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HOW PHYSICAL ENVIRONMENT INFLUENCE CREATIVITY:

A SENSORY-BASED APPROACH

Maria Beatriz Henriques Cordeiro – 30412

A Project carried out on the Master in Management Program, under the supervision of:

Professor Luis F. Martinez and Cátia Alves

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1. Abstract

This research aims to study the influence that incongruent (vs congruent) sensory stimuli displayed at the physical work space as an attempt to boost creativity. We designed a between-subject-design experimental study to test our hypotheses where we manipulate sensory cues (e.g., color and smell) to be congruent (e.g., turquoise color and peppermint scent) versus incongruent (e.g., turquoise color and cinnamon scent), and collected data, on different types of creative tasks: convergent (RAT); divergent (AUT) and writing-task. For the experiment eighty-six students voluntarily participated and were randomly assigned to one of the two conditions (incongruent vs congruent sensory stimuli). Our results demonstrated that the presence of two congruent sensory stimuli partially increases convergent creativity, whereas the presence of two incongruent sensory stimuli, even not significant, revealed a tendency of increment on divergent creativity. No results were found for the writing-task. We believe our research is crucial to better understand how work environments (physical cues) can impact creativity and consequently optimize them to produce a higher creative performance.

Key Words: Creativity, In/congruent, Sensory stimuli, Environment

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2. INTRODUCTION

According to World Economic Forum report, it is anticipated that complex problem-solving skills will remain with the same demand level whereas, content skills (such as oral expression and active learning), cognitive skills (such as cognitive flexibility and creativity) and process skills (critical thinking) will be a growing portion of the core skills required for many industries in the near future (World Economic Forum, 2016; 2018 – Appendix A and B; McKinsey Global Institute, 2017; IBM, 2010). This tendency raises the need to find ways that could help managers and employees improve those types of skills, such as creative performance.

Accordingly, previous research had identified creativity as a crucial factor in organizations and essential to its successful performance (Anderson, 2014). Studies have shown that environmental factors (such as social climate, resources, culture) can not only influence employee's attitudes, behaviors, satisfaction and performance (Crouch and Nimran, 1989), but also boost or hamper creativity (Amabile, 1983; 1989).

By looking at a big and highly desired companies such as Google and Apple, we can notice that they are adopting environments that do not follow a typical workspace (room with a table, computer and chair). Their workspace is organized in a way that allows employees to lay down, relax, play some games – all these features have variability and flexibility as a common ground (Forbes, 2018).

Since aesthetic in organizations (physical space) is fundamental for an integral and enriched understanding in organizational life (Strati, 1992), our work will try to shed some light on how physical space, particular changes in sensory stimuli, will impact different creative tasks. Through this work we could help managers to potentiate creatives' performance with slightly changes in the environment as well as contributing for a theoretical understanding of the process behind creativity.

3. Theoretical Background

3.1.Environmental factors and creative performance

Several types of environmental factors are able to influence creativity. Amabile (1983) identified behavioral-driven factors ("the poet Stephen Spender had to drink tea constantly" or "de la Mare had to smoke"), methodological-driven factors ("Tchaikovsky described interruptions has devastating for his work") and even, sensational-driven factors ("Schiller liked to work with the scent of rotten apples"). Recently, it was also seen that particular physical characteristics were able to facilitate creative performance, such as complexity of visual detail or view of natural environment (McCoy and Evans, 2002).

Literature on psychology help us interpret this results, researchers claim that body perceptions (elicited by physical environment) interfere with downstream cognitive processes (Choi, et al., 2014; Holland et al., 2005). Particularly, embodied cognition (or grounded cognition) theory claims that body exerts a strong influence on individual cognitive representations, in fact cognitive appraisal is an intermediate stage between bodily perception and behavior (Damasio, 1994; Krishna, 2012; Krishna, 2014).

In an attempt to find the specific stimuli who are responsible for altering creative performance, some papers narrowed their approach to sensorial-driven factors, by studying only the impact of one sense in creativity. For instance, it was seen that moderate levels of noise, like the ambient sound of a coffee shop, facilitates abstract processing and consequently enhances both dimensions of creativity (originality and appropriateness) (Mehta et al., 2012). Similarly, the intensity of lighting has also been shown to influence creativity. According to Steidle and Werh (2013), darkness (dim light) increases freedom from constraints and induce an explorative and less vigilant task processing style, which in turn enhances creative performance.

3.2.Senses and creativity

Senses help people reading the environment by producing mental constructs and semantic associations. Typically, individuals tend to connect colors with specific messages, concepts and experiences. For instance, the red color is usually associated with dangers and mistakes (e.g. error signed with red ink pen, warning) (Bellizi and Hite, 1992; Elliot et al., 2007). Similarly, cleanliness thoughts appear in the presence of citrus scent (Holland et al., 2005) and music may transmit more or less arousing states (Mattila and Wirtz, 2001).

Consequently, we must consider the interaction of multisensory associations, since when two senses are present they can produce congruent or incongruent semantic associations between each other. Literature in consumer behavior already tried to understand how cross-modal sensory interactions influence behavior (Spangenberg, 2005; Krishna, 2010; Mattila and Wirtz, 2001). However, it is still unknown how multisensory stimuli could impact creative performance.

3.3.Creative-thinking tasks

The most accepted definition of creativity was introduced by Stein (1953) and Barron (1955), and solidified by many other authors, it states that creativity should be both, original and appropriate/useful (see also Amabile, 1983; Runco et al., 2012).

According to Guildford (1950, 1967), the main components of creativity are divergent and convergent thinking. Divergent thinking is an inductive, ideational process that comprises generating a wide range of solutions or ideas to a certain stimulus; this process encourages the association of distant domains improving originality, sometimes by forgetting the appropriateness side of creativity (Scott, 2004). Convergent thinking is a deductive process that involves systematically applying rules to reach a single and correct solution; this process encourages new connections between ideas within the domain, however it could come at the tradeoff cost of a narrow mental focus and a strong conformity, reducing originality (see, Smith

et al., 1993; Hecht et al., 1995).

Accordingly, it was observed that these two creative-thinking tasks differ in their sensitivity for particular aspects of creative performance (Baas et al., 2008) and rely on different neurocognitive states (Chermahini and Hommel, 2010) as well as specific control states (Hommel et al., 2011). Convergent thinking involves a strict control style with strong top-down bias (focuses the search on very few or only one item) and a reduced cognitive conflict (Hommel et al., 2011; Colzato et al., 2012). As what concerns to sensory responses, it was observed that scents who share semantic connections lead to deeper memory traces (Morrin, 2003), which is highly used during a convergent task, consequently we hypothesize that:

H1: Convergent creativity will increase in the presence of two congruent sensory stimuli.

The cognitive-control state underlying divergent thinking involves a weak top-down guidance (expands the search to activate many items) (Hommel et al., 2011; Colzato et al., 2012). Previous findings show that an environment who is perceived as unusual lead to an increase ability to identify combinations, producing improved outcomes on divergent creativity (Lewis, 2000; Fong, 2006). It seems that a sense of conflict leads to a deep examination and higher understanding of each element, enhancing their capacity to integrate contradictions, generate new ideas and consequently improve divergent thinking performance (Miron-Spektor, 2011), thus we hypothesize that:

H2: Divergent creativity will increase in the presence of two incongruent sensory stimuli.

Additionally, we proposed the usage of another creative task to measure overall creativity – the writing-task, based on an imaginative story test. The lack of previous work using this type of task under conflicting environments preclude us from creating a clear hypothesis about possible results on in/congruent physical spaces on creative performance.

However, as an exploratory work, we propose that overall creativity would be differently impacted by these two types of physical spaces (due to the previous mentioned impact of environment on creative performance), as such we hypothesize that:

H3: Overall creativity (writing-task) will be differently impacted by congruent (vs incongruent) sensory stimuli.

Overall, our work aims to deeply understand the impact of sensory integration on different creative performance tasks.

4. METHODOLOGY

4.1. Stimuli

In this research two sensory modalities will be combined – vision (color) and olfaction (scents). Vision, in particular color, has played a significant role in human perception, cognition and behavior (Varichon, 2006). For this study in particular, we choose the blue color, more precisely turquoise, since it was observed to produce more creative outcomes (Mehta and Zhu, 2009). In addition, we decided to use olfactory stimuli, because it was previous demonstrated that participants were more creative on pleasant scented conditions (lavender and lemon) versus an unscented one (Knasko, 1992). Even some research has been done with the combination of these two scents (Zellner et al., 1991; Demattè et al., 2006; Levitan et al., 2014), none of it has focused on creativity.

For the propose of this research, where we are trying to test the influence of incongruent (vs congruent) sensory cues displayed at the physical workspace, in particular with the olfactory and visual stimuli, it is necessary to understand what exactly means incongruence. According to Demattè et al. (2006), the olfactory and visual sensory stimuli seem to share strong and consistent associations, for instance, the spearmint odor was almost sixty percent associated with the turquoise color, showing a strong semantic nature association between odor and color. The same way, cinnamon should share weak and un-related associations with turquoise color.

In this extend, a preliminary study was conducted in order to verify the semantic association between color and odor, and to clarify the level of in/congruence between those sensory cues. In a sample of 69 individuals (59.4% female; M_{age} = 23.7; SD_{age} = 6.2), 98.5% of them associated the green/blue color to the scent of peppermint/mint and the red/orange color to the scent of cinnamon, confirming the strong association between both sensory stimuli (color and scent). In which regards the in/congruence relationship between scent and color, it was statistically significant for 95% confidence level, p <.05. The result shows that individuals agree that peppermint/mint scent is congruent with the turquoise color whereas, the cinnamon scent is incongruent with the same color (depicted in Fig. 1).

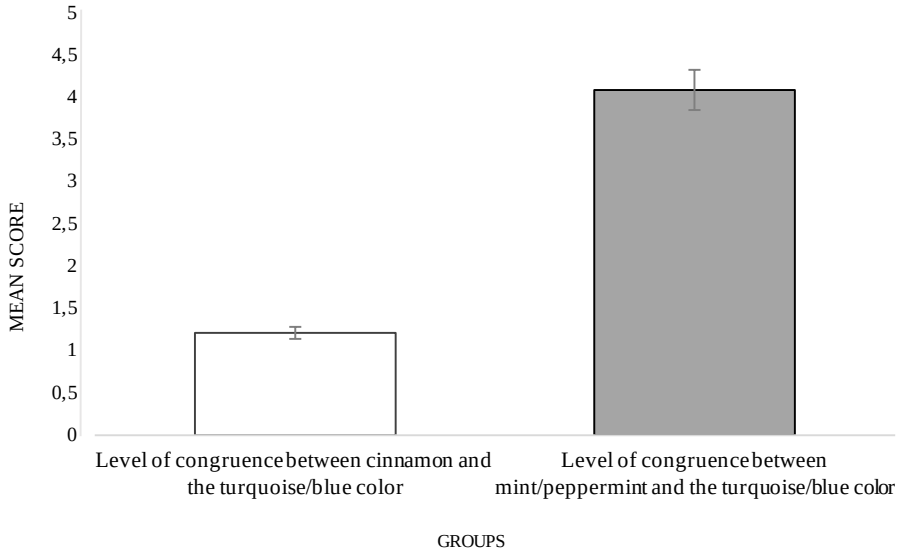

Fig. 1. Results from the preliminary study: mean score of the level of (in)congruence between semantic sensory cues for the two groups of questions. Error bars represent standard errors.

Thus, in order to test our hypotheses, two conditions were conducted. In the first condition, it was manipulated two sensory cues, color and smell, to be congruent (e.g., turquoise color and peppermint scent), while in the second condition the two sensory cues where manipulated to be incongruent (e.g., turquoise color and cinnamon scent).

4.2. Participants and design

Eighty-six national and international students (53.8% female; M_{age} = 21.4; SD_{age} = 1.67) from a Portuguese accredited university participated voluntarily in the experimental study.

From this sample, six participants were eliminated due to the fact that they did not felt the correct scent in the condition where they were in. Among them, 80% were Portuguese and the remaining were foreigners from all parts of the world (e.g., China, Equator, Germany, Italy). All participants were randomly assigned to one of the two conditions: congruent color and scent condition (turquoise with peppermint scent) and incongruent color and scent condition (turquoise and cinnamon scent).

4.3.Materials and procedure

The experiment contained three creative tasks: a Remote Associates Test (RAT) (Mednick, 1962) to test convergent creativity, an Alternate Uses Task (AUT) (Guildford, 1967) to test divergent creativity and a writing task to test general creativity.

All the creative tasks were computer-based (using a survey generated by Qualtrics) and individually executed. Color was manipulated through the background screen of the PC, and the smell through essential oil diluted in water and diffused in the room.

In the room, participants were informed that the experiment involved solving three creative tasks and one questionnaire in the end. After the description and exemplification of the tasks (e.g. RATs: manners, round, tennis [solution: table]; playing, credit, report [solution: card]; AUT: hat example) participants completed one RAT to get familiarize with the task.

When the experiment started participants had 5 minutes to solve seventeen RATs (based on previous papers such, Gino and Ariely, 2012; Gino and Wiltermuth, 2014). After that, they had 4 minutes to list all the uses for a certain object, they were asked to avoid listing typical uses and uses that were virtually impossible (Friedman and Förster, 2001) and, to conclude, they had 5 minutes to write a story (Chen et al., 2005; Lu et al., 2017)

Once the trial finished, the experiment study started with the three creative tasks, followed by the questionnaire.

4.4.Creative Tasks

Remote Associates Test (RAT): Developed by Mednick (1962), this convergent thinking task requires participants to identify a single solution that is related with three presented cue words either semantically or through formation of a compound word. This sort of task is typically used to assess this type of creativity (see: Gino and Wiltermuth, 2014; Zmigrod et al., 2015; Lu et al.,2017). The problems were selected from Gino & Ariely (2012) experiment list (Appendix C).

Measure: Each correct answer was given a score of 1 and each incorrect answer a score of 0. For each participant a final score of creativity was achieved by summing all the points gathered in the seventeen tasks. More points mean better performance on solving the problems, thus indicating more creativity.

Alternate Uses Task (AUT): Created by Guildford (1967), the goal of this divergent thinking task is to list as many uses for a certain item as possible. One of the most common item chosen for this type of task, and thus used in this research, is the brick (see, Friedman et al., 2003; Mehta & Zhu, 2009; Lu et al., 2017).

Measure: The results were scored in four different dimensions: fluency (total number of non-repeated uses mentioned by the participants), flexibility (number of different categories of the responses), novelty (both subjective and objective) and usefulness. Two independent judges evaluated each use for the three latest measures.

Writing task (imaginative story test): This task consists of writing an interesting and exciting story of a certain topic. For the purpose of this experiment, the topic "The dog that doesn't bark" was selected from a set of titles in the Torrance Tests of Creative thinking (Torrance, 1965; 1972; Amabile, 1982). Participants had to write about the topic given in the instructions of the task.

Measure: Two independent judges who were blind to the hypothesis of the study read the story of each participant and judged it in terms of creativity (novelty), following an adaptation of Amabile's (1982) consensual assessment technique.

More information regarding measures will follow within the results.

5. Results

Table 1 reports, for each condition, the means and standard deviations of the main measures included in the study. All the data was analyzed by repeated ANOVAs, with IBM SPSS Statistics 24.

TABLE I
Means and standard deviations of main measures,
Experimental Study

	Congruent Condition (n=37)		Incongruent Condition (n=41)	
	M	SD	M	SD
Fluency	7.14	3.31	7.76	4.12
Flexibility	4.27	1.68	4.88	1.91
Subjective Novelty	2.65	0.73	2.78	0.75
Objective Novelty	0.98	0.0087	0.98	0.0088
Usefulness	5.03	0.96	4.80	0.76
AUT_GlobalCreativity	12.25	6.9	14.23	7.82
	Congruent Condition (n=38)		Incongruent Condition (n=42)	
	M	SD	M	SD
RAT	1.84	1.59	1.29	1.31
Writing Task	4.46	1.28	4.17	1.24

Considering the RAT task, participants in the congruent condition were more successful in the problems (M = 1.84; SD = 1.59) than in the incongruent condition (M = 1.29; SD = 1.31), $F(1,78)$ = 2.94; $p = .09 < 0,10$, showing partial significant results (Fig. 2).

This result allows us to partially accept H1, since two sensory congruent stimuli (color and smell) where able to improve convergent creativity performance (measured by RAT) when compared to sensory incongruent stimuli.

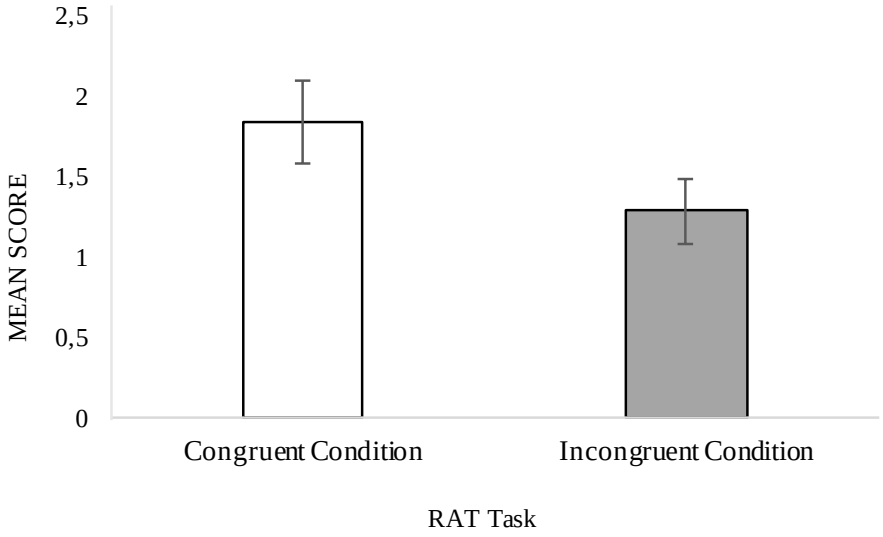

Fig. 2. Convergent Creativity task result.
RAT: mean number of RAT items solved. Error bars represent standard errors.

For the AUT task, to measure divergent creativity, four different dimensions were assessed. Firstly, all the non-repeated uses mentioned by all participants were counted (fluency). Participants in the incongruent condition mentioned more uses (M = 7.76; SD = 4.12) than in the congruent condition (M = 7.14; SD = 3.31), however the statistic test used revealed far from significant results $F(1,76)$= 0.53, p =.47.

For the other dimensions two independent judges (all Portuguese university professors) were asked to judge each use of the brick. To calculate the flexibility of each response, the judges had to generate categories in order to see how many categories each participant mentioned. Overall the judges generated thirteen categories (e.g. construction, violence, decoration, among others). The more categories mentioned the more flexible and thus creative the individual is. In this case, participants in the incongruent condition mentioned more categories (M = 4.88; SD = 1.91) than the ones in the congruent condition (M = 4.27; SD= 1.68) however, the test was also non-significant for 5% significance level, $F(1,76)$ = 2.2, p =.14.

The novelty of each use was calculated in two complementary ways: subjective and objective novelty (see Silvia et al., 2008). The subjective novelty was processed through consensual assessment technique (Amabile, 1982), based on judges "tacit, personal meanings

of creativity" (Silvia et al., 2008; p.70), this approach was used in a wide range of contexts in creative research (see Baer et al., 2004; Kaufman et al., 2007; Hennessey and Amabile, 2010). Judges scored the overall creativity on a scale from 1 (least creative) to 7 (most creative), with an intraclass correlation coefficient of $ICC_{3,2}$ = 0.6, which is an acceptable value taking into account we only used two judges. Participants in the incongruent condition were more subjectively novel (M = 2.78; SD = 0.75), than the ones in the congruent condition (M = 2.65; SD= 0.73), however no significance was revealed, F(1,76) = 0.61, p = .44.

To assess the objective novelty, the "output dominance" measure was analyzed according to Kaufman and Sternberg (2010). To achieve this value, the total number of times each use was generated was divided by the total number of uses listed by all the participants for the object (e.g. "paperweight" was mentioned 22 times and the total number of uses mentioned by all participants was 582; the output dominance of "paperweight" was 22/582 = 3.78%). The objective novelty score was computed by subtracting the output dominant score from 1, thus the higher this value the less common the use listed was. On average, there were no differences from the congruent condition (M = 0.977; SD = 0.0087) to the incongruent condition (M = 0.98; SD = 0.0088), thus no significance was revealed, $F(1,76)$ = 1.78, p =.19.

Lastly, judges used again the consensual assessment technique (Amabile, 1982), to score the usefulness of each use. They used a Likert scale ranging from 1 (least useful) to 7 (most useful) with an $ICC_{3,2}$ = 0.73, demonstrating a good agreement with each other. On average, participants mentioned more useful uses in the congruent condition (M = 5.03; SD = 0.96) than in the incongruent condition (M = 4.8; SD = 1.91), however it was not statistically significant, $F(1,76)$ = 1.42, p =.24.

Note that the final score for the subjective and objective novelty and usefulness was achieved for each participant by summing all scores of each use dividing by the total number of uses listed by each participant.

For the purpose of this research we assume creativity as the generation of ideas, insights or problem solutions that are new and meant to be useful. This statement follows the standard definition of creativity, developed by Stein (1953) and Barron (1955), and has since been supported by other researchers. Thus, an overall score for creativity in the AUT task was computed, for each participant, based on both subjective novelty and usefulness. More precisely, we followed Hoever's (2012) method where both dimension were multiplied by each other. The overall score for creativity in this task confirms that participants in the incongruent condition were more creative (M = 14.23; SD = 7.82) than the ones in the congruent condition (M = 12.25; SD = 6.9). However, the test was not statistically significant, $F(1,76)$ = 1.39, p=.24.

The result for divergent creativity performance is not significant and, objectively, H2 is rejected however we see a tendency, all the dimensions seem to be higher with incongruent sensory stimuli (see Fig. 3). Thus, an immediate rejection of the H2 may not be the most indicated, particularly with such a small sample, instead a replication of the experiment should be done.

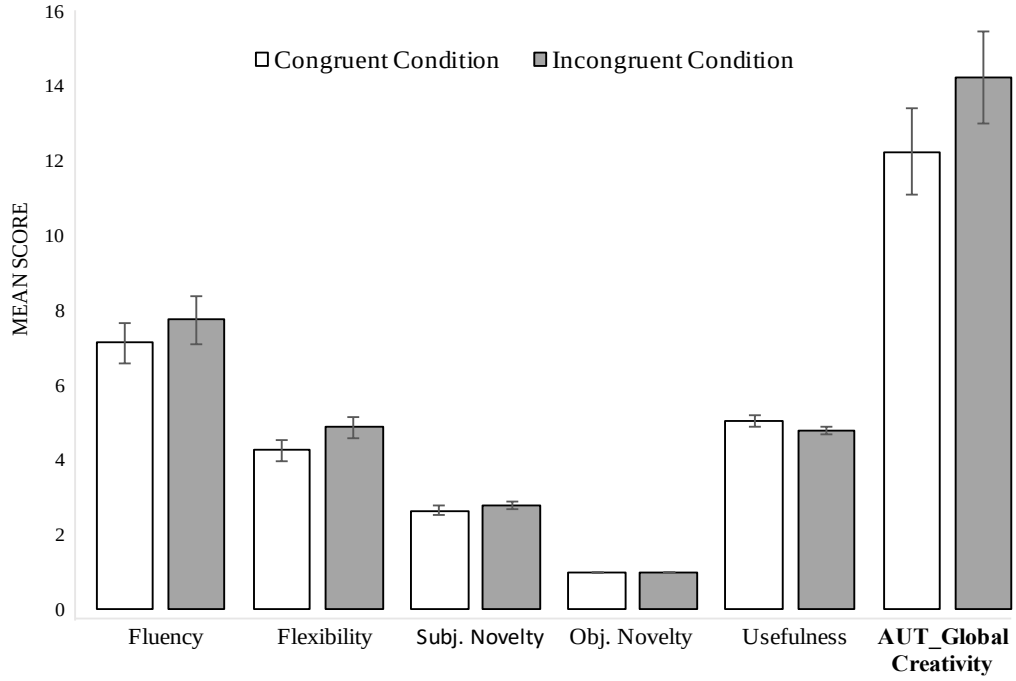

Fig. 3. Divergent Creativity task result, for each measure.
Mean scores of each measure for AUT task. Error bars represent standard errors.

Regarding the Writing Task, the dimension of creativity was assessed by asking the judges, according with their personal opinion of creativity - how creative was each story (Amabile, 1982). This judgement was completed according with a Linkert scale, ranging from 1 (least creative) to 7 (most creative). For this task ($ICC_{3,2}$ = 0.7, an acceptable agreement rate), participants wrote more creative stories in the congruent condition (*M* = 4.46; *SD* = 1.28) than in the incongruent condition (*M*= 4.17; *SD* = 1.24), but the test was not statistically significant *F(1,78)* = 1.09, *p* =.3 (Fig. 4).

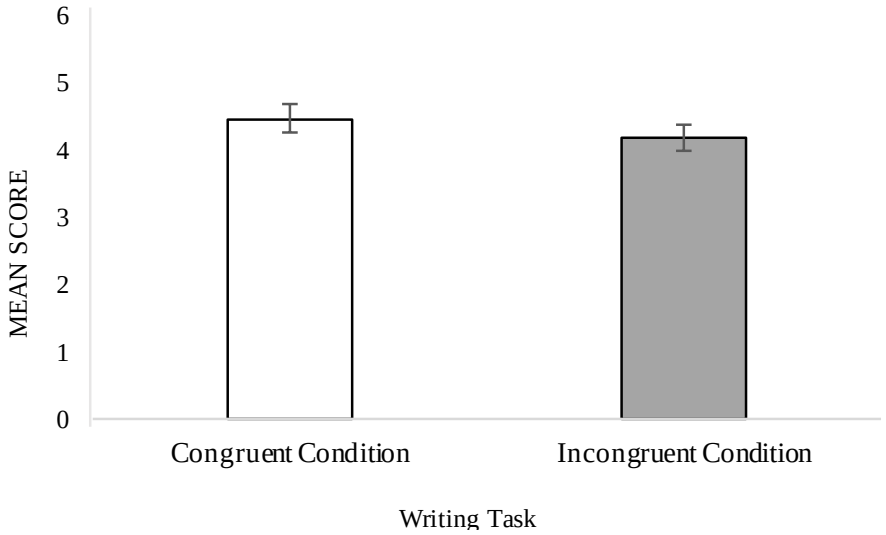

Fig. 4. General Creativity task results.
Writing task: mean creativity score from judges. Error bars represent standard errors.

The result for global creativity performance is not statistically significant, thus H3 is rejected – there are no difference between the two sensory stimuli on creative performance. Although, a slightly higher creative performance was observed in a congruent condition.

6. Discussion

This research aims to test if two semantic incongruent (vs congruent) senses would produce more creative work. To test this, we conducted an experimental study with two conditions of congruent versus incongruent sensory stimuli (turquoise/peppermint and turquoise/cinnamon) and measured several creative tasks.

Previous research on physical space showed that participants in a disorderly room were more creative (divergent creativity) than participants in an orderly room (Vohs et al., 2013). Our results support these findings showing that divergent thinking task (AUT) had a better performance on the incongruent sensory-stimuli condition rather than in the congruent sensory-stimuli condition, although not statistically significant. Previous findings observed that priming people with paradoxical framings of a certain product before asking them about product successfulness (e.g. emphasizing creative and efficient aspects of the product as well as the tension between creativity and efficiency) lead people to be more creative in subsequent divergent creative tasks (Miron-Spektor, 2011). In accordance, primed individuals with unrelated categories (e.g. nutrition and hygiene) increased their creativity (in idea generation task, resembles AUT) in comparison with the use of only one category (Rietzschel et al., 2007). All these findings support our results, it seems that the coexistence of disconnected cues raised diverse connections; in fact, it was stated that creativity allows a reconciliation of contradictory elements (Smith and Tushman, 2005).

It is known that, in consumer behavior, the choice of the sensory stimuli tends to follow some type of congruence criteria. Cross-modal sensory interactions tend to follow a multisensory semantic congruence because it improves marketing-related outcomes such as product evaluations or shop environment satisfaction (Krishna, 2012). Given this findings, and the lack of research in creative outcomes, our second hypothesis tried to demonstrate that two congruent sensory stimuli are able to improve convergent creativity because it intends to achieve a solution – a desired outcome, as marketing does. The results showed an improvement in convergent creativity (RAT) while done in congruent environment rather than an incongruent one. In RAT task, the solution word is not strongly associated with the presented cue words, a broad attentional focus is required (Nijstad et al., 2010), thus the "chaos" induced by the incongruent condition may not help to solve the problems dispersing people attention and focus.

Moreover, this type of task requires a reduced cognitive conflict (Colzato et al., 2012), which may support our finding that a congruent environment hampers convergent creativity.

Regarding the writing task, we did not find differences on this creative task by using incongruent (vs congruent) sensory stimuli (rejection of H3). This may be due to the fact that general creativity is a concept that encompasses different ideas which may difficult or confound results visualization. Even not significant, a slightly higher creative performance was observed in the congruent condition. Like convergent thinking task (RAT), attentional focus is required to accomplish this task, thus two congruent sensory stimuli may have helped participants to write the story, improving their creative performance.

We discourage the use of this measure in future studies due to its ambiguity. We believe convergent and divergent creativity are clearer measures as well as well-stablished concepts that enable a deep understand of what is being measured as well as the process behind it.

Several limitations can be identified in our study. Firstly, due to facilities logistics issues, the sessions were not equal, (e.g. the number of participants in each session varied, the intensity of the smell were irregular and the temperature as well as the light was not controlled). Factors known to influence task performance in previous research papers (Lan et al., 2011) in particular creative performance (Alencar and Bruno-Faria, 1997; Steidle and Werth, 2013). Thus in future research this features should be taken into consideration in order to improve results.

Additionally, since in our sample eighty percent of the students were Portuguese natives, this may have impacted the results justifying the low level of global creativity achieved in the study more precisely in the RAT task. To succeed on this task, participants need to have a good level in English (lexical knowledge) to understand the presented cue words in order to find the correct solution. Looking for the descriptive statistics (see appendix D), it is possible to see that more than half of the sample did not solve any problem or only accomplished one, and that

none succeed more than 6 problems, showing an overall low rate of creativity in both conditions. Therefore, we advise future research to include participants native in the language of the task (in this case was English), to improve the results and consequently achieve more detailed conclusions.

The initial design of the research was changed due to the lack of participants, in the beginning we planned to do more conditions. Beside the ones used, we thought in a control condition (no color and no scent), in a condition with no scent (only with the turquoise color) as well as conditions with only targeted scents (no colors being displayed). This way, we would be able to do a better job in which regards conclusions about the effect that ambient scent has on the workspace. We followed the conclusion of Mehta and Zhu (2009) that the blue color boost creativity, but this results were not replicated in any other studies. So by doing these extra conditions we were able to replicate the test and understand better if in fact blue increases or not creativity.

Another factor that may have influenced the results, it is the Intraclass Correlation Coefficient, thus influenced by lack of judges. In this study only four judges evaluated the tasks (two for the AUT and two for the writing task), which led to acceptable but not optimal ICC values (ranging from 0.6 to 0.73). Therefore, to produce a better estimation for this coefficient it is advised to use a larger number of judges. For instance, Mehta et al., (2012) used in their research 12 judges and Friedman et al. (2003) used 9 judges to score creativity.

Even taking these limitations in mind, we still believe that this study has some important insights to take into account. We aim to help managers to potentiate creatives' performance with slightly changes in the environment (sensory stimuli). The results from this study partially suggest that flexible organizations can potentiate creativity in its workspace, by changing its environment and being more dynamic.

All in all, we must see this research as a preliminary result, thus further new experiments must be developed. As Leppink et al., (2016) stated "a series of studies generally provides more accurate estimates then a single study".

7. Conclusion

The importance that creativity and environmental sensory cues have on organizations and how strongly impacts its performance is widely recognized, yet little research has been done in this field, more precisely in which regards multisensory stimuli. This research aimed to study whether two semantic incongruent (vs congruent) senses would produce more creative work. Our results demonstrated that the presence of two congruent sensory stimuli partially increases convergent creativity, whereas the presence of two incongruent sensory stimuli, even not significant, revealed a tendency of increment on divergent creativity. No results were found for the writing-task. While further investigation is needed to explain the nature of the outcomes, it encourages the view that research from the environment stimuli in particular sensory modalities such vision and olfaction may be useful to understand its impact on creativity.

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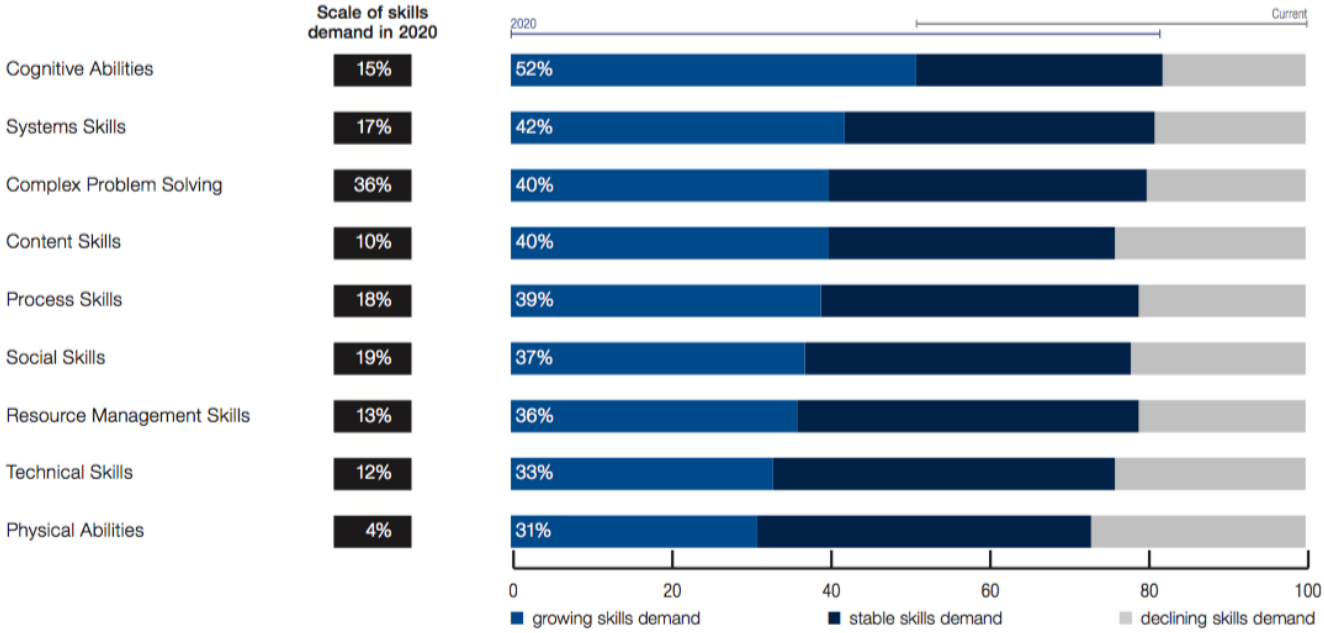
9. Appendix

Appendix A

Change in demand for core work-related skills, 2015-2020, all industries

Share of jobs requiring skills family as part of their core skill set, %



Source: Future of Jobs Survey, World Economic Forum, 2016

Appendix B

Comparing skills demand, 2018vs. 2022, top ten

Today, 2018	Trending, 2022	Declining, 2022
Analytical thinking and innovation	Analytical thinking and innovation	Manual dexterity, endurance and precision
Complex problem-solving	Active learning and learning strategies	Memory, verbal, auditory and spatial abilities
Critical thinking and analysis	Creativity, originality and initiative	Management of financial, material resources
Active learning and learning strategies	Technology design and programming	Technology installation and maintenance
Creativity, originality and initiative	Critical thinking and analysis	Reading, writing, math and active listening
Attention to detail, trustworthiness	Complex problem-solving	Management of personnel
Emotional intelligence	Leadership and social influence	Quality control and safety awareness
Reasoning, problem-solving and ideation	Emotional intelligence	Coordination and time management
Leadership and social influence	Reasoning, problem-solving and ideation	Visual, auditory and speech abilities
Coordination and time management	Systems analysis and evaluation	Technology use, monitoring and control

Source: Future of Jobs Survey, World Economic Forum, 2018

Appendix C

Task 1 (RAT):

You will have **5 minutes** to complete the following Remote Associates Tasks.
Remember: You do not have to complete all of the tasks, do as many as you can.
Please do not use any help other than your own knowledge.
Only the correct answers will be taken into consideration.

RAT items used in the experiment:

Word 1	Word 2	Word 3	Solution
Blank	White	Lines	Paper
Magic	Plush	Floor	Carpet
Thread	Pine	Pain	Needle
Stop	Petty	Sneak	Thief
Envy	Golf	Beans	Green
Chocolate	Fortune	Tin	Cookie
Barrel	Root	Belly	Beer
Broken	Clear	Eye	Glass
Pure	Blue	Fall	Water
Widow	Bite	Monkey	Spider
Chamber	Staff	Box	Music
Mouse	Sharp	Blue	Cheese
Hall	Car	Swimming	Pool
Square	Cardboard	Open	Box
Ticket	Shop	Broker	Pawn
High	Book	Sour	Note
Gold	Stool	Tender	Bar

Appendix D

RAT's descriptive statistics

RAT	N	0 correct answers	At least 1 correct answer	At least 2 correct answers	At least 3 correct answers	Mean	SD	Minimum	Maximum
Congruent Condition	38	9	29	20	12	1.84	1.57	0	6
Incongruent Condition	42	13	29	14	6	1.29	1.31	0	5
Total	80	22	58	34	18	1.55	1.47	0	6

Source: IBM SPSS Statistics 24 – present study information