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To see a painting versus to walk in a painting: an experiment on sense-making through virtual reality

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Abstract

It has been maintained that Virtual Reality (VR) may allow students to "get into" the representation simulated by the computer, so that they can mentally act on the relation they have with the representation of the world instead of acting on the relation they have with the world itself. This should help students to realise some critical issues involved in knowledge construction and to grasp important epistemological implications. This general assumption needs to be empirically tested, for instance by showing that mental operations elicited by VR environments differ from those occurring in traditional instructional settings. The present experiment aimed to provide evidence for this, by focusing on a particular cognitive process: making sense. Forty university students were randomly assigned either to a reflection condition or to a VR immersion condition. In the first condition participants looked at the two-dimensional reproduction of an unfamiliar painting; in the second condition they were taken into a guided virtual tour into the same painting. Four tasks (to propose a title for the painting, to identify its meaning, to list questions suggested by it, and to write a comment) were given. Analyses of protocols revealed that students in the VR condition were induced to assume spontaneously a meta-perspective, namely, to think not to "what" they face, but to "why" or "how" something is in front of them. VR experience also prompted students to conceptualise experience at an abstract level and stimulated a free and imaginative elaboration. The reflection condition, instead, encouraged emphasis to be placed on the cultural or inferential links. Findings suggested that the outstanding features of VR for instruction, refer to the possibility that VR allows users to become aware of some implicit assumptions concerning the relations between our mind and the world.

Keywords: Virtual reality; Media in education; Post secondary education

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1. Introduction

It has been argued that Virtual Reality (VR) may play innovative roles in instruction because of its peculiar features (Wexelblat, 1993). Since VR can produce a three-dimensional representation of phenomena, it helps students both to experience directly some physical properties (shape, size, distance, time duration, and so on) of objects and events, and to realise the actual implications of such properties. VR also favours the discovery of features which are often, in traditional educational tools, perceptually "hidden" because it permits to look at elements which can not be seen, for instance, by inspecting a two-dimensional picture and/or that words or other abstract symbols fail to describe adequately (Pantelidis, 1993; Osberg, 1995). Moreover, VR allows to change one's point of view in a continuous and flexible manner, both by going around (left and right, up and down, near and far) the objects, by "jumping" inside/outside the environment, and by accessing new, unusual perspectives (Ferrington & Loge, 1992). Furthermore, VR permits one to do actions and transformations — which are impossible to do in the real world — so to test perceptually their effects or the effects of hypothetical or conceptual operations (Larijani, 1994). For example, it is able to modify the speed of some events, to stop some processes, or to replicate them ad libitum. Moreover, it permits one to vary the values of physical variables such as gravity, attraction and so on in order to verify the consequences of these changes. In other words, VR may be an heuristic tool which prompts students to manipulate their mental models to understand what happens if things work differently to the norm (Krüger, 1991). In sum, VR induces to explore phenomena according to a "what if" attitude that orientates both logical and creative thinking in peculiar directions (Aukstakalnis & Blatner, 1992).

These remarks suggest that learning processes occurring in a VR environment should be structurally different from those elicited by traditional instructional settings (Helsel, 1992). Consequently, different cognitive activities should be elicited by a VR experience as compared to an instructional experience based on usual tools that do not produce an immersive contact between the student and the content to be acquired. However, this hypothesis needs to be empirically tested. While perceptual processes involved in VR have been extensively investigated (e.g., Ellis, 1991; Kalawsky, 1993; Barfield & Furness, 1995), few studies considered thinking processes — above all those required by learning procedures — activated by VR (e.g., Ainge, 1995; Antonietti, Imperio, Rasi & Sacco, 1998). The aim of this paper was to give a contribution to this issue.

In the experiment reported here, focus is placed on a specific cognitive activity: making sense. This is perhaps best understood via the use of an example. When a naive participant is faced with a painting such as that of Saint Jerome by Antonello da Messina (1474) (held in London: National Gallery), presumably he or she firstly wonders what does it mean: "Who is that man?" ("A scholar?" "A clergyman?"); "Where is he?"; "What is he doing?" ("Is he reading? Writing? Praying?"); "Why is there a peacock?" and so on. To answer these questions the participant is required to interpret the elements given and to construct a whole meaning. Sense-making refers to such a kind of situations, namely, cases in which the learner has to discover or construct a meaning, and attribute it to what is in front of him/her. Thus, the specific question addressed by the present experiment was: does the possibility to have a VR

immersion experience, affect the act of making sense, by orienting thinking processes toward directions which differ from those hinted by traditional instructional experiences?

The example reported above was not fortuitous. Art represents in fact a relevant field where making sense processes occur. Art deals with rich and complex objects which are polysemic in their own nature. Artistic products are open to multiple interpretations and different perspectives are available to analyse them. All this asks for a continuous search of a deeper and deeper understanding which leads to identify further meanings. Therefore, art appears to be suitable field where some conjectures about the cognitive peculiarities of VR in instruction can be tested.

2. Methods

Forty undergraduates in Pedagogics and Psychology volunteered for the experiment, and were neither paid nor received credits. The participants were randomly assigned either to a VR condition or to a Reflection condition, so that two equivalent groups of 20 individuals were constituted. Gender, faculty, and year of course attended were balanced between the two subsamples. All participants included in the sample had never seen the material used in the experiment before (see the final interview).

Participants were studied individually in a session of about 20 min within a quiet room of the university building.

In the *Reflection condition*, undergraduates sat down and were asked to inspect for 5 min a high-quality two-dimensional (20 cm × 30 cm) reproduction of the painting entitled Saint Jerome by Antonello da Messina (1474) (London: National Gallery) which they had in front of them.

In the *VR condition*, participants sat down in front of a computer screen where they were shown a "virtual tour" inside the painting. Desktop VR software[1] was used; this allowed participants "to jump" into the painting and to "walk", or also to "fly" inside it; it was possible to move inside the painting in a continuos way across the three dimensions and to change freely the point of view along the orthogonal axes. In order to assure that all VR participants had the same experience with the painting, they were taken on a standard, visual "guided tour" which led them into the painting and showed them around the environment presented. The virtual experience with the painting lasted 5 min.

Afterwards, both groups of participants were presented with the same tasks, and were asked to respond to them in writing. Participants undertook four tasks in all, aimed at investigating the process of sense-making. The four tasks were: to find out a title to the painting; to describe what, according to one's opinion, the painting meant; to list all the questions that the painting suggested; to write down a brief commentary about the painting. Three min were allowed for each task. The general aim of these tasks was to understand what the painting represented to the participants. From these tasks four different converging dimensions of the making sense process were recorded.

[1] *Camminare nella pittura*. Milano: Electa — Mondadori Newmedia, 1997.

At the end participants were told the aim of the research and were asked whether they had ever seen the painting presented in the experiment. If so, they were excluded.

3. Analysis of the protocols

Two independent judges, who were unaware of the experimental conditions corresponding to the protocols, classified the responses according to multiple criteria. For each criterion various self-excluding categories were devised (participants included in a category could not be included in another category). High inter-judge correlation's (ranging from 0.78 to 0.93) were recorded. Cases of disagreement were discussed so that a shared classification was reached.

3.1. Title of the painting

The titles given to the painting were classified according to their *content* on the basis of their pivot-element: the character (this category included titles such as "A monk in a monastery"); perceptual–spatial elements (e.g. "A church"); abstract elements ("In the poet's imagination"); meta-perspective elements (referring to the alleged goal of the painting — that is, to the reasons which led the painter to produce it — or the effects the painting produced on the observer).

The *kind* of titles were considered by distinguishing among: descriptive titles (titles consisting of a mere report of the scene represented in the painting: e.g. "A man in his room"); inferential titles (when participants tried to interpret the perceptual data by attributing them a meaning which was not directly or univocally prompted by the painting: e.g. "Dante writing a poem"; "The library in the cathedral"); imaginative titles (titles based on a free elaboration which had only a weak link to the pictorial elements: e.g. "Silence"; "Quiet").

The *number of concepts* expressed in the title (1, 2, 3 or more) was computed, too.

3.2. Meaning of the painting

Interpretations of the painting (second task) were classified first of all relating to their *content*. Participants could have focused: on the character, on the environment, or on some abstract elements (e.g. "The painter represented a moment of relax"; "The painting represents how a person can be deeply absorbed by reading").

The *kind* of the interpretation was then considered, and could be: descriptive, technical (participants stressed some features of the production of the painting, pictorial notions, and so on), personal (responses underlying emotions or feelings elicited by the painting), or interpretative (answers focused on external referents — persons, places, or concepts — of the whole picture or of its elements).

The *aim* of the interpretation was also analysed. Participants might have stressed: cultural (consisting in stressing historical or artistic elements), explanatory (if it was suggested that some elements, such as the peacock, had been painted to symbolise something else: "The animal represents the moral features of that man"), literary (if there was a poetic-like response), personal (referring to some memories evoked by the painting), or general elements.

3.3. Questions risen by the painting

As far as the third task was concerned, the number of questions proposed by each participant was considered. Questions were classified according to whether they focused on: perceptual elements (namely, on what one could see), cultural elements (questions referring to the author or to his work or cultural milieu), or personal elements (questions about feelings elicited by the painting). Questions could also investigate the meaning (of a particular element or in general) or be meta-questions (questions concerning reasons that induced the artist to do such a paintings or questions asking for the correspondences between the painting and the real world: e.g. ''Is it a real place?'').

Finally the questions which referred to details (e.g. ''Is it a lion or a horse?'') or to general aspects of the painting were distinguished.

3.4. Comment about the painting

The comment *content* could be technical, personal, or psychological (when the participant mentioned mental effects or problems induced by the painting).

Even for the comment (fourth task) the *kind* of the answers was considered. Participants could make a perceptual, an associative (e.g. ''The painting induces memories of our own studying experiences''), or an abstract (e.g. ''The position of the character suggests that man is at the centre of the world'') comment.

4. Results

The first step of the analyses carried out on the protocols concerned the consistency of the responses given in the four subtasks. The question addressed was: is it possible to identify coherent associations between the categories devised to classify responses within each task and between categories of responses in different tasks? Distributions of responses were crosstabulated by considering each pair of classification criteria. Table 1 reports the X^2 values obtained through such crosstabulations. It is worth noticing that, even though categorisation criteria adopted in a task did not overlap, in the first, second, and fourth tasks they were significantly associated with each other. For instance, as far as the content and the kind of the title were concerned (first task), abstract and meta-titles tended to always be imaginative titles, and titles focused on the character tended to be inferential titles; meaning focusing on the environment were prevalently descriptive meanings (second task); technical comments tended to be perceptual comments and psychological comments tended to be abstract comments (fourth task). Furthermore, significant links between title and interpretation emerged: for example, participants who proposed perceptual titles gave descriptive interpretations and those who found abstract titles identified interpretative meanings; meta-titles were always associated with explanatory interpretations. Finally, the aim of the interpretation was associated both to the content and to the kind of the comments: participants who found literary meanings always wrote personal (content) and associative (kind) comments and who found explanatory meanings wrote psychological (content) and abstract (kind) comments.

Table 1
Chi-squared values concerning crosstabulation of responses in each task according to the classification criteria employed

	Title: kind	Interpretation: content	Interpretation: kind	Interpretation: aim	1st question	2nd question	3rd question	Comment: content	Comment: kind
Title: content	24.04 [c]	12.86 [a]	38.88 [c]	30.49 [b]	15.49	19.68	8.11	8.33	12.23[a]
Title: kind		13.13 [a]	7.32	7.53	6.39	10.21	10.17	4.48	1.81
Interpretation: content			16.63 [a]	20.22 [b]	3.72	12.55	13.47	2.89	3.07
Interpretation: kind				36.39 [c]	11.63	15.38	6.89	10.02	10.19
Interpretation: aim					12.52	12.50	13.89	23.10[b]	25.42[b]
1st Question						27.50 [b]	19.27	3.18	6.62
2nd Question							20.94	3.76	16.10[a]
3rd Question								8.26	7.94
Comment: content									22.96[c]

[a] $p < 0.05$.
[b] $p < 0.01$.
[c] $p < 0.001$.

The second step of the analyses consisted in assessing whether the experimental conditions which participants were assigned to, influenced the frequency of some kinds of responses. Table 2 presents the titles proposed by the participants. For each classification Table 2 reports the percentage of participants within each experimental condition who gave a response included in that category. The distribution of participants according to the experimental condition and to the *content* of the titles revealed statistically significant effects [X^2 (3, N = 40) = 8.00, $p < 0.05$]. In the whole sample the most frequently mentioned titles concerned either the character or some abstract elements. The Reflection group produced more titles focused on the character of the painting than the VR group (comparison of percentages of participants between the two conditions: z = 2.29, $p < 0.01$); the VR immersion group mentioned perceptual–spatial and abstract titles more frequently than the Reflection group, even though these differences were not statistically significant. It is worth noticing that only in the VR condition did titles involving a meta-perspective occur (comparison between the two subsamples: z = 2.11, $p < 0.05$).

Titles were also classified according to their *kind*. The overall distribution of responses failed to reveal significant effects [X^2 (2, N = 4) = 4.25], but inferential elements were statistically more frequent in the Reflection group (z = 1.94, $p < 0.05$), whereas the opposite was true for the imaginative elements (z = 1.91, $p < 0.05$).

There was no significant difference between the mean *number* of concepts embedded in the titles proposed by the two groups [VR immersion: M = 1.75, SD = 0.72; Reflection: M = 1.65, SD = 0.75; $t_{38} = 0.43$, n.s. See also Table 1, third section: X^2 (2, N = 40) = 0.47, n.s.].

When participants were asked to say what they thought the painting meant (second task), different trends of responses emerged (Table 3). According to the *content* X^2 (2, N = 40) = 10.52, $p < 0.01$], Reflection participants focused prevalently on the character (z = 3.28, $p < 0.001$), whereas VR participants — as obvious — on the environment (z = 2.29, $p < 0.05$). Abstract responses were still more frequent in the VR group.

Associations between experimental conditions and categories of response emerged in the

Table 2
Title of the painting (first task): percentage distribution of responses according to the experimental condition

	VR	Reflection	Total
Content			
Character	20	55	37.5
Perceptual–spatial	20	10	15
Abstract	40	35	37.5
Meta-perspective	20	0	10
Kind			
Descriptive	15	15	15
Inferential	25	55	40
Imaginative	60	30	45
Number of concepts			
1	40	50	45
2	45	35	40
3 or more	15	15	15

analysis of the *kind* of interpretation [X^2 (2, $N = 40$) = 39.14, $p < 0.001$]. Technical meanings were mentioned exclusively by VR participants ($z = 2.39$, $p < 0.01$) and Reflection participants preferred interpretative reading of the painting ($z = 2.22$, $p < 0.05$).

Meanings proposed by the participants were classified also with respect to the *aim* they assigned to the painting and also in this case responses were not homogeneously distributed [X^2 (4, $N = 40$) = 9.79, $p < 0.05$]. Cultural meanings were more frequent in the Reflection than in the VR group. Explanatory meanings appeared in the VR group but not in the other group ($z = 2.91$, $p < 0.005$).

If the questions elicited by the painting are considered, their mean numbers did not differ significantly between the two experimental conditions (VR immersion: $M = 4.20$, SD = 1.94; Reflection: $M = 4.85$, SD = 2.18; $t_{38} = -0.99$). The percentage of questions focusing on details was significantly higher in the Reflection (62%) than in the VR (42%) condition ($z = 2.69$, $p < 0.005$). Cultural questions were produced in a larger extent in the Reflection condition as compared to the other condition ($z = 2.53$, $p < 0.05$); production of meta-questions was markedly higher in the VR than in the Reflection group ($z = 3.26$, $p < 0.001$) (Table 4).

Considering the frequency distribution of the comments written by the participants and categorized according to their *content* [X^2 (2, $N = 40$) = 0.75, n.s.], it found that psychological interpretations were given by both the two groups in the same extent; participants in the Reflection group preferred technical contents and VR participants preferred personal contents (Table 5).

Finally, analysing the *kind* [X^2 (2, $N = 40$) = 2.86, n.s.] of comments, it was noticed that abstract concepts and free associations were more frequent in the VR than in the Reflection subsample. However, these differences were not statistically significant.

Table 3
Interpretations of the painting (second task): percentage distribution of responses according to the experimental condition

	VR	Reflection	Total
Content			
Character	15	65	40
Environment	55	20	37.5
Abstract	30	15	22.5
Kind			
Descriptive	45	35	40
Technical	25	0	12.5
Interpretative	30	65	47.5
Aim			
Cultural	15	20	17.5
Literary	10	5	7.5
Explanatory	35	0	17.5
Personal	5	15	10
General	35	60	47.5

Table 4
Questions elicited by the painting (third task): percentage distribution of responses according to the experimental condition

	VR	Reflection	Total
Perceptual	30	31	30.5
Cultural	5	17	11
Personal	5	1	3
Interpretative	47	50	48.5
Meta-questions	13	1	7

5. Conclusions

As cultural psychology perspectives suggest, people can learn via interaction with artificial tools, which allows them to grasp new information, ideas, and models. VR is a new tool, a way to reach new contexts, those far from our capabilities, and those not possible in the real world. Alongside Mercer (1992), this research support the belief that a context is constituted by whatever people find relevant to their interests: we give a sense to our experience by referring to what we know and to what we can interact with. Compared to the traditional learning settings, VR provides us with new contexts by letting us explore new peculiar perspectives and develop different skills. Indeed VR offers a large extent of possibilities in instruction. Because of its peculiarities, we are induced to assume that such possibilities depend on the particular mental operations which are elicited by VR environments and which differ deeply from those occurring in traditional school settings. Consequently, reasons for efficacy of VR in teaching should be researched in this direction. The present research reported, moved in such a direction by addressing the broad question: what kind of thinking processes does VR activate in the learner's mind?

This general issue has been faced by investigating a delimited cognitive activity — making sense — within a specific domain (visual arts). School generally offers the possibility to develop

Table 5
Comments on the painting (fourth task): percentage distribution of responses according to the experimental condition

	VR	Reflection	Total
Content			
Technical	35	45	40
Personal	25	15	20
Psychological	40	40	40
Kind			
Perceptual	20	45	32.5
Associative	35	25	30
Abstract	45	30	37.5

an artistic interest. Everyone has learnt how to appreciate works of art in a traditional way; nowadays we have the possibility to look at such works from a different perspective, thanks to VR. In this research participants received either a reproduction of an unfamiliar painting or the possibility to get into it and have a virtual tour inside the painting and to look at spaces that the author did not represent explicitly. Afterwards, they were requested to give a meaning to the painting that they had inspected by carrying out four different tasks.

Coherent patterns of association among the responses given by the participants were found. This suggests that in elaborating their experience with the painting participants developed a stable line of thinking that they followed across the tasks. Thus, the first conclusion that can be drawn is that the procedure devised to study sense-making in this experiment seems to be sufficiently adequate because it allows us to recognise stable interpretation tendencies or "styles".

In most cases the two different kinds of exposure to the painting manipulated in the experiment (reflective inspection versus virtual immersion) produced different response distributions. If the main trends of responses observed are considered, three main differences emerged between the two experimental conditions. Firstly, it seems that only VR experiences induced participants to assume spontaneously a meta-perspective, namely, to think not to "what" they face to, but to "why" or "how" something is in front of them. For instance, various answers given to the four written tasks by VR participants showed an interest in the painter's pictorial choices or in the representational technique he employed. Secondly, VR prompted participants to conceptualise experience at an abstract level; those who experienced the virtual tour proposed more abstract titles, interpretations, and comments as compared to the other subsample. Thirdly, VR experience tended to stimulate a free and imaginative elaboration of the inputs: participants evoked previous experiences in their real life or rehearsed associative links. The reflection condition induced participants to underline cultural or inferential links and hinted at a speculative approach; in this condition participants honoured the historical features of the painting or were interested in the life of the author and in his work. So, it can be concluded that, at least in the case of understanding paintings, the notion that VR elicits thinking process different from those activated by a non-immersive, static, fixed perspective experience is empirically supported.

It is worth noticing that such a difference is not in line with the usual claim made about VR. It has often been maintained that the innovative educational opportunities opened by VR lean mostly on the fact that VR activates learning procedure grounded on sensory and motory experiences (Ferrington & Loge, 1992): thanks to VR participants can perceive directly, without the mediation of words or conventional symbols, the contents to be acquired. Direct presence and natural interaction have been proposed as the outstanding features of VR for education. Findings of the present experiment suggest that, on the contrary, VR stimulates abstraction and imagination. Features of VR than perceptual accessibility seem to be relevant to learning. For instance VR allows participants to assume a different point of view or to make transformation that would otherwise be impossible in the real world. VR provides a field where participants may attempt to carry out "mental proofs", a set of possibilities that wait to be explored. Thanks to these opportunities, the immersion into a VR environment leads participants to "get into" the representation simulated by the computer. Thus, they can mentally act on the relation they have with the representation of the world instead of acting on

the relation they have with the world itself. This should help learners to realise some critical issues involved in knowledge construction for they can grasp important epistemological implications (for instance, the choices or the conceptual operations underlying the production of a representation). In other words, the main role that VR may play in instruction is to induce participants to reject naive realism and to be aware of some implicit assumptions concerning the relations between our mind and the world (Mantovani, 1996). As Heim (1991) argued, VR should not try to reproduce the world, but it should provide a new environment which can be used to understand how we think about the world.

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