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Managing the impacts of non-verbal devices on idea generation: a new challenge for creative leaders.

Juliette Brun, Hicham Ezzat, Benoit Weil

European Academy of Management , 2015, Varsavoe, Poland.

1. Introduction

Pictures, prototypes or sketches are often considered as inputs enhancing creativity during idea generation sessions. However, these non-verbal devices do not always have the desired effect on creativity: indeed, their use does not ensure the quality of ideas (McGown, Green & Rogers, 1998, 2000) and do not always promote the reinterpretation of concepts (Van der Lugt, 2002, 2005). Both cognitive and organizational factors may explain the potential negative effect of non-verbal tools on idea generation. On the one hand, cognitive studies have shown that non-verbal devices may enhance fixation effects, with a negative impact on variety and originality of ideas (Smith, Ward & Schumacher, 1993). On the other hand, organizational factors may explain productivity loss when dealing with non-verbal tools: for example, social anxiousness (Camacho & Paulus, 1995) can intervene when participants are not familiar to the device or feel uncomfortable regarding its use. In order to overcome both cognitive and organizational issues during creativity sessions, several methods have been developed such as defixation instructions (Agogu e et al, 2013) or sets of rules for brainstorming (Osborn, 1957). However, if managers are well equipped to deal with purely verbal creativity sessions, this does not extend to the use of non-verbal devices, for example pictures or drawings.

In order to avoid potential negative impacts of non-verbal tools on creativity, it first appears important to better understand the way non-verbal devices impact idea generation, i.e., their impact on the design process taking place during creativity sessions: what is the nature of the new insights brought by non-verbal devices to the participants? Do all non-verbal tools have the same impact on creativity? What are the key factors (both cognitive and organizational) for creative stimulation with non-verbal devices? This paper therefore aims both to understand the cognitive impacts of non-verbal devices during idea generation

sessions and to analyze the way interactions between stakeholders (project leaders, facilitators or participants) may influence this impact. This would moreover help to identify success factors for the use of non-verbal tools during creativity sessions. In this research project, we study four cases presenting idea generation sessions during which non-verbal devices were mobilized with the specific aim of enhancing creativity. In each case, this study will present (1) the cognitive and organizational context i.e. the idea generation process and the interactions between stakeholders (2) the cognitive effects generated by non-verbal tools (3) the social impacts i.e. the influence of interactions between stakeholders on the performance of non-verbal devices. We will then compare our four cases and propose both cognitive and organizational success factors, which could help enhancing the use of non-verbal tools during creativity sessions.

2. Managing the use of non-verbal devices in idea generation sessions

2.1. Non-verbal tools for creativity

Pictures, sketches, storyboards, but also movements or fragrances, constitute non-verbal tools for creativity. Non-verbal devices can be opposed to verbal elements such as language or writing. Bürgi and Roos (2003) explain that knowledge can indeed be represented through three modes: the verbal, the pictorial and the spatial modes. The pictorial mode refers to visual perception whereas the spatial mode refers to haptic perception related to the sense of touch. Other modes referring to the senses of smell, hearing or taste could also be considered. Therefore, non-verbal devices may refer to any device that does not contain verbal or narrative information. Two reasons regarding the information related to non-verbal tools also explain why they may enhance the creative process. On the first hand, non-verbal devices support quick information processing by providing an instant feedback to designers

(Schön and Wiggins, 1992). This instant feedback, fast and direct, is therefore very economic cognitively. On the other hand, non-verbal tools allow generating new information and new knowledge, therefore promoting idea generation (Schön, 1983; Suwa et al., 2001). Indeed, non-verbal devices are often ambiguous, which allows the designer reading in them new information and new ideas (Goel, 1995). For example, Goldschmidt (2003) mentions a dialogue between the architect and his sketches. The designer reads new information in the non-verbal device and can thus enrich his reflection in response to this new information. In the same way, participants of creativity sessions can use their knowledge basis to create non-verbal representations and may also receive new knowledge from non-verbal devices.

If non-verbal tools become more and more popular in idea generation sessions, this is because they are expected to enhance creativity i.e. the ability to produce objects both new and relevant (Sternberg & Lubart, 1999). Creativity can also be related to divergent thinking, which consists in giving a various panel of answers to a particular problem. Divergent thinking is opposed to convergent thinking, which consists in giving a single answer to a specific problem. Finding maximum alternative uses for an object – for instance, a brick or a toothbrush – constitutes an example of divergent thinking exercise (Torrance 1962, 1966; Guilford, 1950, 1967). During idea generation meetings in early design, divergent thinking will be encouraged to obtain a various panel of original concepts, whereas convergent thinking will be used in a second step to evaluate and select ideas. Moreover, divergent thinking can be evaluated thanks to three criteria: fluidity, variety and originality of ideas. From a cognitive point of view, the fact that non-verbal devices bring new knowledge to participants can impact divergent thinking, for example, by enhancing fluidity, variety and originality of ideas (Agogué et al., 2013).

However, the effect produced by non-verbal devices on creativity is not always the expected one. Van der Lugt (2002, 2005) studied the impact of non-verbal devices on idea

generation by comparing two specific processes: brainstorming and brainsketching. During brainsketching, participants record ideas with sketches instead of post-it notes. Brainsketching appears to provide a better reinterpretation of ideas at an individual level but presents a lower fluency than brainstorming. Moreover, sketching does not allow a better reinterpretation of ideas produced by others participants, which is surprising since sketches - dense and ambiguous - are expected to offer as many interpretations as the number of observers (Goel, 1995). McGown, Green and Rogers (1998, 2000) also studied the impact of sketching on idea generation. Analyzing industrial designers' sketches, they show that not every sketched exploration led to original ideas. The quality of the exploration is in fact strongly related to the designer's strategy and his ability to extract interesting insights from his sketches.

Both cognitive and organizational factors can explain why non-verbal devices do not always have a positive impact on idea generation. On the one hand, organizational issues may appear when managing ideas produced in the form of non-verbal devices: recording, refining and evaluating these ideas constitute a challenge for managers, who usually work with post-it notes and fact sheets. Moreover, others social causes may explain productivity loss when dealing with non-verbal devices such as loss of interest, perceived lack of expertness or social anxiousness (Camacho & Paulus, 1995). When participants are not feeling comfortable with activities such as drawing or dancing, their ability to produce ideas can therefore be inhibited. On the other hand, issues regarding cognition may explain the negative impacts of non-verbal devices on creativity. Smith, Ward and Schumacher (1993) have shown that non-verbal devices may enhance conformity of ideas i.e. reduce variety and originality. Giving participants some examples through non-verbal devices (such as drawings of potential solutions) before asking them to generate ideas may involve strong fixation effects: if a device contains familiar features, the idea generated from the device will tend to include similar features, thus revealing a conformity effect. Indeed, non-verbal devices bring new

information to participants (for example, visual or haptic), and therefore, constitute examples in the sense of cognition. Such examples are called “restrictive” if they correspond to the participants’ knowledge basis and “expansive” if they are very new and original (Hatchuel & Weil, 2003, Agogu e et al, 2013). During an idea generation session, the introduction of restrictive knowledge will increase fixation effects and impact negatively on divergent thinking (Agogu e et al, 2013).

2.2. Managing idea generation sessions

Several methods have been developed in order to overcome cognitive and organizational issues and better manage creativity sessions. Concerning cognitive factors, defixation instructions help avoiding fixation effects. The introduction of an expansive example indeed allows enhancing the variety and originality of ideas (Agogu e et al, 2013). Concerning organizational factors, several methods allow improving ideas generation, organization, evaluation and selection. Osborn (1957) proposed a set of rules in order to reduce social inhibition and emphasize ideas sharing during brainstorming sessions: at the beginning of the session, participants will be explicitly told to avoid criticism and encourage unusual ideas. In the same way, the six hats’ method (De Bono, 1989) helps seeing the positive aspects of each idea and avoiding negative judgments. These methods tackling both cognitive and organizational issues are already well applied by people managing idea generation sessions. The management of creativity sessions has not to be associated to one particular professional profile: the leader of the session can be as well a project leader (dedicated to one project) as a meeting facilitator, who will be expert in management of collective sessions and can support several different projects. Sometimes, artistic profiles such as designers, illustrators or stage directors can be mobilized to lead creativity sessions. The lead role may therefore be played by employees as well as persons outside of the company. If

several career profiles can take the lead of idea generation sessions, several types of leadership can as well be mobilized.

Leading consists in fact in the ability to influence people and to take decisions in order to enhance global team performance (Hernon & Rossiter, 2006). Several leadership styles can be distinguished such as democratic (Van Vugt, Jepson, Hart & De Cremer, 2004), transactional or transformational leadership (Bass, 1985, 1991). These different forms of leadership are not mutually exclusive. Creative leaders for example are able to develop several leadership styles and to alternate them according to the context (Hersey, Blanchard & Natemeyer, 1979; Rickards & Moger, 2000). Leading creatively can be defined as the ability to lead a group or an organization towards new and innovative paths (Mueller, Goncalo & Kamdar, 2011). Creative leaders are able to generate new ideas, but also, to help enhancing the creativity of other team members. In addition to traditional leadership competencies such as planning, analyzing and decision-making, Palus and Horth (2005) explain that creative leaders must possess an ability to pay attention by asking questions, and also to develop connections between the personal passions and the daily work of team members. Creative leaders also have to make sense of information by promoting the use of images. To provide these images, they are encouraged to use non-verbal devices such as hand graphics or creative collages. This allows reaching into intuition and emotion, which help to enhance team creativity.

Therefore, creative leaders have to deal with conflicting goals: regarding the cognitive aspect, leaders are encouraged both to provide new insights and to avoid fixation. However, fixation effects can precisely result from these new insights. Regarding the organizational aspect, creative leaders have to create a good climate, team spirit and collaboration, but they also have to encourage their team to generate wild ideas, go “out of the box” and open new paths, which can create tensions. These contradictory goals become real issues when dealing

with non-verbal tools, especially if the impact of non-verbal devices is not well understood or managed.

2.3. Managing non-verbal tools for idea generation

If creative leaders are advised to use non-verbal devices, this is first to develop a favorable climate for idea generation. Indeed, the organization of spaces in which creativity takes place appears to play an important role and companies are paying a special attention to this physical environment of innovation (Haner, 2005). More and more creative rooms are dedicated to idea generation and provide post-it notes, pens, large boards, pictures, various material as cardboard, adhesive tape, and sometimes ICT devices, in order to enhance creativity. However, non-verbal devices are not only mobilized to create a favorable climate, but also to directly enhance idea generation through several creativity techniques. During idea generation meetings, non-verbal tools can indeed be used in three types of different protocols: visual stimulation, rearrangement and creation protocols. In visual stimulation protocols, pictures or objects are shown to participants, who are asked to formulate ideas from them. Michael Michalko (2010) proposes to look at Egyptian hieroglyphics to generate new ideas. Other protocols offer to rearrange non-verbal objects, which have to be slightly modified or associated with one another. For example, creative collage consists in associating various images, moving them around into different patterns until an idea emerge. At last, non-verbal devices can be used through creation protocols in order to generate objects expressing a completely different concept than the original devices: this is the case with the Lego Serious Play method (Roos & Victor, 1999), the IDEO “rush to prototype” process (Kelley & Littman, 2001) or with brainsketching, during which participants are asked to draw ideas.

Therefore, it is not uncommon that meeting facilitators use non-verbal devices during creativity sessions to directly give new ideas to participants. Moreover, the intervention of

designers or illustrators during creativity meetings also helps to provide drawings or models, which allow concepts visualization (Weiss, 2002). Ideas visualization plays indeed a major role in creativity (Moultrie et al., 2007): the use of physical devices precisely consists in embodying cognition, which facilitates the creative process and its cognitive operations (Kristensen, 2004). Non-verbal devices are even more important than imagining means giving a representation of what does not exist yet. To do so, Horn (1998) argues that idea generation must be documented by using both verbal and non-verbal descriptions: this will favor new knowledge integration, which is the heart of idea generation. However, as stated before, new knowledge integration can have positive as well as negative impacts, depending on the restrictive or expansive nature of knowledge. Moreover, the restrictive or expansive status depends on the knowledge bases that participants mobilize in relation to the creativity session (Agogu e et al., 2013): new knowledge will be expansive if it is original comparing to knowledge that participants automatically generate when dealing with the topic. However, most existing creativity techniques mobilizing non-verbal devices are generic: if they may bring expansive insights for a particular topic, they may as well bring restrictive inputs for another topic. The leader should thus be able to identify the restrictive or expansive nature of a non-verbal device depending on the topic, which is not an easy task when dealing with visual or haptic information.

Thus, if non-verbal tools are used to create a favorable climate for creativity, they may indeed constitute knowledge inputs, which can increase fixation effects and have negative impacts on idea generation. Moreover, even if non-verbal devices are directly used to give new ideas to participants, their impact on creativity is not always the expected one. The availability of relevant methods concerning the use of non-verbal devices constitutes therefore a real issue for creative leaders. In order to develop such methods, it seems necessary to understand the way non-verbal devices impact the design process during idea generation

sessions: what is the nature of the new insights brought by non-verbal devices? What are their effects on idea generation? What is the impact of interactions between stakeholders on the performance of non-verbal tools? What are the potential levers that creative leaders could use during creativity sessions? In order to propose both cognitive and organizational success factors that could help enhancing the use of non-verbal tools, this paper presents a comparative study of four creativity sessions during which non-verbal devices were mobilized with the specific aim of enhancing idea generation. Special attention was taken in developing a methodology that could help analyzing in a rational way the impact of non-verbal devices on the design process.

3. Research Methodology

3.1. Presentation of selected cases

The selected cases present idea generation sessions during which creative leaders mobilized non-verbal devices with the specific purpose of enhancing team creativity. In order to identify success factors for the use of non-verbal tools, we selected cases presenting different kinds of non-verbal tools, different organizational contexts (group compositions or interactions between stakeholders) and different idea generation protocols.

The first case (Case 1) presents a group meeting led by an experienced architect. Since architects are used to innovate with sketches in their daily work, this case was expected to be a reference case for the use of non-verbal devices. In the first case, an architect led a group discussion about finding innovative solutions for the renovation of a police station's façade. The architect used sketching in order to generate new ideas and also to give new ideas to the group. The resulted sequence of drawings represents about twenty pages of notebook (A5 format). Three pages are presented below (Figure 1).

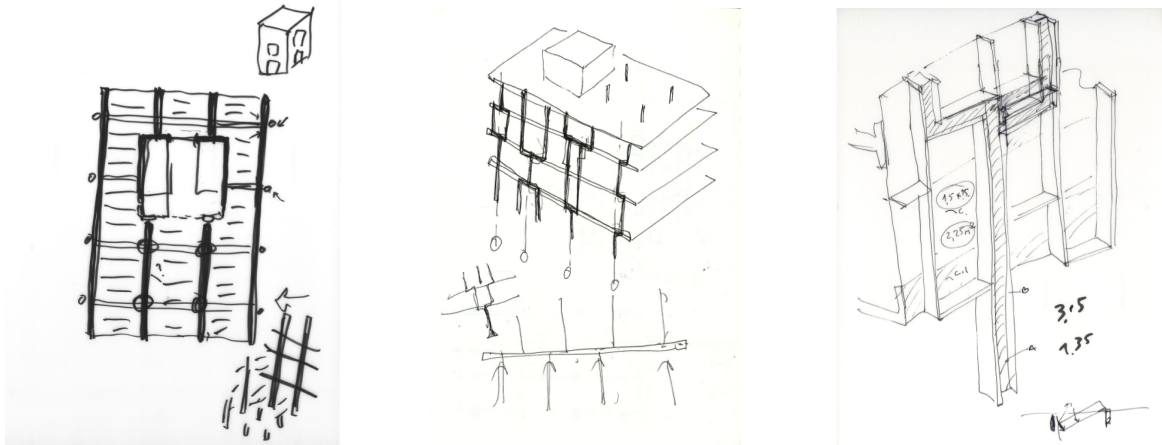


Fig 1. Extracts from the sketches' sequence

The second case refers to a creativity session led following the KCP method (Hatchuel, Le Masson & Weil, 2009) (Case 2). The session took place in a French transport company and corresponds to the “C” phase of the KCP method (an idea generation phase). The participants were separated into groups and had to generate ideas on a given concept. During the session, an experienced illustrator was mobilized to produce drawings in relation to the ideas exchanged by the group. His drawings were expected to give new ideas to the participants. The illustrator could sketch drawings inspired by conversations, but could also be explicitly asked by the participants to draw specific objects or ideas. During the session, the illustrator worked alternately with two groups composed of five or six participants. An innovation officer from the company and two external consultants and KCP experts were also helping the participants finding new concepts.

In the third case, the topic of the creativity session was “the innovative classified ad”, in relation to the Internet of Things thematic (Case 3). The session took place in the Renault automotive company but was related to the activities of an Innovation Community involving several companies. The participants were asked to draw concepts as soon as they had an idea (words could also be added on the drawings), and then, to immediately share their drawing

with the group and fixe it on the wall. After this brainsketching session, the participants were asked to gather the different drawings into categories and to vote for the best ideas.

The last case (Case 4) corresponds to the preparation of a creativity session led by an experienced designer within the Renault Company. A Renault executive had decided to mobilize a designer, who was external to the company, in order to experience the effect of his methods on idea generation. The topic of the creativity session was “new services for electric vehicle charging relying on communities”. The designer had selected pictures less or more related to the initial topic and had constituted a card deck composed of about fifty pictures. A few words were added to the pictures and allowed giving them a title (Figure 2). This card deck was then used to give new ideas to the team that was involved in the preparation of the session: the designer showed the different pictures and asked the participants to explain what the pictures inspired them.



Fig 2. Some pictures of the card deck

3.2. Method of analysis

3.2.1. Presentation of the cognitive and organizational contexts

For each case, the cognitive and organizational context had to be summarized in order to facilitate further comparison. The cognitive context corresponds to the idea generation

protocol involved, whereas the organizational context corresponds to interactions between stakeholders. Furthermore, the proceedings of Case 1 result from interviews that were conducted with the architect after the session, whereas notes were taken during the creativity sessions of Cases 2, 3 and 4. The four cases present varied cognitive and organizational contexts: the non-verbal devices involved were provided sometimes by the project leader himself and sometimes by another stakeholder, for example a designer or an illustrator. Moreover, depending on the case, project leaders played the role of meeting facilitators or non-verbal experts, or even participants. For each case, we thus identify the different stakeholders involved - project leader, facilitator, non-verbal expert (designer, illustrator), participants – and also their interactions. Especially, we establish a model of the idea generation protocol by showing which stakeholder produced the non-verbal device and what were the interactions between the other stakeholders and the device. At last, we indicate which stakeholder played the role of creative leader.

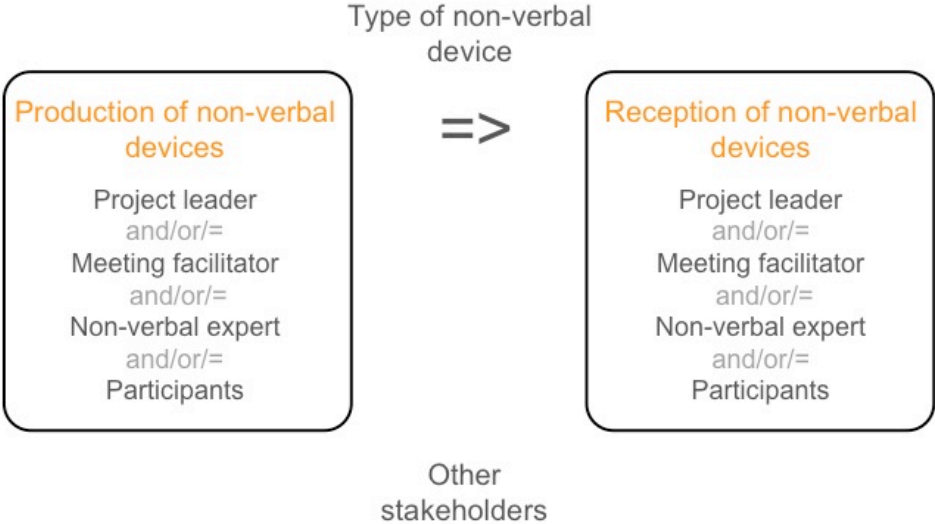


Fig 3. Modeling the cognitive and organizational context

3.2.2. Analysis of the non-verbal devices' contribution to the creative process

In order to analyze the cognitive effects of non-verbal devices, we had to understand the way the new insights brought by these devices impact the emergence of new ideas. It was thus necessary to model (1) the design reasoning involved explaining the emergence of new ideas and (2) the impact of non-verbal devices on the design reasoning. To do so, we used the C-K design theory (Hatchuel & Weil, 2003, 2009), which allows modeling design reasoning. According to the C-K theory, new ideas and new objects are the result of a dialogue between two spaces: the Knowledge space and the Concept space (Figure 4). The Knowledge space (or K-space) refers to propositions that have a logical status: propositions of K are either true or false. On the other hand, the Concept space (or C-space) refers to propositions without logical status: propositions of C refer to objects whose existence is possible but not certain. Furthermore, the Concept or Knowledge status depends on a given knowledge basis: a given proposition may be a concept for someone but knowledge for someone else. According to the C-K theory, imagining a new object consists in starting from an abstract concept, accumulating new knowledge in order to refine this concept until a logical sense appears i.e. until the concept becomes knowledge (Figure 4). Thus, innovation emerges through a co-expansion of both C-space and K space.

The theory moreover distinguishes four operators, which represent different design operations (Figure 4):

- $K \rightarrow C$: this operator adds or subtracts knowledge K to concepts C, then generating alternatives in the C-space. It creates “disjunctions” when it transforms K propositions into a concept;
- $C \rightarrow K$: this operator allows seeking knowledge to understand a concept C without logical status. It creates “conjunction” when a finished design is reached, that is to say, when a final concept makes sense and becomes part of the Knowledge space;

- $C \rightarrow C$: this operator allows creating concept alternatives following rules of set theory (partition or inclusion).
- $K \rightarrow K$: this operator allows a self-expansion of the Knowledge space. It can correspond to deduction, modeling, optimization or evaluation operations;

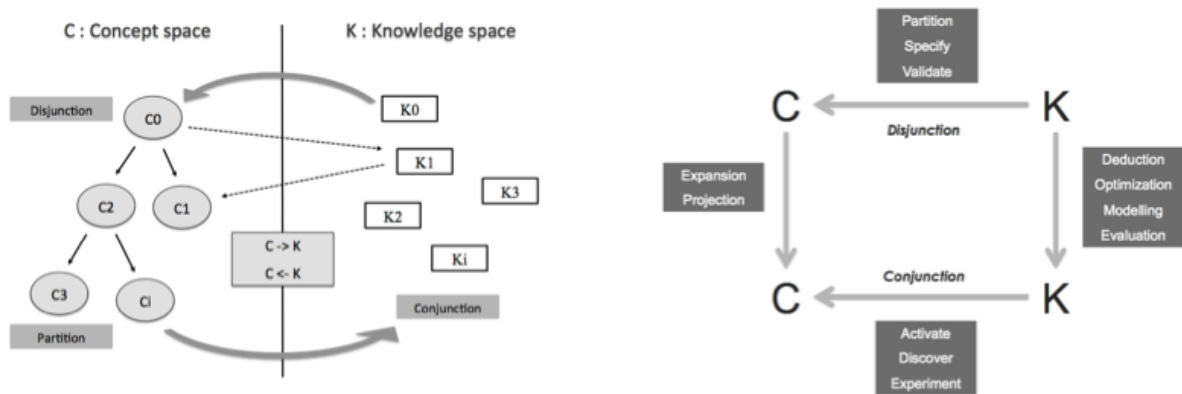


Fig 4. The C-K dynamics and the four design operators

In the C-K methodology, concepts and knowledge refer to propositions or words. Since non-verbal devices are not propositions, they could not refer directly to the C-space or to the K-space. Nonetheless, in order to model their impact on the C and K space, they were put in a design space called D-space. Four new operators can therefore be generated:

- $K \rightarrow D$: This operator corresponds to a situation where a team member (participant and/or meeting facilitator and/or creative leader) uses knowledge that he already had in mind to produce or modify the non-verbal device involved. This could be done in order to visualize this knowledge or even to test it.
- $C \rightarrow D$: This operator allows transferring a concept imagined by a team member into a non-verbal object; since concepts have a non-logical status, this operator could help clarifying concepts by visualization.

- D->K: This operator corresponds to a situation where a non-verbal object brings new knowledge to the group, knowledge that all team members did not have previously in mind thinking about the initial topic. This can be knowledge shared with the group by a team member via a non-verbal device; this can also be a knowledge that nobody had in mind before and inspired by an ambiguous non-verbal object. Moreover, these knowledge inputs can appear less or more related to the initial topic.
- D->C: With this operator, the non-verbal device directly gives birth to an idea concerning something that did not exist yet. For example, an architect can see “a building as puzzle” in a sketch and work with this idea, even if he does not know what such a building could be in practice.

The D->C and D->K operations refer to the direct contribution of non-verbal devices to the creativity session: they help to identify when non-verbal tools brought new knowledge or new concepts to participants. Therefore, in each case, the D->C and D->K operations involved will be identified in order to see the impact of non-verbal devices on design reasoning. Moreover, if a non-verbal inspires a new concept, this concept can be restrictive (if it refers to restrictive knowledge), as well as expansive (if it refers to original knowledge). In the same way, all K-elements do not have the same status. Some knowledge can be restrictive, and some expansive (Hatchuel & Weil, 2003, Agogu  et al, 2013). Moreover, some K-elements brought by non-verbal devices can be related to the exploration: for example, in Case 1, architectural elements, aesthetic expectations or evaluation criteria as stability or cost are K-elements related to the topic of the police station fa ade. However, some knowledge can appear unrelated to the initial topic. For example, the knowledge “puzzle” does not appear directly related to an exploration around buildings. Therefore, an additional distinction between knowledge status must be made: we note K* a K-element that appears unrelated to the initial topic. Concepts cannot however be distinguished in the same way since alternative concepts

are formulated in relation to the initial concept they refine. Moreover, when relevant and possible, we analyze the impact of new knowledge inputs on both the C-space and the K-space: on the one hand, a new K-element can generate a new concept, therefore expanding the C-space; but on the other hand, new knowledge can foster a knowledge restructuration, thus reorganizing the K-basis (Le Masson, Hatchuel & Weil, 2013). This K-reordering can then lead to new innovative paths and new expansive concepts.

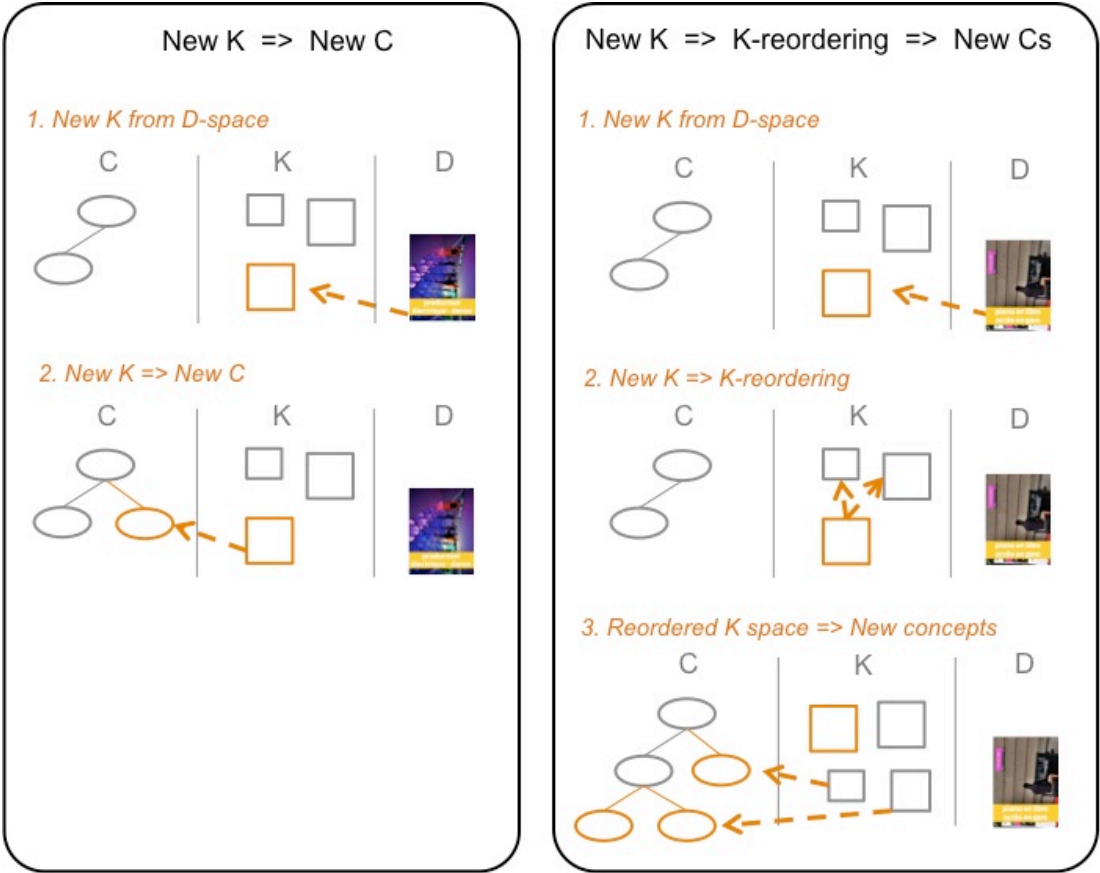


Fig 5. Two impacts of new knowledge on the C-space and the K-space

3.2.3. Impacts of stakeholders

A cognitive analysis is not sufficient to explain the way non-verbal tools impact idea generation. In creativity, organizational factors must also be considered in addition to cognitive factors in order to understand the way concepts are generated and to study the

performance of a given creativity technique. Analyzing the influence of interactions between stakeholders was therefore necessary to understand the effects of non-verbal devices in the four cases. We compared the results expected from the idea generation protocols with the actual results obtained. To do so, we compared the type of design operators involved (D->C and D->K) with the type of operators suggested by the creativity protocol used in each case. We also assessed the performance of the protocol by looking at the number of operators obtained. We then identified both factors explaining potential differences between results and expectations. By comparison between the four cases, we proposed success factors that could be able to enhance the use of non-verbal tools during idea generation sessions and playing on both cognitive and organizational levels.

4. Empirical Results

4.1. Results presentation

4.1.1. Cognitive and organizational contexts

The Figure 7 below summarizes the cognitive and organizational context in each case. In Case 1, the architect worked without explicit protocol. The sketching activity was expected to foster idea generation for the architect leading the discussion, but also for other architects attending the session. The architect thus played the role of creative leader. In fact, during the session, the architect played three roles: since he was expert in using drawings to generate new ideas and was able to produce them, he played the role of non-verbal expert. He was also the project leader and was responsible for the session proceeding and its results. At last, he also played the role of meeting facilitator since he led the discussion. On the other side, other meeting participants received the sketches produced by the architect as inputs.

Since participants were experienced architects too, they were also non-verbal experts themselves.

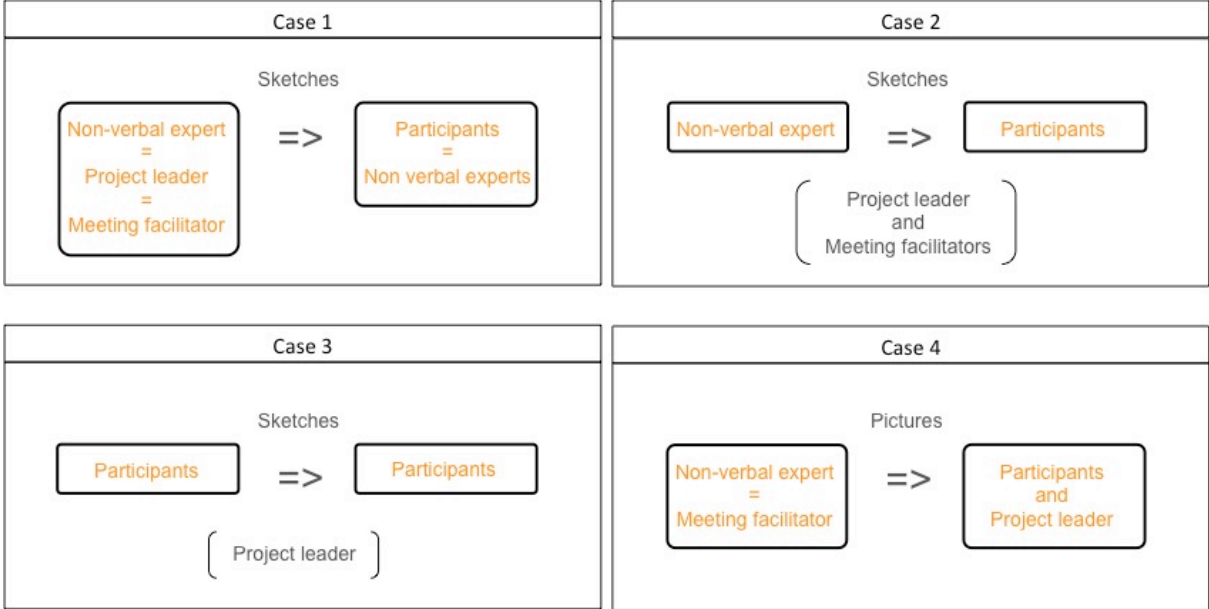


Fig 7. Cognitive and organizational contexts

In Case 2, participants were expected to find new ideas thanks to sketches produced by an illustrator. At the beginning of the session, they were asked to find new concepts and explicitly invited to inspire themselves from the sketches in order to generate new ideas. The illustrator was sitting at the same table than the groups. His drawings were displayed through a digital screen and were thus fully accessible to the participants. However, from the participants and the company’s point of view, the person intended to help the participants having new ideas was not the illustrator but the innovation officer and the two KCP experts. These three stakeholders played the role of creative leaders. Moreover, the two external consultants were in charge of the facilitation of the session, whereas the innovation officer was the project leader responsible for the session’s outputs.

In Case 3, the participants were asked to draw a concept on paper and to immediately explain their idea by commenting on their sketch. Even if they were not expert in using

sketches to reach new ideas, the participants thus ensure the production of the non-verbal devices. They were also the beneficiaries of the drawings since they were asked to use the sketches in order to generate ideas. During the idea generation session, no stakeholder actually played the role of meeting facilitator. The groups were given instructions but no facilitation method was used during idea generation. Moreover, the session was considered as an experiment and was included in the activities of an innovative community to which Renault belongs. The project leader was thus external to the company and was also meant to play the role of creative leader.

In Case 4, the designer showed different pictures to the participants and also presented their titles. Participants were explicitly asked to generate ideas from the pictures. Moreover, the designer was expert in using non-verbal devices for idea generation and was also the meeting facilitator of the session. The project leader, who had asked the designer to lead the session, played the role of participant.

4.1.2. Cognitive effects of non-verbal devices

In Case 1, all D->K and D->C operations identified were generated by the leader himself. For example, looking at the first drawing of Figure 8, the architect thought that the skeleton building appearing on the façade could disappear behind the sun-breaker solution he was trying to add: the two systems could therefore appear to be a single system. In this case, the drawing brought a concept to the architect (“a single visible system actually composed of two systems”): this corresponds to a D->C operation. Looking at the second drawing presented below, the architect explained that the global system reminded him of living cells observed under a microscope: this corresponds to a D->K* operation since the sketch brought the architect knowledge that was not related to the initial topic (a police station’s façade). We thus identify 19 D->K operations (including 5 D->K* operations) and 4 D->C operations.

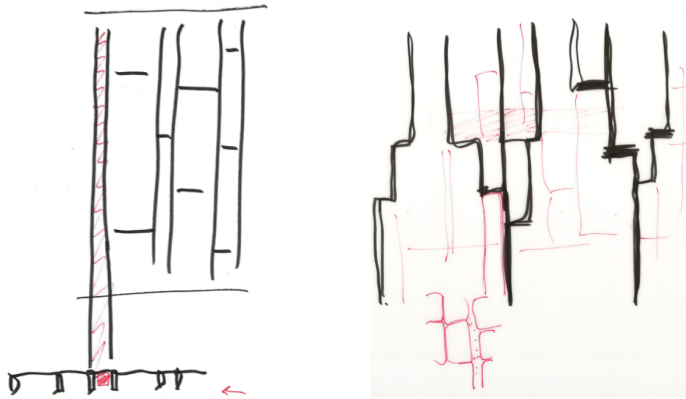


Fig 8. Examples of sketches related to D->C and D->K operations

In Case 2, no interaction was actually observed between the group and the illustrator. Some participants looked at the drawings from time to time but no reaction occurred. Thus, no D->C or D->K operation happened during the session, although these operations were expected. However, at the end of the meeting, the illustrator showed his work through a PowerPoint presentation. This was for an informative purpose, and not in order to continue the creativity session. However, the drawings refer to original knowledge and concepts: for example, the illustrator had sketched ghosts or a cowboy wanted poster. In the same way, a lot of K-elements introduced by the illustrator through his speech appear to be very original, and sometimes, not directly related to the initial topic.

In Case 3, the protocol given to the participants corresponded to $K_i \rightarrow D_i \rightarrow K_i$ and $C_i \rightarrow D_i \rightarrow C_i$ operations: knowledge (or concept) brought with the sketch to the group was exactly the same than the one the team member had put in his sketch. By contrast, few $K_i/C_i \rightarrow D_i \rightarrow K_j/C_j$ operations, which correspond to the emergence of completely new insights, were observed during the session. Therefore, sketches constituted another way than words alone to share knowledge and concepts but they did not brought a lot of new insights to the participants. Sketches thus played a role of intermediary between the team member speaking

to the group and the other participants. Moreover, the fact that the drawings were fixed on the wall and thus accessible to the participants provided a better access to C- or K-elements already shared with the group. 10 D->C operations and 11 D->K operations occurred during the session. Most of them corresponded to the role of intermediary held by sketches except for two D->K operations, which refer to a reinterpretation of someone else's drawings. One of this D->K operation corresponded to a deviation from the protocol: all the participants did not speak the same language and a team member had to explain what a classified ad was. He quickly made a classified ad to show what form it had. He then explained that people write on classified ads what they offer or what they need, and he wrote the word "things", "job" and "love". During the session, this ad and especially the last word gave to a participant the idea that a classified ad could refer to something else than objects and services. This led to the concept of a classified ad that could provide "emotional" services such as hugs, kisses or Friday afternoons.

In Case 4, the idea generation protocol consisted in bringing through pictures new knowledge to participants: this corresponds to D->K operations, where knowledge is the same that those the designer used to produce the card deck. Some knowledge presented in the pictures had already been shared by the participants during previous sessions: the corresponding pictures did not allow K expansion. However, 42 pictures among the 48 cards of the deck brought new knowledge. Some cards had the same title but, since pictures were different, they did refer to different pieces of knowledge. The participants used these new K-elements to produce new concepts. However, these C-expansions corresponded to K->C operations and not to direct D->C operations: each concept was generated after the introduction of new knowledge by a picture. Thus, the pictures were not involved in the production of new concepts through direct D->C operations. Among the new K-elements brought by the pictures, 11 were very original and appeared not directly related to the initial

subject: for example, the designer showed a picture a free access piano in a train station, which appeared to be knowledge not directly related to the subject of new services for EV charging relying on communities.

4.1.3. Occurrence of D->C and D->K operations

The table below summarizes the occurrence of D->C and D->K operations in each case. It is important to point out that the D->K (or D->C) contributions correspond to expansions of the shared K-basis (or the shared C-space) of the group. Thus the new C-elements or the K-elements introduced by non-verbal devices correspond to concepts or knowledge that had not previously been shared by the group.

	Occurrence of D->C and D->K operations	
Case 1	D->K	19 (5 D->K*)
	D->C	4
Case 2	D->K	0
	D->C	0
Case 3	D->K	11 (2 D->K*)
	D->C	10
Case 4	D->K	42 (11 D->K*)
	D->C	0

Table 1. Occurrence of D->C and D->K operations

4.1.4. Impact of new K introduction

In Case 1, the introduction of new K sometimes directly brings new concepts to the architect. However, another phenomena prevailed. The architect was very precautious concerning new K-elements brought by sketches: he chose to work with some of them but to suppress knowledge that did not suit him. He thus built a reduced K-basis, which allowed him to produce an original object. This corresponds to a reorganization of the knowledge basis. New K can indeed directly lead to a concept but can also help to reorganize the K-basis with a direct impact on the K-space before impacting the C-space (see Figure 5). In Case 2, nothing can be told about the impact of new K since the participants did not manage to use this new knowledge without further support. Concerning the brainsketching session of Case 3, two “new K \rightarrow new C” operations were observed (including one K* \rightarrow C operation). However, no effect in terms of knowledge reorganization was noticed. The impact of new K introduction on the K-space was only the classic expansion effect. In Case 4, the introduction of knowledge that had been already shared by participants did not involve any impact in terms of C- or K-expansion. However, the introduction of new knowledge had two types of effects: first, a direct impact in terms of C-expansion with New K \rightarrow New C operations, and second, an effect of restructuration of the knowledge basis. It was also noted that K-elements related to the topic seemed to involve direct concept expansion, whereas the K*-elements seemed to produce K-basis restructuration. A complementary methodology should be applied to confirm the latter assumption.

4.2. Results analysis

The work of the architect (Case 1) appears as a frame of reference: he perfectly managed to use non-verbal tools in order to find original ideas. Three factors tend to explain this success. First, the architect producing the non-verbal devices is also the project leader: he generates sketches that support his objectives. Therefore, (i) the effect produced by the non-

verbal devices is consistent with the creative leader's expectations. Moreover, meeting participants are also architects: they are used to read architectural drawings and thus familiar to these non-verbal devices. Moreover, the architect also provided comments of his drawings, which allowed the participants to receive all necessary information from the sketches. Thus, (ii) participants were able to interpret the non-verbal devices used in the session and to extract from them new information (knowledge or concepts). At last, the sketches were produced by a non-verbal expert, who perfectly mastered the expansive power of drawings: by experience, architects are indeed able to produce very expansive drawings. Therefore, (iii) the non-verbal devices produced had a very high generative power. Moreover, the architect works mainly with K. Thanks to knowledge that appears not directly related to the topic (K^* -elements), he proceeds to a reorganization of the K-space. The generative power of sketches is thus highly related to their capacity to provide the architect with new K^* . In case of idea generation sessions, it may be possible that non-verbal devices bringing mostly K^* -elements to the participants will have a good generative power.

In Cases 2 and 3, the effect produced by non-verbal devices was not the effect expected by the creative leader. In Case 2, even if the leaders explained to participants that they were expected to use the drawings to have new ideas, the participants did not manage to do it by themselves: no interaction occurred between the participants and the sketches. The disposal of non-verbal devices in a room was not enough to bring new knowledge or new ideas to the groups: the participants were not able to use the drawings to generate new ideas. The condition (ii) was therefore not satisfied and the protocol did not work. The association between non-verbal objects and C- or K-elements is indeed not always obvious from the participant's point of view. New C and new K can however be expressed to enhance the generativity of non-verbal tools. In this way, the speech that accompanies the use of non-verbal devices (instructions given to the participants by creative leaders, commentaries or

explanations of the non-verbal expert) appears to be very important in the efficiency of non-verbal tools. In Case 3, the participants rarely used existing drawings in order to produce new ideas. Two reasons can be given to explain this fact. On the one hand, sketches produced by the participants presented a low generative power: participants were indeed not used to produce drawings in order to generate new ideas and did not know how to produce highly generative sketches. Thus, condition (iii) was not satisfied. On the other hand, participants were not used to extract new information from the sketches in order to use it to generate ideas. Condition (ii) was not satisfied. Moreover, participants were told to generate ideas in the form of sketches but were never explicitly told to generate new ideas from the sketches (which was however the aim of the project leader). Explicit instructions and facilitation work could have helped the participants to enhance their creativity. In case 3, it can be noted however that if the sketches rarely allowed generating new ideas, they facilitated drawings classification and ideas evaluation at the end of the session. The drawings indeed allowed participants to easily recall the ideas to which the different drawings referred, which is not always easy with one or two words on post-it notes.

In Case 4, the designer actually managed to give the participants new ideas thanks to the pictures. The effect of non-verbal devices was consistent with the one expected by the project leader (Condition i). Moreover, participants easily interpreted the pictures and manage to generate new ideas from them (Condition ii). At last, the designer had built a varied panel of cards integrating both classic knowledge and very expansive knowledge: he mastered the expansive power of non-verbal devices (Condition iii). It can be noted however that the project leader asked for very expansive concepts, which were favored by the use of K*-elements. The card deck contained however 11 K*-elements among 42 pictures. In order to enhance the generation of very original concepts, more K*-elements could have been

introduced to the participants. Nevertheless, the group generated concepts more easily from the classic K-elements than from the K*- elements.

Indeed, the two types of generative effects following new K introduction have been observed in both Cases 1 and 4. The first effect corresponded to the classic K->C operation: a new K generates a new original C. The second effect consisted in a restructuration of the group's knowledge basis thanks to the introduction of an original K-element. This new K directly impacts the K space and changes its rules. This often made the participants look for new knowledge in order to be able to give a clear sense to their reorganized K-space. This also can have, in a second phase, an impact on the C-space with the generation of new concepts.

Therefore, cognitive operations taking place in idea generation with non-verbal tools are not all of the same nature. Moreover, it can be expected that K-restructuration involves a higher cognitive cost than the direct C-expansion following new K introduction. However, the non-verbal devices involved in the different cases did not seem to present the same ability to support these cognitive operations. In the first case, the architect transforms his sketches to generate new sketches: here, modifications, evaluations and instant feedbacks provided a strong cognitive support to the designer (Schön and Wiggins, 1992). By contrast, the non-verbal devices of Case 4 were pictures: once pictures were given to the group, participants were not invited to modify or transform these pictures, which did not provide the same cognitive support than non-verbal tools including the possibility of transformation. Moreover, some knowledge inputs of Case 4 involved K-basis restructuration: this operation could perhaps have been more successful if the non-verbal devices had provided possibilities of transformation and thus stronger cognitive support. Therefore, the type of non-verbal device and the protocol through which it is used may have to be adapted in relation to the expected generative effect and to the cognitive cost involved.

5. Conclusion and managerial implications

Three success factors could help ensuring the performance of non-verbal devices during creativity sessions: (i) The effect produced by the non-verbal devices is consistent with the creative leader's goals and expectations. (ii) Participants can easily interpret the non-verbal devices used during the session and can extract from them new information (knowledge or concepts). (iii) The non-verbal device produced present a very high generative power.

Creative leaders have therefore a major role to play concerning the use of non-verbal devices during idea generation sessions. A creative leader can enhance the coherence between the protocol given to the participants and the expectations concerning the use of non-verbal tools. The leader can then ensure that the effects of non-verbal devices during the session respond to the impacts he expected. He may indeed help the participants to express new knowledge or new concepts from the non-verbal devices and to use these new insights in relation to the ongoing exploration. Such linking can be made through two phenomena following the introduction of new knowledge: the first is a classic expansion of concepts and the second is a reorganization of the group's knowledge basis. Such reorganization allows opening new paths for innovation and to develop several expansive concepts. New knowledge brought by non-verbal devices can therefore have very different impacts on idea generation. A creative leader could be able to read this new knowledge and anticipate its impact on creativity.

Management tools and methods could thus be developed in order to better control the impact of non-verbal devices on idea generation. In order to satisfy the three success factors, project leaders, non-verbal experts and facilitators could work together in order to enhance the

performance of non-verbal tools on creativity. Moreover, this study helps to understand the different impacts of non-verbal devices during idea generation sessions. It shows that they allow introducing a large amount of new knowledge, which can have very different generative effects. According to whether new knowledge seems related or unrelated to the topic, two different strategies may take place to enhance generativity: a direct expansion of concepts or a reorganization of the knowledge basis. Further developments will be needed to precisely identify the characteristics of knowledge leading to the first or to the second strategy.

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