-1941-1766
- [5]. Al-Lawati, E.H, U.H Abdul Kohar, and E.S. Suleiman. "Entrepreneurial culture in educational institutions: A scoping review." *Cogent Business & Management*, 2022: 9 (1). DOI: 10.1080/23311975.2021.1997237
- [6]. Banha, F, L.S Coelho, and A. Flores. "Entrepreneurship Education: A Systematic Literature Review and Identification of an Existing Gap in the Field." *Education Sciences*, 2022: 12 (5). DOI: 10.3390/educsci12050336
- [7]. Hägg, G, and J. Gabriellson. "A systematic literature review of the evolution of pedagogy in entrepreneurial education research." *International Journal of Entrepreneurial Behavior & Research*, 2020: 26 (5) 829-861. DOI: 10.1108/IJEBR-04-2018-0272
- [8]. Jardim, J, A Bartolo, and A. Pinho. "Towards a Global Entrepreneurial Culture: A Systematic Review of the Effectiveness of Entrepreneurship Education Programs." *Education Sciences*, 2021: 11 (8). DOI: 10.3390/educsci11080398.

- [9]. Martin, B.C, J.J McNally, and M.J. Kay. "Examining the formation of human capital in entrepreneurship: A meta-analysis of entrepreneurship education outcomes." *Journal of Business Venturing*, 2013: 28 (2). 211-224. DOI: 10.1016/j.jbusvent.2012.03.002
- [10]. Oosterbeek, H, M van Praag, and A. Ijsselstein. "The impact of entrepreneurship education on entrepreneurship skills and motivation." *European Economic Review*, 2010: 54 (3) 442-454. DOI:10.1016/j.eurocorev.2009.08.002.
- [11]. Wong, H.Y.H, and C.K.Y Chans. "A systematic review on the learning outcomes in entrepreneurship education within higher education settings." *Assesment & Evaluation in Higher Education*, 2022: 47 (8) 1213-1230. DOI: 10.1080/02602938.2021.2021583
- [12]. Lindberg, E, H Bohman, P Hulten, and T. Wilson. "Enhancing students' entrepreneurial mindset: a Swedish experience." *Education and Trainining*, 2017: 59 (7-8). 768-779. DOI: 10.1108/ET-09-2016-0140
- [13]. Lyu, J, D Shepherd, and K.R.Y. Lee. "The impact of entrepreneurship pedagogy on nascent student entrepreneurship: an entrepreneurial process perspective." *Studies in Higher Education*, 2023: DOI: 10.1080/03075079.2023.2220722
- [14]. Baron, R. A. "Opportunity Recognition as Pattern Recognition: How Entrepreneurs "Connect the Dots" to Identify New Business Opportunities." *Academy of Management Perspectives*, 2006: 20(1), 104–119. doi:10.5465/amp.2006.19873412
- [15]. Ireland, R, M Hitt, and D. Sirmon. "A Model of Strategic Entrepreneurship: The Construct and its Dimensions." *Journal of Management*, 2003: 29(6) 963–989 DOI: 10.1016/S0149-2063_03_00086-2
- [16]. Ma, T.N, and S.Y. Yang. "Impact of entrepreneurial orientation on the performance of new ventures in China: the roles of entrepreneurial bricolage and opportunity recognition." *Chinese Management Studies*, 2022: 16 (4): 924-941. DOI: 10.1108/CMS-11-2020-0478.
- [17]. Mostafiz, M.I, M Sambasivan, and S.K. Goh. "Foreign market knowledge, international opportunity recognition, and the performance of export-manufacturing firms." *Strategic Change*, 2022: 31(1), 179-191. DOI: 10.1002/jsc.2323
- [18]. Niittymies, A, and K. Pajunen. "Cognitive foundations of firm internationalization: A systematic review and agenda for future research." *International Business Review*, 2020: 29(4) 101654. DOI: 10.1016/j.ibusrev.2019.101654
- [19]. Alaybek, B, Y Wang, R.S Dalal, S Dubrow, and L.S.G. Boerman. "Meta-analytic relations between thinking styles and intelligence." *Personality and Individual Differences*, 2021: 168. DOI: 10.1016/j.paid.2020.110322.
- [20]. Beekman, T.L, and H.S. Seo. "Analytic versus holistic: Cognitive styles can influence consumer response and behavior toward foods." *Journal of Sensory Studies*, 2022: 37 (2). DOI: 10.1111/joss.12723
- [21]. Zhu, Y, and J. Meyer. "Getting in touch with your thinking style: How touchscreens influence purchase." *Journal of Retailing and Consumer Services*, 2017: 38. 51-58. DOI: 10.1016/j.jretconser.2017.05.006.
- [22]. Epstein, S. "Integration of the Cognitive and the Psychodynamic Unconscious." *American Psychologist*, 1994: 49 (8). 709-724.
- [23]. Norris, P, and S. Epstein. "An Experiential Thinking Style: Its Facets and Relations With Objective and Subjective Criterion Measures." *Journal of Personality*, 2011: 79 (5) 1043-1079. DOI: 10.1111/j.1467-6494.2011.00718.x.
- [24]. Novak, Thomas P., and Donna L. Hoffman. "The Fit of Thinking Style and Situation: New Measures of Situation-Specific Experiential and Rational Cognition." *Journal of Consumer Research*, 2009: 36 (1), 56–72 <https://doi.org/10.1086/596026>
- [25]. Pacini, R, and S. Epstein. "The relation of rational and experiential information processing styles to personality, basic beliefs, and the ratio-bias phenomenon." *Journal of Personality and Social Psychology*, 1999: 76 (6) 972-987. DOI: 10.1037/0022-3514.76.6.972.
- [26]. Shiloh, S, E Salton, and D. Sharabi. "Individual differences in rational and intuitive thinking styles as predictors of heuristic responses and framing effects." *Personality and Individual Differences*, 2002: 32 (3) 415-429. DOI: 10.1016/S0191-8869(01)00034-4.
- [27]. Alim, M.A, K.L Tan, T.W Jee, B.H Voon, M.J Hossain, and M.U. Mia. "To explain and to predict: analysis of opportunity recognition on the relationship between personal factors, environmental factors and entrepreneurs' performance." *Asia-Pacific Journal of Business Administration*, 2022: DOI: 10.1108/APJBA-09-2021-0475
- [28]. Cárdenas-Figueroa, A, and A. Olmedo-Navarro. "Exploring the Future of the Engineer Profession: the Effect of the Entrepreneurial Engineers' Mental Model on their Opportunity Recognition Capabilities." *IEEE Transactions on Engineering Management*, 2024: 5616-5626. DOI: 10.1109/TEM.2024.3364711.
- [29]. Blume, B.D, and J.G. Covin. "Attributions to intuition in the venture founding process: Do entrepreneurs actually use intuition or just say that they do?" *Journal of Business Venturing*, 2011: 26 (1) 137-151. DOI: 10.1016/j.jbusvent.2009.04.002.
- [30]. Sadler-Smith, E. "The role of intuition in entrepreneurship and business venturing decisions." *European Journal of Work and Organizational Psychology*, 2016: 25 (2) 212-225. DOI: 10.1080/1359432X.2015.1029046
- [31]. Åberg, C., and W. Shen. "Can board leadership contribute to board dynamic managerial capabilities? An empirical exploration among Norwegian firms." *Journal of Management and Governance*, 2020: 24(1), 169-197. DOI: 10.1007/s10997-019-09460-6
- [32]. Martin, J. A., and D. G. Bachrach. "A relational perspective of the microfoundations of dynamic managerial capabilities and transactive memory systems." *Industrial Marketing Management*, 2018: 74, 27-38. DOI: 10.1016/j.indmarman.2018.07.008
- [33]. Silva de Araújo, C., C. Drebes Pedron, and C. Bitencourt. "Identifying and assessing the scales of dynamic capabilities: a systematic literature review." *Revista de Gestão*, 2018: DOI: 10.1108/REGE-12-2017-0021.
- [34]. Teece, D. "Explicating Dynamic Capabilities: The Nature and microfoundations of (sustainable) Enterprise Performance." *Strategic Management Journal*, 2007: 28: 1319–1350. DOI: 10.1002/smj.640.
- [35]. Felin, T., and T. R. Zenger. "Entrepreneurs as theorists: on the origins of collective beliefs and novel strategies." *Strategic Entrepreneurship Journal*, 2009: 3(2), 127-146. DOI: 10.1002/sej.67
- [36]. Kuratko, D.F, G Fisher, and D.B. Audretsch. "Unraveling the entrepreneurial mindset." *Small Business Economics*, 2021: 57(4): 1681-1691. DOI: 10.1007/s11187-020-00372-6.
- [37]. Wiramihardja, K, et al. "Sustainable Economic Development Through Entrepreneurship: A Study on Attitude, Opportunity Recognition, and Entrepreneurial Intention Among University Students in Malaysia." *Front. Psychol.*, 2022: 13:866753. DOI: 10.3389/fpsyg.2022.866753
- [38]. Grégoire, D, P Barr, and D. Shepherd. "Cognitive Processes of Opportunity Recognition: The Role of Structural Alignment." *Organization Science*, 2010: 21(2): 413–431. DOI: 10.1287/orsc.1090.0462
- [39]. Adna, B. E., and B. M. Sukoco. "Managerial cognitive capabilities, organizational capacity for change, and performance: The moderating effect of social capital." *Cogent Business & Management*, 2020: 7(1), 1843310. DOI: 10.1080/23311975.2020.1843310.
- [40]. Åberg, C., and M. Torchia. "Do boards of directors foster strategic change? A dynamic managerial capabilities perspective." *Journal of Management and Governance*, 2020: 24(3), 655-684. DOI: 10.1007/s10997-019-09462-4.
- [41]. Helfat, C. E., and M. A. Peteraf. "Managerial cognitive capabilities and the microfoundations of dynamic capabilities." *Strategic Management Journal*, 2015: 36: 831-850. DOI: 10.1002/smj.2247.
- [42]. Gholampour Rad, M. "Disruptive innovation in media industry ecosystem and need for improving managerial cognitive capabilities in polymediation era." *Cogent business & management*, 2017: 4(1), 1352183 DOI: 10.1080/23311975.2017.1352183.
- [43]. Groves, K, C Vance, and D. Choi. "Examining Entrepreneurial Cognition: An Occupational Analysis of Balanced Linear and Nonlinear Thinking and Entrepreneurship Success." *Journal of Small Business Management*, 2011: 49 (3) 438-466. DOI: 10.1111/j.1540-627X.2011.00329.x
- [44]. Vance, C.M, K.S Groves, Y.S Paik, and H. Kindler. "Understanding and measuring linear-nonlinear thinking style for enhanced management education and professional practice." *Academy of Management Learning & Education*, 2007: 6 (2) 167-185. DOI: 10.5465/AMLE.2007.25223457.
- [45]. Akinci, C, and E. Sadler-Smith. "Assessing Individual Differences in Experiential (Intuitive) and Rational (Analytical) Cognitive Styles." *International Journal of Selection and Assessment*, 2013: 21 (2) 211-221. DOI: 10.1111/ijsa.12030.
- [46]. Ryu, S. "Online luxury goods with price discount or onsite luxury goods with luxury services: Role of situation-specific thinking styles and socio-demographics." *Journal of Retailing and Consumer Services*, 2020: 57. DOI: 10.1016/j.jretconser.2020.102253
- [47]. Phillips, W.J, J.M Fletcher, ADG Marks, and D.W. Hine. "Thinking Styles and Decision Making: A Meta-Analysis." *Psychological Bulletin*, 2016: 142 (3) 260-290. DOI: 10.1037/bul0000027.

- [48]. Armstrong, T, M Rockloff, and M. Browne. "Gamble with Your Head and Not Your Heart: A Conceptual Model for How Thinking-Style Promotes Irrational Gambling Beliefs." *Journal of Gambling Studies*, 2020: 36 (1) 183-206. DOI: 10.1007/s10899-019-09927-z.
- [49]. Elimari, N, and G. Lafargue. "Neural correlates of performance monitoring vary as a function of competition between automatic and controlled processes: An ERP study." *Consciousness and Cognition*, 2023: 110. DOI: 10.1016/j.concog.2023.103505
- [50]. Pennycook, G, J.A Fugelsang, and D.J. Koehler. "Everyday Consequences of Analytic Thinking." *Current Directions in Psychological Science*, 2015: 24 (6) 425-432. DOI: 10.1177/0963721415604610.
- [51]. Armstrong, S.J, E Cools, and E. Sadler-Smith. "Role of Cognitive Styles in Business and Management: Reviewing 40 Years of Research." *International Journal of Management Reviews*, 2012: 14 (3) 238-262. DOI: 10.1111/j.1468-2370.2011.00315.x.
- [52]. Dew, N, Read, S, S.D Sarasvathy, and R. Wiltbank. "Effectual versus predictive logics in entrepreneurial decision-making: Differences between experts and novices." *Journal of Business Venturing*, 2009: 24. 287–309. DOI: 10.1016/j.jbusvent.2008.02.002
- [53]. Ozgen, E, and R.A. Baron. "Social sources of information in opportunity recognition: Effects of mentors, industry networks, and professional forums." *Journal of Business Venturing*, 2007: 22 (2): 174-192. DOI: 10.1016/j.jbusvent.2005.12.001
- [54]. Roszkowski, M. J, and M. Soven. "Shifting gears: consequences of including two negatively worded items in the middle of a positively worded questionnaire." *Assessment & Evaluation in Higher Education*, 2010: 35 (1). 117–134. DOI: 10.1080/02602930802618344.
- [55]. Brislin, R.W. "Back-Translation for cross-cultural research." *Journal of Cross-cultural psychology*, 1970: 1 (3). 185-216
- [56]. Netemeyer, Richard, Williams Bearden, and Subhash Sharma. *Scaling procedures: issues and applications*. Oaks, USA: Sage Publications, 2003.
- [57]. DeVellis, R. F. *Scale development: Theory and applications*. Thousand Oaks : CA: Sage, 2012
- [58]. Schwarz, N. "Self-reports: how the questions shape the answers." *American psychologist*, 1999: 54(2): 93-105. DOI: 10.1037/0003-066X.54.2.93.
- [59]. Parkin, J.V. "Judgmental Model of Engineering Management." *Journal of Management in Engineering*, 1994: 10 (1) 52- 57. DOI: 10.1061/(ASCE)9742-597X(1994)10:1(52).
- [60]. Kowtha, N.R. "Engineering the engineers: Socialization tactics and new engineer adjustment in organizations." *IEEE Transactions on Engineering Management*, 2008: 55 (1) 67-81. DOI: 10.1109/TEM.2007.912809
- [61]. Huang, J, and B.R. Sisco. "Thinking Styles of Chinese and American Adult Students in Higher-Education- A Comparative-Study." *Psychological Reports*, 1994: 74 (2) 475-480. DOI: 10.2466/pr0.1994.74.2.475
- [62]. Fiet, J. O. *The Systematic Search for Entrepreneurial Discoveries*. USA: Bloomsbury Publishing, 2002
- [63]. Madsen, H, H Neergaard, and J. Ulhoi. "Knowledge-Intensive Entrepreneurship and Human Capital." *Journal of Small Business and Enterprise Development*, 2003: 10(4), 426–434. DOI: 10.1108/14626000310504738
- [64]. Jahanshahi, A.A, A Brem, and M. Shahabinezhad. "Does Thinking Style Make a Difference in Environmental Perception and Orientation? Evidence from Entrepreneurs in Post-Sanction Iran." *Sustainability*, 2018: 10 (5). DOI: 10.3390/su10051546
- [65]. Alvarez, S.A, and J.B. Barney. "Discovery and Creation: Alternative Theories of Entrepreneurial Action." *Strategic Entrepreneurship Journal*, 2007: 1: 11–26. DOI: 10.1002/sej.4
- [66]. Shane, S. "Prior knowledge and the discovery of entrepreneurial opportunities." *Organization Science*, 2000: 11 (4) 448-469. DOI: 10.1287/orsc.11.4.448.14602.
- [67]. Wood, M.S, A McKelvie, and J.M. Haynie. "Making it personal: Opportunity individuation and the shaping of opportunity beliefs." *Journal of Business Venturing*, 2014: 29(2): 251-272. DOI: 10.1016/j.jbusvent.2013.02.001
- [68]. Oftedal, E.M, T.A Iakovleva, and L. Foss. "University context matter: An institutional perspective on entrepreneurial intentions of students." *Education and Training*, 2018: 60 (7-8) 873-890. DOI: 10.1108/ET-06-2016-0098.
- [69]. Unger, J.M, A Rauch, M Frese, and N. Rosenbusch. "Human capital and entrepreneurial success: A meta-analytical review." *Journal of Business Venturing*, 2011: 26 (3) 341-358. DOI: 10.1016/j.jbusvent.2009.09.004.
- [70]. Armstrong, S.J, and A. Hird. "Cognitive Style and Entrepreneurial Drive of New and Mature Business Owner-Managers." *J Bus Psychol*, 2009 : 24:419–430. DOI: 10.1007/s10869-009-9114-4